Draft Revised Recovery Plan
for the
Mexican long-nosed bat (*Leptonycteris nivalis*)

Photo credit: Carson M. Brown

Southwest Region
U.S. Fish and Wildlife Service
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An electronic copy of this draft recovery plan may be obtained from the Service's Environmental Conservation Online System (ECOS) species profile for Mexican long-nosed bat.

Prepared by Jade Florence, Ph.D., Wildlife Biologist, U.S. Fish and Wildlife Service, Austin Ecological Services Field Office. Research and expert input were provided by Bat Conservation International and the Nivalis Conservation Network. We dedicate a special thanks to their staff members, Ana Ibarra for recovery plan research and help gathering source material, along with Jon Flanders and Kristen Lear for consultation on the recovery actions and budget estimation for this plan.

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Chapter 1: Introduction

The Mexican long-nosed bat (*Leptonycteris nivalis*) was listed as endangered under the Endangered Species Act of 1973 as amended (16 U.S.C. 1531 et seq.) on September 30, 1988 (53 FR 38456-38460). The Mexican long-nosed bat is a nectivorous species of bat, ranging from the southwestern United States to central Mexico, and is mainly found in desert and pine-oak forest habitats. A subset of the species engages in an annual long-distance migration that coincides with flowering phenology of food resources, mainly agaves and columnar cacti. Loss of food resources due to conversion of foraging habitat to agriculture and ranching, in addition to disturbance by humans, is thought to have contributed to rangewide population decline.

Section 4(f) of the ESA requires the development of recovery plans for listed species unless such plans would not promote the conservation of particular species. In 2016, the USFWS adopted a new recovery planning process called "Recovery Planning and Implementation" (RPI). This is a streamlined approach to recovery planning and is intended to reduce the time needed to develop recovery plans, increase the relevancy of recovery plans over a longer time frame, and add flexibility to recovery plans so they can be adjusted to new information or circumstances. Under the RPI framework, a Recovery Plan includes:

> (i) A description of such site-specific management actions that are necessary to achieve the plan's goal for the conservation and survival of the species;
>
> (ii) objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this section, that the species be removed from the list; and
>
> (iii) estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

The RPI Recovery Plan is supported by the Species Status Assessment (SSA) for the Mexican long-nosed bat, which was completed in 2018 (USFWS, 2018). It includes a thorough review of this species' taxonomy, natural history, habitats, ecology, populations, and range. The SSA analyzes individual, population, and species requirements; factors affecting survival; and the current condition of each species to assess their current and future viability in terms of resilience, redundancy, and representation.

Additionally, under the RPI process a separate working document called the Recovery Implementation Strategy (RIS) is being developed that will provide a stepped-down schedule of specific recovery activities needed to implement the recovery actions described in the Recovery Plan. The SSA and RIS allow for incorporation of new information, as needed, without revising the Recovery Plan, unless there is a need to also change the statutory elements.

Chapter 2: Overview

This overview summarizes information from the Mexican long-nosed bat SSA (USFWS 2018).

2.1 Species Description

The Mexican long-nosed (*Leptonycteris nivalis*) is a relatively large glossophagine bat. Glossophagine bats are a subfamily of leaf-nosed bats, which belong to the Phyllostomidae family—a grouping of bats characterized by a pointed projection on the snout. A typical Mexican long-nosed bat has a total length of 83 mm (3.46 inches); forearm length ≥ 55mm (2.17 in); and fur length of 7 to 8 mm (0.28–0.32 in) in dorsum. The average body mass is 26–28 grams, and it has a drab brown color, darker in the dorsum and paler ventrally.

2.2 Species Habitat & Distribution

The Mexican long-nosed bat inhabits areas in central Mexico, along the eastern coast, to southwestern United States. It is found as far south as the states of Guerrero and Puebla in Mexico. In the United States, this species is known from western Texas (i.e., Presidio and Brewster Counties) to Hidalgo County, New Mexico (Figure 1). Specimens from Arizona and northwestern Mexico collected before 1980 exist in several museum collections but should be re-examined for proper identification because during that time the name *L. nivalis* was assigned to individuals currently recognized as *L. yerbabuenae*. *Leptonycteris nivalis* is not found in Arizona (Hoffmeister, 1986).

The species spends fall and winter in central Mexico, migrating northward to northern Mexico and the southwestern United States at the end of February/early March. The Mexican long-nosed bat remains in this area forming maternity colonies during spring and early summer and starts migrating to central Mexico by mid-summer (Easterla, 1972; Arita, 2005). Téllez-Zenteno (2001) reports that this migration is mainly made by pregnant females (i.e., moving northward by the end of winter) and post-lactating females (i.e., moving southward by the end of summer) while it is still uncertain what happens to males and research suggests they remain scattered in roosts in central Mexico.

Cockrum (1991) and Fleming et al. (1993) suggest that migratory movements of *Leptonycteris* species are driven by the need to find floral resources, therefore, they take advantage of seasonal blooming of different cacti and Agave species along a nectar corridor. More recently, Gómez-Ruiz and Lacher (2017) have modeled the geographic distribution of the species in relation to the distribution of floral resources and describe a "nectar corridor" across Mexico and the southwestern United States.

Appropriate roosts are required in summer and winter areas, and along the migration pathway. Mexican long-nosed bats typically roost in caves, although they have been found in mine tunnels, and found at elevations of 1,000 to 2,300 m, typically in pine-oak habitats. The species requires roosts (caves, mines, crevices) with appropriate temperatures

(around 18 °C) and humidity, with limited human disturbance and limited access to predators.

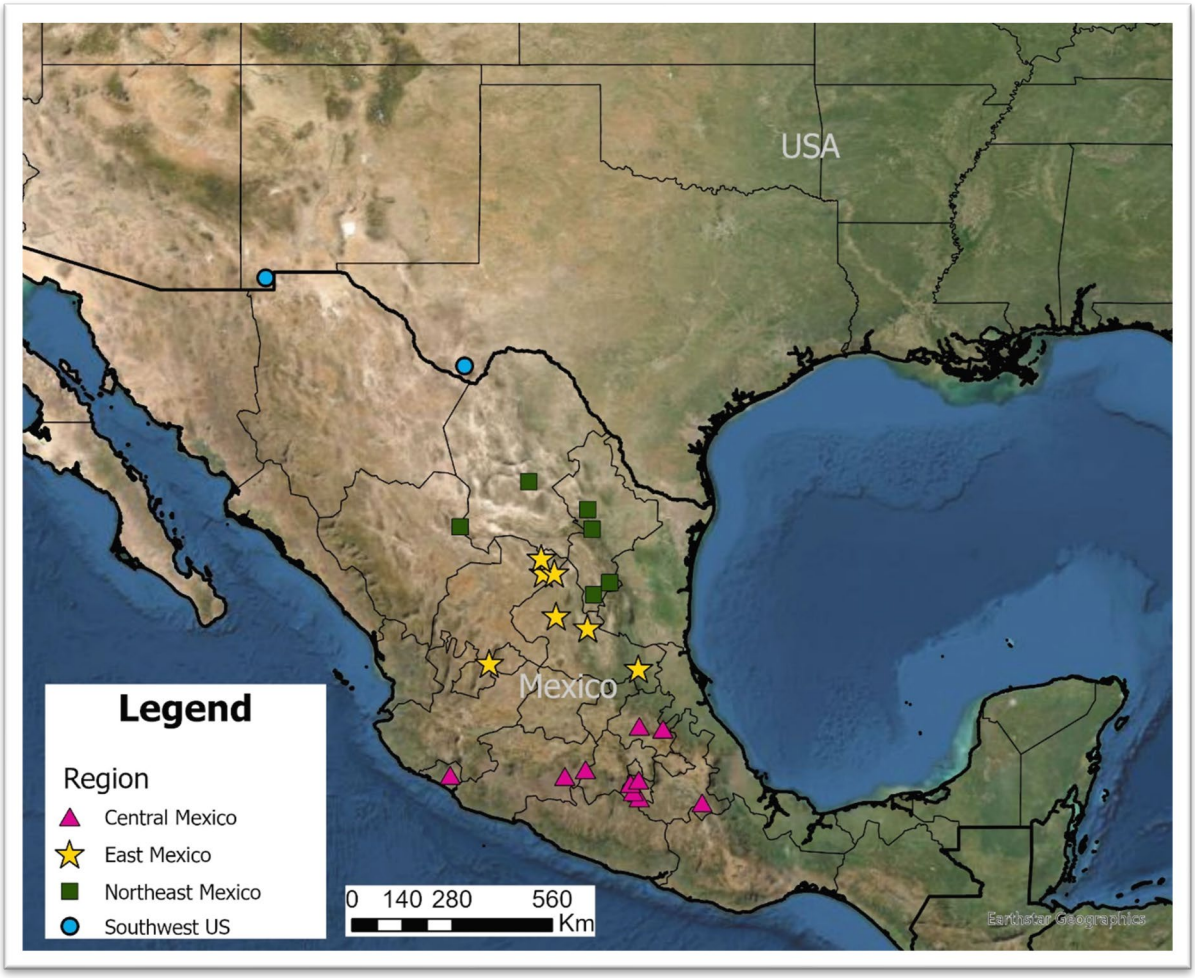

Figure 1. Locations of all Mexican long-nosed bat roosts that have been confirmed to be inhabited by the bat either in the past or currently. Roost locations are divided into four regions: central Mexico, eastern Mexico, northeastern Mexico, and southwestern United States. Museum specimens from two caves do not have confirmed coordinates: El Coyote Cave and El Murcielago Cave. Subsequently, these caves are not on any of the maps with roost locations.

2.3 Life History

The following overview summarizes life history information for the Mexican long-nosed bat. For a more thorough review of the species' individual needs, see USFWS (2018).

2.3.1 Diet

Mexican long-nosed bats are known to consume the nectar or pollen from at least 49 different species of flowering plants across their range. They are thought to specialize in feeding on species from the families Agavaceae and Convolvulaceae, specifically those in the genus *Agave* and *Ipomoea.*

The Mexican long-nosed bat requires healthy populations of these flowering plants near roosting sites and along migratory routes. Valiente-Banuet (1997) reports the bat as the main pollinator of *Neobuxbaumia* species, a dominant columnar cactus genus in central Mexico. Mexican long-nosed bats in New Mexico were found to travel 20–30 kilometers (km) (12–19 miles) one-way each night to forage on Agave (Bogan et al., 2017). In Texas, they have been found to make foraging trips ranging from 13–30 km (8–19 miles) round-trip and twice as much *Agave* habitat overlapped with the home ranges used by adults compared to juveniles (England, 2012). Generally, adequate foraging resources within 50 km (30 miles) of roosting sites are considered crucial, especially for maternity colonies.

2.3.2 Reproduction

The Mexican long-nosed bat has a monoestrous reproductive pattern, mating and giving birth only once a year (Racey and Entwistle, 2000). Accordingly, bats gather in central Mexico during fall-winter to mate (Téllez-Zenteno, 2001). Cueva del Diablo is the only known mating roost where males and females concentrate in the winter range and likely is where most mating occurs (Téllez-Zenteno, 2001). Females and males have been reported from other roosts in central Mexico during winter but groups of Mexican long-nosed bats in these roosts are only a few dozen in number (Téllez-Zenteno, 2001; Torres-Knoop, 2014).

A 1:1 sex ratio has been determined at Cueva del Diablo and La Peña Cave. Males at the latter cave are reproductively active (i.e., scrotal testis) around October to November. Pregnant females arrive by February, similar to reports from Cueva del Diablo, suggesting this could be another mating roost (Téllez-Zenteno, 2001).

Another measure of sex ratio occurred at Tziranda Cave, which Téllez-Zenteno (2001) suggested may be another mating roost. However, the data reported by López-Segurajáuregui (2010) does not support this idea. In this colony, the sex ratio was biased towards males. However, there were no more than a few hundred individuals present, most captures occurred between August and October, and all captured individuals (i.e., males or females) were reproductively inactive.

2.3.3 Dispersal and Movement

The Mexican long-nosed bat is a migratory bat that travels between the United States and Mexico. The needs of the Mexican long-nosed bat are strongly influenced by their migratory habits.

Between the months of September and early March, males and females congregate at specific mating roosts in central Mexico. To date, Cueva del Diablo, in the State of Morelos, is the only known mating roost of the species. After spending late fall and early winter in central Mexico, males are thought to remain in central Mexico, or migrate to unknown areas, separated from the females. During this time, an unknown proportion of females will migrate north, most likely using many unknown caves as stopover sites on their way to female-only maternity caves in northeastern Mexico and the southwestern United States (i.e., New Mexico and Texas), where they will raise their young. This subpopulation of females and juveniles then migrate south to central and southern Mexico in the fall. This migratory subpopulation forages on flowering plant species along the route and therefore the timing and availability of these resources are critical to their survival.

Migration closely correlates with blooming and nectar production phenology of several *Agave* species along the latitudinal gradient (1200 km) between Cueva del Diablo (i.e., mating roost in central Mexico) and Emory Cave (i.e., maternity roost in Texas) (Moreno-Valdez et al., 2000; Gómez-Ruiz and Lacher, 2017). In addition, there seems to be a positive correlation between altitude and *Agave* species richness and presence of Mexican long-nosed bats suggesting that greater diversity and availability of resources attracts the species (Gómez-Ruiz and Lacher, 2017). According to Gómez-Ruiz and Lacher (2017), high elevation mountainous areas in Nuevo León and Coahuila—where bats are likely to find more foraging resources (*Agave* spp.) and roosting sites—may function as stepping-stones that support the bat's migration.

2.4 Threats

Section 4 of the ESA describes five factors that may lead to endangered or threatened status for a species. These include:

> A) the present or threatened destruction, modification, or curtailment of its habitat or range;
> B) overutilization for commercial, recreational, scientific, or educational purposes;
> C) disease or predation;
> D) the inadequacy of existing regulatory mechanisms; or
> E) other natural or manmade factors affecting its continued existence.

The primary threats to the species include the reduced availability of adequate roost sites, along with a lack of sufficient forage plant species and habitat connectivity to support annual migratory movements (Factor A). Overutilization (Factor B) is a threat due to recreational human disturbance (in the form of people entering bat roosts and hindering their survival). Further, lack of protection for several roosts (Factor D) and climate change (Factor E) will exacerbate all these risk factors. Currently, disease/predation (Factor C) does not appear to be a major risk factor affecting the Mexican long-nosed bat.

2.4.1 Habitat Loss and Degradation (Factor A)

Persecution of Vampire Bat Colonies

In Mexico, cattle rabies outbreaks are commonly associated with the common vampire bat (*Desmodus rotundus*). Small colonies (usually no more than a couple dozen individuals)

roost in caves. The common vampire bat is considered a harmful and dangerous species due to its propensity to transmit rabies, especially cattle rabies. As a result, the Mexican government (DOF, 2011) has established control programs that specifically target the species. However, sometimes cattle owners and community members apply control measures that involve the destruction of caves where bats roost. Most times, these roosts are inhabited by species other than vampire bats. As a result, entire colonies of other bats are annihilated, with little to no effect on the vampire bat population (USFWS, 2018). Although common vampire bats and Mexican long-nosed bats are not usually found together due to latitude and altitudinal restrictions, cave destruction to control the vampire bat population is an important threat for the species, especially in eastern and central Mexico.

Sufficient Forage Plant Species and Habitat Connectivity

Although Mexican long-nosed bats utilize 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) who found that the bat's presence records are highly correlated with the distribution of *Agave* species and their migratory route is characterized by *Agave* availability. The loss of key floral resources, but especially *Agave*, near roosts and along migratory corridors has a detrimental effect on the health of the population. A variety of actions including land use change and agave harvesting practices are having a detrimental effect on the health of foraging grounds.

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 (USFWS, 2018). Out of a potential 60 million hectares (ha)— or 148 million acres (ac)— of desert scrub habitat in Mexico, only 44.2 million ha (109 million ac) was estimated to remain by 2002 as primary vegetation, mainly in the Baja California peninsula, northern plains, and the central plateau, with at least 10.2 million ha converted for agriculture/livestock and nearly 5 million ha changing to secondary vegetation, mainly in Tamaulipas, San Luis Potosí and Zacatecas (Sánchez-Colón et al., 2009). Temperate forests in Mexico have faced similar declines, with 10 million ha of habitat loss between 1970 and 2002 (Sánchez-Colón et al., 2009).

Gómez-Ruiz et al. (2015) studied the land cover change in three vegetation types where chiropterophilous *Agave* occur in Coahuila and Nuevo León, Mexico over three decades (1985–2011) and found an overall reduction of 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 land cover category with the highest increase (i.e., 84%) occurring between 1985 and 1993. The reduction and fragmentation of *Agave* habitat can reduce the foraging areas available to the Mexican long-nosed bat and increase the time and energy needed by the bats to find foraging resources. The changes in foraging habitat may also impact the migration patterns of the species.

Local and Industrial Scale Harvesting of Agave

The rising popularity of tequila and mezcal has meant that there has been a concurrent increase in the number of remaining wild *Agave* plants being harvested and an increase in the size of commercial *Agave* plantations, which typically consist of clones (USFWS, 2018). With the exception of the Tequila Interchange Project's "Bat Friendly Tequila", harvesting *Agave* plants will occur before it is allowed to flower meaning these plants cannot be considered as a foraging resource for the Mexican long-nosed bat. As *Agave* plantations will occur on suitable land for wild, flowering Agave, this must be considered as a reduction in foraging habitat for the bat.

Unregulated Harvesting of Agave

Due to the lack of information on this topic it is impossible to conclude what impact it has on the species' foraging habitat. However, there are reports that harvesting of hundreds or even thousands of wild *Agaves* in Miquihuana, Tamaulipas occurred in 2015 (USFWS, 2018). It is believed that each plant or "piña" can sell on the black market for around 900 pesos (approximately $43.74 US Dollar). 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 *L. nivalis* foraging habitat (USFWS, 2018).

2.4.2 Overutilization (Factor B)

All the roosts are at risk of recreational use, while Cueva Del Diablo is particularly vulnerable to expansion of the town of Tepoztlan. Anthropogenic activities, such as disturbance from people entering a roost, pollution (e.g., trash), noise, and vibrations are all threats 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 of the bat 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 well-regulated.

2.4.3 Lack of Roost Protection (Factor D)

While the five most critical roosts to the survival of the Mexican long-nosed bat are federally protected by the Mexican government (Cueva del Diablo, Aguacatitla Tunnel, El Infierno Cave, El Rosillo Cave, and Mount Emory Cave), there are many roosts that lack these protections. A combination of enforcement of existing laws and granting of new protections is needed to consistently protect all roosts across the bat's range.

2.4.4 Climate Change (Factor E)

While habitat conversion is still the primary driver of global endangerment for most taxa, if current projections are correct, climate change will pose a considerable threat to the Mexican long-nosed bat, via potential changes in flowering phenology and increased likelihood of drought and wildfire. Microclimates of the roosts themselves may also be affected, making some caves unsuitable for the bats to use. While the predicted effects of climate change are highly dependent on the modeling efforts being used, a study by Zamora-Gutierrez et al. (2018) looking at the effect of climate and land use change

predicts that even under an optimistic scenario, 59% of the *L. nivalis* range will be unsuitable by 2050.

Plant-pollinator Relationships

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) studied the potential climate change impacts on the bat and *Agave* for the years 2050 and 2070. Models show that the suitable environments for the Mexican long-nosed bat and the *Agave* species studied are reduced under future scenarios (USFWS, 2018). Models show a reduction of up to 80% in its area of environmental suitability by 2070. Moreover, the overlap between *Agave* and the bat will be reduced by at least 75%. In addition, the results reveal a change in the *Agave* richness pattern with a smaller proportion of areas with one or more *Agave* 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). This suggests that *Agave* have a limited dispersal potential and incorporating this variable in the models will likely further restrict 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 *Agave*, but there is consensus that precipitation is an important variable (Gentry, 1982; Pau et al., 2011).

Wildfire

As a result of predicted increases in hot temperatures and drier climate, fire frequency is expected to increase. The effect of fire on *Agave* is a concern because of the bat's reliance on this genus for nectar in the northern part of their range. In southeastern Arizona, Slauson (2002) found less than 4% of *Agave* (i.e., *A. palmeri*) in a 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 *Agave* and the fire increased germination. However, the size of the plant and the specific fuel load around the *Agave* might affect survival. Johnson (2001) studied the effects of fire on *A. palmeri* and found more mortality in small *Agave*, 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) study and she suggested that patches of dead parent *Agave* 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 Mexican long-nosed bat 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 and/or migration.

Chapter 3: Species Viability

To evaluate a species' viability, or long-term persistence in the wild over time, we use the conservation principles of redundancy (the ability of a species to withstand catastrophic events; spreading risk to minimize loss from catastrophic events), representation (the ability of a species to adapt to changing environmental conditions over time, via the range of genetic and ecological variation found within the species), and resiliency (the ability of a population to withstand environmental and demographic stochasticity and disturbance).

3.1 Species Redundancy

The Mexican long-nosed bat needs to have multiple resilient roosts spread throughout its range and multiple resilient types of roosts to provide redundancy. The more roosts, and the wider the distribution of those roosts, the more redundancy the species will exhibit. Specifically, the bat needs sufficient numbers of resilient maternity roosts distributed throughout the northern part of its range to migrate and give birth to their offspring. Since there is currently only one known mating roost, securing multiple resilient mating roosts in central Mexico would also provide greater redundancy to the species.

3.2 Species Representation

Maintaining representation in the form of genetic or ecological diversity is important to maintain the capacity of the Mexican long-nosed bat to adapt to future environmental changes. Based on the limited genetic work done on the species, it is believed to be one large migratory population owing to the fact that there is only one known mating roost. Therefore, it is important for the bat to maintain ecological diversity across its range. To maintain ecological diversity, multiple resilient roosts in each region are needed.

3.3 Population Resiliency

For the Mexican long-nosed bat to maintain viability, the roosts, or some portion thereof that have housed bats, must be resilient. Specifically, for the one population of bats that make up this species, it is vital for the one known mating roost to be resilient. Stochastic events that have the potential to affect Mexican long-nosed bat roosts include disease, human disturbance, drought, and illegal harvest of wild *Agave*. A number of factors influence the resiliency of roosts; those factors can be divided into two categories: foraging and roost conditions. Foraging factors include habitat condition, abundance of floral resources, diversity of nectar plant species, and disruption to flowering ability. Roost condition factors include barriers to cave disturbance, colony size, and level of protection.

Foraging habitat needs include a habitat condition characterized by less than 20% habitat loss within 50 km (31 miles) of the roost, a high abundance of flowering plants within 50 km of roost, greater than 10 species of flowering plants present, and low disruption (<25%) to flowering plants. Roost condition factors needed include substantial barriers to cave entry, large colony size (over 1,000 individuals for high quality roosts), and regulatory protection of the roost. The details of how we arrived at the condition for each roost can be found in the Mexican long-nosed bat SSA, section 3.2, Roosting (USFWS, 2018).

Chapter 4: Recovery Program

4.1 Recovery Goal

Our recovery goal is to ensure the conservation and long-term viability of the Mexican long-nosed bat in the wild such that the species no longer requires protections under the ESA.

4.2 Recovery Strategy

The purpose of the recovery strategy is to present a recommended approach for recovery that will address the threats to the Mexican long-nosed bat and reduce those threats to a point at which the viability of the species can be maintained. Establishing recovery criteria is an essential part of the recovery planning process. Recovery criteria are measurable, objective conditions that, when met, indicate downlisting or delisting may be warranted.

The overall recovery strategy for the Mexican long-nosed bat involves preserving, restoring, and managing their habitat, along with the resources necessary to support resilient populations of these species and the ecosystems on which they depend.

4.3 Recovery Objectives

Specific recovery objectives for the Mexican long-nosed bat include:

- Effective protection and management of known critical roosts
- Providing adequate food resources, mainly through protection of existing foraging habitat, and restoration and management of *Agave* habitat
- Environmental education to gain support for conservation and management practices
- Research on biology and demography (determining location of roosts, known and historical; demography and seasonality; estimation of population sizes; population viability analysis). Research in ecology (migratory movement patterns and its association to food resource phenology, establishing connectivity patterns; determining the effects of climate change on population dynamics of the species, its food resources, and the plant-pollinator interaction).

4.4 Objective and Measurable Recovery Criteria (Amended recovery criteria)

Section 4(f)(1)(B)(ii) of the ESA states 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."

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 protections afforded by the ESA are no longer necessary and the species may be

delisted. Delisting is the removal of a species from the Federal Lists of Endangered and Threatened Wildlife and Plants (Lists). Downlisting is the reclassification of a species from endangered to threatened. The term "endangered species" means any species (species, subspecies, or DPS) that is in danger of extinction throughout all or a significant portion of its range. The term "threatened species" means any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Since the Mexican long-nosed bat is an endangered species, this recovery plan includes both downlisting and delisting criteria. Recovery criteria represent our best assessment, at the time the recovery plan is completed, of the conditions that may result in a determination that listing under the Act as threatened or endangered is no longer required. However, revisions to the lists, including delisting or downlisting a species, must reflect determinations made in accordance with sections 4(a)(1) and 4(b) of the Act. Section 4(a)(1) requires that the Secretary determine whether a species is an endangered species or threatened species because of threats to the species, based on an analysis of the five listing factors in section 4(a)(1). Section 4(b) requires that the determination be made "solely on the basis of the best scientific and commercial data available." As noted in the disclaimer section, while recovery plans provide important guidance to the Service, States, and other partners on methods of minimizing threats to listed species and measurable criteria against which to measure progress towards recovery, they are guidance and not regulatory documents. Thus, a decision to delist or downlist a species may be informed by the recovery criteria but is ultimately based on the definitions of threatened species and endangered species and an analysis of threats using the best scientific and commercial data available.

The Mexican long-nosed bat may be considered for downlisting and delisting when the following criteria have been met. Downlisting and delisting criteria are subject to change as additional information becomes available about the species' biology and threats.

4.4.1 Downlisting Criteria

The following are objective, measurable criteria which, when met, would result in a determination that the Mexican long-nosed bat be reclassified as a threatened species:

Downlisting Criterion 1: The threat of disturbance, mainly in the form of recreational human disturbance and urban development, is eliminated from Cueva del Diablo, along with at least two more of the five major roosts for the Mexican long-nosed bat: Aguacatitla Tunnel, El Infierno Cave, El Rosillo Cave, and Mount Emory Cave. This criterion is met at a cave when there is no evidence of illegal entry/human disturbance for five consecutive years.

> *Justification*: One of the chief threats to the species is disturbance of roosts in the form of human disturbance and urban development. Eliminating disturbance and development could be accomplished through various means such as increasing the security of the roost by fencing the area, adding no trespassing signs, and installing game cameras to photograph trespassers or enforcing the protected status of the roosts through regulatory mechanisms to deter trespassers.

*Downlisting Criterion 2***:** Cueva del Diablo maintains a colony size of at least 10,000 bats over a 10-year period.

Justification: The largest colony count at Cueva del Diablo since the bat was listed was approximately 8,000 bats in 2006. Downlisting would require a stable population with numbers significantly higher than when the bat was listed. To achieve consistent population numbers, the cave should be protected from human disturbance and destruction and protections should be enforced. 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.

Downlisting Criterion 3: An annual monitoring program of both the bat and its food sources should be implemented. Bats should be monitored once annually at each of the five major roosts, along with monitoring of food sources around at least one roost per region annually. If the region has a major roost, a major roost should be selected as the survey location. In addition, agave availability should be surveyed annually within 50 km of all five major caves with confirmed nectar availability of at least 200 agave plants for five consecutive years.

Justification: The *Agave* species that the Mexican long-nosed bat relies upon for food are expected to undergo range contractions due to land use and climate change. Because so little is known about the status of the food sources of the bat, it is imperative that research and continuous monitoring of both the bat population and its food begin as soon as possible to inform management decisions in response to climate change and land use change.

4.4.2 Delisting Criteria

A delisting decision will involve evaluating the five statutory factors (i.e., threats) which were also evaluated when the species was listed, as specified in section 4(a)(1) of the ESA. These criteria address the threats in the listing rule and reflect our best assessment of what needs to be achieved based on our current understanding of the subspecies and its environment. Circumstances can change in unpredictable ways, so it is not a requirement for delisting that all 3 criteria be met. For example, a species may be able to tolerate one ongoing threat if another is eliminated or reduced. Conversely, all criteria could be met but delisting may not be warranted should, for example, a catastrophic event or new threat arise.

The following are objective, measurable criteria which, when met, would result in a determination that the Mexican long-nosed bat be removed from the endangered species list:

Delisting Criterion 1: The threat of disturbance, mainly in the form of recreational human disturbance and urban development, is mitigated at all five major roosts for the bat: Cueva del Diablo, Aguacatitla Tunnel, El Infierno Cave, El Rosillo Cave, and Mount Emory Cave by prohibiting all recreational caving through the natural entrance via fencing and

video monitoring or requiring all cavers to obtain permits. This criteria is met when no evidence of illegal entry/unpermitted human disturbance is recorded for five consecutive years.

> *Justification*: One of the chief threats to the species is disturbance to roosts in the form of human activity and urban development. Eliminating disturbance and development could be accomplished through various means such as increasing the security of the roost or enforcing the protected status of the roosts through regulatory mechanisms.

Delisting Criterion 2: In addition to the five major roosts, at least five additional roosts maintain a minimum colony size of 500 bats over a 10-year period.

> *Justification*: While it is vital that the five major roosts are protected and healthy, protecting 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. This would require the protection of additional roosts from human disturbance and habitat destruction.

Delisting Criterion 3: Cueva del Diablo maintains a colony size of at least 12,000 bats over a 25-year period.

> *Justification*: The largest colony count at Cueva del Diablo since the bat was listed was roughly 8,000 bats in 2006. Delisting would require a 50% increase from this number. This would represent a population significantly larger has been observed at the cave since the bat's listing, but is not an unrealistic goal, as it has been seen at another cave in the same central Mexico region—Aguacatitla Tunnel, which has an estimated colony size of up to 13,596 (USFWS, 2018). Because Cueva del Diablo is the only mating roost, it is assumed that most or all the bats will filter through the cave. 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.

Delisting Criterion 4: Five consecutive years of data showing that at least 200 *Yucca* spp. plants are available within 50 km of 50% of roosts in each region. This corresponds to at least 5 roosts in central Mexico, 4 roosts in east Mexico, 3 roosts in northeastern Mexico, and one roost in the southwest US. This selection of roosts should include all five major roosts−Cueva del Diablo and Aguacatitla Tunnel in central Mexico, El Infierno Cave and El Rosillo Cave in northeastern Mexico, and Mount Emory Cave in the southwestern US. There should also be programing to ensure that the yucca plants will be sustained for the next 20 years. This agave should be available throughout the bat's migration path that will allow the bat to complete its migration. When fewer than 200 individuals are recorded, appropriate nectar resource plants should be replanted and established around selected roosts. Additional plantings to bolster this effort can be supplementally planted in gaps throughout the migration path where it has been determined, through research studies, that the plant was historically present, or nectar sources could be established and thrive.

Justification: As monitoring provides insight into the status of Mexican long-nosed bat food resources, gaps in food resources along the bat's migration path that have been caused by human activity or climate change shifts in range should be addressed by replanting. For existing food resource patches, sustainable management techniques and programs to increase land manager awareness should be implemented.

4.5 Prioritized Recovery Actions

The following is a list of prioritized, site-specific management actions that when fully implemented are expected to result in the recovery of the Mexican long-nosed bat. Implementation of this recovery plan is strictly voluntary and dependent on the cooperation and commitment of numerous partners in conservation. A separate Recovery Implementation Strategy (RIS) will provide additional detailed, site-specific near-term activities needed to implement the recovery actions identified below and will identify potential responsible parties. We intend to update the RIS as frequently as needed by incorporating new information, including the findings of future 5-year status reviews. The RIS will provide near-term (e.g., 1–5 years) activities that will be continually updated as recovery implementation progresses. Therefore, we will provide a greater degree of site-specificity in the RIS than do the recovery actions in the recovery plan. We will only revise the recovery actions in this recovery plan if there are needed changes based upon the findings of future 5-year status reviews.

As stated in the Disclaimer, recovery plans are advisory documents, not regulatory documents. A recovery plan does not commit any entity to implementing the recommended strategies or actions contained within it for a particular species, but rather provides guidance for ameliorating threats and implementing conservation measures, as well as providing context for implementation of other sections of the ESA, such as section 7(a)(2) consultations on Federal agency actions, development of Habitat Conservation Plans, or the establishment of experimental populations under section 10(j).
Priorities for recovery actions are assigned using the following guidelines:

Priority 1 – An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 – An action that must be taken to prevent a substantial decline in species population/habitat quality or some other substantial negative effect short of extinction.

Priority 3 – All other actions necessary to meet the recovery objectives. The assignment of these priorities does not imply that some recovery actions are of low importance, but instead implies that lower priority items may be deferred while higher priority items are being implemented.

Table 1 indicates the linkage between threats, the recovery actions that address them, their priorities, and the recovery criteria they contribute to. Table 2 shows the protection status of all known roosts to support recovery activities. The RIS will describe in greater detail how these actions will be coordinated and scheduled.

Priority 1 Actions

Recovery Action 1. Conserve, Restore, and Protect Habitat: This action includes the successful conservation, restoration, and protection of foraging habitat. This means securing land rights and protection status for all caves, enforcing existing laws, and creating action protocols for monitoring, reporting, and resolving threats covered by laws and regulations (chain of command, jurisdictions, enforcement mechanisms, coordination among institutions, etc.). It also includes defining a strategy for land acquisition, management, and promoting sustainable practices that minimize disturbance.

Recovery Action 2. Establish Agave Restoration Program: This action includes *Agave* replanting, along with teaching and supporting bat-friendly management practices (limit harvest and/or support current practices that maintain agave populations, allow development of flowering stalks, reduce or eliminate cattle foraging to induce recruitment of young *Agave*) in areas *Agave* (wild and cultivated) are harvested for human consumption across the range.

Priority 2 Actions

Recovery Action 3. Identify Effective Management Strategies: Project and adapt restoration and management plans according to climate change projections for all roosts and along the migratory pathway.

Recovery Action 4. Research including but not limited to:

- Conducting a study and design a strategy to preserve the structural integrity of the Aguacatitla roosting tunnel in the long-term;
- Identifying potential roost locations using a habitat model;
- Researching the location of migratory pathways, foraging grounds, and associated roosts;
- Tracking bat movements to identify alternate roosts near known roosts;
- Determining the diet of the bat across the range to identify *Agave* species that are part of the diet as well as food resources other than *Agave*; and
- Researching the threat and effect of fire on *Agave*.

Recovery Action 5. Education & Outreach: Promote and enforce cave-friendly conservation and management practices through environmental education and public outreach programs for all roosts. Develop environmental awareness programs to support bat-friendly *Agave* management (wild and cultivated) and land restoration programs using Agave for all roosts.

Priority 3 Actions

Recovery Action 6. Effective Planning and Coordination: Host a workshop with Nivalis Conservation Network and the government of Mexico (Commission on Natural Protected Areas (CONANP)) to design and approve the PACE (Action Program for the Conservation of Species) and link it to management plans for protected areas in Mexico. Partner with other protected lands in the vicinity of each roost and conduct meetings with landowners, stakeholders, and authorities to raise awareness of laws and regulations that protect the species and its habitat for all roosts. Develop a fire management plan for Big

Bend National Park that addresses the protection of Emory Cave. Work with Bureau of Land Management to create a management plan for Romney Roost.

Recovery Action 7. Expand Monitoring: Design a standardized monitoring program for roosts and foraging habitat across the species' range. This may include but is not limited to:

- Monitoring the phenology of Agave across the species' range;
- Monitoring nightly behaviors of the Mexican long-nosed bats near roosts between May and August to identify important foraging areas;
- Monitoring poorly known roosts or potential roosts for demographics, seasonality, stability, etc.; and
- Evaluating the conservation status of historical roosts and determine their contribution to the viability of the species.

Table 1. ESA listing factors, threats to *L. nivalis*, recovery actions that will address threats, and the recovery criteria to which the actions contribute.

ESA Listing Factors	Threat	Recovery Actions	Downlisting Criteria	Delisting Criteria
Factor A: The present or threatened destruction, modification, or curtailment of its habitat or range.	Availability of Adequate Roost Sites	1, 3, 4, 5, 6, 7	1, 2	1, 2, 3, 5
	Sufficient Forage Plant Species and Habitat Connectivity	2, 4, 5	3	4
Factor B: Overutilization for commercial, recreational, scientific, or educational purposes;	Recreational human disturbance	1, 2, 3, 5, 7	1, 2	1, 2, 3
Factor C: Disease or predation.	-	-	-	-
Factor D: The inadequacy of existing regulatory mechanisms	Lack of protected status for many roosts	1	1, 2	1, 3
Factor E: Other natural or manmade factors affecting its continued existence.	Effects of climate change	6	3	4, 5

Table 2. This table shows locations of previously reported and potential roosts of *L. nivalis* across its distribution, shown by region. Roost type is reported for those locations where published information is available. The roost is marked as Unknown if the original observation did not specify its type. Protection status notes what protection (e.g., federal, private property, etc.) if any, is provided to the cave. The Location Details and Agency columns provide details of where the cave is located and who the managing entity is. If either column has a question mark (?) in this cell, this information was not able to be obtained by the author. Regions are the same as those presented in the 2018 Species Status Assessment Report for the Mexican long-nosed bat (USFWS, 2018). The five major roosts for the Mexican long-nosed bat—Cueva del Diablo, Aguacatitla Tunnel, El Infierno Cave, El Rosillo Cave, and Mount Emory Cave—are bolded and italicized. Abbreviations are as follows: RB= Biosphere Reserve; NP= National Park; APFF: Area for the Protection of Flora and Fauna; APRN: Area for the Protection of Natural Resources.

Table 2 for Central Mexico

Roost	Roost Type	Protection Status	Location Details	Agency
Aguacatitla tunnel, Aguacatitla, Hidalgo, MEX	Maternity	Federally protected	Reserva de la Biósfera Barranca de Metztitlán	CONANP
Cueva del Diablo, Tepoztlán, Morelos, Mex	Mating	Federally protected	Parque Nacional El Tepozteco	CONANP
Del Ferrocarril cave, San Juan Tlacotenco, Morelos, MEX	Unknown	Federally protected	APFF Corredor Biológico Chichinautzin	CONANP
Del Salitre cave, Ticuman, Morelos, MEX	Unknown	Private property		
De la Chichihuiteca cave, Morelos, MEX	Unknown	Federally protected	APFF Corredor Biológico Chichinautzin	CONANP
De la Peña cave, Valle de Bravo, Estado de Mexico, MEX	Potential mating	Private property	Tourist visitation managed by local group	?
El Amate cave, Tlaltenango, Morelos, MEX	Unknown	?	?	?
El Coyote cave, Tonatico, Estado de México, MEX	Potential mating	Community	Eco-park Grutas de la Estrella	?
La Fábrica cave, el Gallo, Colima, MEX	Unknown	?	?	?
Ídolo cave, Tepoztlán, Morelos, MEX	Unknown	?	?	?
San Lorenzo cave, Tehuacán, Puebla, MEX	Summer roost	Federally protected	Reserva de la Biósfera Tehuacán-Cuicatlán	CONANP
Tziranda caves, Ciudad Hidalgo, Michoacán, MEX	Unknown	Community park	Ecotourism park, communally owned. Dispute between communities for ownership?	
Xoxafi cave, Santiago de Anaya, Hidalgo, MEX	Unknown	Community park	Ecotourism park, communally owned	El Palmar (community)

Table 2 for Eastern Mexico

Roost	Roost Type	Protection Status	Location Details	Agency
Cueva Azul, Zacatecas, MEX	Unknown	?	?	?
De los Coyotes cave, Los Amoles, San Luis Potosí, MEX	Unknown	?	?	?
El Chiquihuite cave, Zacatecas, MEX	Unknown	Archeological site under investigation?	Not sure if this is the same Chiquihuite as the one where archeological research is taking place	INAH?
El Durazno mine, La Pardita, Zacatecas, MEX	Unknown	Private property	In the area of influence of APFF Sierra La Mojonera (federally protected)	CONANP
El León cave, El Calvillo, Aguascalientes, MEX	Unknown	?	?	?
El Murciélago cave, El Calvillo, Aguascalientes, MEX	Unknown	?	?	?
La Montaña mine, between La Laja and Mazapil, Zacatecas, MEX	Unknown	Private property	In the area of influence of APFF Sierra La Mojonera (federally protected)	CONANP
San Pedro de la Anonas mine, Paligual, San Pedro de las Anonas, San Luis Potosí, MEX	Unknown	?	?	?
Todos los Santos mine, Zacatecas, MEX	Potential maternity	Private property	In the area of influence of APFF Sierra La Mojonera (federally protected)	CONANP

Table 2 for Northeastern Mexico

Roost	Roost Type	Protection Status	Location Details	Agency
Del Guano cave, Durango, MEX	Unknown	Private property	Ejido/community owned. In communal agricultural lands	?
De los Guzmán mine, Doctor Arroyo, Nuevo León, MEX	Unknown	?	?	?
El Infierno Cave, Las Cumbres National Park, Monterrey, Nuevo León, MEX	Maternity	Federally protected	Las Cumbres National Park	CONANP
El Rosillo cave, Área de Protección de Recursos Naturales Cuenca Don Martin, Coahuila, MEX	Potential maternity	Federally protected	Área de Protección de Recursos Naturales Cuenca Don Martín	CONANP
La Joya Honda cave, General Zaragoza, Nuevo León, MEX	Unknown	Private property	Ejido/community owned. Check if under voluntary conservation?	?
San Antonio mine, General Escobedo, Nuevo León, MEX	Unknown	?	?	?

Table 2 for Southwestern United States of America

Roost	Roost Type	Protection Status	Location Details	Agency
Mount Emory cave, Big Bend National Park, Texas, USA	Maternity	Federally protected	Big Bend National Park	NPS
Romney Cave, Big Hatchet Mountains, Hidalgo Co., New Mexico, USA	Summer. Mixed male/female	Federally protected	Wilderness Protected Area	BLM

4.6 Time and Cost of Recovery

Within 40 years, we expect the status of the Mexican long-nosed bat to improve such that we can achieve downlisting and delisting criteria. In other words, 2062 is the approximate date to reach the goal of recovery for the Mexican long-nosed bat. The time to recovery is based on the expectation of full funding, implementation as provided for in the recovery plan and RIS, and full cooperation of partners.

The estimated minimum cost to achieve recovery is $11,226,571 (Table 3), with an estimated minimum cost of $7,843,571 for downlisting. This amount is not adjusted for inflation and is based on costs of similar actions, as well as best professional judgment.

This budget reflects costs associated with the paid support of external community partnerships and the supplies required to facilitate projects. Significant contribution to the actions included in this plan is performed by organizations, institutions, and communities. The estimated costs generally reflect the amount necessary to implement any combination of activities (restoration, protection, management, environmental education) with a participating community. Additionally, there are costs associated with start-up funding (including professional consulting organizations that would work with communities).

This recovery plan does not commit the USFWS or any partners to carry out a particular recovery action or expend the estimated funds.

Table 3. Estimated costs of recovery actions for downlisting and delisting of the Mexican long-nosed bat.

Recovery Action	Total Estimated Cost ($1,000s)	Estimated Cost ($1,000s) by Fiscal Years					
		1-5	6-10	11-15	16-20	21-30	31-40
1. Conserve, Restore, and Protect Habitat	1,936	932	412	235	151	127	79
2. Establish Agave Restoration Program	3,383	1,354	1,017	510	257	193	52
3. Identify Effective Management Strategies	124	16	16	16	16	30	30
4. Research	2,901	1,924	809	37	37	47	47
5. Education & Outreach	470	91	61	61	61	98	98
6. Effective Planning and Coordination	745	110	91	91	91	181	181
7. Continue & Expand Monitoring	1,668	1,407	153	27	27	27	27
Total	**11,227**	**5,834**	**2,559**	**977**	**640**	**703**	**514**

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