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The state of the bats in North America

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Abstract

The world's rich diversity of bats supports healthy ecosystems and important ecosystem services. Maintaining healthy biological systems requires prompt identification of threats to biodiversity and immediate action to protect species, which for wide-ranging bat species that span geopolitical boundaries warrants international coordination. Anthropogenic forces drive the threats to bats throughout North America and the world. We conducted an international expert elicitation to assess the status of 153 bat species in Canada, the United States, and Mexico. We used expert assessment to determine the conservation status, highest impact threats, and recent population trends

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for these species. We found that 53% of North American bat species have moderate to very high risk of extinction in the next 15 years. The highest impact threats varied with species and country, and four IUCN threat categories had the greatest overall impacts: Climate Change, Problematic Species (including disease), Agriculture, and Energy Production. Experts estimated that 90% of species assessed had decreasing population trends over the past 15 years, demonstrating the need for conservation action. Although the state of North American bats is concerning, we identify threats that can be addressed through internationally collaborative, proactive, and protective actions to support the recovery and resilience of North American bat species.

KEYWORDS
biodiversity, Chiroptera, conservation status, expert elicitation, NatureServe

INTRODUCTION

Maintaining biodiversity is key to preserving ecosystems and ecosystem services worldwide.[1–3] To support this goal, conservation groups and agencies assess species status, identify conservation targets, and strategize and execute actions that can help prevent species loss.[4–6] International collaboration can amplify the impact of each step in this conservation response chain,[7] especially when partners coordinate efforts effectively without delaying action.[8] Rapid response to extinction risk is critical because populations of many species are decreasing and extinction rates are rising globally.[1] Elicitation of information from an international group of experts pools knowledge and experience to assess the status of multiple species, identify their threats, and prioritize response actions in a timely manner. Gathering information through expert elicitation can address many species at once—including species with ranges that cross international boundaries—to understand individual species conservation status and broad trends within taxonomic groups. Here, we used international expert elicitation to evaluate the conservation status of bat species and their threats across North America.

Bats are vital components of diverse ecosystems around the world, but they face numerous anthropogenic threats that jeopardize their survival. Bats provide ecosystem services through activities such as pollination or insect consumption, both of which contribute to agricultural productivity.[9,10] Sustainable guano harvesting[11] and tourism around viewing bat emergence flights[12] provide economic opportunities for communities. Threats to bats and the ecosystem services they provide include climate change, habitat loss, collision with wind turbines, persecution, and invasive species.[13–15] Understanding the importance of these threats for different species and regions is necessary for effective conservation efforts.

The relative and cumulative impacts of threats vary between species and across a species' range according to the ecology of each species, which determines how it interacts with the environment. For example, white-nose syndrome (WNS), caused by the invasive fungus *Pseudogymnoascus destructans* (*Pd*), infects bats while they hibernate and has spread across most of the North American continent since the fungus was first discovered in New York in 2007.[16–19] The disease can cause mass mortality, and affected populations of at least three species have declined by more than 90%.[20] Several bat species are threatened by collisions with turbines at wind energy facilities, which cause hundreds of thousands of bat fatalities each year in North America.[21] This threat is especially significant for species that migrate through regions with rapidly expanding wind energy development.[22,23] The effects of threats vary among species and locations such that some threats may impact many bat species in localized areas where the threat is prominent, while others have a pronounced impact influenced by the biology of a species throughout its range. Many North American bat species have ranges spanning geopolitical borders such that international collaboration is required to fully assess the threats they face.

Identifying the drivers underlying threats to bats is essential to forecast how threats may be expected to change in the future and how they can be reduced or eliminated. For example, climate change can cause temperature shifts that alter bat hibernation behavior,[24] the timing of insect availability,[25] and bat foraging opportunities.[26] Climate change is also leading to more extreme weather events that can trigger multiple mortality events for bats.[14,27] All of these disparate challenges for bats will continue with the progression of climate change, and all would benefit from reduced fossil fuel use to slow this progression. Understanding threat drivers is also important when interactions occur between threats. In the case of climate change, the development of wind energy that helps reduce dependence on fossil fuel-based energy production also poses a threat to multiple bat species through collisions with turbines, and conservation action must balance the need to reduce fossil fuel use with the need to protect bats from wind turbines. Recognizing threat drivers and their interactions can inform strategies to reduce or mitigate their impacts. A nested threats assessment process, such as NatureServe's methodology,[28,29] using expert knowledge and standardized classifications of threat categories[30] is a valuable tool for establishing this understanding.

In this study, scientists from Canada, the United States, and Mexico met to assess the state of North American bats using an adapted NatureServe approach via a structured expert elicitation process.[31,32]

Over 10% of the world's bat fauna by species live in North America, accounting for 153 of the 1474 species globally.[33] A total of 102 experts assessed the scope and severity of 44 threats to North American bat species as part of a trinational effort led by the North American Bat Conservation Alliance (NABCA, www.batconservationalliance.org), which supports collaborative bat conservation in Canada, the United States, and Mexico. Expert elicitations are used to assist decision-making when empirical data are limited, and problems are time-sensitive,[32] as is often the case with bat conservation.[15,34] We analyzed the input provided by experts to address three focal questions about North American bat species: (1) What is the current conservation status for North American bat species? (2) Which threats are expected to have the highest impact on bat species in North America over the next 15 years? (3) What are expert assessments of population trends for bat species in North America over the past 15 years? By meeting with bat experts from multiple countries, we aimed to establish a baseline understanding of the status of bats and strengthen the collaborations responsible for designing bat conservation at continental scales. We present the results of this study to help inform and prioritize conservation research and action in conjunction with collaborative population monitoring to determine whether conservation actions are working to improve the conservation status of bats in North America before it is too late.

METHODS

Expert elicitation process

The NABCA steering committee and regional bat working groups nominated bat experts from throughout North America to participate in the assessment, ensuring comprehensive regional participation. Qualifications to participate as an expert included experience conducting scientific research (a minimum of one peer-reviewed publication) on North American bat species and/or experience working on the management of populations of North American bat species at local, state, or federal jurisdictions and have contributed to at least one technical report on a bat species. In total, 102 experts contributed species assessments (Canada: 14, USA: 46, Mexico: 42; see Table S1).

We held our first meeting and conducted the assessment in the summer of 2020 for experts in the United States and Canada and in the spring of 2021 for those in Mexico. We created an assessment tool to capture independent input from meeting participants using a web-based platform to gather information, LimeSurvey (v. 3.22.17+200525, www.limesurvey.org, see Supporting Information). We adapted NatureServe Assessment methods[29,35] to evaluate each species by country using four factors: range extent, population size, short-term population trend, and threat impact. For each factor (except range extent), we used a four-point elicitation procedure to capture within-expert uncertainty[31]; experts provided minimum, most likely, and maximum estimates and their confidence level that the real value lay within the range they provided. Confidence levels had to be greater than 50%, because a 50% confidence level would indicate there was also a 50% chance the true value lay outside of the range estimated. We encouraged the setting of estimate ranges so that experts were at least 75% confident that the true value fell within the range.[36]

We followed a modified Delphi approach[36] for the expert elicitation that was designed to reduce the effects of expert overconfidence and bias. Our elicitation process had four steps: (1) we invited experts and met to discuss objectives and train them on the elicitation process; (2) experts provided information independently on each species for each country using the assessment tool; (3) we met with experts to review and discuss anonymous, collated responses; and (4) experts reviewed their responses independently after the meeting and adjusted their assessment, if warranted. Experts were provided written instructions and virtual training to familiarize themselves with the assessment tool and interface before starting their assessments. During the initial meeting, we also reviewed the NatureServe methods and factors to establish a shared understanding of the NatureServe factors and the International Union for Conservation of Nature (IUCN) Threat Categories. In Canada (17 species; Table S2) and the United States (44 species), experts completed their assessments individually, and then regional groups met to review and discuss summarized species reports of the assessment results. After discussion, experts had the opportunity to revise their assessments. We adjusted the elicitation process in Mexico based on what we learned from the assessment process in Canada and the United States. Due to the high diversity of bats in Mexico (142 species), we identified a subset of 53 species that would not be assessed (Table S3). Using expert knowledge of the Mexican species on the NABCA Steering Committee and national listings, we identified species that were common, well-studied, and already deemed not of conservation concern (37 species), and of known conservation concern, federally listed, or endemic (16 species).[4,37] Mexican experts then discussed and completed their assessments for the remaining 89 species in a series of online workshops. In January 2024, a subset of Mexican experts assessed population trends for 22 of the 53 species previously identified as secure and endangered/threatened. Due to these differences in the extent of species assessment, the number of species assessments available to answer each focal question varies.

Data inputs

Range extent

Experts estimated the current range of each species within each national boundary. Within the online assessment tool, we provided a mapping tool to help visualize the focal species' range extent based on occurrence records from the Global Biodiversity Information Facility (GBIF, www.gbif.org). Based on the GBIF range extent, we provided the calculated area (km^2) for the extent of occurrence of each species in the assessed country. If experts disagreed with the GBIF range extent (e.g., if they felt the range was larger, or conversely, some records may be erroneous), they could redraw the polygon for a new area calculation. Experts then selected at least one of the NatureServe range extent categories (zero; <100 km^2; 100–250 km^2; 250–1000 km^2; 1000–5000 km^2; 5000–20,000 km^2; 20,000–200,000 km^2; 200,000–

2,500,000 km^2; >2,500,000 km^2; unknown). Experts could select more than one category to indicate uncertainty.

Population size

Experts estimated each species' current total population size by country with the four-point estimates (see Supporting Information). We provided a tool to help put their population size in context with their range extent estimates by calculating population density (central population size/mean range extent) for the number of bats per 100 km^2.

Short-term population trend

We assessed the trend of each species' population by country over the past 15 years. The NatureServe recommended standard is 10 years or three generations,[35] but we lack generation time estimates for most bat species. Given that many bat species may have generation times of at least 5 years,[38] we felt that 15 years provided a reasonable timeframe for standardizing the assessment of all bat species in North America. It also allowed us to capture the impact of WNS on bat populations from the start of the epizootic.[16,39] We provided a population trend estimation tool in the assessment with a figure and table showing how, based on an expert's central current population size estimate, different trend scenarios translate to the population size 15 years prior (i.e., 2005). Experts could adjust the population size slider for different population trend scenarios. This tool was also an opportunity for experts to check the reasonableness of their central population size estimate.

Threat impact

The IUCN Threats Classification Scheme Version 3.2 is a hierarchical classification with 11 Level 1 threat categories and 44 Level 2 threats (hereafter referred to as *threat categories* and *threats*, respectively; see www.iucnredlist.org/resources/threat-classification-scheme).[30] We calculated the impact of each threat based on the experts' assessments of estimated scope and severity following this system. The scope of the threat is the percent of the population currently or likely to be affected over the next 15 years.[40] We provided a tool to help experts estimate the scope of a threat by drawing a polygon over the GBIF range map of the species to get the percentage of the species' range impacted by the threat but cautioned that area was not a perfect surrogate for population size, especially for species with uneven distributions. The severity of a threat is the anticipated change in the affected portion of the species' population due to the threat over the next 15 years.[41] If an expert considered the scope or severity of a threat <1%, they selected "negligible."

Analysis of short-term population trend and threat impact

Following Oakley,[42] we incorporated the four-point expert assessment (minimum, most likely, and maximum estimates, and confidence level) of trends and threats for each species–country combination analytically to account for confidence levels in subsequent analyses. We estimated distribution parameters for each expert's scope and severity assessments for each threat with the gamma distribution and simulated 10,000 estimates from each assessment, bounding estimates between 0 and 1. We report the percentile summaries, primarily relying on the 50th percentile (median) for the scope and severity of each replicate within a species–country combination. We also drew directly from scope and severity estimates to simulate 10,000 impact estimates (impact = scope * severity). We assessed species trend estimates using a similar approach, where trend estimates were simulated from a Gaussian distribution and bounded between −1 (100% decrease expected within 15 years) and 1.4 (reflecting an estimate of the expected maximum growth rate possible for a bat population within 15 years).[23] Range extent and population size were used as required inputs in NatureServe Conservation Status Assessment Rank Calculator but were not analyzed for this study.

What is the current conservation status for each species?

We used the NatureServe Conservation Status Assessment Rank Calculator Version 3.2[35] to calculate the conservation status based on the results of the expert assessments for each species nationally.[28,29] This method scales and weights multiple factors related to species rarity, threats, and trends according to the impact of each factor on extinction risk, providing a consistent way to include many types of data in an overall status assessment. We calculated the median (50th percentile) impact estimate across the expert assessments for each species by country to calculate the National (N) Conservation Status Rank. We determined the Global (G) Conservation Status Rank by rounding N-ranks to the most imperiled rank when species were evaluated in two countries and to the median rank for species evaluated in Canada, the United States, and Mexico. We report G ranks when > 99% of a species range[43,44] falls within the evaluated countries of Canada, the United States, and Mexico. Following NatureServe's definitions, we considered the status of Critically Imperiled, Imperiled, and Vulnerable to be at very high, high, or moderate risk of extinction or elimination, respectively, due to very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors.[35] Species with these three statuses are collectively considered *at-risk* (Table S4). While the IUCN G ranks are qualitatively aligned with federal protection statuses in each of the three countries involved in this study, it is not uncommon for status ranks to differ for a given species.

Which threats are expected to have the highest impact over the next 15 years?

We analyzed threats and threat categories for each evaluated species and country using median impact estimates for the next 15 years. From the expert assessments, we identified the top threats to bats for each species–country combination by ranking those estimates and top threat categories for each country by summing impact values of threats contained within those categories and ranking those summed totals. A total of 150 species/country combinations were evaluated for threats, representing 109 species across North America.

What was the population trend for each species over the past 15 years?

We categorized the results of the short-term population trends based on the distribution of the summed estimates from the expert assessment for each species–country combination, where species' past 15-year population trends were categorized as decreasing (100 to 80% of simulated trend estimates < 0), likely decreasing (80 to 60% < 0), no trend (60 to 40% < 0), likely increasing (60 to 80% > 0), or increasing (80 to 100% > 0).

RESULTS

What is the current conservation status for each species?

Of the 153 species assessed in this study, 81 (53%) were considered at-risk (Vulnerable, Imperiled, or Critically Imperiled) in at least one country (Figure 1). In Canada, 14 of 17 (82%) species were considered at-risk. In the United States, 33 of 44 (75%) species were considered at-risk. In Mexico, 49 of 142 (35%) species were considered at-risk. Species assigned to at-risk conservation status by expert assessment are distributed across taxonomic groups, and no family appears to be generally secure (Figure 1 and Table S5). Of 20 species in the family Molossidae, 35% were considered at risk in a national conservation status rank (N-rank). Of 58 species in the family Phyllostomidae, 50% were considered at-risk in an N-rank. Of 56 vespertilionids, 68% were considered at-risk in an N-rank.

Which threats are expected to have the highest impact over the next 15 years?

We chose four top threat categories for closer analysis based on the cumulative impacts of threats estimated by experts: Climate Change (ranked first in both the United States and Mexico); Invasive & Other Problematic Species, Genes, & Diseases (hereafter referred to as "Problematic Species," ranked first in Canada and second in the United States); Agriculture & Aquaculture (hereafter referred to as "Agriculture," ranked second in Mexico); and Energy Production & Mining (hereafter referred to as "Energy Production," ranked second in Canada, Table 1). Across North America, experts assessed these four threats to have the highest impact on 43 species (Climate Change), 30 species (Agriculture), 16 species (Energy Production), and 14 species (Problematic Species); and at least a medium or greater impact on a total of 60 species (Climate Change), 35 species (Agriculture), 22 species (Energy Production), and 21 species (Problematic Species), out of a total of 109 species assessed.

Drought, within the threat category of Climate Change, is the most commonly identified leading threat, as it is the top-ranked threat in at least one country for the most species (35 of 109 species, or 32%). Drought is also the most common top threat among all species–country assessments (41 of 150 assessments, or 27%, Figure 2) and among species in the United States (21 of 44 assessments, or 48%). In Canada, invasive non-native/alien species/disease (includes WNS; hereafter referred to as "invasive species"; this threat occurs within the threat category of Problematic Species) is the top-ranked threat for most bat species (71%) (Figure 2). The most commonly identified top threat for species in Mexico is livestock farming and ranching, ranked highest for 34% of Mexican species (Figure 2). Multiple threats impact each species (Table S2), and high threat impact can result from a broad scope, high severity, or both. For example, drought has a broad scope in impacted species (large or pervasive scope for 48% of species–country assessments), and invasive species has a high severity in impacted species (serious or extreme severity in 17 assessments). In contrast, renewable energy has both a broad scope and high severity for impacted species (large or pervasive scope and serious or extreme severity for 14 assessments).

What was the population trend for each species over the past 15 years?

Experts estimate that 90% of bat species have experienced population declines ($n = 62$ with high confidence; $n = 55$ with moderate confidence) in at least one country (Figure 3). In Canada, experts have high confidence that 6 of 17 (35%) species have decreased and moderate confidence that 5 of 17 (29%) additional species have decreased. In the United States, experts have high confidence that 8 of 44 (18%) species have decreased and moderate confidence that 15 of 44 (34%) additional species have decreased. In Mexico, experts have high confidence that 55 of 111 (50% of the species assessed) have decreased and moderate confidence that 48 of 111 (43%) additional species have decreased.

Three species (*Leptonycteris yerbabuenae*, *Myotis grisescens*, and *Nycticeius humeralis*) are estimated to have positive population trends (Figure 3). Two of these were protected as endangered under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531, et seq.; ESA) and had recovery plans: gray bats (*M. grisescens*, listed 1976; Box 1) and lesser long-nosed bats (*L. yerbabuenae*, Figure 1.4, listed 1988, delisted 2018; Box 2).

DISCUSSION

Fifty-three percent of North American bat species were estimated to have moderate to very high risk of extinction or elimination in the next 15 years, and 90% are estimated to have populations that decreased

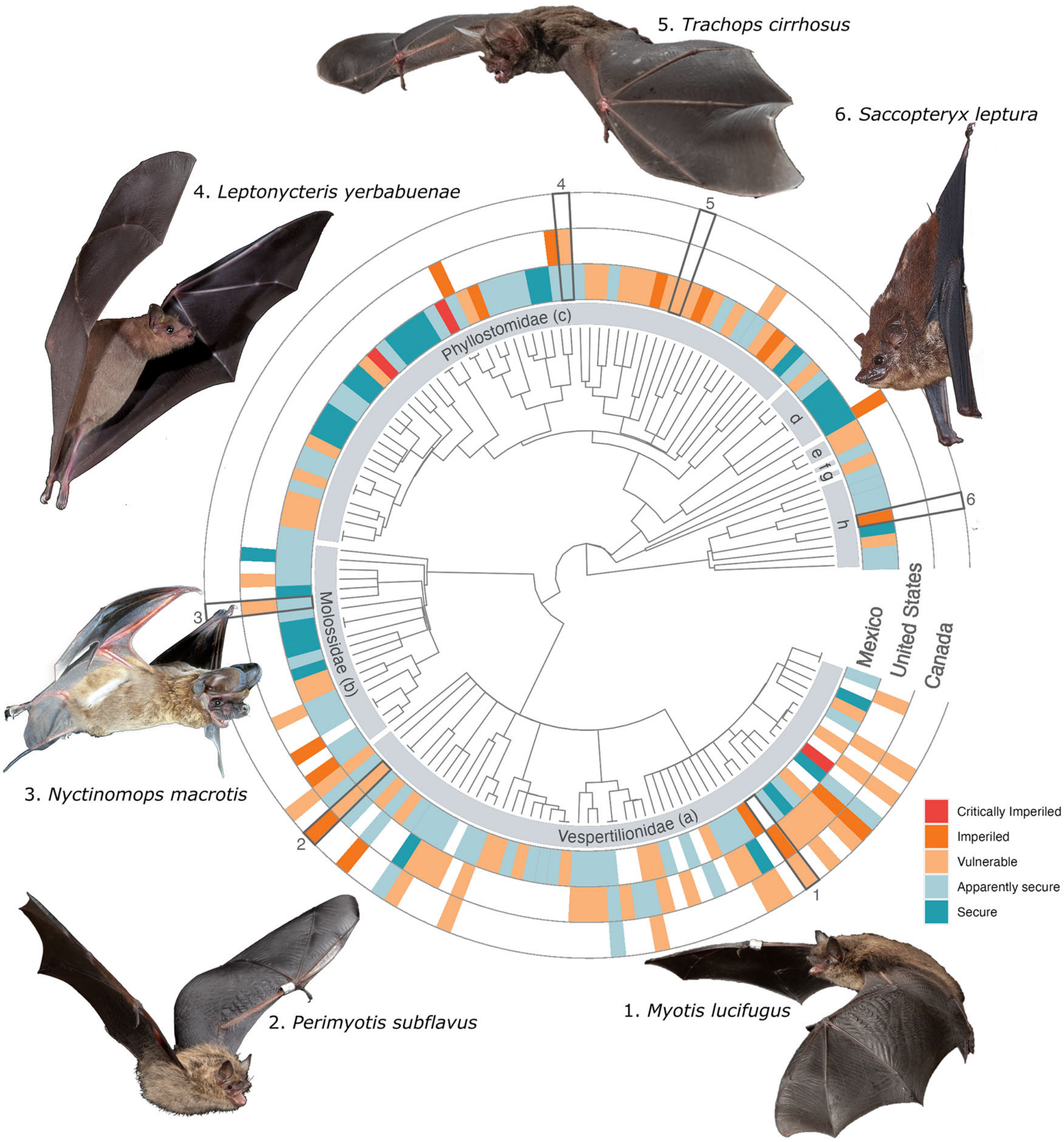

FIGURE 1 The results of expert elicitation assessment of NatureServe conservation status of bats in Canada (outer ring), the United States (middle ring), and Mexico (inner ring). Eight families are represented in North America: Vespertilionidae (a), Molossidae (b), Phyllostomidae (c), Mormoopidae (d), Noctilionidae (e), Natalidae (f), Thyropteridae (g), and Emballonuridae (h). Species pictured are (1) *Myotis lucifugus*, little brown bat (photo by C.M.F.), (2) *Perimyotis subflavus*, tricolored bat (photo by C.M.F.), (3) *Nyctinomops macrotis*, big free-tailed bat (photo by Dustin Smith), (4) *Leptonycteris yerbabuenae*, lesser long-nosed bat (photo by J. Scott Altenbach), (5) *Trachops cirrhosus*, fringe-lipped bat (photo by Sherri and Brock Fenton), and (6) *Saccopteryx leptura*, lesser sac-winged bat (photo by Carlos N. G. Bocos).

or likely decreased over the past 15 years, indicating that conservation action is urgently needed in all three countries. We identified 18 bat species (12%) as Imperiled or Critically Imperiled according to expert assessment. Eleven of these species are federally protected in at least one country in their range, 8 species are federally protected in all of the countries where they occur in North America, and 10 species do not currently have protected status in at least one country within their range (Table S6). Twenty-four percent of North American bat species have transnational ranges across one or more international boundaries within Canada, the United States, and Mexico, making international collaboration crucial to conservation planning at relevant range-wide scales. We found that multiple threats impact North American bat species, and according to experts, four threat categories with the highest impact per country were Climate Change, Agriculture, Energy Production, and Problematic Species. Some imperiled species have one consistent top threat in each country within their range (e.g., *Choeronycteris mexicana*: drought in the United States and Mexico), while others have distinct top threats in each country within their range (e.g., *Antrozous pallidus*: invasive species in Canada, drought in the United States, and agricultural and forestry effluents in Mexico).

TABLE 1 The top five threat categories are ranked by the estimated cumulative impact on bat populations over the next 15 years in North America (Canada: 17 species, United States: 44 species, Mexico: 89 species).

Rank of threat category impact	Canada	United States	Mexico
1	Problematic Species	Climate Change	Climate Change
2	Energy Production	Problematic Species	Agriculture
3	Climate Change	Natural Systems Modification	Pollution
4	Biological Resource Use	Energy Production	Biological Resource Use
5	Residential & Commercial Development	Pollution	Energy Production

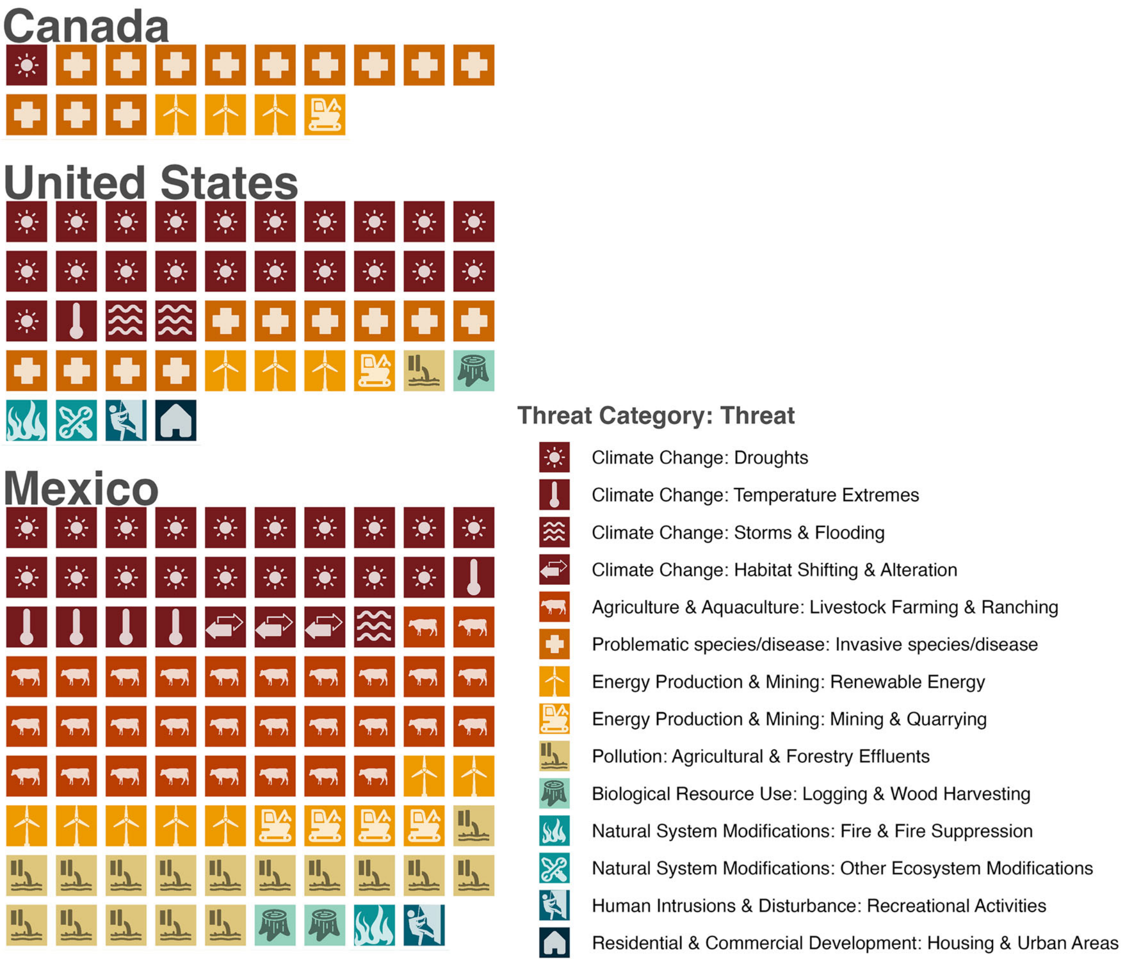

FIGURE 2 Summary of the highest impact threats, within various threat categories, for each bat species (represented as a square) for each country in North America represented as the threat category (color) and threat (icon).

The conservation status and threats identified in this expert elicitation can inform conservation decisions at a critical moment before species become more imperiled.

The four top threat categories identified in this study have understood or presumed underlying drivers of population declines in bats. Most species with Climate Change as a top threat category are threatened specifically by drought according to experts (35/43 species). Water availability and precipitation are known to affect nightly traveling distances and times; timing and amount of insect, nectar, and fruit resources; and reproductive rates and survival of young—all of which can significantly affect population trends.[45–47] All species with Agriculture as a top threat category are specifically threatened by habitat conversion for livestock farming and ranching in Mexico, according to experts (30/30 species), as the expansion of this practice can reduce

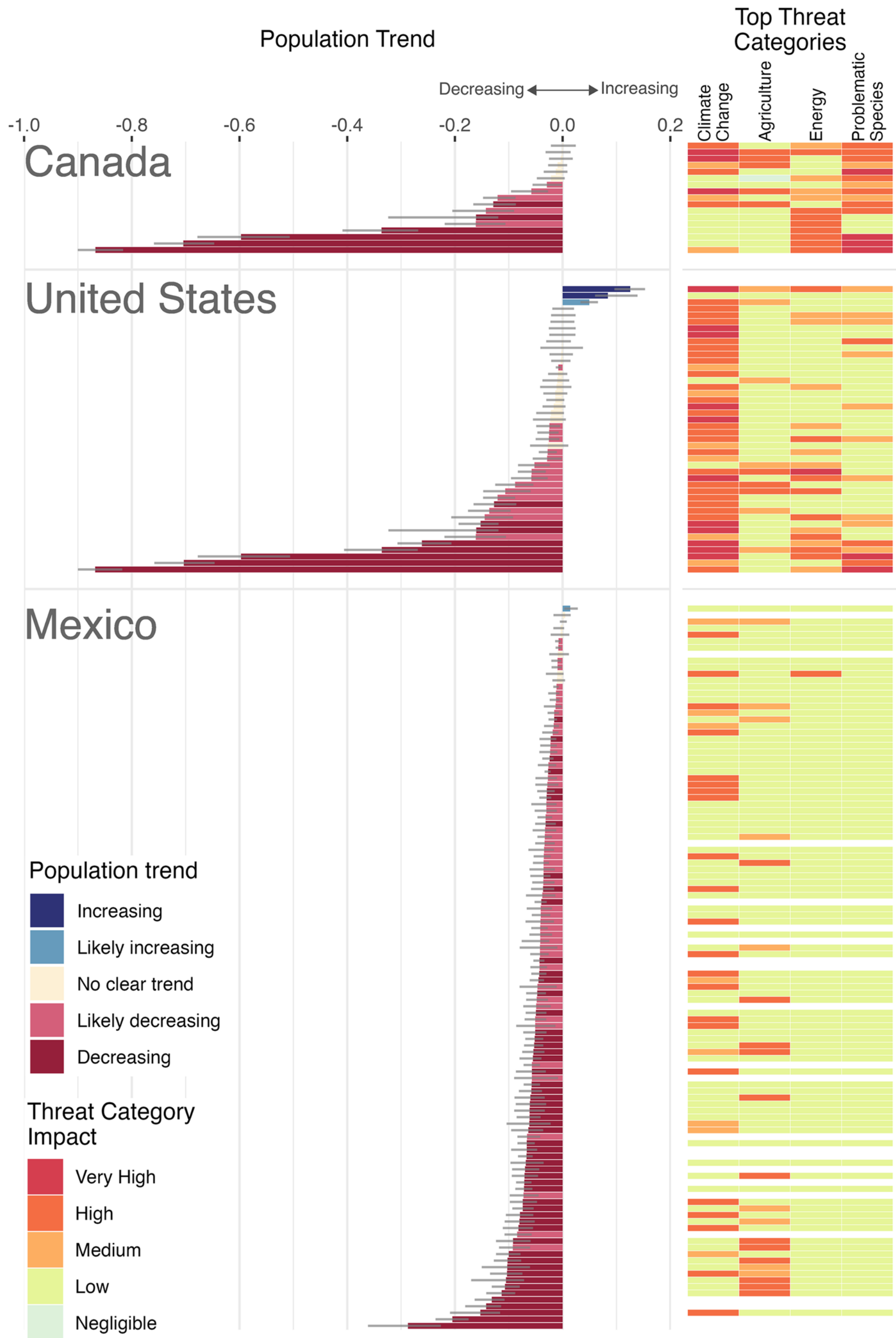

FIGURE 3 Population trend bars for bat species in North America based on expert opinions, showing estimated population change over the 15 years preceding the expert elicitation (2005–2020). Each bar represents the median trend estimate for a species. Bar color indicates trend direction and confidence level, and error bars (in gray) indicate the range of the 40th to 60th percentiles of expert estimates. Threat boxes show the projected impact of four top threat categories (Climate Change, Agriculture, Energy Production, and Problematic Species) on each species represented by the aligned trend bar.

or degrade foraging and roosting habitats.[48] Many of the species with Energy Production as a top threat category according to experts (10/16 species) are specifically threatened by renewable energy through fatal collisions with wind turbines.[21] This threat has a high impact on the seven species for which experts have the highest confidence of population decline in Canada (Figure 3). All bats with Problematic Species as a top threat category identified by experts (14/14 species) have declining populations due to the disease WNS.[20] This threat has a very high impact on five of the six species, with the most severe decreases in Canada and the United States (Figure 3); population declines from WNS have been well documented.[20]

Management response to the threats to bats can draw from evidence-based conservation strategies,[49] which can proactively and/or reactively reduce and mitigate their impacts. For example,

Box 1. Gray bat recovery

Myotis grisescens, the gray bat, is an insectivorous species limited to limestone karst areas of the Southeastern United States. Gray bats occupy caves year-round and migrate between summer and winter sites, where roost size can vary from a few thousand to over a million bats. Hibernating populations are concentrated in caves across northern Alabama, Arkansas, Kentucky, Missouri, and Tennessee. The summer range extends from eastern Oklahoma to central North Carolina. The gray bat primarily forages over water, hawking for aquatic insects.

The U.S. Fish and Wildlife Service (FWS) listed the gray bat as endangered in 1976 under the Endangered Species Act, primarily due to cave commercialization, improper cave gating, and roost disturbance, modification, or destruction. At the time of listing, the total estimated population of gray bats was 1.5 million.[76] Through the installation of bat-friendly gates and cave protections, the FWS, state natural resource agencies, private landowners, and other conservation organizations successfully reduced human disturbance and protected over 95% of the 15 major winter hibernacula and over 50% of 95 biologically significant summer colonies. Monitoring efforts show that gray bat numbers have increased dramatically at locations where threats were resolved, and currently, there are nearly 5 million gray bats range-wide (V. Kuczynska, FWS Missouri Field Office, written comm., 2024). White-nose syndrome exists within the entire range for the species but has not caused mass mortality events (V. Kuczynska, FWS Missouri Field Office, written comm., 2024), in contrast to some other species of bats.

Experts identified Human Intrusions & Disturbance and Climate Change as the top threat categories for gray bats in this assessment. Wind energy facilities are expected to expand into much of the gray bat range, and siting decisions will determine how wind energy development will impact gray bats. Avoiding migration pathways and the locations of hibernacula and maternity colonies will help minimize the impact on gray bats range wide.

Box 2. Lesser long-nosed bat recovery

Leptonycteris yerbabuenae, the lesser long-nosed bat (Figure 1.4), is a nectar-feeding species that migrates north in the spring to give birth in northern Mexico and parts of the Southwestern United States.[77] The FWS listed the species as endangered in 1988 due to reports of long-term declines and concerns about habitat loss in the Sonoran Desert ecosystem, roost disturbance, and human persecution.[62,78] In Mexico, the Secretaría de Desarrollo Social (SEDESOL) listed the species as threatened on the first Federal List of Endangered Species in 1994 (as *L. sanborni*).[79] Federal listing in the United States triggered funding for recovery actions such as roost protection and an FWS recovery plan[62] initiated research to understand the species' ecology and identified conservation actions that included protecting and monitoring roost sites, protecting foraging access, designing and implementing public education, and research into reproductive behavior.

Stakeholders in both countries took action to protect the species, determine status and population trends, and assess ongoing threats. Roost protection measures included legal protection of caves, gating or fencing caves and roads, public education, and enforcement.[63] Cave vandalism in Mexico was successfully reduced.[80] Biologists discovered new roosts and studied roost switching and species distribution.[63] The research examined foraging behavior and the impact of livestock grazing and agave harvesting.[63] Maternity roost monitoring practices improved by accounting for seasonal movement and using new technology such as infrared videography.[63,81]

Mexico delisted *L. yerbabuenae* in 2013, and the United States removed it from the Endangered Species Act in 2018.[63,81] Officials determined that threats had been reduced or managed, the total population size was stable or increasing across its range, and the species could adapt to some habitat disruption.[63] Ongoing education programs spread public support for protecting bat pollination services.[63,82] The delisting from the endangered species list in the United States included a post-delisting monitoring plan.[63]

although the frequency and intensity of droughts are projected to increase under climate change scenarios, protecting, restoring, and creating wetlands or other water sources can lessen the impacts of these events on species that are most susceptible to this threat.[50] Adopting low-intensity farming practices such as using diverse native trees for shading rather than high-intensity practices such as unshaded monocultures can avoid the drop in species richness and abundance associated with high-intensity farming.[51] Feathering turbines at low wind speeds and curtailing turbine operation at night during migratory periods can reduce fatalities at wind energy facilities.[49,52] Employing solutions to improve the survival of bats with WNS and disinfection strategies to reduce the abundance of the fungal pathogen in the environment is key to addressing the threat of invasive *Pd* for multiple bat species across North America.[19,53–57] The evidence base for conservation actions for bats is still growing, but many actions are known or expected to benefit bat populations or reduce harm with little to no risk and can be used in adaptive management and research efforts.

Legal protection of imperiled species is a management response that can create positive outcomes for imperiled species.[58] Two of the only three species identified with positive population trends over the past 15 years, according to experts, *M. grisescens* (Box 1) and *L. yerbabuenae* (Box 2), were legally protected as endangered species during this time frame.[59,60] Both these species had associated recovery plans[61,62] under the Endangered Species Act (ESA) in the United States. For *L. yerbabuenae*, listed in both the United States and Mexico, there were binational collaborations on monitoring and conservation efforts that ultimately resulted in this species being the first bat to be delisted due to recovery, first in Mexico and then in the United States.[63] Federal protection has been provided for some species of bats in Canada, the United States, and Mexico, although processes vary for considering additional species.[64] Many states and provinces also have mechanisms to protect bats by identifying species as endangered, threatened, or of special concern (or similar). Such legislative actions provide natural resource agencies with additional tools to protect species at the state or provincial level. At a minimum, legal protections draw attention to at-risk species, which can motivate support for additional research or conservation by various stakeholders.

Our results show an increase in at-risk species relative to a 2017 assessment using similar metrics for bats in Canada and the United States, where 31% of species in these two countries were considered at risk.[65] Our expert elicitation results indicate that North American bats may be more imperiled than is suggested by the IUCN Red List (accessed January 2024), which lists 6 of 49 species (12%) in the North American region (including only the United States and Canada) as critically endangered, endangered, vulnerable, or data deficient, and just 20 of 182 species (11%) in these categories for the Mesoamerican region. A comparison of various status designations for all species found to be Imperiled or Critically Imperiled in this study reveals that the statuses of many imperiled species are not consistently recognized across geopolitical borders (Table S6). This comparison indicates that international communication, updated species assessments, and expanded conservation efforts may be helpful in addressing a growing need for supporting bats.

Knowledge gaps in our understanding of species status and ecology can hinder the success of bat conservation efforts around the globe.[15] For many bat species, ecology, distribution, and migratory behaviors remain poorly known, making conservation planning more uncertain. Research enabling informed conservation decisions is an important priority, and the results of this elicitation study point to the need for greater research efforts focused on particular species with imperiled status, the highest impact threats, and the species most likely to be experiencing population decline. However, knowledge gaps need not delay management action. Adaptive management can test conservation actions based on currently available data while building a knowledge base to modify and improve management efforts over time.[66–68] Ideally, adaptive management incorporates monitoring at appropriate temporal and spatial scales to measure population response.[69] The North American Bat Monitoring Program (NABat, www.nabatmonitoring.org) is designed to monitor bat population status and trends at multiple scales through collaborative data collection and data sharing across the continent,[34,70] offering repeatable, statistically rigorous, data-driven solutions for measuring bat population response to management efforts at local and range-wide scales.

Given that many bat species have wide ranges, effective management often requires coordinated, interagency, and interjurisdictional efforts.[71] When a species' range crosses international borders, aligning the efforts of cross-boundary organizations that share the goal of species protection can increase the likelihood of positive conservation outcomes.[8] Internationally collaborative bat conservation alliances can generate effective management guidance[72–74] and support from community and industry stakeholders.[26] Bringing together international teams to address specific shared problems can create a network of stakeholders that coordinate responses to broadly relevant bat conservation issues. For example, federal, state, provincial, and nongovernment collaborators in the United States, Canada, and Mexico have been working together in a coordinated effort to address the threat of WNS to North American bats. The novel problematic fungus that causes WNS was identified as a threat to bats soon after it arrived in the United States. The *US National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-nose syndrome in Bats*[71] was formalized as a multispecies recovery plan to coordinate conservation efforts through research, management, and communication to benefit WNS-affected species regardless of their federal listing status under the ESA. Soon after, *A National Plan to Manage White-nose Syndrome in Bats in Canada*[75] further outlined cross-border consistency and collaboration in addressing the threat. Recognizing the importance of international collaboration to address WNS and other threats to bats, the Trilateral Committee for Wildlife and Ecosystem Conservation and Management (www.trilat.org), a collaboration between Canada, the United States, and Mexico that was created to address shared conservation goals across North America, signed a letter of intent to unite federal, state, provincial, and nongovernmental organizations across all three countries in support of bat conservation. This commitment led to the formation of NABCA, support for developing and establishing NABat, and successful bat conservation initiatives, including this expert elicitation study.

Expert elicitation can play an important role in conservation strategies protecting bats or any broadly distributed taxonomic group. International expert elicitations can contribute to conservation by conducting widespread assessment, pointing to effective management actions, and establishing networking pathways for ongoing partnerships. Results from expert elicitation provide valuable information to be incorporated into management and recovery plans, legal listing decisions, and research priorities. Expert elicitation can also reveal data gaps and uncertainties. Nongovernmental organizations, academic and research institutions, and the public can use elicitation results to prioritize research and conservation initiatives. The expert elicitation process can be a timely way to assess progress toward conservation goals and gain perspective on whether conservation methods have been effective. Future expert elicitation projects assessing international bat assemblages in regions across the globe would strengthen bat conservation knowledge, efforts, and networks.

CONCLUSION

Our expert assessment of the state of North American bats highlights areas of concern for biodiversity, but also opportunities to address common threats among bat species. Our understanding of bats and threats to bats is growing, and lessons from successful conservation can guide diverse practitioners to effective planning. Addressing threats early and before they have had severe impacts on species often leads to the best outcome for conservation efforts. When threats cannot be addressed early, and species have been severely impacted, the protective power of legal federal listing is a valuable tool to help ease the threat and recover an imperiled species. Targeted efforts to change public attitudes toward bats can also generate broad support for bats, as well as bring economic gain for communities through bat-based tourism.[12] Research on bat biology can spark innovative ideas for effective conservation actions that reduce population decline, and these actions can bring complementary benefits to habitats that other taxa also rely on. With coordinated efforts to reduce threats, raise public awareness, protect and restore habitat, and monitor species status and trends, conservation efforts can improve the outlook for bat species across North America and globally.

AUTHOR CONTRIBUTIONS

A.M.A.: Conceptualization, methodology, validation, formal analysis, investigation, resources, data curation, writing, project administration. K.L.A.: Writing. J.A-C.: Methodology, investigation, writing. C.J.C.: Formal analysis, methodology, visualization, writing. J.T.H.C.: Conceptualization, methodology. R.D.D.: Conceptualization, writing. C.M.F.: Conceptualization, methodology, writing. M.G.-R.: Investigation. V.K.: Writing. A.M.: Conceptualization, writing. R.A.M.: Conceptualization, methodology, investigation, writing. K.M.M.: Conceptualization. J.O.: Conceptualization, investigation, resources, writing. J.D.R.: Conceptualization, writing. B.R.: Conceptualization. J.L.S.: Conceptualization, writing. L.A.T.: Validation, investigation, resources, data curation, writing. M.D.W.: Conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, visualization. W.F.F.: Conceptualization, methodology, investigation, writing, supervision, project administration, funding acquisition.

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COMPETING INTERESTS

The authors declare no competing interests.

DATA AVAILABILITY STATEMENT

Data are available from the author on reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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