WYOMING BAT WORKING GROUP

A Strategic Plan for White-nose Syndrome in Wyoming

Version 2

Wyoming Bat Working Group

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Cover photo: cluster of hibernating myotis in a central Wyoming cave. Photo taken by Alex Lewis.

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Note to readers – Each section begins with bullet points that summarize the key points of the section, followed immediately by more detailed information. Each section in the conservation and management strategies is followed by a set of recommendations developed by the Wyoming Bat Working Group designed to promote bat populations and bat habitat in the face of white-nose syndrome.

Introduction

- Bats are integral in many ecosystem services and represent 15% of all mammal species in Wyoming. The majority of these species have sensitive species designations due to limited population sizes or potential population threats.

- White-nose syndrome (WNS) is a fungal disease introduced from Europe that has killed millions of hibernating bats in North America. The disease has been found in over half of all states in the United States and Canadian provinces. The fungus that causes the disease, *Pseudogymnoascus destructans* (Pd), was first documented in Wyoming in 2018.

- Mortality rates from WNS are high in the eastern US and may reach 100% in some bat populations. While many bat species in Wyoming have yet to be exposed to Pd, it has the potential to affect many of the bat species that occur in the state.

Bats are integral in many ecosystem services. They serve as primary consumers of terrestrial and aquatic invertebrates, many of which cause damage to agricultural resources and threaten human health (Kunz and Parsons 2009). They are also an important component of biodiversity and ecosystems worldwide. For example, the 18 bat species documented in Wyoming represent 15% of all mammal species in the state, making them a large component of the state's biodiversity. The majority of bat species that occur in Wyoming have sensitive species designations due to limited population sizes or potential population threats from wind energy, roost disturbance, habitat loss, persecution, climate change, and disease (Table 1).

White-nose syndrome is a fungal disease that has caused the mortality of millions of hibernating bats in North America. WNS was first documented at Howes Cave, near Albany, New York in 2006 (Blehert et al. 2009). The causative agent of WNS is the fungal pathogen *Pseudogymnoascus destructans* (formerly classified as *Geomyces destructans*), which is commonly referred to as Pd (Blehert et al. 2009, Gargas et al. 2009, Minnis and Lindner 2013). Pd is thought to have originated in Europe (Puechmaille et al. 2010, Wibbelt et al. 2010), where the fungus infects hibernating bats but does not appear to cause widespread mortality. Pd was likely accidentally introduced to North America by humans. The disease has since spread rapidly westward across the continent and is the principle threat to the persistence of bat populations that hibernate during winter in Canada and the United States. In 2016, WNS made a large geographic jump and was detected in Washington (Lorch et al. 2016). As of the finalization of this plan, WNS has been confirmed in 35 states and 7 Canadian provinces (White-nose Syndrome Response Team 2020). Pd has been confirmed in 4 additional states, including Wyoming. Pd was first documented in Wyoming in 2018 in a single little brown myotis (*Myotis lucifugus*) at Fort Laramie National Historic Site in Goshen County (Abernethy 2018). In 2019, Pd was documented near Lusk in Niobrara County on multiple little brown myotis. To date, WNS has not been documented in Wyoming. Both Pd and WNS are expected to continue to spread across Wyoming and beyond in the near future.

Mortality rates from WNS are high and may reach 100% in some bat populations in the eastern US. All bats in North America have low fecundity, with most species giving birth to only 1 pup

each year. Bats are long-lived and generally have low mortality rates in the absence of disease. These life history traits reduce the probability of long-term persistence of bat species affected by WNS. Most species of bats that have been exposed to Pd are found in the eastern United States; most western bat species have yet to be exposed to the fungus, including many species in Wyoming. Pd has the potential to affect many of the bat species that occur in Wyoming, but it is unknown how the disease will affect bat populations in the state. However, evidence from portions of North America where WNS has occurred for some time suggests that most hibernating bats will potentially face large declines (Knudsen et al. 2013). Specifically, species within the most speciose genera of bat in Wyoming, *Myotis*, has shown high rates of decline in the east. Thirteen of the bat species that occur in Wyoming hibernate in winter. Eight of these species have been affected by WNS elsewhere in their range, and Pd has been confirmed in an additional 4 species (Table 1). Little brown myotis, northern long-eared myotis (*M. septentrionalis*), and American perimyotis (*Perimyotis subflavus*) are particularly vulnerable to WNS, and large declines have been observed in other portions of these species' ranges. Additionally, western small-footed myotis (*M. ciliolabrum*), which has been confirmed with Pd, is closely related genetically and displays similar ecological traits to eastern small-footed myotis (*M. leibii*), which has experienced high mortality from WNS in eastern North America.

Purpose

Wyoming's bat populations have only recently been exposed to Pd, and wildlife and land managers, researchers, and conservation organizations are concerned about the potential consequences for local bat populations. To that end, the purpose of this plan is to 1) assist decision makers in coordinating a statewide response to WNS and 2) preserve and manage Wyoming's bats and bat habitat in the presence of the emerging threat posed by WNS. While this plan is primarily written for land and wildlife managers with regulatory and statutory authority of wildlife species and landscapes that support bats and bat habitat, all stakeholders have a role in furthering these cooperative efforts to minimize impacts of WNS on bats in Wyoming. Consequently, this plan provides a consistent and durable response strategy for all stakeholders with an interest in bat conservation and management in Wyoming.

Plan Development and Maintenance

- This plan is a product of the Wyoming Bat Working Group (WYBWG), which is a subgroup of the Western Bat Working Group. Members of the WYBWG represent a diverse set of stakeholders interested in bat conservation and management in Wyoming.

- This plan represents the 2nd version of "A Strategic Plan for White-nose Syndrome in Wyoming". This version incorporates new knowledge, survey methodologies, and other relevant information that has been learned since the first version was published in 2012.

- This plan will be reviewed annually by the WYBWG, which will facilitate revisions as necessary.

This plan is a product of the WYBWG. The WYBWG is a subgroup of the larger Western Bat Working Group, whose mission is to facilitate communication among interested parties and reduce risks of species decline or extinction; provide a mechanism by which current information regarding bat ecology, distribution, and research techniques can be readily accessed; and develop a forum in which conservation strategies can be discussed, technical assistance provided, and education programs encouraged. Membership in the WYBWG is voluntary and represents stakeholders interested and experienced in bat conservation and management in Wyoming, including state and federal wildlife and land managers, researchers, local conservation districts, non-governmental organizations, and cave recreation groups.

This plan represents the 2nd version of "A Strategic Plan for White-nose Syndrome in Wyoming". Version 1.1 was published in 2012, when Pd and WNS were >250 miles from Wyoming. Since that time, major advances in our understanding of the disease and its ecology have been made, and the distribution of Pd and WNS has increased to include much of the United States and Canada. Also during this time, the WYBWG, through its member agencies and organizations, has made significant strides in our understanding of bat distribution and ecology in Wyoming pre-WNS. This updated version incorporates this new knowledge along with survey methodologies and other relevant information. Major accomplishments made since the publication of the 1st version are detailed in Appendix 2.

Because Pd and WNS have only recently been described, the state of knowledge is continually growing. Similarly, the distribution of the fungus and disease has recently affected habitats and bat species not previously exposed, including those in Wyoming. Consequently, it will be important to continually evaluate this plan and update when necessary. At a minimum, the plan will be reviewed annually by the WYBWG to evaluate recent information and assess the need for updates. Future updates will be facilitated through the WYBWG.

Ecology

At the time of publication of this plan, only the little brown myotis has been documented with Pd in Wyoming; the fungus has not been found in any hibernacula tested, and it is unknown where these active bats hibernated or acquired the fungus. It is thought that Pd and WNS have the potential to affect many of the bat species that occur in Wyoming, including species that have yet to be exposed, and evidence from portions of North America where WNS has occurred for some time suggests that most hibernating bats may potentially face large declines (Knudsen et al. 2013).

Bat Hibernation Ecology

- The majority of bat species in Wyoming hibernate in winter. Hibernacula are generally characterized by relatively stable cold temperatures and high humidity throughout the hibernation season.

- Microenvironment requirements for hibernation vary by bat species, with larger species generally able to hibernate at colder temperatures. Behavioral adaptations and body condition may further determine where bats hibernate within a hibernaculum.

- Bats hibernate in a variety of structures throughout their range, including caves, abandoned mines, badland formations, rock crevices, boulder fields, and concrete culverts. Hibernacula in the western United States generally contain orders of magnitude fewer bats than those in the East.

- There are few known hibernacula for any bat species in Wyoming, with the exception of Townsend's big-eared bats (*Corynorhinus townsendii*). Ongoing research suggests that most bats in the West are selecting features much smaller than the caves and abandoned mines documented in eastern North America.

The majority of bat species that occur in Wyoming hibernate in winter (Table 1). In Wyoming, hibernation likely spans mid-October to late April. Spending winter in a torpid state allows bats to remain near their summer range during a time of year when harsh environmental conditions and limited prey availability would otherwise not allow survival. In general, suitable hibernation sites are characterized by relatively stable low temperatures and high humidity throughout the hibernation season (Perry 2013). Low temperatures allow bats to sustain long bouts of torpor, and high relative humidity levels reduce evaporative water loss (Perry 2013).

Microenvironment requirements for hibernation vary by bat species. The full range of temperatures that allow successful hibernation are 0° – 18° C. Most bats that hibernate in select caves with temperatures between 2° – 10° C with 60% – 100% relative humidity (Perry 2013). In Wyoming, average temperatures in known hibernacula are 4.7° – 9.4° C (range -5.5° – 25.2° C), and average relative humidity ranges from 65.4% – 100% (Beard 2016). Larger bats (e.g., big brown bats [*Eptesicus fuscus*] and Townsend's big-eared bats) are generally able to hibernate at colder temperatures and lower relative humidity than smaller bats (e.g., little brown myotis and western small-footed myotis). Behavioral adaptations such as clustering may allow smaller-bodied bat species to utilize colder hibernation sites. Body condition may also affect microsite selection, with bats with higher body fat composition selecting warmer locations within hibernacula than those with lower body fat composition (Boyles et al. 2007).

Physical structures in which bats hibernate (i.e., hibernacula) may include a variety of geologic or anthropogenic structures. Often these include caves and abandoned mines but may also include badland formations, rock crevices, boulder fields, and concrete culverts (Neubaum et al. 2006, Perry 2013, Barnhart and Gillam 2017, Klug-Baerwald et al. 2017, Neubaum 2018). Landscape level hibernacula use and selection in Wyoming and other portions of western North America are poorly understood (Neubaum 2018, Weller et al. 2018). In general, hibernation ecology of bats in western North America is quite different than that of bats in the eastern half of the continent, with western hibernacula containing orders of magnitude fewer bats than eastern hibernacula (Weller et al. 2018).

There are few known hibernacula for most bat species in Wyoming, with the exception of Townsend's big-eared bat, and it is thought that most bats are selecting features much smaller than the caves and abandoned mines documented in eastern North America. The small number of bats roosting in known cavernous roosts over the winter in Wyoming cannot account for the large numbers known to occupy summer roosts in the state (WGFD, unpublished data). In Colorado, bats have been documented using talus slopes and rock crevices (Neubaum et al. 2006, Neubaum 2018), and bats in North Dakota and Alberta, Canada hibernated in badland formations (Barnhart and Gillam 2017, Klug-Baerwald et al. 2017). Mean winter temperatures in these types of hibernacula were lower than those typically found in caves or abandoned mines used as hibernacula elsewhere, but warmer than similar surrounding features that were not used by hibernating bats (1.5° C [SE = 0.3° C] in crevices and 0.8° C [SE = 0.87° C] in rock formations; Klug-Baerwald et al. 2017, Neubaum 2018). Temperature and relative humidity at these sites in winter could support Pd, but temperature and relative humidity conditions in summer are unknown. No microclimate data for these types of features are available for Wyoming. Where evaluated, very small numbers of bats have been observed using any single non-cavernous hibernation site at any given time, which may reduce transmission of Pd among individual bats (Klug-Baerwald and Brigham 2017, Neubaum 2018), although this has yet to be thoroughly explored.

Disease Ecology

- Pd is the causal agent of WNS. The fungus is cold-adapted and grows best at high relative humidity, conditions mirroring those found in bat hibernacula.

- Pd persists and grows in cave soil for many years, even in the absence of bats, indicating that contamination of hibernation sites may affect bats using these sites even if unoccupied for multiple seasons.

- Pd can present as a conspicuous white fungal growth on the muzzle, ears, and wing and tail membranes, although some bats may not display any outward clinical signs. Bats may also display wing damage including thinning of the wing membrane, loss of pigmentation, holes, or a general flaky appearance.

- Other signs of WNS may include bat mortality beyond typical levels; observed declines in wintering populations; or odd behavior, including live bats on the ground in or near hibernacula, bats roosting nearer than normal to the hibernacula entrance, and increased bat activity outside of the hibernacula during cold weather conditions.

- The mechanisms of WNS infection that lead to death are not entirely understood, but may be related to water loss, electrolyte imbalance, infection, and increased arousals resulting in loss of fat reserves.

- It is thought that Pd is primarily spread by bat-to-bat interactions, but it is also easily transferred from bat to environment and environment to bat. The role of summer roosts in the spread is unknown. Human-aided spread remains a significant concern.

- As of the writing of this plan, WNS has been confirmed in 12 bat species in North America. Six additional species have been documented with Pd but have not yet been documented with diagnostic signs of WNS.

- Data collected at a number of known hibernacula in Wyoming indicated that temperature and relative humidity are within the range that supports growth of Pd. There is still some uncertainty as to whether microclimate conditions at all hibernacula will allow the fungus to persist in all portions of the state.

Pd is a fungal pathogen and the causative agent of WNS (Gargas et al. 2009, Minnis and Lindner 2013). The fungus was described originally as *Geomyces destructans*, and literature published prior to 2013 uses this scientific name, including version 1.1 of this plan. Pd is cold adapted, with optimal growth temperatures ranging from 5° – 10°C, similar to temperatures found in bat hibernacula in winter (Blehert et al. 2009, Gargas et al. 2009). However, Pd growth in laboratory settings occurred between 3° – 20°C, suggesting growth across a fairly broad temperature profile and potential year-round growth in many hibernacula settings (Blehert et al. 2009, Perry 2013). In addition to being cold adapted, Pd growth is most pronounced at high relative humidity, also a key characteristic of hibernacula. Specifically, growth of Pd was highest at relative humidity of ≥81.5% (Marroquin et al. 2017). However, growth occurred at relative humidity levels of ≤70%, indicating that drier sites may still support Pd (Marroquin et al. 2017).

Pd persists in cave soil for many years, even in the absence of bats (Hoyt et al. 2015). In laboratory settings, Pd was capable of persisting multiple years, indicating that contamination of hibernation sites with Pd may affect bats using these sites even if unoccupied for multiple seasons (Hoyt et al. 2015). Likewise, Pd displays growth in cave sediments, leading to increased WNS infection rates for bats through time at a site (Reynolds et al. 2015). Within hibernacula, prevalence of Pd is very low when first introduced but increases to nearly 80% of sediment samples within 3 years (Verant et al. 2018). Bats and cave sediments (i.e., surface soil, fresh guano) generally support higher levels of Pd than cave or mine walls (Verant et al. 2018).

When affecting bats at high levels, Pd can present as a conspicuous white fungal growth visible around the muzzle, ears, and wing and tail membranes of infected bats, leading to the name "white-nose syndrome". This fungal growth is only visible in winter (United States Geological Survey National Wildlife Health Center 2018) when bats are hibernating and not actively grooming. The amount of visible fungus varies from inconspicuous to obvious, and other non-pathogenic fungus species may be similar in appearance, highlighting the need for laboratory confirmation. However, bats harboring Pd or affected by WNS may not display outward clinical signs, particularly in certain seasons. Affected bats may also display delayed arousal from torpor following disturbance events in hibernacula. Bats that appear thin and / or dehydrated (characterized by wrinkly and flaky appearance of wing and tail membranes) may be affected by WNS. Individual bats may also display wing damage including thinning of the wing membrane, loss of pigmentation, holes, or a general flaky appearance, which may present well into the active season. Long-wave UV light may also show light orange fluorescence on hairless portions of bats infected with Pd (Turner et al. 2014).

Within hibernacula, signs of Pd contamination or WNS infection of bats may include bat mortality beyond typical levels or observed declines in wintering populations. Also, odd behavior of bats at or near hibernacula may be associated with WNS including live bats on the ground in or near the hibernacula, bats roosting near the hibernacula entrance (either inside the hibernacula or nearby), and increased bat activity outside of the hibernacula during cold weather conditions. Townsend's big-eared bats in Wyoming routinely roost in the twilight zone near hibernacula entrances in the absence of Pd. Discretion should be used before revisiting or further disturbing hibernacula that support Townsend's big-eared bats.

The mechanisms of WNS infection that lead to death are not entirely understood. Bats infected with Pd have higher rates of water loss and develop electrolyte imbalances as a result of damage to the skin from the fungus (Cryan et al. 2013, Ehlman et al. 2013). Additionally, bats with WNS suffer from fat depletion both from the initial infection of the epidermis and from increased rates of arousal events (Verant et al. 2014). These fat reserves are critical for overwinter survival of hibernating bats, and depletion can lead to death via starvation. Some bats with WNS also die from exposure when leaving the hibernacula in winter.

Pd and WNS can be readily transferred across the landscape, but how and when the fungus spreads is poorly understood (Ballmann et al. 2017). It is thought that the fungus is primarily spread by bat-to-bat interactions, but it is also easily transferred from bat to environment and environment to bat. Because Pd can persist in hibernacula year-round, the fungus may be spread at any time if bats use infected sites as day or night roosts during the active season (Ballmann et al. 2017). The role of summer roosts (e.g., maternity roosts, etc.) in the spread of Pd and WNS is still unknown. Human-aided spread is also a significant concern, either through the movement of spores or of bats infected with Pd. Bat researchers and cavers should adhere to the most recent decontamination procedures and protocols (see Appendix 1).

As of the writing of this plan, WNS has been confirmed in 12 bat species in North America. Of these 8 are found in Wyoming (Table 1). Six additional species have been documented with Pd but displayed no diagnostic signs of WNS. This includes 4 species found in Wyoming (White-nose Syndrome Response Team 2020).

Overall, microclimate conditions suitable for hibernating bats align with growth conditions required by Pd (Blehert et al. 2009, Verant et al. 2012, 2018). For some time, it had been assumed that temperature and relative humidity in caves and abandoned mines are warmer and drier, respectively, in the western United States (Knudsen et al. 2013), which would provide less favorable environmental conditions for growth of Pd. However, these assumptions are not supported by data (Knudsen et al. 2013). While microclimate conditions of most caves and abandoned mines in Wyoming remain largely unknown, data collected at a number of known hibernacula in the state indicated that temperature and relative humidity are within the range that supports growth of Pd (Beard 2016). Based on these data, it is likely that at least some bat hibernacula in Wyoming can support Pd. Because known hibernacula cannot account for the entire population of bats in Wyoming, there is still some uncertainty as to whether microclimate conditions at all hibernacula will allow the fungus to persist in all portions of the state.

Table 1. Bat species that occur in Wyoming, agency status, biological parameters that may influence potential sensitivity to Pd or WNS, and national disease status as of 2020. All United States Fish and Wildlife Service (USFWS) status designations are in response to population declines from WNS. For up-to-date information on species confirmed with WNS or Pd, visit the WNS National Response Team website (see Appendix 1).

Species*	WGFD SGCN	USFWS listed	Wyoming BLM Sensitive	USFS Sensitive	Hibernating species	Migrating species	WNS confirmed (national)	Pd confirmed (national)
Antrozous pallidus Pallid bat	X				X			
Corynorhinus townsendii Townsend's big-eared bat	X		X	R2/R4	X			X
Eptesicus fuscus Big brown bat					X		X	X
Euderma maculatum Spotted bat	X		X	R2/R4	X			
Lasionycteris noctivagans Silver-haired bat					X	X		X
Lasiurus borealis Eastern red bat	X					X		X
Lasiurus cinereus Hoary bat				R2		X		
Myotis californicus California myotis					X			
Myotis ciliolabrum Western small-footed myotis	X				X			X
Myotis evotis Long-eared myotis	X		X		X		X	X
Myotis lucifugus Little brown myotis	X	UR			X		X	X
Myotis septentrionalis Northern long-eared myotis	X	LT			X		X	X

Table 1 continued.

Species*	WGFD SGCN	USFWS listed	Wyoming BLM Sensitive	USFS Sensitive	Hibernating species	Migrating species	WNS confirmed (national)	Pd confirmed (national)
Myotis thysanodes Fringed myotis	X		X	R2	X		X	X
Myotis volans Long-legged myotis	X				X		X	X
Myotis yumanensis Yuma myotis	X				X		X	X
Nyctinomops macrotis Big Free-tailed bat								
Perimyotis subflavus American perimyotis		UR			X		X	X
Tadarida brasiliensis Brazilian free-tailed bat								

WGFD SGCN = Wyoming Game and Fish Department Species of Greatest Conservation Need (WGFD 2017)
USFWS Listed: UR = Under Review; LT= Listed Threatened
Wyoming BLM Sensitive (BLM 2010).
USFS Sensitive: R2 = Rocky Mountain Region (USFS Region 2 2018); R4 = Intermountain Region (USFS Region 4 2016).

* National Park Service, at-risk species include all species native to national park units that are listed (i.e., endangered, threatened, proposed, and candidate) under the Endangered Species Act; state, tribal, and locally listed species; and other native species that are of special conservation management concern to parks (e.g., rare, declining, sensitive, or unique species; NPS 2006)

Conservation and Management Strategies

Communication and Collaboration

- The WYBWG will meet annually to coordinate bat management and conservation efforts in Wyoming.

- The United States Fish and Wildlife Service (USFWS) leads the national WNS Response Team. In Wyoming, the regional WNS coordinator for USFWS legacy Region 6 facilitates information dissemination from the National Team. The Wyoming Game and Fish Department (WGFD) Nongame Mammal Biologist serves as the state WNS coordinator.

- All bat handling activities require permits from the WGFD that stipulate researchers evaluate each captured bat for wing damage indicative of WNS and report to the WGFD. In the case of federally listed species, the USFWS requires additional permits. Any bats captured or observed that appear to be infected with Pd or symptomatic of WNS should be reported immediately to the WGFD Nongame Mammal Biologist.

Conservation and management of bats and bat habitat in Wyoming in the face of WNS requires coordination and collaboration among many partners and stakeholders. This includes coordinated education and outreach, research, management actions, and communication both prior to and when Pd or WNS is detected in an effort to minimize spread. The WYBWG provides a valuable conduit to coordinate bat management and conservation efforts throughout the state. At a minimum, the WYBWG will continue to meet annually to discuss and coordinate conservation, management, and monitoring needs for bats in Wyoming. Many organizations and stakeholders have an interest in bats and their habitats. Consequently, it will be critical to maintain open communication and collaboration among all stakeholders (e.g., citizen scientists, cavers, wildlife rehabilitators, etc.).

At a national level, the USFWS leads the WNS Response Team, which is comprised of biologists, researchers, land managers, and other stakeholders (United States Fish and Wildlife Service 2011). The USFWS further identifies regional WNS coordinators to facilitate communication and collaboration among neighboring states; Wyoming is included in USFWS legacy Region 6. The regional WNS coordinator facilitates quarterly conference calls among all interested parties within the legacy region. As specified in the first version of this plan, the WGFD Nongame Mammal Biologist serves as the state WNS coordinator and point of contact for the National WNS Response Team. As such, the state WNS coordinator is responsible for coordinating communication among agencies and interested parties regarding surveillance efforts, status updates, and other information or data needs as they pertain to Wyoming. The state WNS coordinator maintains a list of interested partners and stakeholders, and, at a minimum, updates all interested parties twice per year, once at the beginning of the hibernation season and again at the conclusion of the WNS surveillance season. These stakeholders are responsible for further disseminating this information among relevant personnel in their agencies or organizations. At a minimum, biannual updates include ongoing activities, new developments, objectives that are being implemented, surveillance plans and results, and any new management recommendations for Wyoming. If disease testing results in

a change in status for a county, the state WNS coordinator will notify all personnel on this list as soon as possible.

Any activity that includes handling live bats requires a WGFD Chapter 33 Permit. If the activity includes a bat listed as Threatened or Endangered under the Endangered Species Act, a permit is also required by USFWS. Surveys conducted on public lands may require additional permitting and coordination. The WGFD Nongame Mammal Biologist coordinates with the WGFD Permitting Officer to ensure that updated permit stipulations and information is disseminated via the Chapter 33 Permit annually and upon any change of status within the state. Any bats captured or observed that appear to be infected with Pd or symptomatic of WNS (e.g., wing damage, UV fluorescence, depigmentation of wings, etc.) should be reported immediately to the WGFD Nongame Mammal Biologist, who will facilitate submission for disease testing and communication with the WNS Coordinator for the relevant land management agency. However, field signs are not direct evidence of Pd or WNS infection as they may be caused by other factors. As such, caution in describing these observations and attributing their cause should be taken. Prompt reporting is critical as it may allow any observations to be confirmed or otherwise followed up on. If Pd or WNS is detected in a county or in a bat species for which the fungus or disease has not been documented, the observing party or agency should coordinate closely with the WGFD to develop any public information dissemination. The WGFD Nongame Mammal Biologist will coordinate with the National WNS Response Team to update spread maps as needed.

RECOMMENDATION: Continue to identify and involve key stakeholders for bat conservation and management in Wyoming to expand the reach and breadth of the WYBWG.

RECOMMENDATION: Disseminate WNS information among stakeholders biannually via email or conference call, including information on on-going activities, surveillance results, objectives being implemented, and any new management recommendations for Wyoming. Update stakeholders as soon as possible when surveillance results lead to a change in county status.

Disease Surveillance and Monitoring

- Disease surveillance and monitoring are central components of the National WNS Plan. The national WNS Response Team and National Wildlife Health Center have established case definitions for Pd and WNS confirmation in bats.

- Early detection is critical to implement management actions and includes both passive and active surveillance.

- Passive WNS surveillance relies on the public, cavers, or other entities to report sick or dead bats or unusual behavior or evaluation of bats collected for other reasons (e.g., rabies testing).

- Active WNS surveillance includes hibernacula surveys or spring trapping efforts designed to detect the presence of Pd or WNS. Spring efforts are important in Wyoming due to the relatively small numbers of bats observed in hibernacula in the state.

- Surveillance needs will dictate the types of samples needed and timing of sample collection.

- Environmental samples, including sediment collection and swabs from walls, can be collected at any time of year at roosts, thus minimizing disturbance to roosting bats as well as sampling effort. Pooled guano samples can be collected in spring and early summer as bats return to maternity roosts. Pd can be detected through these samples, but WNS cannot be confirmed.

- Sampling bats at hibernacula or through spring trapping can confirm both Pd (swabs from bats) and WNS (wing biopsies) if present.

Disease monitoring and surveillance for Pd and WNS is a central component of the "National WNS Plan" (United Sates Fish and Wildlife Service 2011). The White-nose Syndrome Response Team in conjunction with the National Wildlife Health Center (NWHC) has established case definitions for Pd and WNS confirmation in bats (see Appendix 1; White-nose Syndrome Response Team 2020). Confirmation of WNS requires histologic evidence of disease and presence of Pd, while a determination of the presence of Pd indicates that the fungus, but not signs of the disease, have been detected. Pd infection at a site can precede clinical signs by 1-2 winters based on prior observations in the eastern United States. However, it is unclear whether this pattern will remain consistent across the western United States due to differences in species and hibernation ecology as described above. Because case definitions are subject to change, users should consult the USGS NWHC for the most recent information (see Appendix 1).

Early detection is critical to implement management actions to benefit bats in a timely way, minimize the spread of the disease, better predict areas likely to be affected next, evaluate population and species-level impacts, and improve understanding of transmission dynamics. This is particularly true throughout Wyoming where the majority of bat species and habitat features are not currently affected by WNS or Pd. Several specific information gaps are filled by WNS and Pd surveillance, including mapping the distribution of the fungus and disease in Wyoming through time and identifying which bat species may be susceptible to WNS. WNS surveillance and monitoring is generally broken down into passive and active surveillance.

Passive surveillance efforts do not include intentional exploration for WNS or Pd presence and require active engagement and education to promote reporting by the general public, cavers, and other entities. Reports made by the general public or recreational cavers may be critical in early detection of WNS and should be reported as soon as possible. For example, a public report in Washington led to the first detection of Pd and WNS in that state (Lorch et al. 2016). Observations of sick or dead bats or unusual bat behavior should be reported immediately to the WGFD. In many states, including Wyoming, sick or dead bats are often submitted to veterinary diagnostic labs for rabies testing. The WGFD Nongame Mammal Biologist coordinates with the Wyoming State Health Laboratory to facilitate disease testing of rabies-negative bats during the surveillance season.

Active surveillance efforts occur specifically to obtain samples for laboratory testing to detect Pd or WNS. These include hibernacula surveys or spring trapping in an effort to detect Pd- or WNS-affected bats. The most frequently implemented surveillance method to date is hibernacula surveys to collect wing swabs, wing biopsies, whole bats, and / or environmental samples within hibernacula or at hibernacula entrances as bats emerge during the winter or spring. While hibernacula surveys are important in tracking the progression and effects of the disease, they are not sufficient as the sole surveillance method in Wyoming because bats at risk for WNS congregate in relatively small numbers during the winter in the West, and hibernacula locations are largely unknown (Weller et al. 2018). To ensure the earliest possible detection of the fungus, bats may be captured at maternity roosts or on the landscape in early spring shortly after emerging from hibernation and before bats have had time to clear the fungus. At a minimum, all bat researchers must assess the wing membranes for signs of WNS damage using the Wing-damage Index (Reichard 2010), regardless of season, and follow USGS NWHC protocols (see Appendix 1) for swabbing the wing / muzzle of the infected individual and taking field photographs of any bats suspected of being infected with Pd as a condition of state permits.

Sample types and data needs will determine active surveillance techniques. Detection of Pd or WNS require that surveillance activities take place when the fungus is present in sufficient concentrations to be detectable via laboratory analysis or visible outward signs. Timing of surveys depends on the type of surveillance and environment in which samples are being collected. Table 2 outlines optimal timing for each survey technique. Sample types include environmental samples and samples from bats, including swabs, wing biopsies, and whole bats. Each sample type is discussed below. Refer to the most recent version of the "Bat White-Nose Syndrome (WNS)/Pd Surveillance Submission Guidelines" (see Appendix 1) for the most up-to-date methods for sample collection.

Environmental samples allow for detection of Pd in the environment and can be collected within hibernacula at any time of year, thus avoiding the need to disturb hibernating bats. They can also be collected to increase sample size in hibernacula with limited or inaccessible bats. In general, Pd is detectable in environmental samples 1 - 3 years after detected in bats hibernating at a site (Verant et al. 2018). Consequently, bats may be exposed to Pd up to 3 years before the fungus is detectable via environmental sampling.

Samples collected from bats are generally of higher diagnostic value, but require specific permitting from WGFD and the USFWS in the case of bat species listed under the ESA. Sampling bats, either at a hibernation site or on the landscape, allows surveyors to look for visible fungus and evaluate wing membranes for damage or fluorescence (Reichard and Kunz 2009, Reichard 2010, Turner et al. 2014). Swab samples allow for the detection of Pd in a minimally invasive way. However, swab samples alone do not provide evidence of WNS, only presence of Pd. If permit stipulations allow, or upon direction of the Nongame Mammal Biologist, a wing biopsy or whole bat should be collected if WNS is suspected at a new site. Wing punch biopsies and whole bats may be used for histopathology to confirm WNS and genetic testing for Pd. However, these samples should only be taken from bats with lesions characteristic of Pd/WNS or that display fluorescence under UV light and upon coordination with WGFD.

Table 2. Summary of timing and sample types that may be obtained by different Pd and WNS survey techniques.

Survey type	**Sample type**	**Timing**	**Surveillance results**
Hibernation site (environmental samples only)	Cave / mine sediments Substrate swabs	Year round (after bats emerge from hibernation)	Pd detection only - early detection unlikely.
Hibernation site	Wing swabs, wing biopsies, whole bats	Last half of hibernation season (mid-January – mid-March) For sites with poor access, any time during hibernation (mid-November – mid-March)	Pd detection for all sample types; WNS confirmation for biopsies and whole bats
Landscape (includes spring emergence at hibernacula, maternity colony, and general landscape)	Wing swabs, wing biopsies, whole bats, pooled guano	~ 4 weeks following emergence from hibernation (April – May, high elevation sites may be sampled into June)	Pd detection for all sample types; WNS confirmation for biopsies and whole bats

<u>RECOMMENDATION</u>: Identify surveillance needs for state and federal land management and wildlife agencies. Identify, prioritize, and coordinate surveillance locations based upon identified objectives. Secure funding and ensure cost sharing to allow for effective surveillance and analyses.

<u>RECOMMENDATION</u>: Utilize the WYBWG and other mechanisms to collaboratively develop and implement strategic, statewide surveillance to ensure timely tracking of Pd and WNS in Wyoming. Coordinate activities prior to the WNS surveillance season to maximize coverage and address local, regional, and national surveillance objectives.

<u>RECOMMENDATION</u>: Develop mechanisms for the public to report sick or dead bats or unusual behavior of bats in Wyoming, particularly in the winter and early spring that may be indicative of WNS.

<u>RECOMMENDATION</u>: Ensure all WNS surveillance results are uploaded to national platforms (e.g., NABat) following discussions with appropriate state and federal WNS coordinators.

Conservation Measures

- To date, prevention of WNS is limited to reducing human spread of Pd. Anyone handling bats or entering hibernation or maternity sites should follow the National WNS Decontamination Protocol to minimize human-facilitated spread of Pd. Researchers and biologists conducting bat work in Wyoming must ensure that capture equipment has not been previously used in Pd- or WNS-positive areas.

- When appropriate, it is recommended that management agencies require anyone entering a cave to secure a cave use permit to allow agencies to better understand cave use, manage visitor use, disseminate educational and outreach material, and stipulate decontamination protocols.

- Installation of bat-friendly gates should be considered at important roosts where recreational use or disturbance negatively affects bats or compromises human safety.

- Use of caves by bats and humans should be monitored before and after installing bat-friendly gates to evaluate effectiveness of the closure as well as effect on the cave environment and biota.

- When managing hibernacula, it is recommended that the majority of management and disease monitoring efforts be focused on important hibernacula, especially where human disturbance may be a significant concern.

- Supporting bat survival and reproduction during the active season is necessary to maintain healthy bat populations and promote recovery following WNS-caused declines. WNS is one of a suite of conservation challenges that should be considered by managers when supporting bats and their habitat.

To date, prevention of WNS is limited to reducing human spread of Pd. Because Pd can persist year-round, anyone accessing hibernation sites at any time could potentially acquire and spread the fungus. Additionally, biologists and researchers handling bats could transmit spores on clothing and capture equipment. To reduce the potential for human-aided transmission of Pd, a group of state and federal agencies and researchers have developed "The National WNS Decontamination Protocol." This document was developed to provide science-based recommendations to clean gear and equipment (e.g., clothing, capture and caving gear, etc.) that may have been exposed to Pd. In the United States, these decontamination procedures should be followed any time bats or bat habitats (e.g., caves) are contacted. Researchers and biologists conducting bat work in Wyoming must ensure that capture equipment has not been previously used in Pd- or WNS-positive areas. Surveyors should identify in which counties work will occur and consult their WGFD Chapter 33 permit for specific details regarding acceptable use of capture gear. At the national scale, gear used within the Endemic Area should not be used in the At-risk/Intermediate Area (refer to most recent version of "The National WNS Decontamination Protocol"). Researchers should develop a clear strategy for where all equipment will be stored,

transported, and decontaminated, with separate storage areas for gear used in management areas or counties with different statuses. When working in states or counties with different disease statuses, separate vehicles should be utilized for each status area. Use of dedicated site-specific gear should be considered when possible.

Important hibernacula or subterranean sites used as maternity colonies may be further protected by developing permitting systems for recreational cavers, installing bat-friendly gates, or implementing partial or full caving closures. When appropriate, it is recommended that management agencies consider requiring anyone entering a cave to secure a cave use permit. The permitting process allows agencies to better understand cave use and, in the case of gated caves, control visitor use. Limiting the number of individuals accessing a cave during any given period or precluding use during specific seasons can help limit disturbance to roosting bats. Permitting may also allow for targeted education and outreach efforts, which may reduce the probability of introducing Pd to a site or spread of Pd from a contaminated site. Additionally, stipulations such as following the most recent National WNS Decontamination Protocol may be included to ensure equipment has not previously entered caves in areas affected by Pd as well as proper decontamination upon exiting the cave. Guidance for managing subterranean sites and operating show caves to prevent spread of WNS and minimize disturbance of bats has been developed by the National WNS Team (see Appendix 1).

Installation of bat-friendly gates should be considered at known hibernacula when visitor use or other disturbance may negatively affect bats or compromise human safety. A number of considerations should be made when determining if a gate should be installed. Bat gates may alter natural air flow at cave and mine entrances, reducing suitability for hibernation. Consequently, gates should be installed only when necessary. In some cases, controlled human access may be desired, but in other cases all human access should be restricted. Restricted-access gates may provide weak points that allow access by vandals but also facilitate authorized access by recreationists or managers. In the case of abandoned mines, hard closures (i.e., closing all access to humans and bats) may be appropriate if the structure is extremely unsafe or does not provide bat habitat. However, hard closures may result in the loss of bat habitat and cause bat mortality if closures occur when bats are present. Bat surveys should occur prior to proposed closures, potentially across multiple seasons to determine if bats are present at the site or if a bat gate is a preferable alternative.

If installation of a bat-friendly gate is warranted, cave use by bats and humans should be monitored before and after installation to evaluate the effects of the gate on bat use and assess potential effects on the cave climate itself. Monitoring may include bat surveys and acoustic monitoring to understand timing and magnitude of bat use, motion activated cameras and lumen detectors to determine level of human use, and temperature and humidity loggers to monitor climate. If cave management plans are developed and specific management options are discussed, it will be important to maintain open communication with all affected stakeholders (e.g., wildlife and land management agencies, caving organizations, etc.).

Not all cavernous structures are used by bats or bat populations that are susceptible to WNS, and

not all hibernacula receive human visitation. To ensure that resources dedicated to managing bats and bat habitat under the possible influence of WNS are not expended in locations that do not support WNS susceptible bats, a risk assessment framework has been developed by WGFD and the WYBWG (Bjornlie et al. 2018). Considerations such as the numbers and species of bats, season of use, distance to nearest WNS or Pd detection, and level of human use are considered when assessing risk to specific cave resources in Wyoming. Additional consideration should be given before increasing disturbance of species potentially unaffected by WNS, such as Townsend's big-eared bat, although the risk that these bats could be a source of fungal spread should also be taken into account when considering research priorities.

Concurrent with strategies outlined in this plan, enacting conservation and management actions to support bats during the active season will be important to supporting healthy populations. Because mortality from WNS is typically high and the disease may have a negative effect on juvenile recruitment, implementing management practices that reduce mortalities from other causes and promote reproduction of bats will be critical in maintaining bat populations as Pd and WNS become more prevalent in Wyoming. WNS is one of a suite of conservation challenges that have the potential to negatively affect bat populations across North America. Maternity season is particularly important for bats, especially species and populations that are declining because of WNS. Consequently, management actions that reduce disturbance during this time and protect or enhance roosting structures and habitat are critically important. For example, forest management practices that protect maternity roost trees or promote formation of additional roost trees may increase reproductive output within local bat populations (Thalken and Lacki 2018). Similarly, construction of bat houses that may be used by female bats may also be beneficial to local bat populations. In addition to bat houses, other human structures represent important roost sites for many bat species. In some cases, exclusion of bats from these structures may be warranted, but these activities should follow best practices such as avoiding exclusion during the maternity season and using one-way exclusion devices. The WGFD has developed a number of informational and educational documents and materials detailing best management practices for bats, including A Conservation Plan for Bats in Wyoming (Hester and Grenier 2005), that should be referenced when managing habitat for bats (see Appendix 1).

<u>RECOMMENDATION</u>: Consider implementing protective measures at important subterranean and above-ground roosts where potential conflicts exist, such as developing and disseminating informational materials, installing signs at the entrance of caves, implementing permitting systems that regulate human visitation, establishing caving closures (either year-round or seasonally), and installing bat-friendly gates that limit or eliminate human access. Where possible, involve organized caving organizations (e.g., grottos) in discussions and implementation of conservation actions.

<u>RECOMMENDATION</u>: Consider requiring, facilitating, and enforcing the use of national WNS decontamination procedures for all users before entering and after exiting caves and mines. Consider establishing decontamination centers at commonly used caves / regional agency offices to encourage and simplify decontamination.

RECOMMENDATION: Monitor both human and bat use before and after the implementation of any management actions (e.g., permitting systems, caving closures, etc.) at roosts to ensure compliance and evaluate effectiveness. Evaluate management actions regularly, incorporating input from stakeholders where appropriate.

RECOMMENDATION: Where significant cave resources are present, develop cave management plans to help ensure proactive and consistent management of these resources. Cave management plans may be part of a resource management plan or a standalone document and should consider both biological and recreational resources and be responsive to evolving considerations.

RECOMMENDATION: Update and refine the WNS risk assessment framework to help identify caves known to support bats that are at highest risk of acquiring Pd. Evaluate the potential to expand the assessment to include other, non-cavernous, priority roosts that may be important to WNS transmission.

RECOMMENDATION: Evaluate the value of abandoned mines as bat habitat prior to closures. Make decisions regarding closure designs to protect bat habitat. Consider bat-friendly closure of abandoned mines when adequate surveys are impractical.

RECOMMENDATION: Update A Conservation Plan for Bats in Wyoming (Hester and Grenier 2005) to include new information on species status in Wyoming, habitat use, management actions, survey guidelines, and new and emerging threats.

RECOMMENDATION: Conserve bats and bat habitat outside of the hibernation season by implementing actions to reduce mortalities from other causes and promote reproduction of bats.

RECOMMENDATION: Whenever possible, promote management actions to protect and enhance maternity roosts.

Education and Outreach

- A number of stakeholders are engaged and have an interest in conserving and managing bats and their habitat. Involving outreach specialists and educators can help ensure that efforts are reaching target audiences effectively.

- Outreach efforts should address what WNS is, including what actions can be taken to prevent the spread of Pd, characteristic signs of WNS, and how to report observations to facilitate prompt reporting of potential WNS cases; how WNS affects bats; benefits that bats provide; and how the public can be active in supporting bats and bat habitat.

- Consider developing interpretive and educational materials specifically targeting users of cave resources to minimize human-facilitated spread of Pd at these sites. Consider including education and outreach materials in the permitting process when special use permits are required for access to caves.

- Outreach topics should include information from research, results from surveillance and monitoring efforts, and ongoing management actions. Educational and informational documents should be made widely available on web-based platforms.

Education and outreach are critical components of managing and conserving bats and bat habitat in Wyoming, especially in the face of WNS. A number of stakeholders are engaged and have an interest in the conservation and management of bats and their habitats (e.g., state and federal management agencies, researchers, citizen scientists, recreational cavers, wildlife rehabilitators, general public, etc.). Education and outreach efforts should be well thought out in order to ensure the target audience is reached as effectively as possible, understanding that user groups, such as cavers or the general public, may have a wide range of awareness of bats and their habitat. Involving outreach specialists and educators in these efforts will help to convey information accurately and effectively. Additionally, caving organizations with active membership in Wyoming are well positioned to provide outreach and education through their organizations. Education and outreach should be facilitated by the WYBWG and member agencies whenever possible through a variety of strategies, such as media releases, websites, oral presentations, and informational brochures and signs.

Although WNS has affected bats in the United States and Canada for over a decade, the fungus has only recently been detected in Wyoming. Consequently, various stakeholders may not be aware of what WNS is and how it affects bats. Outreach efforts should seek to address this knowledge gap as well as highlight the benefits that bats provide. Specific education is needed on what actions can be taken to prevent the spread of Pd, characteristic signs of WNS, and how to report observations to facilitate prompt reporting of potential WNS cases.

Because caves represent important habitat features for bats as well as provide recreational opportunities for cavers and the general public, interpretive and educational materials may be critical in reducing human-aided spread of Pd at these sites. At caves with high human visitation rates, interpretive programs or informational signs should be considered where feasible. Consider including education and outreach materials in the permitting process when special use permits are required for access to caves. Such materials may include brochures that discuss the risks, impacts, transmission, and prevention of spread of Pd, as well as the benefits of bats.

Outreach should also focus on disseminating information from research, results from surveillance and monitoring efforts, and ongoing management actions. Whenever possible, any educational and informational documents should be made as widely available as possible on web-based platforms. Anyone engaged in bat outreach activities should be prepared to address additional disease vector concerns, such as rabies, especially when addressing the general public. Aside from obvious human health implications of providing correct information, failing to address commonly held fears and misconceptions about bats undermines the credibility of the intended message. Non-medical personnel should never give medical advice. Refer to the Centers for Disease Control and Prevention for more information including educational materials.

RECOMMENDATION: Collaborate with agency outreach specialists to develop materials to inform the public about bats and WNS and encourage behaviors that support bat habitat and populations.

RECOMMENDATION: Provide actionable ideas and opportunities for the public to support bat conservation (e.g. adopt-a-bat program, educational events or activities to share and learn more about bats, best practices for addressing bats in homes or structures, and habitat management practices that benefit bats for landowners).

RECOMMENDATION: Assess feasibility and need to implement special use permits and associated educational materials for important cave hibernacula.

RECOMMENDATION: Construct and install informational signs at caves with high human visitation.

RECOMMENDATION: Post informational and educational materials, updates on WNS status in Wyoming, and results from research and monitoring efforts on relevant websites and social media sites. Expand bat- and WNS-specific webpages on these platforms where needed, and provide links to external informational sites (e.g., whitenosesyndrome.org) when appropriate.

RECOMMENDATION: Provide easily accessible resources for wildlife professionals and the public to learn about bats and WNS in Wyoming.

RECOMMENDATION: Develop a process for reporting dead bats in the winter and bat roost observations to WGFD.

Data and Research Needs

- Key research needs still exist for bats and WNS in Wyoming, which will require collaboration among diverse wildlife and land management agencies and stakeholders.
- Transmission of Pd, especially during the active season, and potential treatment options are still relatively unknown or undeveloped, but are currently being researched.
- Bats in Wyoming do not congregate in large hibernacula (>50 individuals), suggesting they are using other structures for hibernation. More information is needed on distribution and habitat selection of bats in winter. Monitoring programs, surveillance strategies, and management actions should be tailored to Wyoming.
- Cave management strategies with a specific focus on the potential for WNS to be a driver of bat populations are important. Recreational use studies may be needed to understand how recreational cavers and the general public use these resources

- Early detection of Pd and WNS may provide for more options to locally manage disease spread or mitigate other stressors. Disease surveillance should be statewide and address local, statewide, and national surveillance and monitoring priorities.

- More information is needed on ecology, seasonal habitat use, population status, threats, and management techniques for bats in Wyoming. Long-term population monitoring strategies are needed that are both Wyoming-specific and can be scaled up to regional and national levels both before and as Pd and WNS spread.

Because bats are nocturnal, small, and display unique life history traits, there is still much to be learned about this taxon. Many facets of our understanding of Pd and WNS are rapidly evolving, requiring managers and other stakeholders to make a concerted effort to stay abreast of the most up-to-date research and management recommendations. Although not comprehensive, below is a list of key research needs that would help further management and conservation of bats in Wyoming. Addressing these needs will likely be challenging, time-consuming, and costly, requiring collaboration among diverse wildlife and land management agencies and stakeholders.

Our understanding of Pd and WNS has increased since first discovered in 2006. However, many data and research needs still remain regarding transmission, especially during the active season, and potential treatment options. Dispersal of Pd outside of the hibernation season is poorly understood. Because Pd persists year-round in hibernacula, bats entering contaminated hibernacula in spring, summer, and fall are exposed to Pd and can in-turn harbor Pd on their skin and in their guano (Ballmann et al. 2017), potentially transmitting viable fungus or fungal spores to unaffected sites. The role of roosts used during the active season (e.g., maternity, day, and night roosts) in Pd transmission is also poorly understood. As outlined above, the range of structures used as hibernation sites in Wyoming is largely unknown, adding to the uncertainty of how Pd might spread throughout the state. Although not ready for wide-scale application, exposure to ultraviolet light (Palmer et al. 2018), inoculation with bacteria and fungi known to inhibit Pd growth (Cheng et al. 2017, Hoyt et al. 2019), vaccines (Rocke et al. 2019), and fumigants to kill Pd in the environment have all shown promise under controlled conditions. Many of these treatments are in the early stages of development and further evaluation of their efficacy and safety, both for bats and the hibernacula environment, is needed.

Many Pd and WNS management strategies are based on information developed in the eastern United States. In the East, bats typically hibernate in large numbers within caves and abandoned mines (Perry 2013, Klug-Baerwald et al. 2017). As a result, researchers have traditionally assumed that bats across the continent use similar features for hibernacula. In Wyoming, where caves and abandoned mines exist in areas with suitable geology and topography, surveys for hibernating bats rarely find congregations of bats >50 individuals (Beard 2016). This suggests that bats are likely using other landscape features for hibernacula. Basic information on distribution and habitat selection of bats in winter is largely unknown, especially in the western United States (Johnson et al. 2017, Klug-Baerwald et al. 2017), leaving a considerable knowledge gap for a critical portion of their annual lifecycle. It is clear that Wyoming's landscapes and bat populations differ from those in the eastern United States, and previously held assumptions about the disease may not

pertain to the state. As such, monitoring programs, disease surveillance strategies, and management actions should be tailored to the Wyoming landscape.

Because caves and abandoned mines are critical resources for hibernating bats as well as an important source of Pd on the landscape, cave management strategies with a specific focus on the potential for WNS to be a driver of bat populations may be particularly important to conserving these areas. Management of cave resources is often hindered by a limited understanding of how recreational cavers and the general public use these areas. In many cases, a thorough recreational use study may be appropriate to better understand factors such as how many visitors access specific caves, what time of year they access them, what type of activities are carried out while in the cave, and what areas of the cave are visited. In some areas, rock crevices, boulder fields, and cliff faces may be used by bats year round. Similar management plans, outreach, and recreational use studies may be warranted when rock climbing occurs in these areas.

Although there is currently no wide-scale effective treatment or cure for WNS, early detection of WNS or Pd may provide for more options to manage disease spread or mitigate additional stressors. Prioritizing when and where to conduct surveillance efforts is dependent on a number of factors, including: presence of bat species that are or are likely to be susceptible to WNS, the number of individual WNS-susceptible bats, overall use by bats, proximity to existing Pd or WNS positive sites, and level of human use. Additional considerations should include accessibility to the site by surveyors and proximity of sites to one another. Surveillance locations should provide statewide geographic coverage to allow detection of Pd or WNS through space and time and need to address local, statewide, and national surveillance and monitoring priorities. Because intensive surveillance is time and resource intensive, funding resources should be identified to implement a robust statewide surveillance program.

Our knowledge of distribution and habitat associations of Wyoming's bats has increased dramatically in recent years, but there are still outstanding data needs for many species, including information on ecology, seasonal habitat use, population status, threats, and management techniques. In general, research on Wyoming's bats and bat habitats is critical in order to better understand all aspects of biology, distribution, habitat associations, and many other poorly understood factors. As the distribution of Pd and WNS in Wyoming increases, long-term population monitoring programs will be critical to better understand the impacts of WNS on Wyoming's bat populations. The WGFD, in collaboration with the WYBWG, is developing a comprehensive statewide monitoring program designed to evaluate population trends of Wyoming's bat species as Pd and WNS continue to spread throughout the state. As with statewide surveillance, population monitoring will require continued collaboration and participation among a variety of stakeholders to fully evaluate population status, trends, and effects of WNS on Wyoming's bats.

<u>RECOMMENDATION</u>: Identify and prioritize research and data needs. Explore funding and collaborative opportunities to address needs for bats, bat habitat, and WNS in Wyoming.

RECOMMENDATION: Participate in external research efforts as feasible and appropriate to support bat populations and inform management in the state by addressing transmission, treatment options, and management strategies that are tailored to the West, where large hibernacula are less widely used by bats (e.g., research focused on active-season surveillance, transmission, monitoring, and treatments).

RECOMMENDATION: Update and distribute Wyoming-specific standardized protocols and datasheets for monitoring hibernacula. Internal roost survey forms can be found in "A Wyoming Bat Conservation Plan".

RECOMMENDATION: Coordinate statewide participation in national WNS surveillance efforts.

RECOMMENDATION: Evaluate the potential for human-bat conflict at important subterranean roosts through the use of targeted, recreational use studies.

RECOMMENDATION: Implement studies that evaluate hibernacula use and selection in Wyoming, including importance and use of non-cavernous structures such as rock roosts, bridges, and buildings.

RECOMMENDATION: Finalize the statewide monitoring plan for bats. Establish processes that allow data sharing across agencies and jurisdictions to allow for more effective management. Secure funding and ensure cost sharing to fully implement the plan.

Adaptive Management

- Research is ongoing to address disease transmission, ecology, population status, and management techniques for bats at regional and national scales. It will be critical to adapt conservation and management strategies as data and research needs are addressed.

- Currently, there is no treatment or cure for WNS. Maintaining and enhancing on-going monitoring and research projects will be critical to implementing effective treatments or mitigation strategies for WNS. Continued involvement with regional and national bat groups will allow Wyoming to remain abreast of relevant research to better conserve bats and bat habitat in the state.

As Pd and WNS continue to expand across Wyoming and encounter new bat species and habitats, bats will likely experience additional challenges that are not covered or prioritized in this plan. In addition to work conducted by agencies and organizations within Wyoming, many researchers are attempting to address questions pertaining to disease transmission, ecology, population status, and management techniques at regional and national scales. Agencies should continue to evaluate these projects on a case-by-case basis and contribute to and collaborate with these efforts where feasible. As outstanding data and research needs are addressed, it will be critical to adapt conservation and management strategies to better mitigate WNS and other stressors that may compound the impacts of WNS on bats in Wyoming.

Currently, there is no treatment or cure for WNS, although considerable effort and resources are being dedicated to this effort. Should one of these potential treatments or another, yet-to-be developed technique prove effective at treating or mitigating WNS, understanding the current status of bats in Wyoming will be critical to effective implementation. Consequently, maintaining and, where feasible, enhancing on-going monitoring and research projects is essential, including identifying and securing dedicated funding for disease surveillance and population monitoring as well as enacting management actions such as those identified in the Conservation Measures section above. Continued involvement with regional and national bat groups, such as the Western Bat Working Group and the WNS Response Team, will allow Wyoming to remain abreast of relevant WNS research and collaborative efforts to better conserve and manage bats and bat habitat in the state.

RECOMMENDATION: Utilize the WYBWG, Western Bat Working Group, national WNS Response Team, and other organizations to keep abreast of new and emerging research and treatment options as they pertain to bats and WNS.

RECOMMENDATION: Review this plan annually at the WYBWG meeting to evaluate progress on action items and the need to update based on increased knowledge of WNS, surveillance results in Wyoming, and treatment options.

RECOMMENDATION: Continue involvement with regional and national working groups, such as the Western Bat Working Group and the WNS Response Team.

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Appendix 1 – Additional Resources

White-nose Syndrome Response Team:

whitenosesyndrome.org

- Information on WNS and the national response in North America
- Up-to-date spread maps and lists of species affected
- Approved decontamination protocols
- Recommended practices for forest management, bat control activities in structures, managing access to subterranean sites and operating show caves to protect bats, etc.

USGS National Wildlife Health Center WNS information:

usgs.gov/centers/nwhc/science/white-nose-syndrome

- Bat submission guidelines for WNS and Pd analysis
- WNS and Pd case definitions
- Training videos for surveillance and sample collection

Wing Damage Index Protocol (WDI):

fws.gov/northeast/PDF/Reichard_Scarring%20index%20bat%20wings.pdf

National Speleological Society WNS information:

caves.org/WNS/

USFS Rocky Mountain Region WNS Adaptive Management Strategy:

fs.usda.gov/detail/r2/home/?cid=stelprdb5319926

Western Bat Working Group:

wbwg.org

Wyoming Game and Fish Department Nongame Program:

wgfd.wyo.gov/nongame

- Strategic and Conservation Plans for bats in Wyoming
- Best management practices for bats in Wyoming
- Additional informational and educational materials

Bat Conservation International:

batcon.org

- General bat conservation and education materials
- WNS information
- BCI Cave and Mine Gating Guide

United States Centers for Disease Control and Prevention rabies website:

cdc.gov/rabies/index.html

Appendix 2 – Accomplishments Made Under V1.1

- Systematic and targeted bat survey efforts to increase our understanding of population dynamics and species distributions.

- Implementing statewide disease surveillance in an effort to facilitate early detection of the presence of Pd and WNS.

- Assessing climate conditions within known hibernacula to evaluate the potential growth and maintenance of Pd.

- Evaluating the risk of known bat roosts in Wyoming to WNS.

- Implementing the North American Bat Monitoring Program (NABat) to evaluate trends of bat distributions statewide through acoustic monitoring surveys.

- Requiring decontamination protocols consistent with national protocols and immediate notification of any bats suspected to have WNS for all permit holders conducting bat research or monitoring activities in Wyoming.

Version 1.1 defined three Management Response Stages (MaRS). At the time of development, Wyoming was operating under the Management Response Stage 1 (MaRS 1). Specific achievements defined and addressed under MaRS 1 included:

- Development of a central point of contact to facilitate coordination and implementation of the WNS Strategic Plan (WGFD Nongame Mammal Biologist).

- Reviewing and disseminating information among agencies (e.g., WGFD, US Forest Service, Bureau of Land Management, etc.), NGOs (e.g., WBWG, WYBWG, etc.), and the public by:

    - Coordinating with agencies through the WYBWG to ensure that management actions were consistent with and correspond to the appropriate threat level identified in version 1.1.

- Implementing survey and reporting standards that facilitated the detection of WNS or Pd in Wyoming by:

    - Ensuring that all personnel capturing and handling bats in Wyoming were able to recognize symptoms (e.g., wing damage) properly and that all handled bats were screened using the Reichard wing damage index (WDI).

    - Revising the language of the WGFD Chapter 33 Scientific Collection Permit to ensure that all personnel requesting to capture bats in Wyoming received additional

information about WNS symptoms, a copy of the WDI, and reporting procedures for suspected bats.

- Implementing a strategy for effectively detecting the arrival of Pd and WNS in Wyoming by:
    - Reviewing, summarizing, and classifying all existing data for all roosts and all species.
    - Developing criteria and a prioritization system for selecting roosts that are most vulnerable to WNS (e.g., hibernacula vs. night roost, *Myotis lucifugus* vs. *Corynorhinus townsendii*, large vs. small, etc.).
- Reviewing, implementing, and promoting outreach efforts aimed at preventing the spread of WNS and Pd via human activities by:
    - Reviewing and revising all existing products (e.g., decontamination protocols, awareness signs, etc.) and developing products that were consistent with objectives and threat levels for Wyoming.
    - Revising the language of the WGFD Chapter 33 Scientific Collection Permit to ensure that all personnel requesting to capture bats in Wyoming received additional information about WNS symptoms and guidance on approved decontamination procedures for Wyoming.
- Minimizing the risk to Primary Priority Roosts by:
    - For known bat roosts that were not gated, discouraging unnecessary entry, particularly when bats are present.
    - Identifying roosts that required gates and pursuing opportunities to gate them.
- Cooperating with existing media venues (e.g., WGFD Information and Publications Branch) and outreach efforts (e.g., WBWG website) to promote and disseminate information to the public and other interested parties by:
    - Developing and publishing a WNS awareness brochure and disseminated to all agencies for public consumption.
    - Cooperating with the U.S. Fish and Wildlife Service to create a link on the national WNS website that directed interested parties to Wyoming specific information, including the Strategic Plan.

Additional actions implemented under MaRS 2 of version 1.1 included:

- Implementing targeted surveys at roost sites to facilitate the detection of WNS or Pd in

Wyoming by:

  - Securing funding for sustaining these survey events.

  - Selecting a subset of roost sites for targeted surveys (e.g., abundance, population health, substrate, etc.).

- Ensuring that protocols that are disseminated are consistent with the level of threat prevention by:

  - Coordinating with the WGFD permitting officer to ensure that updated information (e.g., decontamination protocols, etc.) is disseminated via the Chapter 33 Scientific Collection Permit

With the confirmation of Pd in Wyoming in May 2018, the state began implementing MaRS 3. Specific objectives that were implemented under this Stage of version 1.1 included:

- Increasing frequency of coordination efforts by:

  - Initiating a statewide notification call to participating agencies and NGOs.

  - Implementing semi-annual statewide conference calls with interested parties to facilitate implementation of the objectives under MaRS 3.

  - Notifying all interested parties in the state that threat level had increased and the anticipated resulting changes in actions that would be implemented.

- Ensuring that protocols that are disseminated are consistent with the level of threat prevention by:

  - Coordinating with the WGFD permitting officer to ensure that updated information (e.g., decontamination protocols, etc.) is disseminated via the Chapter 33 Scientific Collection Permit.

- Expanding outreach efforts to reflect new threat levels by:

  - Cooperating with existing media venues (e.g., WGFD Information and Publications Branch) and outreach efforts (e.g., WBWG website) to develop a WNS special press release for Wyoming.