Little Brown Myotis and Northern Myotis Bat Recovery Plan

Alberta Species at Risk Recovery Plan No. 49

DRAFT

AUGUST 2024

Classification: Public

Alberta

Cover photo: Jason Headley

Alberta Environment and Protected Areas. 2024. Little Brown Myotis and Northern Myotis Bat Recovery Plan for Alberta. Alberta Species at Risk Recovery Plan No. 49. Edmonton, AB. 33 pp.

Little Brown Myotis and Northern Myotis Bat Recovery Plan for Alberta - Draft | Environment and Protected Areas

 | Published: August 2024

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Recovery Planning in Alberta

Albertans are fortunate to share their province with an impressive diversity of wild species. Populations of most species of plants and animals are healthy and secure. However, a small number of species are either naturally rare or are now imperiled because of human activities or natural processes. Alberta Species at Risk recovery plans establish a basis for cooperation among government, Indigenous Communities, industry, conservation groups, landowners and other stakeholders to ensure these species and populations are restored or maintained for future generations of Albertans.

Alberta has a robust provincial recovery program to support its commitment to the federal/provincial *Accord for the Protection of Species at Risk* and the *National Framework for the Conservation of Species at Risk*, and its requirements established under Alberta's *Wildlife Act* and the federal *Species at Risk Act*. An overall goal of the program is to restore species identified as *Threatened* or *Endangered* to viable, naturally self-sustaining populations within Alberta.

Alberta Environment and Protected Areas is committed to providing opportunities for Indigenous communities, stakeholders, and the Alberta public to provide their perspectives and influence plan content during the recovery planning process. The process for how Albertans are engaged can vary based on the socio-economic and conservation issues and the level of interest expressed. Draft recovery plans undergo a review by the Fish and Wildlife Policy Branch and are then posted online for public comment for at least 30 days. Following public review, Alberta's Endangered Species Conservation Committee reviews draft plans and provides recommendations on their acceptability to the Minister of Environment and Protected Areas. Plans accepted and approved for implementation by the Minister are published as a provincial government recovery plan. Approved plans are a summary of the Ministry of Environment and Park's commitment to work with involved stakeholders to coordinate and implement conservation actions necessary to restore or maintain vulnerable species.

Recovery plans include two main sections: (1) a situational analysis that highlights the species' distribution and population trends, threats, and conservation actions to date; and (2) a recovery section that outlines goals, objectives, associated broader strategies, and specific priority actions required to maintain or recover *Threatened* or *Endangered* species. Each approved recovery plan undergoes regular review and at that time progress on implementation is evaluated. Implementation of each plan is subject to internal and external resource availability.

Recovery plans will be systematically reviewed every five years. Where there are large changes in the goals, objectives, or strategy sections due to a new understanding or circumstance, a plan may need to be redrafted, consulted on, reviewed by the Endangered Species Conservation Committee, and the changes approved by the Minister.

Acknowledgements

The draft plan was developed by Robert Barclay (University of Calgary), Lynne Burns (Environment and Climate Change Canada), Cory Olson (Alberta Community Bat Program), and Lisa Wilkinson (Alberta Environment and Protected Areas). The following reviewed the draft plan and provided comments: Alberta Forestry and Parks, Alberta Forest Products Association, and Parks Canada. Additional review comments were provided by Pat Fargey and Cindy Kemper (Alberta Environment and Protected Areas).

Executive Summary

White-nose Syndrome (WNS) is a fungal disease that has killed millions of bats in eastern North America and has been spreading west. The little brown myotis (*Myotis lucifugus*) and northern myotis (*Myotis septentrionalis*) were listed as Endangered species in Alberta in 2021 because of predicted population declines. The fungus was detected in Alberta in 2022.

This plan was written under the expectation that there will be unavoidable bat population declines. At this time, it is not possible to stop the spread of the fungus, destroy the fungus, or cure the disease. Accordingly, this plan is focused on ways to support current bat populations to be as healthy and resilient as possible (short-term goal), and to support recovery of future bat populations (long-term goal). This plan will address objectives to achieve the short-term goal and support the long-term goal, the latter of which will likely take decades.

It is important to track the spread of the fungus and WNS while simultaneously monitoring impacts on bat populations, both in terms of population trends and species distribution. A comprehensive monitoring plan will be developed and implemented, involving a variety of methods including guano collection at bridges (for presence of fungus and species identification), acoustic monitoring, mist-netting, and winter and summer roost counts. Monitoring will help to focus recovery efforts.

The primary way to support current and future bat populations is through effective habitat management and protection. Highest priority for habitat protection are 'essential' roosts', where bats hibernate (*e.g.,* caves, crevices) and where females raise their young (*e.g*., large, mature trees). The Alberta *Wildlife Act* affords protection to these essential roosts; however, known hibernacula are few and natural tree roosts are rarely found. Consequently, it is important to maintain adequate amounts of suitable habitats that provide these types of roosts, such as mature and old-growth forests for maternal roosts. Additional habitat types are required to support foraging, drinking, commuting and non-reproductive roost sites. A variety of guidelines will be developed to ensure land-use activities maintain bat habitat. Public outreach is also important to support habitat protection, especially of anthropogenic roosts.

Although impacts of human-caused mortality are small relative to impacts of WNS, efforts should be made to prevent additional, and usually avoidable, mortality. The plan recommends ways to reduce human-caused mortality and bat-human issues. Effective communication at targeted audiences is key to this strategy.

Finally, possible WNS mitigation options need to be evaluated to determine if any would be practicable for Alberta. Throughout North America, various types of mitigation are being tested to help reduce the impact of WNS on bat populations. Mitigation is still in experimental stages and in general, success is limited and site specific. A scientific team will evaluate mitigation options and if any are deemed suitable, a mitigation plan will be developed and implemented.

The Recovery Plan recommends potential partners and timelines for all actions and includes a substantial communication and outreach component to support actions.

1.0 Introduction

The little brown myotis (*Myotis lucifugus*) and northern myotis (*Myotis septentrionalis*) were listed as Endangered species in Alberta in 2021. This designation was based primarily on severe population declines in the eastern parts of their range from a fungal disease, White-nose Syndrome (WNS). The fungus responsible for the disease, *Pseudogymnoascus destructans* (Pd), was detected in Alberta in 2022, and WNS was later confirmed on two little brown myotis in 2024.

Nationally, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) designated these species as Endangered in Canada in 2014 because of declines from WNS.

Pd grows in caves and was first detected in New York in 2006. The fungus irritates bats and causes them to arouse more frequently from hibernation. This uses up stored energy and because insect prey is not available during the winter, bats starve to death. Millions of bats have died since 2006, and some eastern populations have declined by over 90% (Cheng et al. 2021). The fungus has been detected in all provinces and most US states.

While efforts to minimize the spread of the fungus are important, ultimately it will spread throughout the province where site conditions are suitable. Maintaining habitat to support bat populations is key to recovery. Actions in this plan will benefit all bat species in Alberta, many of which are susceptible to WNS.

2.0 Process for Developing the Plan

The initial draft of the Recovery Plan was developed by a scientific team, then circulated to relevant government departments, partner agencies, and stakeholders for review.

Scientific team:

- Lisa Wilkinson (Chair), Alberta Environment and Protected Areas (EPA)
- Dr. Robert Barclay, University of Calgary (UC)
- Lynne Burns, Environment and Climate Change Canada (ECCC)
- Cory Olson, Wildlife Conservation Society Canada (WCSC), Alberta Community Bat Program (ACBP)

Stakeholders and partners:

- Parks Canada (PC)
- Alberta Forestry and Parks (AFP)
- Alberta Forest Products Association (AFPA)

Following internal engagement, a draft of the plan was posted for public review from August 1 to September 5, 2024, soliciting feedback through a questionnaire. Indigenous communities were directly notified when the plan was posted for public review, and were invited to fill out the questionnaire or submit comments directly to EPA. During the engagement, XX individuals/ organizations responded; their feedback was reviewed and incorporated into the plan as appropriate.

3.0 Situational Analysis

3.1 Biology

Little Brown Myotis

Little brown myotis is a small (7-10 g) brown bat (van Zyll de Jong 1985). It is long-lived, with one bat in Alberta recorded at least 39 years old (D. Hobson, pers. com.). Females typically have one pup per year; this low reproductive output makes it difficult for populations to recover from declines. Females may have their first pup after their first year. Pups begin flying at about 4 weeks of age.

Little brown myotis is a habitat generalist. In the summer, females roost in maternal colonies to raise their pups, often in old trees or buildings. In the fall, little brown myotis travel to hibernation sites, such as caves and rock crevices, sometimes several hundred kilometres away from their summer sites.

This species uses an aerial hawking strategy, capturing insects on the fly. It eats a variety of small insects such as moths, mayflies, caddisflies, and flies.

Northern Myotis

Northern myotis is a small (5-8 g) brown bat (van Zyll de Jong 1985). It has similar reproductive characteristics to the little brown myotis; 18.5 years is the oldest longevity record in the wild (Caceres and Barclay 2000).

Northern myotis is found in forested areas where it roosts primarily in old trees. It has similar hibernation patterns to little brown myotis, although fewer records exist. It often forages for prey in or near forests, either gleaning insects from plants or catching them on the fly.

3.2 Population Status

Population sizes for both species, nationally and in Alberta, are unknown. Prior to the arrival of WNS, little brown myotis and northern myotis were considered common in much of their range, with little brown myotis being the most abundant and ubiquitous species of bat in Canada. WNS was first detected in New York in 2006 and arrived in eastern Canada in 2010. Since then, millions of bats have died due to WNS. In eastern Canada, population declines for both species are estimated at around 95% (e.g., Cheng et al 2021). There is some evidence from areas where WNS was first detected that little brown myotis populations are slowly beginning to recover, however, this has not been observed for northern myotis (Lanwig et al. 2017).

The fungus that causes WNS (Pd) was first detected in Alberta in 2022. As of 2024, it has been found in all provinces, and WNS itself has been found in all provinces except BC and in most USA states (see https://www.whitenosesyndrome.org/where-is-wns; map is updated regularly).

Currently in Alberta, there are no data indicating that little brown or northern myotis populations have declined; the Endangered listing is based on anticipated declines from WNS. Bat population declines are not usually observed until at least one year following detection of the fungus. Previously, the Alberta general status of the little brown myotis was Secure. Northern myotis is less common than little brown myotis and was previously listed as May be at Risk because of its reliance on mature to old forests. It is unknown whether populations have been declining because of habitat loss but it is possible (ASRD and ACA 2009).

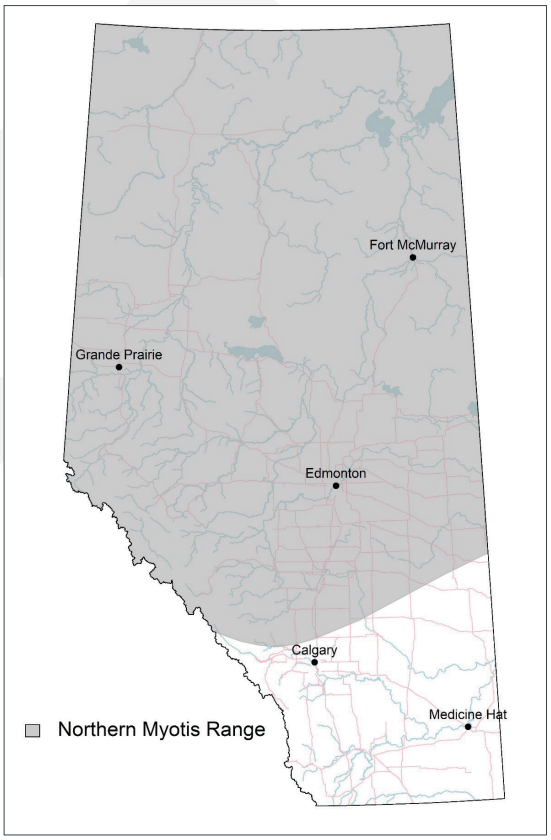
3.3 Distribution

Little brown myotis has the largest distribution of all Canadian bats and is found throughout North America. It is found throughout Alberta in all natural regions (Figure 1).

Northern myotis is distributed across Canada and parts of the USA. In Alberta, it is most often reported in the Boreal Forest Natural Region and the northern section of the Foothills Natural Region, with some records in the Parkland Natural Region (Figure 2). Recent DNA analyses detected northern myotis in Edmonton and near Cremona (C. Olson, pers. comm.).

Figure 1: Little brown myotis (Myotis lucifugus) range in Alberta.

Figure 2: Northern Myotis (Myotis septentrionalis) range in Alberta.



3.4 Conservation actions to date

- Education and information
  - Alberta Environment and Protected Areas (EPA)–website and resources
  - Alberta Community Bat Program (ACBP) – outreach resources and presentations, general information, support for people with bat issues
  - Parks Canada (PC) – website and educational programs
- Population monitoring:
  - North American Bat Monitoring Program (NABat) – standardized long-term acoustic monitoring (multiple agencies participate) started in 2015; the number of grid cells sampled each year varies, with over 100 cells sampled in some years
  - Hibernacula surveys – largest hibernaculum, Cadomin cave, is surveyed annually, other large hibernacula surveyed periodically
  - Bats and Bridges – guano analysis for species identification and presence of fungus that causes WNS
- Hibernacula (natural, not human-made) protection (Wildlife Act) – year-round protection from physical disturbance or alteration of the cave and people prohibited from entering the cave during hibernation
- Maternity roost protection (*Wildlife Act*) as of 2021, all bat species are designated as licensed animals; as such, bats cannot be molested or killed, and roosts cannot be altered or destroyed during the summer breeding season; for natural roosts (versus building roosts), this protection exists year-round
- Roost monitoring- Citizen Science (ACBP) – members of the public report and monitor building roosts (over 60 roosts reported)
- WNS surveillance and prevention
  - Public Education and Information
    - Carcass submission to the Government of Alberta (GOA) between December–May
    - Campgrounds: signage to not accidentally transport bats in vehicles or equipment (e.g. awnings, umbrellas)
    - Cave hibernacula that are closed to the public year-round
  - Caving community
    - Decontamination protocols in place for clothing and gear
    - Bats and Cavers Program (ACBP)–work with cavers to place roost loggers in potential cave hibernacula
  - Other relevant groups (e.g., wildlife rehabilitation facilities, pest control operators)
    - How to look for signs of WNS
    - Bat handling protocol in place to reduce risk of disease transmission
  - Guano testing for Pd (Bats and Bridges Program, operated by ACBP))
  - Bat capture to look for signs of WNS following hibernation – capture efforts are focused in the region where the fungus was first detected; the first two cases of WNS were detected on little brown myotis in spring 2024
  - AEP participates in National and North American WNS working groups

3.5 Threat Assessment

A threats assessment, using the IUCN Threats Calculator, was conducted for each species. This involves evaluating a suite of threats (level 1), within which there are a series of subcategories (level 2). They are rated on their scope, severity, and timing, resulting in an overall impact ranking. The primary threats for little brown and northern myotis, including relevant threat subcategories, are summarized for each species in Tables 1 and 2, respectively.

Table 1: Primary threats summary for little brown myotis (*Myotis lucifugus*).

Threat	Impact[1]	Scope[2]	Severity[3]	Timing[4]
Invasive & other problematic species and genes	Very High			
Invasive non-native/alien species	Very High (22-100%)	Pervasive – Large (31-100%)	Extreme (71-100%)	High (Continuing)
Natural system modifications	Medium -Low			
Fire & fire suppression	Medium–Low	Large (31- 70%)	Moderate – Slight (1-30%)	High (Continuing)
Dams & water management/use	Low	Small – Negligible (<1–10%)	Serious (31-70%)	High (Continuing)
Pollution	Medium -Low			
Industrial & military effluents	Low	Restricted -Small (1-30%)	Slight (1-10%)	High (Continuing)
Agricultural & forestry effluents	Medium–Low	Large (31-70%)	Moderate – Slight (1-30%)	High (Continuing)
Air-borne pollutants	Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)

Table 2: Primary threats summary for northern myotis (*Myotis septentrionalis*).

Threat	Impact	Scope	Severity	Timing
Invasive & other problematic species and genes	Very High			
Invasive non-native/alien species	Very High	Pervasive – Large (31-100%)	Extreme (71-100%)	High (Continuing)
Biological resource use	Medium			
Logging & wood harvesting	Medium	Large (31- 70%)	Moderate (11-30%)	High (Continuing)
Natural system modifications	Medium-Low			

[1] **Impact** is defined as the degree to which the species is directly or indirectly threatened and is based on an interaction between assigned scope and severity values

[2] **Scope** is defined as the proportion of the species population expected to be affected by the threat within 10 years, with continued circumstances (within the area of interest).

[3] **Severity** is defined as the level of damage expected within the longest of ten years or three generations, within the scope of the threat and is usually measured as the degree of reduction of the species population.

[4] **Timing** is recorded (ranging from continuing to unlikely) but is not used to calculate impact.

Threat	Impact	Scope	Severity	Timing
Fire & fire suppression	Medium	Large (31- 70%)	Moderate – Slight (1-30%)	High (Continuing)
Dams & water management/use	Negligible	Negligible (<1 %)	Serious (31-70%)	High (Continuing)
Pollution	Medium-Low			
Industrial & military effluents	Low	Restricted -Small (1-30%)	Slight – Negligible (0-10%)	High (Continuing)
Agricultural & forestry effluents	Medium-Low	Large (31-70%)	Moderate – Slight (1-30%)	High (Continuing)
Air-borne pollutants	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)

3.5.1 Details of primary threats:

1. Invasive & other problematic species & genes

WNS[5] is a 'very high' threat to both little brown myotis and northern myotis, with the potential to reduce populations by over 90%. It is important to monitor the spread of the disease and track bat populations to understand the impacts of the disease and help focus recovery efforts. Experimental treatment options will be evaluated to see if any may be worth trying in Alberta. However, it is important to recognize that at this time there is no treatment that can prevent Pd/WNS or cure WNS on a large scale; rather, treatments are applied at a local scale in an effort to reduce the level of impact to populations. The fungus cannot be eradicated from Alberta.

Although cats fall under this category as non-native predators of bats, their impact is negligible relative to WNS, and is addressed through outreach recommendations.

2. Biological resource use

Logging and wood harvesting are a threat to habitat because both species roost in mature/old trees. Because northern myotis roost almost exclusively in trees and often forage within forests, while little brown myotis roost and forage in a wider variety of habitat types, the threat is 'medium' for northern myotis and 'medium-low' for little brown myotis.

Bats that use tree roosts for maternity colonies require large mature or dead trees that provide suitable cavities or loose bark. Seral stage planning to maintain these types of trees is necessary, as is retention of old growth forest patches. Bats use a suite of tree roosts in a forest patch, switching roosts every few days. Protection of stands that support maternity roosts, rather than trying to identify individual roost trees, is required.

3. Natural system modifications

The driver in this category is fire as a threat to habitat, primarily roosting habitat and secondarily habitat that supports insect prey and optimal foraging habitat for northern myotis. The threat to both species is 'medium-low'.

Large forest fires are difficult to control and can be unpredictable with variable impacts on habitat. Wildfires are becoming more numerous and severe as a result of climate change. Moreover, when focusing firefighting efforts, human safety is the priority over wildlife habitat.

[5] The fungus, Pd, is the causative agent of WNS. Thus, it is the spread of Pd that leads to the spread of WNS. Most documents refer to pre- and pos-WNS, even though the fungus arrives first. Moreover, there are different surveillance methods for the fungus and the disease. This document will refer to pre- and post-Pd.

Consequently, this plan does not attempt to address fire prevention or suppression, rather, recommends forest management practices to optimize retention of old growth forests as the best way to ensure bat habitat is maintained.

4. Pollution

Water contamination (*i.e.*, riparian and wetland areas), from a variety of sources, ranks as 'medium-low'. Specifically, pesticides and effluents can have a direct impact on bats by contaminating water or can have an indirect impact by contaminating insect prey leading to bioaccumulation (Stechert et al. 2014, Gerell and Gerell Lunderg 1993). Unfortunately, the scale of these impacts is not well studied.

Moreover, sources of pollution and types of contaminants are myriad and complex, making it difficult to prescribe detailed actions. Accordingly, this plan provides only general recommendations to reduce sources of pollution, particularly in water.

3.5.2 Details of additional threats:

5. Human intrusion & disturbance

This is ranked 'low' for both species in the threats calculator but bears mentioning because some of these threats can be readily addressed.

a. Recreational caving. Cave hibernacula are key habitat components for bats where they are vulnerable to both human disturbance and WNS; however, there are few known (or suspected) cave hibernacula in Alberta so the scope is low. Recreational caving can indirectly lead to bat mortality: i) when disturbed, bats arouse from hibernation, using up important stores of fat and may not survive until spring, and ii) spreading fungal spores (on gear or clothing) to other hibernacula, thereby increasing spread of WNS, both in scope and time. Appropriate messaging to cavers needs to be maintained and updated.

b. Human activity/persecution–primarily little brown myotis. In urban areas, human activity can cause direct or indirect mortality of bats by: i) deliberately killing bats, ii) destroying roosts and other key habitat, and ii) evicting bats from building roosts when pups are non-volant, leading to the death of pups. Public outreach about bat conservation needs to be expanded to ensure various audiences are informed.

6. Climate change – This threat was assessed as 'unknown'; however, it is likely climate change will create additional risks to bats, such as through extreme weather events and more frequent or severe wildfires. Maintaining bat habitat, especially essential roosting sites, is the best way to address climate change.
7. Pesticides – Pesticides impact bats by reducing insect prey availability, which is not explicitly covered in the threats calculator. Although it is difficult to quantify the impact of this threat on bats, it is widely recognized as an issue and reduction in pesticide use would benefit bats and other insectivores.

Photo: Jason Headley

4.0 Recovery Goals and Objectives

At this time, it is not possible to stop the spread of the fungus, destroy the fungus, or cure the disease (outside of limited treatment trials). Pd will likely be here forever. There is evidence from eastern North America that some bats are developing a resistance to WNS (Langwig et al. 2017), suggesting that some populations will slowly recover over decades. Accordingly, this plan is focused on ways to support current bat populations to be as healthy and resilient as possible, and to support recovery of future bat populations. Bat populations are expected to begin declining as Pd becomes more prevalent across Alberta.

4.1 Goal

The short-term goal is to support current bat populations to be as healthy and resilient as possible in anticipation of declines from WNS. This will be achieved primarily through habitat management and protection.

The long-term goal, following the expected decline, is to have little brown myotis and northern myotis populations that are increasing (ultimately stabilizing at pre-Pd levels) and distributed over their natural range[6]. Although there is no way to know whether bat populations will ever return to pre-Pd size, self -sustaining, healthy populations should be achievable in the long-term.

A goal that will take decades to achieve is clearly beyond the time frame of this plan. Objectives that support the long-term goal have been developed and will be tracked over time and modified as needed.

[6] Natural range does not include little brown myotis range expansions facilitated by human development. However, persistence of little brown myotis in these ranges will not be discouraged.

4.2 Objectives

Details of how these objectives will be achieved and tracked are outlined in section 6.0.

Objective 1

Timely and accurate monitoring to track:

a. the spread of Pd and WNS

b. changes in bat population trends and distribution trends

Rationale: Monitoring is necessary to understand the impacts of the disease and target recovery efforts.

Indicator: Successful Implementation of a provincial monitoring plan to track Pd, WNS, and bat populations. This will be evaluated based on the number of established monitoring sites located in different natural regions throughout the province. The recovery implementation team will identify sites, and monitoring will be reviewed annually.

Considerations for bat population and distribution monitoring:

Population trends: We do not know current population sizes so cannot empirically track changes; however, various metrics are available to evaluate the magnitude and direction of population trends post-Pd. Methods include: number of known building roosts occupied and the number of bats using them (little brown myotis), number of bats in known hibernacula, activity levels based on acoustics, capture rates, and anecdotal information. Selected hibernacula, maternity roosts and capture/detector sites will serve as sentinel sites to closely monitor population trends.

Species distribution: Distribution can be tracked through a combination of methods, including: DNA barcoding of guano samples (collected at bridges, bat boxes and building roosts), acoustics, captures and anecdotal information. Impacts of WNS may vary regionally; for example, colder temperatures in the north and montane habitats may mitigate impacts.

Other species: Although the focus of this plan is little brown myotis and northern myotis, data for all bat species will be collected through disease and population monitoring. This is critical because not only are other *Myotis* sp. expected to decline from WNS, but there could be shifts in bat species distribution and abundance that need to be considered in management and recovery.

Objective 2

Bat habitat management and protection for:

a. known hibernacula and maternity roosts, and habitat that provides those types of roosts (priority)

b. foraging, drinking and commuting habitat, and roosting habitat for non-reproductive bats

Rationale: The best way to support current and future recovering bat populations is by providing adequate types and amounts of habitat, especially for overwinter survival and successful reproduction.

Indicators: Development of clear land use guidelines to ensure that key bat habitat is maintained on the landscape. This includes Best Management Practices (BMPs) and incorporation of bat habitat needs into relevant provincial guidelines and policies. Timelines for completion are included in actions. Ways to evaluate the efficacy of guidelines will need to be developed.

Objective 3

Mitigation to reduce sources of bat mortality:

a. reduce direct and indirect mortality caused by human activity,

b. evaluate mitigation options to help reduce impacts of WNS and implement if appropriate.

Rationale:

a. Although most types of human-caused mortalities are negligible relative to impacts from WNS, it is prudent to reduce preventable mortalities. This is especially important for little brown bats because they often live in urban areas and roost in buildings.

b. Reducing or preventing mortalities from WNS is the subject of extensive research (i.e., Pd/WNS prevention and treatment), which is still in experimental stages with limited field trials. These types of mitigation options need to be closely examined to determine if any may be effective in Alberta. If deemed possible, a mitigation plan will be developed and implemented. Because it is not possible to eliminate Pd, the goal of WNS mitigation is to minimize the impact to populations while bat populations slowly recover (*i.e.*, develop resistance and/or tolerance to WNS). This type of mitigation will be ineffective without adequate habitat protection.

Indicators:

a. Because most human-caused mortalities are unreported, various surrogate measures that indicate public support for bats will be tracked, such as the number of social media followers.

b. Evaluating Pd/WNS mitigation involves stepwise metrics: i) successful evaluation of options through a robust decision framework with clear recommendations, and ii) if mitigation is recommended, development and initiation of a mitigation plan.

5.0 Habitat Needed to Support Recovery

Highest priority habitats are hibernacula and maternity roosts, referred to as ‘essential roosts’ in this plan. Additional habitat types are required to support foraging, drinking, commuting and non-reproductive roost sites. The Alberta Wildlife Act has provisions to protect essential roosts, as outlined below.

5.1 Hibernacula

Currently, only eight cave hibernacula have been identified in Alberta, all but one of which are in the mountains. Undoubtedly there are more cave hibernacula (although less likely that any are larger than those already identified) and bats may also hibernate in abandoned mine shafts. In western Canada, many bats likely hibernate in cracks and crevices in rocky areas (rather than caves) and are consequently difficult to detect. Some bat species have been found hibernating in the coulees along the Red Deer River in southern Alberta (Lausen and Barclay 2006), and it is likely other river valleys and riparian areas have suitable habitat for hibernacula. In eastern USA, northern myotis have been found hibernating in rocky areas around small creeks (White et al. 2020). More research into identifying non-cave hibernacula is required to ensure adequate protection.

Most known hibernacula are on land protected through provincial or federal parks, and all natural hibernacula are protected from disturbance under the Alberta Wildlife Act. However, protection does not extend to include habitat around the hibernacula, which is necessary for foraging and drinking opportunities while bats are preparing to hibernate. Prior to entering hibernation, bats exhibit a swarming behaviour (for mating) around hibernation sites. We have little data about this behaviour but presumably it occurs near roosting, foraging, and drinking habitats. Moreover, it is possible that excessive noise or light near hibernaculum entries could deter bats from entering.

Habitats that are likely to support non-cave hibernacula, such as riparian areas and rocky areas, are accessible to the public and could be disturbed.

5.2 Maternity Roosts

Maternity roosts, where pups are raised, need to be warm and secure from predators (*e.g.*, Lausen and Barclay, 2006). Bat roosts are typically within 1-2 kilometres of a water source.

Natural Roosts

Both species use old, large-diameter deciduous trees (e.g., *Populus* sp.) for maternity roosts in various stages of decay where cracks, holes and peeling bark provide roosting opportunities (e.g., Crampton and Barclay, 1998; Vonhof and Wilkinson 1999). Bats may roost in coniferous trees if there are suitable cavities (Micalizzi et al. 2023). Females roost in groups and change roost sites every few days (e.g., Crampton and Barclay, 1998; Vonhof and Wilkinson 1999; Willis and Brigham, 2004; Russo et al. 2017). Consequently, a suite of suitable roost trees is required within a forest patch. Moreover, younger trees need to be included as future roost sites through seral stage planning. There are limited data on minimum sizes of forest patches required, with variation among species and forest types.

Under the Wildlife Act, a natural maternity roost is protected from disturbance/destruction throughout the year. However, it is difficult to identify individual tree roosts and they are rarely found, so landscape-level protection of suitable tree patches is a priority.

Human-made Roosts

Little brown myotis often use buildings for maternity roosts, typically showing high fidelity to these sites. Examples include attics, barns, cracks in log buildings and under shingles. For obvious reasons, these types of maternity roosts are easily identified and monitored. Bats that use building roosts may switch roost sites periodically, including bat boxes and natural roosts. An established building maternity roost will likely be used throughout the summer by a number of female bats, although the number of individuals present may fluctuate from night to night.

Arguably, the availability of human-made roosts has allowed little brown myotis to expand its range, especially into mountain towns and resorts, where trees are too small to provide suitable roosts (Johnson et al. 2017, Micalizzi et al. 2023). Similarly, prairie towns have likely provided roosting opportunities in areas where trees were lacking. There is concern that this could negatively affect other bat species through increased competition. However, in light of projected population declines from WNS, building roosts could be important for population recovery. Additionally, they provide opportunities to monitor populations.

Maternity roosts in buildings are protected from disturbance/destruction during the pup-rearing season (June 1 – August 31). There are provisions to exclude bats from a building roost before August 31 when there are extenuating circumstances that threaten human health or safety.

Bat houses have become increasingly popular in recent years, and as with building roosts, there is concern that bat houses could give some species a competitive advantage. Notably, there are

different types and styles of bat houses, only some of which are suitable for maternity roosts. Provided natural roosting sites are available, maternity bat houses are not required. In cases where a building maternity roost needs to be excluded, one or more maternity bat houses are recommended to provide a variety of suitable thermoregulatory options (Holroyd et al. 2023)

Little brown myotis do not hibernate in buildings or trees because they do not provide the correct thermal environment during the winter.

5.3 Other Habitat

Other roosting habitat

Males and non-reproductive females also roost in trees, but do not need roosts that are as large or as warm as those used by females raising pups. *Populus* sp. are the most commonly reported roost trees in Alberta but other species may be used (*e.g.*, Vonhof and Wilkinson 1999). Consequently, a greater variety of trees, in terms of both species and age, can provide roosting opportunities as long as they provide minimum temperature thresholds. By maintaining forested areas for maternity roosts, there should be adequate roosting trees for males and non-reproductive females. Moreover, young trees will eventually reach a stage that renders them suitable for maternity roosts.

Bats may travel long distances between summer roosts and hibernation sites (sometimes several hundred kilometres), likely following riparian corridors, and need places to roost along the way. It is challenging to plan for roosting habitat along travel routes; ideally general habitat protection measures will cover this.

Foraging habitat

Bats need habitat that supports a diversity of insect prey (and in some cases other invertebrates such as spiders). Although bats may feed over a variety of habitats, areas with lush vegetation and/or productive aquatic habitats are most likely to support a range of insect prey. The latter supports insects with aquatic larvae as well as terrestrial larvae in the surrounding vegetation. Vegetated areas with a variety of native plants support diverse insect communities, providing a consistent food supply.

The suitability of foraging habitat will also depend on the degree of protective shelter, such as ridges and treed corridors, with northern myotis likely being more reliant on vegetation cover than little brown myotis.

Agricultural areas may be less suitable for foraging bats because of monocrops (reduced insect diversity) and use of pesticides. Tree patches and shelter belts may provide foraging opportunities.

Despite the ability of some bats to exploit insect congregations around lights, highly urbanized areas provide little foraging habitat.

Drinking sources

Bats drink each night, needing water that has open access to allow bats to take a drink while in flight. Still or slow-moving water is ideal. While some large human-made water sources, such as dugouts, can provide suitable drinking opportunities, small human-made water sources, such as rain barrels and drinking troughs, can lead to drowning and should be covered or provide escape options. Importantly, drinking sources should not be polluted.

Commuting habitat

Bats commute between roosts and foraging and drinking sites. Little brown myotis tend to avoid large open areas and travel along treed edges or riparian corridors, and it is likely that northern myotis show a similar or stronger avoidance to open areas. In agricultural landscapes, shelterbelts could provide commuting habitat and shelter.

6.0 Recovery Strategies and Actions

6.1 Strategy 1: Monitor and minimize rate of spread of Pd and WNS

This strategy addresses Objective 1a, to understand the impacts of WNS on bat populations by tracking the spread of both the fungus and disease. Confirmation of WNS in an area will be useful to target mitigation efforts. In addition, we will be able to compare the spread of Pd and bat mortality levels from WNS to what was observed in eastern North America, which will help to identify any regional variations in the susceptibility of bats to WNS.

A variety of methods are required to track Pd and WNS. Evidence of the fungus can be found in bat guano, environmental substrates where bats roost, and on bats (living and dead), with guano being the easiest and most reliable source. Evidence of WNS can be found only on bats (on living and dead). Monitoring is outlined in Strategy 6.1.1.

Public outreach is necessary to help with surveillance (i.e., reporting dead or dying bats) and to a lesser extent, reduce the spread of the fungus by humans. The fungus is primarily spread by bats, but reducing additional sources of spread, such as fungal spores on caving gear, is desirable. Outreach is outlined in Strategy 6.1.2.

6.1.1 Monitor Pd and WNS

Desired outcomes

1. Timely and accurate tracking of spread of Pd and WNS to understand population impacts and inform recovery actions across the province.

Progress Measures

1. Development and implementation of provincial monitoring plan in the first year.
2. Annual updates/reporting on the presence and spread of Pd and WNS, posted on the GOA website and shared with partners.

Recovery Actions

Develop and implement a surveillance and monitoring plan in conjunction with partners. Plan should include the following:

- Guano collection under bridges: primary Pd detection method because all *Myotis* sp. use bridges as night roosts, it is relatively easy to collect samples, and provides coverage throughout the province
- Bat capture: capturing bats during mid to late spring may reveal signs of WNS, or evidence of Pd from wing swabs and/or guano collected directly from handled bats
- Hibernacula surveys: look for signs of WNS on bats and carcasses in hibernacula (in summer or in conjunction with hibernacula surveys as per 6.3.3) and collect suspicious bat carcasses for analysis (unnecessary after WNS confirmed at site)
- Other: opportunistic Pd testing from guano and/or soil samples around roosts
- Reporting: all lab results will be reported to the Canadian Wildlife Health Co-operative (CWHC) and updates will be provided on GOA websites and shared with partners and other North American jurisdictions
- Partner organizations and responsibilities
- Details on schedule, methods, data management, delivery partners and reporting guidelines will need to be updated and revised as Pd/WNS spread is discovered

6.1.2 Outreach to assist with monitoring WNS and minimizing spread of Pd

Desired outcomes

1. Adequate public awareness to stop human transmission of the fungus and to help with disease surveillance, *i.e.,* report dead bats suspected of having WNS.

Progress Measures

1. WNS specific messaging that is current and readily available on all relevant websites and social media.
2. Number of carcasses submitted by public for WNS testing.

Recovery Actions

1. Deliver messaging to the public and other groups, such as municipal-level organizations and cavers, to increase the scope of surveillance and limit the accidental spread of the fungus by humans. In some cases, new public outreach is required, but in most cases, continuation and/or improvement of current public outreach initiatives are recommended. Considerations include:
   - Advise the public to submit carcasses with signs of WNS found between Dec and May to the GOA
   - Advise the public to report sightings of bats flying in winter to the GOA
   - Provide information to counties/municipalities about WNS surveillance and how to support bats and their habitats
   - Reinforce messaging to cavers about the importance of decontamination protocol
   - Ask cavers to report bat sightings, both live and dead
   - Reinforce bat handling protocols to wildlife rehabilitation centres and pest control/nuisance wildlife control operators and advise them to look for signs of WNS and report to GOA
   - Ensure messaging on all GOA websites is current and relevant
   - Discuss and share all messaging with the ACBP
   - Share messaging with ACA, NGOs, and other environmental organizations
   - Provide updates to media as required
   - Support messaging at campgrounds to avoid accidentally transporting bats in recreational vehicles

6.2 Strategy 2: Survey and monitor bats to track changes in population trends and distribution

This strategy addresses Objective 1b, to track changes in bat population trends and species distribution to understand the impacts of WNS and help focus recovery efforts. While the focus of the plan is little brown and northern myotis, data on other species will be collected and may reveal changes in bat species composition and distribution. Unfortunately, it is difficult to determine the population size of bats, so a combination of methods will be used to infer population changes. Relative to population size, it is easier to monitor species distribution although there are some limitations to species identification. A suite of methods needs to be employed to achieve monitoring objectives.

Desired outcomes

1. Appropriate data collection to support annual updates on little brown myotis and northern myotis population trends and distribution. Secondarily, data on other bat species will be collected to determine if they are impacted by WNS and if distribution and activity change as a result of little brown and northern myotis declines.

Progress Measures

1. Development and implementation of monitoring plan in first year.
2. Annual updates on changes to bat species' presence/absence, activity levels, and distribution, posted on GOA website and provided to partners.

Recovery Actions

1. Develop and implement a bat population monitoring plan in conjunction with partners. Plan should include the following:
   - Some methods overlap with Pd surveillance so need to coordinate monitoring efforts
   - Scope of plan is province wide
   - Partner organizations and their responsibilities
   - How data will be shared with partners and public
   - Ways to communicate, and possibly work, with adjacent jurisdictions (*e.g.*, Montana)
   - The following methods, including timing considerations, should be included:
     - Guano collection at bridges: species presence/distribution and possibly occupancy
     - Acoustic monitoring using NABat bat monitoring stations, including mobile transects: species presence/distribution (recognize limitations of distinguishing *Myotis* species) and activity levels as indices of population size[7].
     - Exit counts at building roosts, bat houses and bridge roosts (little brown myotis): species presence/distribution and number of bats as indices of population size. Interpreting changes in exit counts needs to take into account that roost size and use varies throughout the season (*i.e.*, frequent monitoring is required to estimate maximum occupancy). Large, well-established roosts will have the greatest reliability for monitoring trends. Citizen science can play a role in this.
     - Bat counts in hibernacula: compare counts to previous years; use number as index of population size. The species composition of most caves is unknown although tends to be more little brown myotis than other species.
     - Bat capture at sentinel sites (likely in conjunction with acoustic monitoring sites) using standardized techniques; northern myotis are less common so need to prioritize suitable sites. Review historic capture data from FWMIS to select sentinel sites.
     - Anecdotal information: number of bats, and proportion of each species, submitted for rabies testing, etc.
     - Ratio of little brown myotis to big brown bat roosts reported through citizen science program: big brown populations will likely not decline as much as little brown myotis, so could potentially exploit little brown myotis roosting sites

6.3 Strategy 3: Protect known hibernacula and maternal roosts, and habitat that provides these roosting sites

This strategy addresses Objective 2; habitat protection is fundamental to supporting bat populations. The priority is essential roosting sites: hibernacula and maternity roosts. Known sites are protected from disturbance and alteration under the Alberta Wildlife Act, and will be monitored through Strategy 6.1b, so monitoring is not included here.

[7] *It may be possible to use occupancy modelling in the future (using mobile acoustic transect data); however, for small areas (and in the short term), relative activity may be a better representation of local bat populations than occupancy*

6.3.1 Hibernacula Protection

Known hibernacula likely support only a small portion of the suspected bat population and the majority of hibernacula are unknown. It is challenging to locate hibernacula, and while some effort is required to identify new sites, more effort is required to identify and protect habitat that supports hibernacula. In particular, the value of riparian habitat for overwintering bats needs to be better understood.

Currently, looking for new cave hibernacula is done opportunistically with the assistance of the caving community. Additional effort to actively search for cave hibernacula, in most cases, is not recommended because is it resource intensive and rarely successful. The exception is in situations where development in or around caves, such as mining, is planned. Predevelopment surveys, such as acoustic surveys from fall through spring to detect bat activity, is required. Surveys are also required before land reclamation to ensure hibernacula are maintained.

Where hibernacula or hibernacula habitat are identified, maintenance of surrounding habitat (e.g., foraging) is required. This will be accomplished through guidelines, such as setting buffers zones to protect habitat, along with timing restrictions for activities that could negatively affect hibernating bats.

Desired Outcomes

1. Effective protection of all known hibernacula including surrounding habitat
2. Awareness of the importance and types of potential hibernacula habitat, and how to identify and protect that habitat

Progress Measures

1. Messaging about cave restrictions that is current and readily available on all relevant websites and social media
2. Development of BMPs, within two years, to:
    a. create buffers around hibernacula to maintain habitat and prevent excessive disturbance. Ways to evaluate the efficacy of guidelines will be developed concurrently
    b. ensure pre-development and pre-reclamation surveys are done in areas where hibernacula are likely
3. The number of field studies conducted to improve understanding of non-cave hibernation habitat

Recovery Actions

1. Ensure hibernacula database (location, number of bats, monitoring history) is updated if a new hibernaculum is discovered, and incorporated into the monitoring schedule as per strategy 6.2.
2. Where appropriate, ensure cave hibernacula and access restrictions are identified to relevant audiences such as cavers, *i.e.*, signage, web posting. Additional messaging is covered in 6.1.2.
3. Develop guidelines and/or BMPs for mines and other lease holders in rocky habitat to determine if bat hibernacula exist before development, and specifically for mines, before reclamation begins. Ways to identify potential hibernacula include: i) placing roost loggers in openings or caves to detect bat activity entering or leaving hibernation, and ii) operating acoustic detectors near the potential cave hibernacula from late summer to spring to detect winter bat activity. Bursts of activity in spring have been used to identify rocky outcrops with hibernacula in Alaska.
4. Develop protocols to identify non-cave hibernacula in riparian areas and rock cracks and crevices and implement field studies to verify.
5. Develop guidelines and/or BMPs to protect non-cave hibernation habitat as data become available.

6.3.2 Maternity roost protection

Similar to hibernacula, natural maternity roosts are difficult to locate and are rarely identified. Moreover, bats usually switch roosts every few days. At this time, the focus is on tree roosts because other natural roosts, such as stumps and crevices, are less common and poorly understand.

For the most part, actively looking for tree roosts is not recommended because it is resource intensive and rarely successful. Tree use is well understood and in most cases field verification of bat presence in an area is not necessary to identify good roosting habitat. It is important to identify and protect forest patches that provide medium and old growth deciduous and mixedwood trees. This will be achieved through land-use guidelines, and recommendations for the public.

Building roosts can be important for little brown myotis and should be maintained when possible. They require a different management approach than natural roosts, as outlined below.

Desired Outcomes

1. Protection of adequate types and amounts of habitat for maternity tree roosts.
2. Effective management and monitoring of maternity roosts (anthropogenic)

Progress Measures

1. Development of BMPs, within two years, to protect forest patches that provide a suite of suitable maternity roosts. Ways to evaluate the efficacy of guidelines will be developed concurrently.
2. Number of building roosts in monitoring database
3. Current and accessible messaging, directed at target groups (e.g. pest control) and public about regulations regarding bats and building roosts and how to address and prevent bat issues.

Recovery Actions

1. Natural roosts – trees

a. Identify and protect habitat used for maternity roosts through effective stand management to retain mature and old trees patches in deciduous and mixedwood stands. Considerations include:

   - Review, and update if required, forestry guidelines to ensure adequate bat roosting habitat is included, *i.e.*, old forest targets in the Forest Management Plan; adequate retention of old and recruitment stands in the Non-timber Assessment[8] and Master Schedule of Standards and Conditions (MSSC)[9].
   - Develop guidelines and/or BMPs for lease holders (*e.g.*, forestry, oil and gas) regarding the best ways to determine if habitat is suitable for roosts (current and future), and how to maintain bat roosting habitat. Recognize that, in many cases, it is possible to identify bat roosting habitat based on a habitat assessment without field detection of bats.
   - Promote maintenance of forests and other bat-friendly practices, as well as bat-friendly communities (urban, agricultural, rural); emphasize the importance of natural roosts through public outreach.

[8] *Non-timber Assessment – part of a Forest Management Plan, developed by EPA and AFP
[9] MSSC – identifies conditions that apply to formal dispositions applications approved under the Public Land Act; developed by EPA and Alberta Energy Regulator (AER)

2. Building roosts – little brown myotis only

a. Continue to work with ACBP to:

- Promote current citizen science program to identify, report, maintain and monitor building roosts; will need verification about species (big brown bats also roost in buildings) and colony size.
- Provide information and support to building owners with bat issues through appropriate and readily available messaging.
- Provide guidelines on maternity bat houses, *i.e.*, when is it appropriate, number and placement.
- Consider program to encourage maintenance (*i.e.*, incentives) of maternity roosts and provide maternity bat houses when established maternity roosts need to be excluded.

6.4 Strategy 4: Protect other types of bat habitat: foraging, drinking, connectivity and roost sites for males and non-reproductive females

This strategy addresses the second part of Objective 2 by maintaining a variety of habitats that are required to support healthy and recovering bat populations. Because these types of habitats support other types of wildlife, there are already some guidelines and policies in place that benefit bats, such as maintenance of healthy wetlands through the Alberta Wetland Policy. Appropriate management and protection of old growth tree patches, as outlined in Strategy 6.3b, will provide roosting and some foraging habitat. This strategy supports maintenance of a variety of habitat types not yet covered in this plan.

Desired Outcomes

1. Awareness and support of best management practices to maintain bat habitat.
2. Adequate habitat to support recovering bat populations.

Progress Measures:

1. Develop 'bat friendly' BMPs for types of land development not covered in 6.3. All BMPs should be completed within four years, with a minimum of one BMP completed in the first year.
2. Number of people/companies that directly received messaging about BMPs

Recovery Actions

1. Identify relevant types of land development activities and associated land owners, and target messaging accordingly. Habitat management provisions may be in place for some circumstances and should be reviewed for efficacy. BMPs should include the following:

a. Other roosting habitat– should be protected through previous strategy

b. Foraging habitat considerations:

- Maintain/plant trees and natural vegetated areas
- Riparian areas are a high priority
- In agricultural areas, promote natural vegetation, mixed crops and shelterbelts
- Waterflow (*e.g.*, dams, flooding, especially in SE) can impact foraging habitat along rivers
- Reduced pesticide use for forestry, oil and gas, and agriculture

c. Drinking sources:

- Slow moving is water best
- Riparian areas are a high priority
- Prevent and reduce contaminants/effluents getting into drinking sources – agricultural and industrial (forestry, mining, oil and gas), and military if possible
- Prevent accidental bat drowning by modifying rain barrels and water troughs

d. Commuting habitat – should be achieved through actions recommended for foraging habitat

2. Outreach to maintain or create bat habitat

Work with ACBP to promote 'bat friendly' habitat to the public, including municipalities, land owners, and home and cabin owners through social media. Update, and create if required, guidebooks relevant to bat habitat.

6.5 Strategy 5: Identify, reduce, and mitigate human-caused mortality and promote bat conservation. This requires outreach to targeted audiences

This strategy addresses objective 3a. Sources of human-caused mortality, direct and indirect, are myriad. With many bat populations expected to decline significantly with the onset of WNS, it is important to reduce additional sources of mortality, even though in most cases, the number of human-caused bat mortalities is small relative to mortalities from WNS. While some sources of mortality are difficult to control, (*e.g.,* collisions with vehicles), others are relatively easy to target and are likely a major cause of preventable mortality.

Desired Outcomes

1. Awareness and support of bat conservation leading to a reduction in avoidable human-caused bat mortalities

Progress Measures

It is difficult to track changes in people's attitudes, and it is not possible to track reductions in human-caused bat mortalities because most are unknown or unreported. Accordingly, the best proxy to measure is:

1. Increased awareness about bats as demonstrated by an increase in social media followers (ACBP: Twitter, Facebook, Instagram).

Recovery Actions

Work with the ACBP to maintain, improve or create messaging, and share with partners, to:

1. Eliminate/reduce persecution- Broad education campaign:
   - importance of bats – ecosystem role, bats as pest control, etc.
   - reduce fear of bats by debunking myths about disease, etc.
   - inform about threats, endangered status, and legalities (cannot kill bats)
   - guidance on what to do if you find a bat

2. Maintain, or conduct proper exclusions from, building roosts – additional considerations not covered under 6.3, 2 b):

   - in addition to the public, target messaging for Pest control operators, builders, etc.; consider developing standards of practice
   - encourage building maintenance to avoid unwanted bat roosts
   - determine circumstances under which a maternity bat house is appropriate if roost is excluded
   - encourage monitoring through exit counts (citizen science)
   - how to avoid accidental mortality in buildings

3. Eliminate/reduce accidental entrapment:

   - Ensure chimneys and vents have proper caps and that trim/flashing around chimneys and vents are intact.

4. Eliminate/reduce drowning risks, e.g., Water barrels, troughs

   - cover small surface-area water sources or provide adequate escape options (mostly rural areas)

5. Avoid disturbing bats and destroying roosts at bridges by working with counties/ transportation to:

   - identify potential bridge maternity roosts,
   - develop guidelines or BMPs for timing of cleaning, maintenance and construction of bridges

6. Wind turbines – although mortality of little brown myotis and northern myotis is low relative to migratory species, this is an additional source of mortality, particularly for little brown myotis:

   - ensure policy/BMPs have proper siting considerations to avoid building windfarms near known hibernacula and maternity roosts, river valleys, and old growth stands; policy/BMPs to reduce mortalities of migratory bats will be beneficial for other bat species.

7. Ways for people to help bats:

   - Learn more about Alberta's bats, including benefits and conservation issues
   - Maintain and plant trees
   - Maintain wetlands
   - Keep cats indoors (cats are likely a significant source of bat mortality in urban and rural areas)
   - Do not use glue traps for pest management
   - Where appropriate, provide appropriate maternity bat houses

6.6 Strategy 6: Evaluate and implement Pd/WNS treatment and prevention if appropriate.

This strategy address objective 3b: WNS mitigation. Currently there is considerable research on prevention and treatment of Pd and WNS, and some jurisdictions are applying techniques in the field. As of yet, there is no 'silver bullet'. Designing and implementing research and field trials is a lengthy process and it usually takes years for results. We need to understand and evaluate mitigation options to determine if any would be practicable for Alberta.

An important consideration is that hibernacula in western Canada are typically smaller and more dispersed than in eastern Canada. This could reduce the spread of Pd (Blejwas et al. 2023), although impacts may be more difficult to detect. Similarly, Alberta has few known large maternity colonies (i.e., hundreds of bats). Therefore, mitigation strategies that target hibernacula or maternity colonies will reach only a small portion of the population.

Some little brown myotis populations in eastern North America are beginning to stabilize in the absence of mitigation because of growing natural resistance (Langwig et al. 2017). However, northern myotis are not showing similar signs of recovery.

Desired Outcomes

1. confidence that there is, or is not, a suitable Pd/WNS treatment for Alberta at the time the review is conducted
2. If a suitable treatment option is identified, successful initiation of the treatment

Progress Measures

1. Number of potential treatments evaluated for use in Alberta
2. If recommended, timely implementation of treatment, e.g., within three years

Recovery Actions

1. Within year one, establish a scientific team with representation from government and academia to develop a decision framework and valuate mitigation options. Considerations include:
   - Understanding of current research into prevention, reduction, and treatment of Pd and WNS
   - Evaluation of mitigation applicability in Alberta, *e.g.*, ability to implement, likelihood of success, and cost effectiveness.
2. If mitigation is recommended, develop a comprehensive plan within two years. Considerations include:
   - Roles of partners
   - Budget and logistical considerations
   - Timing and location
   - How to evaluate success of mitigation
3. Implement mitigation plan within three years.

7.0 Implementation Plan

7.1 Implementation timetable

Table 3: Priorities, partners, and timing of implementation of actions.

This is a summary of recovery actions, including priority, recommended year(s) for implementation, and recommended partners. Priorities are identified as: Urgent (U), Necessary (N), Beneficial (B).

Urgent actions need to be implemented immediately. In some cases, necessary and beneficial actions are also recommended for immediate implementation because work is already ongoing and/or they are easy to implement.

#	Strategy and Actions	Priority	Year 1	Year 2	Year 3	Year 4	Year 5	Agency*	Notes
6.1	**Monitor and minimize rate of spread of Pd and WNS**								
6.1.1	Develop and implement Pd and WNS surveillance and monitoring plan	U	x	x	x	x	x	GOA, WCS, PC. Other potential partners: universities, ACA, ECCC, NGOs	Develop plan and implement pilot monitoring program in first year.
6.1.2	Outreach to assist with monitoring WNS and minimizing spread of Pd	N	x	x	x	x	x	GOA, WCS, PC.	Build upon existing outreach
6.2	**Survey and monitor bats to track changes in population trends and distribution**								
	Develop and implement provincial bat monitoring plan	U	x	x	x	x	x	GOA, WCS, PC. Other potential partners, universities, ACA, ECCC, NGOs	Develop plan and implement pilot monitoring program in first year.
6.3	**Protect known hibernacula and maternal roosts, and habitat that provides these roosting sites**								
6.3.1	Hibernacula protection								
a-c d e	Maintain database and targeted outreach Guidelines/BMPs Research into riparian areas and other areas	N N N-B	x	x x x	x x x	x x x	 x	GOA, WCS, PC	Some protections and outreach already in place
6.3.2	Maternity roost protection								
a b	Natural roosts -Guidelines/ BMPs Building roosts–outreach	N N-B	 x	x x	x x	x x	 x	GOA, WCS,	Some protections and outreach already in place

#	Strategy and Actions	Priority	Year 1	Year 2	Year 3	Year 4	Year 5	Agency*	Notes
6.4	**Protect other types of bat habitat: foraging, drinking, connectivity and roost sites for males and non-reproductive females**								
6.4.1	Guidelines/BMPs	N			x	x		GOA, WCS	
6.4.2	Outreach	B	x	x	x	x	x	GOA, WCS	Some outreach already in place
6.5	**Reduce and mitigate human- caused mortality and promote bat conservation**								
a	Broad education campaign	N	x	x	x	x	x	GOA, WCS, NGOs	Some outreach already in place
b-c	Reduce building issues	N	x	x	x	x	x		
d	Reduce drowning risks	B	x	x	x	x	x		
e	Bridge guidelines	N	x	x	x	x	x		
f	Wind turbine guidelines	U	x	x	x	x	x		
g	Ways to help bats	B	x	x	x	x	x		
6.6	**Evaluate Pd/ WNS treatment and prevention and implement if appropriate**								
a	Establish scientific team and evaluate mitigation options	N	x					GOA lead, include WCS, ECCC, Universities	
b	Develop mitigation plan			x				Same as above	
c	Implement mitigation				x	x	x	Same as above	

*Agencies: GOA- Government of Alberta; WCS – Wildlife Conservation Society Canada (NGO that operates Alberta Community Bat Program); PC – Parks Canada

**NGO examples: Nature Conservancy, Edmonton Land Trust, Waterton Biosphere Reserve Association, watershed councils

7.2 Plan progress review, evaluation and amendment

Progress measures will be reviewed on an annual basis. If there is a lack of progress on implementation, reasons will be identified, and adjustments may be required to better define and/or achieve performance measures. Actions pertaining to surveillance and monitoring of Pd and WNS will likely need to be modified following positive detections.

7.3 Implementation opportunities and barriers

Although there are still some barriers in terms of people viewing bats as pests, for the most part public attitudes are changing. Awareness of the potential impacts of WNS on Alberta bat populations is a strong motivator to support bat conservation.

Photo: Jason Headley

8.0 Socio-economic Scan

The socio-economic scan provides an overview of anticipated reactions/impacts to strategies based on current social and economic conditions. Impacts are scored as positive or negative (Table 4).

Table 4: Socio-economic considerations of recovery plan strategies

Impacts resulting from conditions in the Wildlife Regulations are not included, *i.e.*, protection of bats in maternity roosts during breeding season and protection of bats in hibernacula.

Strategy	Socioeconomic impacts: (-) is a cost / (+) is a benefit
6.1 Monitor and minimize spread of Pd and WNS	(++) Understand the spread of disease and its impact on populations to: (a) inform the strategies to support healthy populations, and (b) inform experimental mitigation strategies. (+) Ability to address potential stakeholder and public concerns with current data on the extent of issue. (+) Perception that GOA is actively tracking and trying to minimize spread of Pd. (+) Proactively demonstrated compliance or action towards prospective federal action on a species at risk.
6.2 Survey and monitor bat populations	(++) As with 6.1, this action provides data to inform strategy, stakeholders and discussions regarding prospective federal action. (+) Perception that GOA recognizes the importance of bats. (+) Data will help inform recovery actions

Strategy	Socioeconomic impacts: (-) is a cost / (+) is a benefit
6.3 Protect essential roosts and habitat that supports these roosts	(+++) Underlying focus of strategy to support healthy bat populations as there is no know way to mitigate disease spread. (+) Demonstrated action to in regard of a prospective federal action on species at risk. (-) Restrictions to forest harvest, however, incorporating bat roosting considerations into existing practices should reduce impact, *e.g.*, seral stage targets. Alberta Forest Products Association consulted to inform actions. Extent of potential impact on forest actions has not been quantified at this time. (-) Additional environmental considerations for mine development and reclamation. Extent of potential impact on mining actions not assessed. (+) Clear guidelines for industry on how to maintain bat habitat reduces uncertainty for investment decisions and helps streamline development of mandatory mine reclamation plans. (+) Promotes Citizen Science.
6.4 Protect other types of bat habitat	(+) Clear guidelines for various stakeholders and landowners on how to maintain bat habitat. (+) Supports other wildlife.
6.5 Reduce and mitigate human caused mortality	(+) Support for people with bat issues (+) Empower people to help bats.
6.6 Evaluate and implement WNS mitigation if appropriate	(+) Perception that GOA is actively addressing impacts of WNS in a scientific way (+) Knowledge monitoring and experimentation regarding prospective mitigation strategies assures Alberta can quickly implement appropriate and cost effective strategies as they become available. (+) Alberta demonstrates proactive consideration of mitigation strategies in consideration of potential federal action on species at risk.

9.0 Effects on Other Species at Risk

Many species, including other provincially and federally listed species-at-risk, will benefit from habitat conservation measures in this plan, such as maintenance of mature/old forest stands and wetlands.

The plan includes provisions to ensure that actions will not inadvertently disadvantage other species. For example, careful consideration will be given to when maternity bat houses should be provided for little brown bat colonies to avoid a competitive advantage in areas where they did not previously live. Similarly, evaluation of WNS treatment or prevention will take into account potential impacts on non-target species, including other species of bats.

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