Recovery Plan for the Mexican Long-nosed Bat (*Leptonycteris nivalis*)
https://ecos.fws.gov/docs/recovery_plan/940908.pdf

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Original Prepared by: Rodrigo A. Medellín (Centro de Ecologia, Universidad Nacional Autónoma de México) and Carol J. Beardmore (U.S. Fish and Wildlife Service, Austin, TX)

DRAFT AMENDMENT 1
We have identified best available information that indicates the need to amend recovery criteria for this species since the Mexican Long-nosed Bat Recovery Plan was completed. In this proposed modification, we synthesize the adequacy of the existing recovery criteria, show amended recovery criteria, and the rationale supporting the proposed recovery plan modification. The proposed modification is shown as an appendix that supplements the Mexican Long-nosed Bat Recovery Plan (Recovery Plan), superseding only Section II, pages 33-35 (U.S. Fish and Wildlife Service (USFWS) 1994).

For
U.S. Fish and Wildlife Service
Southwest Region, Region 2
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Approved: _____DRAFT_____ Date: _____
Regional Director, Region 2
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BACKGROUND INFORMATION
Recovery plans should be consulted frequently, used to initiate recovery activities, and updated as needed. A review of the recovery plan and its implementation may show that the plan is out of date or its usefulness is limited, and therefore warrants modification. Keeping recovery plans current ensures that the species benefits through timely, partner-coordinated implementation based on the best available information. The need for, and extent of, plan modifications will vary considerably among plans. Maintaining a useful and current recovery plan depends on the scope and complexity of the initial plan, the structure of the document, and the involvement of stakeholders.

An amendment involves a substantial rewrite of a portion of a recovery plan that changes any of the statutory elements. The need for an amendment may be triggered when, among other possibilities: (1) the current recovery plan is out of compliance with regard to statutory requirements; (2) new information has been identified, such as population-level threats to the species or previously unknown life history traits, that necessitates new or refined recovery actions and/or criteria; or (3) the current recovery plan is not achieving its objectives. The amendment replaces only that specific portion of the recovery plan, supplementing the existing

recovery plan, but not completely replacing it. An amendment may be most appropriate if significant plan improvements are needed, but resources are too scarce to accomplish a full recovery plan revision in a short time.

Although it would be inappropriate for an amendment to include changes in the recovery program that contradict the approved recovery plan, it could incorporate study findings that enhance the scientific basis of the plan, or that reduce uncertainties as to the life history, threats, or species' response to management. An amendment could serve a critical function while awaiting a revised recovery plan by: (1) refining and/or prioritizing recovery actions that need to be emphasized, (2) refining recovery criteria, or (3) adding a species to a multispecies or ecosystem plan. An amendment can, therefore, efficiently balance resources spent on modifying a plan against those spent on managing implementation of ongoing recovery actions.

METHODOLOGY USED TO COMPLETE THE RECOVERY PLAN AMENDMENT

In coordination with the USFWS, a team of bat biologists from Angelo State University, Bat Conservation International, New Mexico State University, University of Georgia, Universidad Nacional Autónoma de México (UNAM), and Universidad Autónoma de Nuevo León completed a species status assessment (SSA) for the Mexican long-nosed bat (USFWS 2018, entire). A Traditional Section 6 Grant awarded to Bat Conservation International by Texas Department of Parks and Wildlife supported development of that SSA. That award also supported creation of a network of bat biologists in Mexico for the Mexican long-nosed bat (i.e., the Nivalis Network) and a monitoring program in 2017 at Mount Emory Cave (Texas, USA) and Cueva Del Diablo (Morelos, Mexico). The SSA informed the developed of delisting criteria for the Recovery Plan along with individual conversations with members of the Nivalis Network.

ADEQUACY OF RECOVERY CRITERIA

Section 4(f)(1)(B)(ii) of the Endangered Species Act (Act) requires that each recovery plan shall incorporate, to the maximum extent practicable, "objective, measurable criteria which, when met, would result in a determination…that the species be removed from the list." Legal challenges to recovery plans (see Fund for Animals v. Babbitt, 903 F. Supp. 96 (D.D.C. 1995)) and a Government Accountability Audit (GAO 2006) also have affirmed the need to frame recovery criteria in terms of threats assessed under the five delisting factors.

Recovery Criteria

The 1994 Recovery Plan only established downlisting criteria for this species (USFWS 1994, pp. 33-35, https://ecos.fws.gov/docs/recovery_plan/940908.pdf).

Synthesis

The SSA for the Mexican long-nosed bat contains the most up to date information on the species (USFWS 2018, entire). The Mexican long-nosed bat appears to consist of one large migratory population, rather than the multiple population model proposed in the original Recovery Plan (Brown 2008, p. 53-62). Primary threats to the Mexican long-nosed bat include land-use changes, human visitation of caves, and climate change. The downlisting criteria suggest

maintaining six populations of Mexican long-nosed bat (USFWS1994, pp. 33-35). As a result of the SSA demonstrating that species consists of only one population, previously defined downlisting criteria are out of date and do not align with current knowledge of the species. Cueva del Diablo, Tepoztlán, Morelos, México is the only known mating roost of the Mexican long-nosed bat. After mating in Cueva del Diablo, bats migrate north to three major maternity roosts: Mount Emory Cave in Big Bend National Park, Brewster County, Texas: El Infierno in Santiago, Nuevo Leon, Mexico; and El Rosillo Caves in Sabinas, Coahuila, Mexico. The migratory route the Mexican long-nosed bat follows is still unknown and requires additional research. Aguacatitla Tunnel, in Aquacatitla, Hidalgo, Mexico, hosts a non-migratory, maternity colony of the Mexican long-nosed bat (Rojas-Martínez et al. 2010, entire). A small number of other caves in Mexico and the United States (i.e., New Mexico) have hosted low to moderate numbers of bats. However, the key sites for species persistence are Cueva del Diablo, El Infierno Cave, El Rosillo Cave, and Aguacatitla Tunnel in Mexico and Mount Emory Cave in the United States.

AMENDED RECOVERY CRITERIA

Recovery criteria serve as objective, measurable guidelines to assist in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the the Mexican long-nosed bat may be delisted because it no longer meets the definition of an endangered species. Delisting is the removal of a species from the Federal Lists of Endangered and Threatened Wildlife and Plants. Downlisting is the reclassification of a species from endangered to threatened. The term "endangered species" means any species (species, sub-species, or DPS) which is in danger of extinction throughout all or a significant portion of tis range. The term "threatened species" means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

We provide amended downlisting criteria and establish delisting criteria for the Mexican long-nosed bat, which will supersede those included in the 1994 Recovery Plan, as follows:

Downlisting Recovery Criteria

The Mexican long-nosed bat will be considered for reclassification from endangered to threatened when:

(1) The five major roosts (Cueva del Diablo, Aguacatitla Tunnel, El Infierno Cave, El Rosillo Cave, and Mount Emory Cave) have protections in the form of enforcement, management and education to reduce human interaction, from a non-permitted person, with the bat colony to zero and eliminate construction that could threaten the structural integrity of the roost, impede entry by the bats into the roost, or cause abandonment of the roost.

(2) Cueva del Diablo maintains a colony size of at least 10,000 bats over a 10-year period.

(3) A continuous, standardized monitoring program is implemented for food sources of the bat to manage for the threats of land use change and climate change.

Justification:

Criterion 1 addresses one of the chief threats to the species, which is disturbance of roosts in the form of human disturbance and urban development. All of the roosts are at risk of recreational use, while Cueva Del Diablo is particularly vulnerable to expansion of the town of Tepoztlan, as discussed in the rationale for recovery criteria section. The species cannot persist unless these threats are ameliorated by increased security of the roost and protected status.

Criterion 2 addresses resiliency of the species. The largest colony count at Cueva del Diablo since the bat was listed was approximately 8,000 bats in 2006 (Caballero-Martínez 2004, p. 52; Toledo-Gutiérrez 2009, p. 39). Downlisting would require a 25 percent increase from the largest colony size since the colony size was first estimated. Because Cueva del Diablo is the only mating roost, it is assumed that most or all of the bats will filter through the cave. Colony size estimates of the roost can be used as a surrogate for overall population size. A larger population size will increase the resiliency of the species to stochastic events. Representation will also be preserved with a larger population size, reducing the potential effects of genetic drift and inbreeding depression that can be problematic with rare species. A ten-year period was decided based on the results of an expert elicitation, as this represents 10 generations and would be enough time to account for fluctuations in population number.

Criterion 3 addresses threats to the *Agave* species that the Mexican long-nosed bat relies upon for food. Due to agricultural expansion and urbanization along with expected increase in drought and temperatures resulting from climate change, *Agave* species are expected to undergo range contractions (Gomez-Ruiz 2015, p. 26-45, Zamora-Gutierrez 2018, table S1). Because so little is known about the status of the food sources of the bat it is imperative that research and continuous monitoring begin as soon as possible to inform management decisions in response to climate change and land use change.

Delisting Recovery Criteria

The Mexican long-nosed bat will be considered for delisting when:

(1) The five major roosts (Cueva del Diablo, Aguacatitla Tunnel, El Infierno Cave, El Rosillo Cave, and Mount Emory Cave) have protections in the form of enforcement, management and education to reduce human interaction, from a non-permitted person, with the bat colony to zero and eliminate construction that could threaten the structural integrity of the roost, impede entry by the bats into the roost, or cause abandonment of the roost.

(2) In addition to the five major roosts, there are at least five additional roosts with a minimum colony size of 500 bats over a 10-year period.

(3) Cueva del Diablo maintains a colony size of at least 12,000 bats over a 10-year period.

(4) A continuous, standardized monitoring program is implemented for food sources of the bat to manage for the threats of land use change and climate change.

Justification:

Criterion 1 addresses one of the chief threats to the species, which is disturbance to roosts in the form of human activity and urban development. All of the roosts are at risk of recreational use, while Cueva Del Diablo is particularly vulnerable to expansion of the town of Tepoztlan, as discussed in the rationale for recovery criteria section. The species cannot persist unless these threats are ameliorated by increased security of the roost and protected status.

Criterion 2 for delisting addresses redundancy of the species. While it is vital that the five major roosts are protected and healthy, having other roosts increases the ability of the species to persist through catastrophic events. In the case of roost abandonment from one of the five primary roosts, it would be important to have other roosts with potential to hold displaced bats. The minimum number of 500 bats was the result of an expert elicitation and the SSA resiliency tables that have 500-1000 bats rated as a moderate condition for a roost (USFWS 2018). A ten-year period was decided based on the results of an expert elicitation, as this represents 10 generations and would be enough time to account for fluctuations in population number.

Criterion 3 addresses resiliency of the species. The largest colony count at Cueva del Diablo since the bat was listed was roughly 8,000 bats in 2006 (Caballero-Martínez 2004, p. 52; Toledo-Gutiérrez 2009, p. 39). Delisting would require a 50 percent increase from the largest colony size estimated since the species was first listed. Because Cueva del Diablo is the only mating roost, it is assumed that most or all of the bats will filter through the cave. Colony size estimates of the roost can be used as a surrogate for overall population size. A larger population size will increase the resiliency of the species to stochastic events. Representation will also be preserved with a larger population size, reducing the potential effects of genetic drift and inbreeding depression that can be problematic with rare species. A ten-year period was decided based on the results of an expert elicitation, as this represents 10 generations and would be enough time to account for fluctuations in population number.

Criterion 4 addresses threats to the *Agave* species that the Mexican long-nosed bat relies upon for food. Due to agricultural expansion and urbanization along with expected increase in drought and temperatures resulting from climate change, *Agave* species are expected to undergo range contractions (Gomez-Ruiz 2015, p. 26-45, Zamora-Gutierrez 2018, table S1). Because so little is known about the status of the food sources of the Mexican long-nosed bat it is imperative that research and continuous monitoring begin as soon as possible to inform management decisions in response to climate change and land use change.

Rationale for Recovery Criteria

The downlisting and delisting criteria for the Mexican long-nosed bat are linked to the following factors that continue to impact the species' extinction risk.

Human Disturbance of Caves

Anthropogenic activities, such as disturbance from people entering a roost, pollution (e.g. trash), noise, vibrations, and development around roosts is the main threat to the conservation of roosts. These anthropogenic threats can lead to changes in Mexican long-nosed bat roosting behavior

and potential abandonment of the roost. All roosts discussed in this document have a threat of disturbance and vandalism unless they are located within a protected area with well-enforced regulations. Even those roosts with a protected status are still at risk from human disturbance unless access is regulated.

Human visitation and disturbance of caves is one of the main threats to Cueva del Diablo in Morelos, Mexico, which is significant as this cave is the species' only known mating colony. Visitors (e.g., local and tourists) and speleologists would visit the cave without supervision, usually disturbing the colonies due to noisy activities, light, and flash photography (pers. comm. Ana Ibarra, UNAM). This disturbance usually caused the colonies to temporarily move between different chambers inside the cave (pers. comm. Ana Ibarra, UNAM). During monitoring visits (2011-2015), evidence of disturbance was found (e.g., trash in the cave, remains of fire torches, and even ritual statues) and the colony would be found roosting in chambers not usually occupied by the colonies (pers. comm. Ana Ibarra, UNAM). After a couple of weeks of this behavior, if no disturbance was detected, the colony would be back in the usual chambers (pers. comm. Ana Ibarra, UNAM).

In 2015, unsupervised visits were stopped by installing a fence surrounding the main entrance to the cave, accompanied by an environmental education program directed to local communities and tourist and speleologist guides (pers. comm. Ana Ibarra, UNAM). During a series of workshops, local guides were advised on the importance of the cave and the bat species using it and on responsible visits practices (pers. comm. Ana Ibarra, UNAM). In addition, in order to enter the cave, every visitor has to report to a park ranger, who ensures that visitors are accompanied by a responsible guide and follow the rules (pers. comm. Ana Ibarra, UNAM).

Surface construction work, including associated vibrations and noise, above the main roosting tunnels continue to be major threats to the persistence of the colony roosting in Cueva del Diablo and the stability of the cave itself (pers. comm. Ana Ibarra, UNAM). Despite being part of a National Park, land above the cave is of communal property (pers. comm. Ana Ibarra, UNAM). Some of landowners have built houses above the cave (pers. comm. Ana Ibarra, UNAM). In the past, these structures have been small, low impact buildings. However, due to increasing urbanization, land is now being sold and larger houses are being constructed (pers. comm. Ana Ibarra, UNAM). During the last earthquake (September 19, 2017), the cave sustained minor damage, but with increased development and the associated vibrations, the risk of collapse continues to be a threat (pers. comm. Ana Ibarra, UNAM). Cases in which urban development has encroached on roosting caves, possibly causing roost abandonment, have been detected (i.e., Del Ferrocarril cave in Morelos, Mexico), and this continues to be a risk at Cueva del Diablo (pers. comm. Ana Ibarra, UNAM).

At El Infierno cave in Nuevo Leon, Mexico, speleological activities are known to occur inside the cave, but the level of activity is unknown. In the past, the cave, which is a large sinkhole, was used by locals as a trash dump, which may have negatively affected the bats roosting inside. Some known Mexican long-nosed bat roosts have been abandoned, likely due to human disturbance. For example, during the summer of 2013 researchers visited Del Guano Cave in Durango, Mexico finding evidence of vandalism, particularly fire inside the cave and Mexican

long-nosed bats were not present (pers. comm. Celia López González, Centro Interdisciplinario de Investigacion para el Desarrollo Integral).

Finally, drug trafficking and immigration across the United States-Mexico border poses threats to roosts in northern Mexico and southwestern United States. These activities can introduce additional sources of roost disturbance (e.g. drug traffickers or immigrants entering and using caves) that may impact bats. Crime and violence also hinder research and educational programming. For example, Del Guano Cave has not been monitored regularly for several years due to drug cartel-related conflicts in the area, and access to Romney Cave in New Mexico, United States, is often limited to daytime visits because of potential conflicts in the area (pers. comm. Ana Ibarra, UNAM; pers. comm. Kathryn Stoner, New Mexico State University). The decline in research and conservation activities can have lasting impacts on the knowledge and conservation of roosts in these areas.

While visits by people can negatively impact roosts, as discussed above, at some roosts there is successful regulation of human access and therefore reduced threats to the bats. At the Aguacatitla tunnel in Hidalgo, Mexico, visitation of a roosting tunnel and bat observation are one of the main attractions in the park (pers. comm. Ana Ibarra, UNAM). However, the managers of this park strictly enforce visitation rules that cause minimum disturbance to the colony and the roosts (pers. comm. Ana Ibarra, UNAM).

Loss of Food Sources

Although the Mexican long-nosed bat utilizes a wide array of floral resources, species in the genus *Agave* remain a very important component of their diet. This is supported by Gómez-Ruiz and Lacher (2017, p. 74-75) who found that bat presence is highly correlated with the distribution of *Agave* species and their migratory route is characterized by agave availability. The loss of any floral resources, but especially *agave*, near roosts and along migratory corridors will have a detrimental effect on the health of the population.

Evaluating and monitoring the impact that each one of the mentioned anthropogenic activities have on the conservation of the Mexican long-nosed bat is difficult without knowing their location. A study conducted by England (2012, p. 156) suggests monitoring the bat's main roosts should include efforts to determine location of potential associated foraging grounds. Currently, efforts are under way to initiate a study that includes using micro-GPS technology for Mexican long-nosed bats at Cueva del Diablo to locate potential foraging grounds (pers. comm. Ana Ibarra, UNAM).

Land use change

Areas that once represented potential foraging grounds have been, and continue to be, threatened with conversion for agricultural use, cattle ranching, and urban development (Téllez-Zenteno 2001, p. 34-38; Salinas-Galicia 2013, p. 87-88; Rojas-Martínez pers. comm.). Out of a potential 60 million hectares (ha)[148,263,229 acres (ac)] of desert scrub habitat in Mexico, only 44.2 million ha (109,220,579 ac) was estimated to remain by 2002 as an unaltered, undisturbed vegetation structure, mainly in the Baja California peninsula, northern plains and the central Plateau, with at least 10.2 million ha (25,204,749 ac) converted for agriculture/livestock and

nearly 5 million ha (12,355,269 ac) having an altered and/or disturbed vegetation structure, mainly in Tamaulipas, San Luis Potosí y Zacatecas (Sánchez-Colón et al. 2009, p. 106-110). Temperate forests in Mexico have faced similar declines, with approximately 10 million ha (24,710,538 ac) of habitat loss between 1970-2002 (Sánchez-Colón et al. 2009, p. 102-106). Gómez-Ruiz (2015, p. 50-67) assessed land cover change in three vegetation types where bat-pollinated agaves occur in Coahuila and Nuevo León, Mexico over three decades (1985-2011) and found an overall reduction on the three vegetation types and an increase in fragmentation. Desert scrub had the largest negative net change from 1985 to 2011. Most of the change occurred between 1985 and 2002 with most of the area transitioning to agriculture. Human settlements were the class with highest increase (i.e., 84 percent) occurring between 1985 and 1993. The reduction and fragmentation of agave habitat can reduce the foraging areas available to Mexican long-nosed bats and increase the time and energy needed by bats to find foraging resources. The changes in foraging habitat may also impact the migration patterns of the species.

Harvesting of Agave

The popularity of Tequila and Mescal has resulted in an increase in the number and size of agave plantations as well as harvesting of agave plants from natural habitat. With the exception of the Tequila Interchange Project's "Bat Friendly Tequila," harvesting agave plants occurs before the plant is allowed to flower, eliminating most plantations as potential foraging habitat. In addition, agave plantations have been and will likely be established on habitat hosting existing wild agave populations, further reducing available foraging resources.

Due to lack of information it is impossible to conclude what impact unregulated harvesting of wild agave has on Mexican long-nosed bat foraging habitat. However, there are reports that harvesting of hundreds or even thousands of wild agave in Miquihuana, Tamaulipas, occurred three years ago (pers. comm. Arnulfo Moreno). It is believed that each plant or "piña" can sell on the black market for around 900 Mexican pesos (MXN) [$47.00 U.S. Dollars (USD)]. A similar report of the Procuraduría Federal de Protección al Ambiente (PROFEPA) seizing a shipment of agave heads in Durango illustrates that this may have a considerable impact on Mexican long-nosed bat foraging habitat.

Expansion of Energy Industry and Mining

In a recent study, Hammerson et al. (2017, p. 148) found that wind energy development was the second most serious threat for North American bats. Recent legal reforms in Mexico (i.e., Reforma Energética, Ley de Cambio Climático) encouraged growth of renewable energy. Several areas in the state of Coahuila and Nuevo Leon had been identified with good potential for wind energy and these areas overlap with the range of the Mexican long-nosed bat.

Abandoned mines, in general, could represent potential roosts. In northeastern Mexico, some bat species, including the Mexican long-nosed bat, have established colonies in mines abandoned in the 1970s (e.g. Todos Santos and Santa Rosa mines). At that time, these mines were abandoned because extraction was no longer profitable. However, due to new extractive technologies, some mines could potentially be re-opened, causing these colonies to abandon these roosts. None of the five primary roosts are the result of abandoned mines.

Factor D: Inadequate existing regulatory mechanisms.

Aguacatitla Tunnel, Aguacatitla, Hidalgo, Mexico

Aguacatitla roost is part of an ecotourism park, maintained and managed by a cooperative association (pers. comm. Ana Ibarra, UNAM). As a group, the cooperative embraces the conservation of bats and the Mexican long-nosed bat colony in particular. Visiting the roosting tunnel and seeing the bats are one of the main attractions in the park. However, the managers of this park strictly enforce a set of rules so these visits cause minimum disturbance to the colony and the roost. During these visits, they share information about the bats, their ecological role, ecosystem services, and the importance of this tunnel for the species. They actively maintain the integrity of the tunnel system and make restorations when needed. Rojas-Martínez (pers. comm.) collaborates closely with the group that manages this park, offering advice on management, responsible practices and public outreach and education. Being part of privately owned lands, access to the site is strictly controlled and always under supervision of a guide. For this reason, conservation threats due to anthropogenic activities is low. In addition, the Aguacatitla Canyon is within the boundaries of the Barranca de Metztitlán Biosphere Reserve, which also confers federal and state protection to the site.

Currently, there is not a long-term monitoring program for this roost. However, Dr. Rojas-Martínez from the State University of Hidalgo conducts annual visits to the roost while the colony is present (March-August). In 2017, Instituto de Ecología-UNAM started a collaboration with Rojas-Martínez and the Aguacatitla managers in order to establish a regular monitoring program in this roost (pers. comm. Ana Ibarra, UNAM).

Cueva Del Diablo, Tepoztlán, Morelos, Mexico

Cueva del Diablo is the only mating roost for the species and only major roost known for the winter range of the species. However, this site is under threat due to anthropogenic activities. This cave is a popular site for professional speleological groups and amateur explorers and visitors are regularly present (Téllez-Zenteno 2001, p. 37; pers. comm. Ana Ibarra, UNAM). Despite being part of a federally protected area (i.e., El Tepozteco National Park), the land where the cave is located is privately owned and subject to urban development. Each year the expansion of urban settlements encroaches on surrounding lands and even on the land directly above the cave (pers. comm. Ana Ibarra, UNAM). Currently, the Laboratory for Ecology and Conservation of Terrestrial Vertebrates (LECVT) is actively collaborating with the Commission of Natural Protected Areas (CONANP), local landowners and the public to manage and protect this cave and surrounding foraging areas (pers. comm. Ana Ibarra, UNAM). In 2016, in collaboration with CONANP, a protective fence was placed surrounding the entrance to the cave (pers. comm. Ana Ibarra, UNAM). The purpose of this fence is to control the access of visitors to the cave, ensure that they are accompanied by the local park guard and follow recommendations to prevent disturbance to the cave and the bat colony. The installation of this fence was accompanied by an extensive environmental education program with local tourist guides, landowners and public (pers. comm. Ana Ibarra, UNAM).

Surface construction work, and associated vibrations, and noise, on top of the main roosting tunnels continue to be major threats to the persistence of the Mexican long-nosed bat colony roosting in Cueva del Diablo and the stability of the cave itself (pers. comm. Ana Ibarra, UNAM). Despite being part of a National Park, the land on top of the cave is of communal property. Some of the owners have built houses in the land. These structures had been small, low impact buildings. However, due to increasing urbanization, land is now being sold and new owners are developing bigger houses. During the last earthquake (September 19, 2017), the cave sustained minor damage, but with increased development and the associated vibrations, the risk of collapse continues to be a threat (pers. comm. Ana Ibarra, UNAM). Cases in which urban development has encroached on roosting caves, possibly causing roost abandonment, have been detected (e.g. at Del Ferrocarril cave in Morelos, Mexico), and this continues to be a risk at Cueva del Diablo (pers. comm. Ana Ibarra, UNAM).

El Rosillo Cave, Sabinas, Coahuila, Mexico

The entrance to this cave is located on the face of a cliff making human access is difficult. While the cave is located within a Natural Resources Protected Area, no official conservation or management plan exists for the cave and associated fauna. However, the Don Martin Basin Natural Resources Protected Area included the Mexican long-nosed bat as a target species in their recently announced, soon to be published, climate adaptation plan. The plan considers protection of roosting sites and foraging resources to maintain connectivity of the corridor and highlights as specific actions to identify and protect roosting sites and conduct an inventory and monitoring of agave. Communities surrounding El Rosillo Cave participated in educational and outreach programs implemented for El Infierno Cave (Especies, Sociedad y Habitat A.C. – Comission Nacional de Areas Naturales Protegidas (ESHAC-CONANP) 2013, entire; Gómez-Ruiz et al. 2015, entire) with the objective of informing people on the relevance of bats and their ecological roles and the importance of the area for the conservation of *L. nivalis.* In 2018, CONANP, under the Species-at-risk Protection Program (PROCER), announced funding for protecting and monitoring Mexican long-nosed bats in five protected areas in Coahuila (i.e., Cuatro Ciénegas, Distrito de Riego 004 Don Martín, Maderas del Carmen, Ocampo y Río Bravo del Norte).

El Infierno Cave, Laguna de Sánchez, Santiago, Nuevo León, México

Given its morphology, an almost vertical tunnel, El Infierno Cave can only be accessed by experienced climbers with appropriate climbing equipment. However, the cave is a very popular site for speleological groups. Several authors suggest that the protection of the cave and the surrounding foraging grounds is of vital importance for the conservation of the Mexican long-nosed bat (Moreno-Valdez et al. 2004, p. 456, 458; Gómez-Ruiz et al. 2015, p. 93). Despite being part of a National Park, the cave is not included in the official management and conservation plan of this park. Private organizations and researchers, in collaboration with CONANP, have implemented a series of educational and outreach programs with the communities that live in the area in order to raise awareness about bats in general, and Mexican long-nosed bats in particular, their ecological role, the relevance of agaves for the species, threats and conservation actions (ESHAC-CONANP 2013, p. 56-70; Gómez-Ruiz et al. 2015, p. 93, 94). In 2017, efforts to establish a standardized, long-term monitoring program were initiated. These

studies aim to understand migratory patterns and connectivity among the main roosts of the species in Mexico (i.e., Cueva del Diablo) and the United States (i.e., Mount Emory and Romney Caves). In 2018, CONANP, under the Protected Areas Management Program (PROMANP), announced funding for monitoring at El Infierno Cave with three specific objectives: 1) understand the population structure at the site by conducting population counts using infrared cameras, and obtaining information on site use, site fidelity, and population structure using mark-recapture methods; 2) characterize the echolocation calls of the species; and 3) estimate the abundance and phenology of foraging resources within the Cumbres National park.

Mount Emory Cave, Big Bend National Park, Texas, United States of America

Emory Cave is within the National Park Service's Big Bend National Park. Its remoteness and inaccessibility reduces the probability of visitation by tourists and disturbance. However, the cave opening is visible from a hiking trail and there is nothing to prevent hikers from entering the cave. Plans have been made with Raymond Skiles, resource manager at Big Bend National Park, to erect a sign near the cave to inform visitors of the presence of an endangered bat species as well as the risk of introducing the fungus that causes White-nose Syndrome. Colony size is monitored yearly by researchers from Angelo State University using thermal imaging to estimate emergence counts.

Effects from climate change

Recent work does suggest that climate change may impact Mexican long-nosed bat habitat, particularly *Agave* species. While the predicted effects of climate change are highly dependent on the modeling efforts being used, a study by Zamora-Gutierrez et al. (2018, table S1) looking at the effect of climate and land use change predicts that even under an optimistic scenario, 59 percent of the Mexican long-noses bat's range will be unsuitable by 2050. The driving climatic variables in this model were mean temperature of the warmest quarter, mean temperature of the coldest quarter, annual precipitation, and precipitation seasonality (Zamora-Gutierrez et. al. 2018, p. 365).

There is particular concern that climate change will affect plant-pollinator relationships directly by shifting the distribution of the plants and the pollinators and by delaying flowering periods and causing a mismatch with the presence of key migratory pollinators. This might be the case for the *Agave*-Mexican long-nosed bat interaction. Gómez-Ruiz (2015, p. 26-45) studied the potential climate change impacts on Mexican long-nosed bats and agave for the years 2050 and 2070. Models show that the suitable environments for the bat and the *Agave* species studied are reduced under future scenarios. Models for Mexican long-nosed bat show a reduction of up to 80 percent in its area of environmental suitability by 2070. Moreover, the overlap between agave and Mexican long-nosed bat will be reduced by at least 75 percent. In addition, the results reveal a change in *Agave* species richness pattern with smaller proportion of areas with one or more species in future scenarios than under current climate conditions.

In general, for all *Agave* species, most of the seeds produced fall from the fruit capsules near the parent plant, but others in strong wind may be blown several meters (Gentry 1982, p. 42). This suggests that agaves have a limited dispersal potential and incorporating this variable in the

models will likely restrict even more the size of the areas with suitable environments in future scenarios. Changes in temperatures and precipitation will also affect agave phenology in ways we do not clearly understand. There is little information about the specific cues that trigger flowering in agaves, but there is consensus that precipitation is an important variable (Gentry 1982, p. 271, 324, 418, 521; Pau et al. 2011, p. 3633).

As a result of predicted increases in hot temperatures and drier climate, fire frequency is expected to increase. The effects of fire on agave is a concern because of the bats' reliance on this genus for nectar in the northern part of their range. In southeastern Arizona, Slauson (2002, p. 7) found less than 4 percent of agave (*A. palmeri*) in the burned area died due to fire and there was no effect on nectar and pollen production. It was suggested that there was a long-term benefit to the agaves and the fire actually increased germination. However, the size of the plant and the specific fuel load around the agave might affect survival. Johnson (2001, p. 34) studied the effects of fire on *A. palmeri* and found more mortality in small agaves, unless the agave was in an environment with higher fuel loads and then larger agave also were affected. Agave associated with mesquite (*Prosopis*) or *Acacia* trees during a fire had higher mortality in the Johnson (2001, p. 37-38) study and she suggested that patches of dead parent agaves that burn would have the same impact on mortality on live plants in the area. *Agave* might be less likely to die though if they are found on rocky slopes where there are low fuel loads. Further research is needed to understand if *Agave* that are used by *L. nivalis* change nectar volume or sugar content after a fire, if fruit or seed set is affected, how burn intensity affects flowering (and non-flowering) rosettes, and how it affects bat foraging behavior/migration.

ADDITIONAL SITE SPECIFIC RECOVERY ACTIONS

Not applicable.

COSTS, TIMING, PRIORITY OF ADDITIONAL RECOVERY ACTIONS

Not applicable.

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