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Revision 0

Idaho National Laboratory Site Bat Protection Plan Annual Report 2022

December 2022

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ABSTRACT

Bats are important ecosystem components and represent over 30% of mammals described on the Idaho National Laboratory (INL) Site. Over the past decade white-nose syndrome and wind-energy development have caused wide-spread bat mortality in the United States (U.S.). These threats have resulted in precipitous declines of numerous common bat species and have led to the little brown myotis (*Myotis lucifugus*) being considered for listing under the Endangered Species Act (ESA), with a determination for listing potentially occurring in 2023. Because of these threats and the potential consequences to affect development and operations on the INL Site, in 2018 the U.S. Department of Energy – Idaho Operations Office (DOE-ID) produced a Bat Protection Plan for the INL Site in conjunction with the Idaho Department of Fish and Game (IDFG) and U.S. Fish and Wildlife Service (USFWS). That plan was developed to: (1) document the ecology of bats on the INL Site, allowing DOE-ID to better conserve and manage bats and the habitat they use; (2) provide information on trends of abundance, distribution, and seasonal habitat used by bats, allowing DOE-ID to make informed decisions for project planning required by the National Environmental Policy Act; (3) maintain current information on sensitive bat species on the INL Site, facilitating the biological assessment and biological opinion process required by the ESA; (4) share data collected from the monitoring program with biologists from state and federal agencies, supporting conservation and management of bats and their habitat in areas adjacent to the INL Site; and (5) tier bat conservation actions at the INL Site with those in the Idaho State Wildlife Action Plan.

This 2022 annual report provides current information on bats counted during hibernacula surveys, passive acoustic monitoring, participation in the North American Bat Monitoring Program, white-nose syndrome surveillance, bat carcass recovery and assessment at INL Site facilities, relocating live bats at facilities, and public outreach for bats on the INL Site. Herein, we also assess conservation measures and recommendations for additional studies for bats on the INL Site, management actions, and Bat Protection Plan revisions. This annual report will ensure that the USFWS, IDFG, and other collaborators have current information concerning bats on the INL Site, especially for those species of conservation concern. Such information will help contractors at the INL Site with project planning and construction and will allow DOE-ID to continue its mission with minimal delays with ESA listed bats.

ACKNOWLEDGEMENTS

We thank biologists from the IDFG and the USFWS. We also thank Kurt Edwards, Colby Kramer, Gregg Losinski, Bill Doering, Brenda Pace, Sue Vilord, and Brande Hendricks for their support and help.

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ACRONYMS

ATR	Advanced Test Reactor
BEA	Battelle Energy Alliance, LLC
COTO	Townsend’s big-eared bat
DOE	U.S. Department of Energy
DOE-ID	U.S. Department of Energy, Idaho Operations Office
DOT	U.S. Department of Transportation
ECP	Environmental Compliance Permit
EPFU	big brown bat
ESA	Endangered Species Act
ESER	Environmental Surveillance Education and Research
IDFG	Idaho Department of Fish and Game
INL	Idaho National Laboratory
LACI	hoary bat
LANO	silver-haired bat
MYCA	California myotis
MYCI	western small-footed myotis
MYEV	western long-eared myotis
MYLU	little brown myotis
MYVO	long-legged myotis
MYYU	Yuma myotis
NEPA	National Environmental Policy Act
NRF	Naval Reactors Facility
STEM	Science, Technology, Engineering, and Math
U.S.	United States
USFWS	U.S. Fish and Wildlife Service
WNS	White-nose syndrome

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1. INTRODUCTION

The Idaho National Laboratory (INL) Site is a U.S. Department of Energy, Idaho Operations Office (DOE-ID), reservation encompassing 890 mi^2 (230,509 ha) on the eastern Snake River Plain approximately 25 mi (40 km) west of Idaho Falls (Doering et al. 2018, Reynolds et al. 1986). The INL Site is federal property administered by DOE-ID. DOE-ID oversees operations at the INL Site (Doering et al. 2018). In December 2020, DOE-ID initiated transition of the Environmental Surveillance Education and Research (ESER) program from DOE management to the INL contract managed by Battelle Energy Alliance, LLC (BEA). A team composed of DOE, BEA, and the ESER program contractor, Veolia Nuclear Solutions – Federal Services, successfully transitioned the program on September 30, 2021, and the new program is now called the Environmental Monitoring and Natural Resource Services. The ESER program land and wildlife management support has been integrated into BEA where they conduct ecological monitoring on the INL Site to provide support to DOE-ID.

Bats are important ecosystem components on the INL Site (Doering et al. 2018, Whiting et al. 2015, Whiting et al. 2018a) and represent over 30% of mammals described on the Site (Reynolds et al. 1986). A mosaic of high-quality, shrub-steppe habitat overlying near-surface basalt deposits with abundant lava-tube caves, fractured rock outcrops, talus-flanked buttes, and juniper (*Juniperus* spp.) uplands provide foraging and roosting habitat for resident and migrant bat species, including at least six with heightened conservation concern (Doering et al. 2018, IDFG 2017, Whiting et al. 2015). Since the early 1980s, DOE-ID has supported bat monitoring on the INL Site (Genter 1986, Haymond and Rogers 1999, Whiting et al. 2022). Results of that monitoring have advanced bat conservation at the INL Site and provided important data to state and federal resource agencies in Idaho and the western United States (U.S.) for the conservation of bats and their habitat (Whiting et al. 2021, Whiting et al. 2018a, Whiting et al. 2018b).

Over the past decade, the emergence of white-nose syndrome (WNS) and large-scale commercial wind-energy development have caused wide-spread mortality in bats in the U.S. (Hoyt et al. 2021, Hein and Schirmacher 2016, Hammerson et al. 2017). These threats have resulted in precipitous declines of numerous common bat species, and elevated conservation concern for bats across the U.S. (O'Shea et al. 2018, Knudsen et al. 2013, Weller et al. 2018). In October 2021, the fungus that causes WNS (*Pseudogymnoascus destructans)* was documented on bats in Minnetonka Cave in southern Idaho, which is about 118 miles (190 km) southeast of the INL Site. A 450-megawatt wind-energy facility has been approved for construction off the INL Site and within 0.6 mile (1 km) of the southeast border of the INL Site in Bingham and Bonneville counties. Moreover, the little brown myotis (*Myotis lucifugus*) is currently being considered for listing under the Endangered Species Act (ESA), with a determination to list that species potentially occurring in 2023. In 2018, DOE-ID produced a bat protection plan for the INL Site (Doering et al. 2018) and has since produced an annual report providing current information on the conservation of bats and their habitat on the INL Site in light of these impending conservation concerns. Doering et al. (2018) indicated the purpose of that plan was to complete the following objectives:

1. Document the natural history and bat ecology on the INL Site to better conserve and manage these mammals and their habitat.
2. Provide information on trends of abundance, distribution, and seasonal habitat use by bats, which will allow DOE-ID to make informed decisions for project planning required by the National Environmental Policy Act (NEPA).
3. Maintain current information on sensitive bat species on the INL Site to facilitate the biological assessment and biological opinion process required by the ESA, if a species becomes listed under the ESA. Such information will allow the DOE-ID to continue its mission with minimal delays from an ESA listing.

4. Identify credits to DOE-ID for voluntary prelisting conservation actions as described by the U.S. Fish and Wildlife Service (USFWS), if that policy is enacted.
5. Share data collected from the monitoring program with biologists from the USFWS, Idaho Department of Fish and Game (IDFG), the U.S. Bureau of Land Management, and Craters of the Moon National Monument and Preserve to support conservation and management of bats and their habitat in areas adjacent to the INL Site.
6. Tier bat conservation actions at the INL Site to the Idaho State Wildlife Action Plan.

1.1 Bat Protection Plan Annual Report

This annual report provides the USFWS, IDFG, and other collaborators with current information concerning bats on the INL Site, especially for those species of conservation concern. Such information will help contractors at the INL Site with project planning and construction. This report will also provide the following required information as described in the Idaho National Laboratory Site Bat Protection Plan (Doering et al. 2018):

- Describe objectives, methods, results, and interpret findings from monitoring data
- Assess the efficacy of conservation measures
- Make recommendations for additional study, management actions, and plan revisions.

This annual report appends the 2020 annual report and contains data from the monitoring program from November 2018 to March 2022. In conjunction with this update, DOE-ID, USFWS, IDFG, BEA Monitoring and Natural Resources Services Group, and Naval Reactors Facility (NRF) will meet to discuss changes in any section of the plan (e.g., fluctuations in trends of bat abundance on the INL Site or WNS monitoring), changes in the conservation status of bats that occur on the INL Site, or new policies that will benefit the conservation and management of sensitive bat species or their habitat (Doering et al. 2018).

2. DESCRIBE OBJECTIVES, METHODS, RESULTS, AND INTERPRET FINDINGS FROM MONITORING DATA

2.1 Hibernacula Counts

Counts in hibernacula on the INL Site in 2019, 2020, and 2021 were unable to be completed. The last hibernacula count was conducted in 2018. Hibernacula are usually surveyed every other year, however, due to national and state-wide restrictions of entering caves during the COVID-19 pandemic, hibernacula bat counts were not conducted during the winters of 2019/2020 or 2020/2021. Hibernacula surveys are scheduled to be conducted during the winter of 2022/2023 in all caves.

Estimating long-term population changes of bats is critical for targeting management and providing important information for habitat management (Whiting et al. 2018b, Ingersoll et al. 2016). Population estimates are determined by counting bats in caves during hibernation (Ellison et al. 2003, Prendergast et al. 2010). These counts are one of the best ways to estimate population change because bats use the same hibernation sites for decades (Gillies et al. 2014, Whiting et al. 2018a, Whiting et al. 2021). Counts of hibernating bats on the INL Site were conducted between November 1 and March 31 using established protocols and care to minimize disturbing the bats (Whiting et al. 2018a, Whiting et al. 2018b). Counts from 2013 to 2018 conducted in all eight known hibernacula on the INL Site, except Link Sausage Cave, were used to document the number of Townsend's big-eared bats (*Corynorhinus townsendii*) and western small-footed myotis (*Myotis ciliolabrum*) by year (Whiting et al. 2018a, Whiting et al. 2018b). Counts from 1993 to 2018 that were conducted using consistent methods were also used to provide a historical view of population changes of bats in Middle Butte, Rattlesnake, and Aviators caves (the three largest hibernacula, and the caves that have been consistently surveyed for the longest time on the INL Site).

The mean (± *SD*) number of researchers that entered caves and counted bats was 3 ± 1 researcher (range = 2 to 5 researchers) from 2013 to 2018, for 24 surveys of hibernacula on the INL Site. During those years, researchers counted 1,878 Townsend's big-eared bats and 101 western small-footed myotis (Figure 1). During 18 hibernacula surveys conducted from 1993 to 2018 in Middle Butte, Rattlesnake, and Aviators caves, the mean number of researchers that entered caves and counted bats in hibernacula was 4 ± 1 researcher (range = 2 to 6 investigators). During those years researchers counted 3,267 Townsend's big-eared bats and 214 western small-footed myotis (Figure 2 and Figure 3).

Hibernacula counts of Townsend's big-eared bats and western small-footed myotis often exhibit large amounts of variation across years (Sherwin et al. 2003, Whiting et al. 2018b). That variation is normal as bats likely use different caves for hibernation (Bosworth 1994, Wackenhut 1990, Whiting et al. 2018b) and because of variation in use of areas inside hibernation sites, which influences observers seeing and counting those species (Safford 1990). Counts of those species in 2018 fell within the normal variation of historical population counts on the INL Site (Figure 1, Figure 2, and Figure 3), that indicated there was not a decline in number of Townsend's big-eared bats and western small-footed myotis on the INL Site.

Understanding long-term changes in bat populations is needed for conservation of these mammals (Weller et al. 2018, Whiting et al. 2018b). Our data from hibernacula surveys underscore the importance of the INL Site, regionally, for hibernating Townsend's big-eared bats and western small-footed myotis (Whiting et al. 2018a, Whiting et al. 2018b). These results quantify long-term trajectories of these populations and will guide biologists in prioritizing caves to sample for the arrival of WNS and help with the management and conservation of bats and their habitat as well as aid in land-use planning on the INL Site (Whiting et al. 2018a, Whiting et al. 2018b).

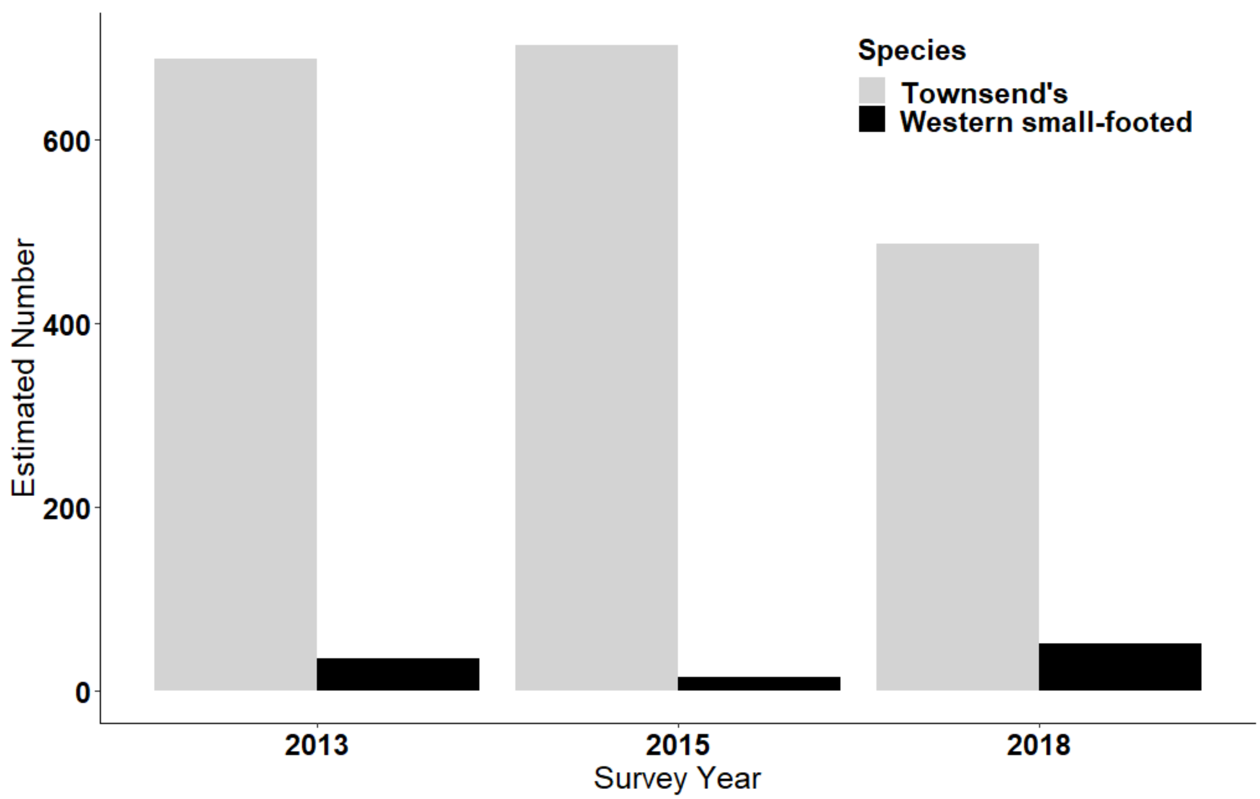

Figure 1. Number of bats counted in eight caves on the INL Site in each year when consistent survey methods were used.

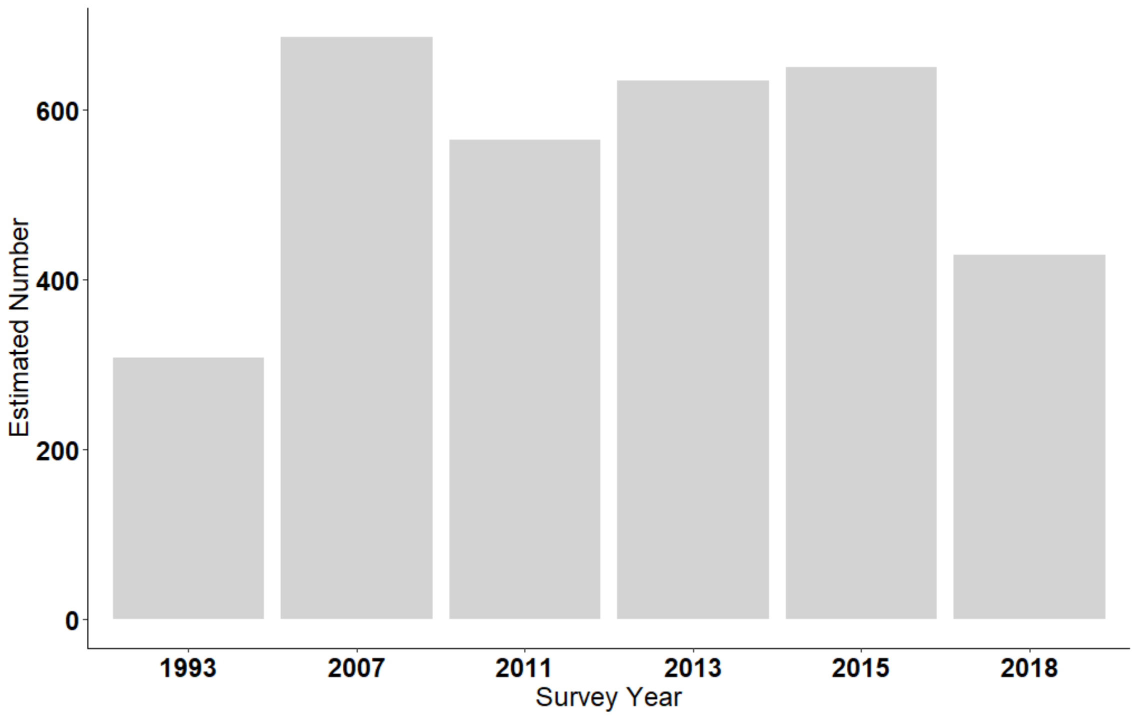

Figure 2. Number of Townsend's big-eared bats counted in Middle Butte, Rattlesnake, and Aviators caves on the INL Site in each year when consistent survey methods were used.

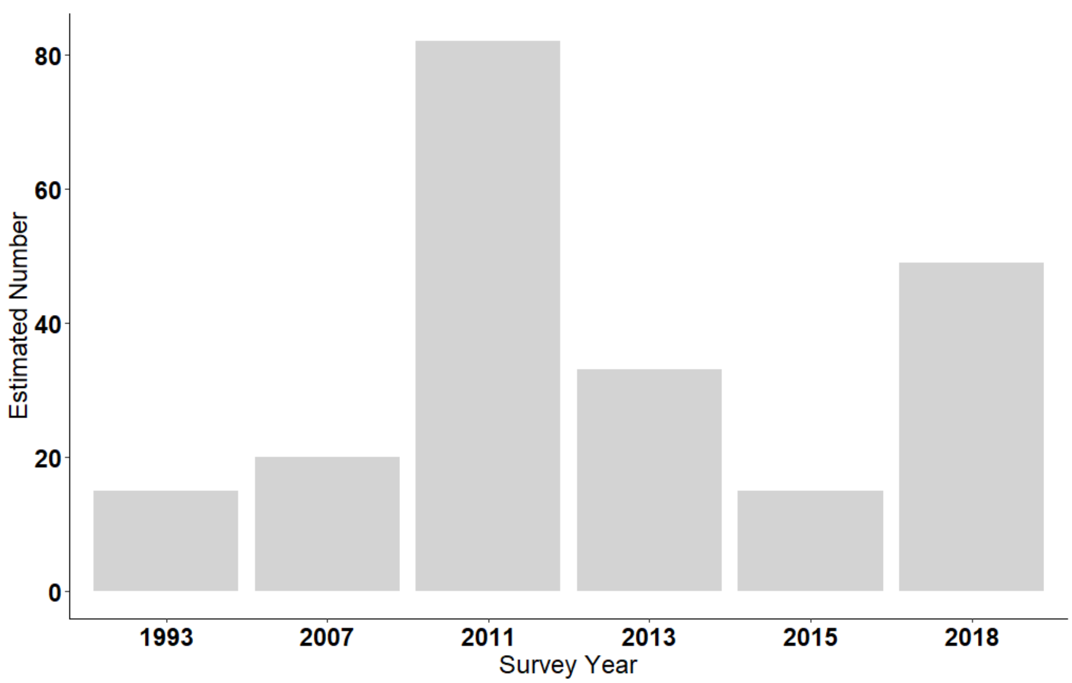

Figure 3. Number of western small-footed myotis counted in Middle Butte, Rattlesnake, and Aviators caves on the INL Site in each year when consistent survey methods were used.

2.2 Passive Acoustic Monitoring

2.2.1 Winter Passive Acoustic Monitoring

Acoustic detectors are effective at identifying bat species and quantifying bat activity because bat calls are consistent in structure and have species-specific characteristics (Miller 2001, O'Farrell and Gannon 1999, Whiting et al. 2022). These devices have been used extensively to study bat winter ecology (Whiting et al. 2019, Bernard and McCracken 2017, Lausen and Barclay 2006). Little is known about bat hibernation behavior in the western U.S. prior to the arrival of WNS (Knudsen et al. 2013, Schwaband Mabee 2014, Weller et al. 2018). Anabat SD2 and Swift detectors were set at nine hibernacula on the INL Site during winter (November 1 to March 31) from 2018 to 2022. Detectors were powered by external batteries and solar panels. Each unit was equipped with a BatHat to reduce damage to equipment from rain, snow, and freezing temperatures (Britzke et al. 2010). Anabat SD2 units also had reflector plates oriented at a 45 degree angle from the center axis of the microphone to minimize echo and clutter noise (Britzke et al. 2010, Reynolds et al. 2017, Skalak et al. 2012). Detectors were programmed to record at least from sunset to sunrise (Johnson et al. 2017, Nocera et al. 2019) and the division ratio was set at eight (Skalak et al. 2012). The sensitivity was adjusted to exclude ambient noise (Britzke et al. 2013, Whiting et al. 2019).

Microphones were placed about 3 m above the ground and positioned so the center axis of the zone of reception was approximately 15 degrees above the horizon (Johnson et al. 2017, Klüg-Baerwald et al. 2016). Microphones were oriented to maximize detection near cave entrances while trying to avoid recording near-ground noise and echoes (Britzke et al. 2010, Schwab and Mabee 2014). When triggered by bats flying outside of hibernacula, detectors created one ≤ 15 second call file labeled with a date and time stamp. Only call files of western small-footed myotis and Townsend’s big-eared bats were analyzed because those species represent greater than 99% of bats observed in hibernacula counts over the last 30 years (Whiting et al. 2018a, Whiting et al. 2018b). Data from December, January, and February were used because extensive cave-exiting activity of western small-footed myotis and Townsend’s big-eared bats in those months has been documented (Whiting et al. 2021, Whiting et al. 2022). November and March were not included because data would incorporate bats that were swarming and preparing to leave hibernation (Whiting et al. 2021).

Kaleidoscope Pro version 5.4.8 was used to analyze winter bat activity in the caves (East Boundary, Middle Butte, Moonshiners, North Tower Earl, North Tower Wackenhut, and Rattlesnake caves) (Clement et al. 2022, López-Baucells et al. 2021, Laverty and Berger 2022). Under the *Signal Parameters* tab, the minimum and maximum frequency range was set to 20 to 90 kHz to minimize noise while still catching all the potential species. Under the *Auto ID for Bats* tab, *Bats of North America 5.4.0* was selected. The default was set at *0 Balanced (Neutral)* and Idaho was selected from the *Select by region* drop-down list. In the list of bats of Idaho, Townsend’s big-eared bat and western small-footed myotis were selected. Files were then processed for Townsend’s big-eared bats first and then for western small-footed myotis.

To accept a classification as a Townsend’s big-eared bat, Kaleidoscope was required to detect ≥ 2 pulses within a call sequence. After calls were filtered by Kaleidoscope, all calls were manually vetted (López-Baucells et al. 2021, Richardson et al. 2021, Ednie et al. 2021). To accept a classification as a western small-footed myotis, Kaleidoscope was required to detect ≥ 4 pulses within a call sequence. Each call sequence then had to have a matching ratio of western small-footed myotis calls to all classified calls of ≥ 0.9 (Clement et al. 2022). After calls were filtered by Kaleidoscope, all calls were manually vetted (López-Baucells et al. 2021, Richardson et al. 2021, Ednie et al. 2021).

From 2018 to 2022, Anabat units recorded a total of 2,380 nights at nine caves (23,019 files passed the filter in Kaleidoscope [Townsend's big-eared bat = 7,052 files, western small-footed myotis = 15,967 files]). After manually vetting those 23,019 files, a total of 5,861 files (Townsend's big-eared bat = 195 files and western small-footed myotis = 5,666 files) were classified. An index of winter activity for both species was only calculated at Middle Butte and Rattlesnake caves because too few calls were recorded in other caves. The number of identified calls divided by the number of nights the detector functioned each year was calculated. The number of calls for Townsend's big-eared bats has remained steady across that time (Figure 4); whereas the number of calls for western small-footed myotis has decreased since winter 2018 in Middle Butte and Rattlesnake caves (Figure 4).

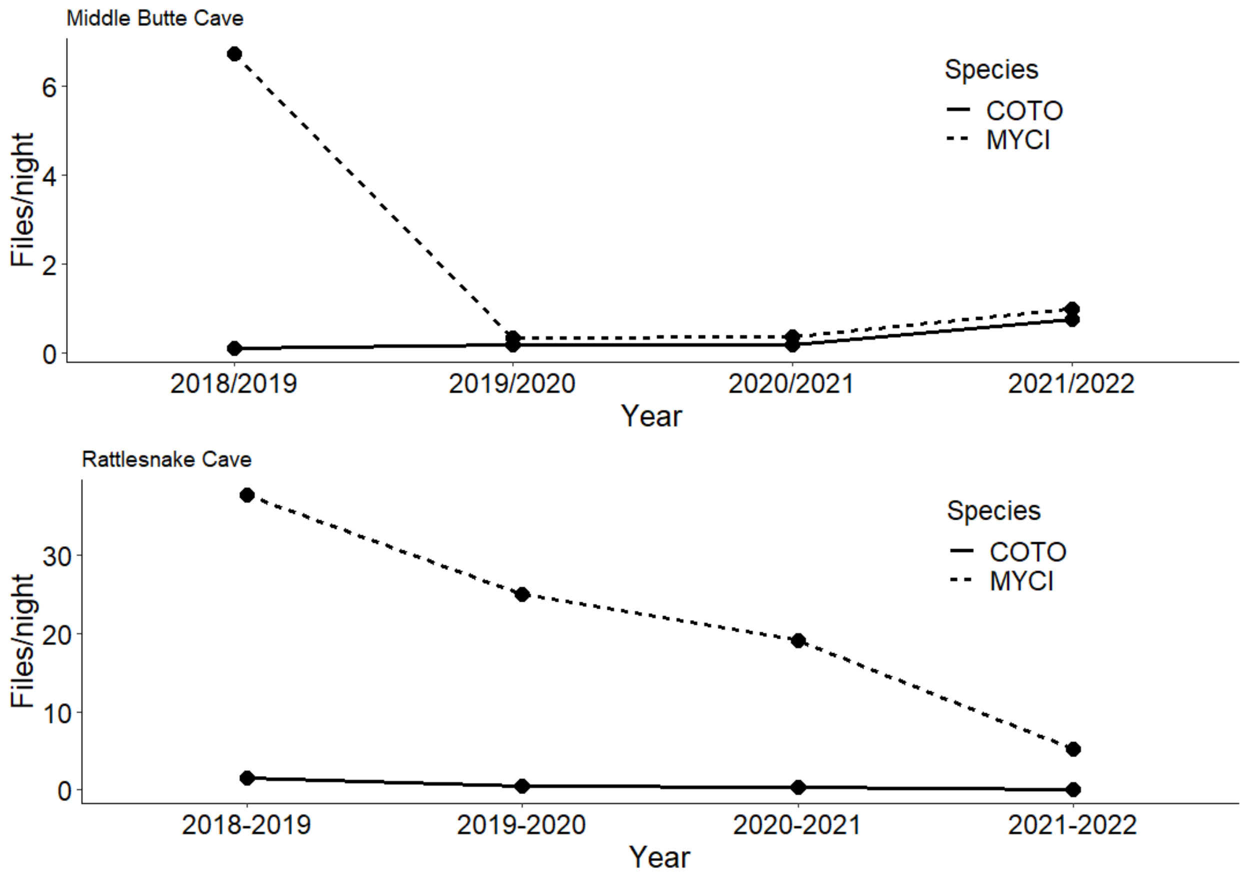

Figure 4. The number of files/number of nights acoustic detectors functioned in a year for Townsend's big-eared bats (COTO) and western small-footed myotis (MYCI) during December, January, and February 2018-2022 at Middle Butte and Rattlesnake caves on the INL Site.

Anabat detectors recorded too few nights of activity for Townsend's big-eared bats at the other seven caves to analyze the data. However, there was sufficient data for western small-footed myotis combined across East Boundary, Moonshiners, North Tower Earl, and North Tower Wackenhut caves. Across those caves, the number of identified calls of western small-footed myotis divided by the number of nights the detector functioned each year was calculated. We then produced a mean number (± *SD*) of files/night for each year across caves. The number of calls for western small-footed myotis has remained similar in those caves since winter 2018 (Figure 5).

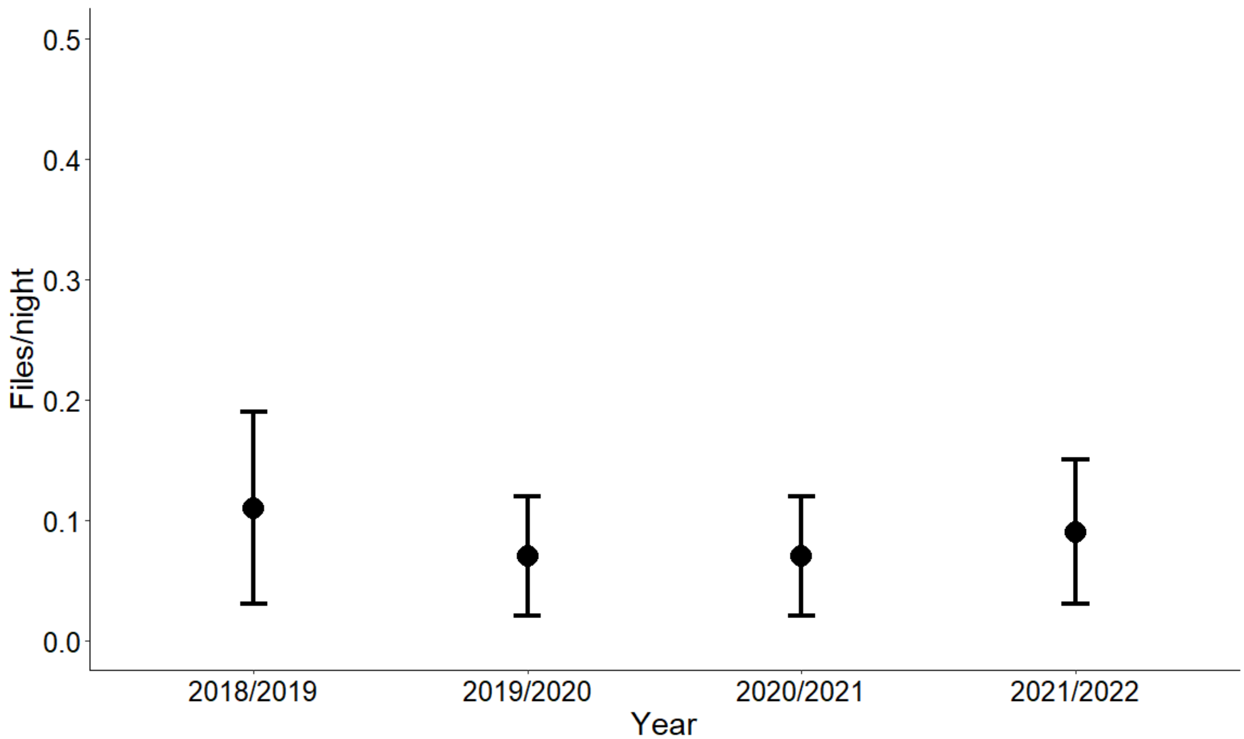

Figure 5. The mean number of files/number of nights acoustic detectors functioned across years for western small-footed myotis during December, January, and February 2018-2022 in East Boundary, Moonshiners, North Tower Earl, and North Tower Wackenhut caves on the INL Site.

Interest exists in developing long-term acoustic monitoring of bats (Frick 2013, Nocera et al. 2019), and deploying several stationary detectors is valuable for understanding bat activity at a landscape scale (Stahlschmidt and Bruhl 2012). With the arrival of WNS in western North America (Lorch et al. 2016) and with fungus that causes WNS now documented in Minnetonka Cave in southern Idaho, which is about 190 km from the INL Site, it is important to understand winter cave-exiting behavior of bats (Bernard et al. 2017, Reynolds et al. 2017). Trends in the number of files for western small-footed myotis decreased across time in Rattlesnake and Middle Butte caves; that trend was not apparent in four other caves. It will continue to be watched. Bat cave-exiting behavior in winter is highly variable across the years on the INL Site (Whiting et al. 2021, Whiting et al. 2022). In 2023, it is planned to analyze all bat call data from 2011 to now using the Kaleidoscope methods described above to document long-term patterns of cave-exiting behavior of those species. This will provide a better picture of trends in the number of call files across time. Such data will provide a long-term baseline dataset of that cave-exiting behavior, which can be used in future analyses to quantify the potential impact of WNS on these species when this disease arrives on the INL Site (Whiting et al. 2021).

2.2.2 Spring, Summer, and Autumn Passive Acoustic Monitoring

Monitoring bats acoustically throughout the year is important and can provide data on how WNS and wind-energy development affect bat populations (Brooks 2011, Dzal et al. 2010). Anabat SD2 and Swift detectors were placed from May 1 to September 30 at eight facilities (Advanced Test Reactor-Complex, Central Facilities Area, Critical Infrastructure Test Range Complex, Idaho Nuclear Technology and Engineering Center, Materials and Fuels Complex, NRF, Radioactive Waste Management Complex, and Test Area North) and five caves (Middle Butte, Rattlesnake, East Boundary, Aviators, and North Tower Wackenhut caves) from 2019 to 2021. These detectors documented the occurrence of bat species at those features during the non-hibernation season. Each detector was programmed to record at least from sunset to sunrise (Miller 2001, Whiting et al. 2019). The division ratio was set at eight to allow analysis of short duration calls. The sensitivity of Anabat detectors was adjusted to exclude the ambient noise (Britzke et al. 2013, Whiting et al. 2019). When triggered by a bat call, detectors created a, ≤ 15 sec file, labeled with a unique date and time stamp. For facility acoustic monitoring, detectors were oriented to maximize detection of bats at areas likely to concentrate bat activity (e.g., facility surface-water features such as sewage lagoons). For cave acoustic monitoring, microphones were oriented to maximize detection near the area of interest (i.e., cave entrance or crater) at each site while trying to avoid recording near-ground noise and echoes.

Kaleidoscope Pro version 5.4.8 was used for species identification to analyze bat occurrence at a facility or a cave (Clement et al. 2022, López-Baucells et al. 2021, Laverty et al. 2022). Under the signal parameter tab, the minimum and maximum frequency range was set to 14 to 120 kHz to minimize noise while still identifying all the potential species. In the *Auto ID for Bats* tab, *Bats of North America 5.4.0* was selected, the default *0 Balanced (Neutral)* from the drop-down list was selected, and Idaho was selected in the *Select by region* drop-down list. In the list of bats of Idaho, the following species documented in the 2020 update of the INL Site Bat Protection Plan were selected: Townsend's big-eared bat, big brown bat (*Eptesicus fuscus*), hoary bat (*Lasiurus cinereus*), silver-haired bat (*Lasionycteris noctivagans*), California myotis (*M. californicus*), western small-footed myotis, long-eared myotis (*M. evotis*), little brown myotis, and Yuma myotis (*M. yumanesis*). These species were selected because from May to September in 2017 to 2019, Anabat detectors recorded 612,956 files of those species on the INL Site and automated acoustic identification is improved by only considering species that occur in the study area (Fraser et al. 2020).

After the files were filtered by facility and cave in Kaleidoscope, the nights during which a species was present was quantified using the maximum likelihood estimator produced by Kaleidoscope (i.e., if the p-value was < 0.05 that species occurred on that night). A sum of the species presence was divided by the number of nights detectors functioned for each facility and cave from 2019 to 2021, and then were plotted. Across those years, Anabat units functioned for a mean of 57 nights (SD = 31.2, range = 0 to 134 nights) at facilities and 145 nights (SD = 20.0, range = 91 to 153 nights) at caves. Kaleidoscope documented 6,329 nights species were present across all caves, and 3,952 nights species were present across all facilities. The presence of seven species predominately at facilities were recorded (Figure 6) and the presences of nine species at caves (Figure 7). Little brown myotis and western small-footed myotis had the highest number of nights of occurrence at all facilities, as well as at four of five caves. Tree bats (hoary and silver-haired bats) had a higher frequency of occurrence at facilities than caves (Figure 6 and Figure 7).

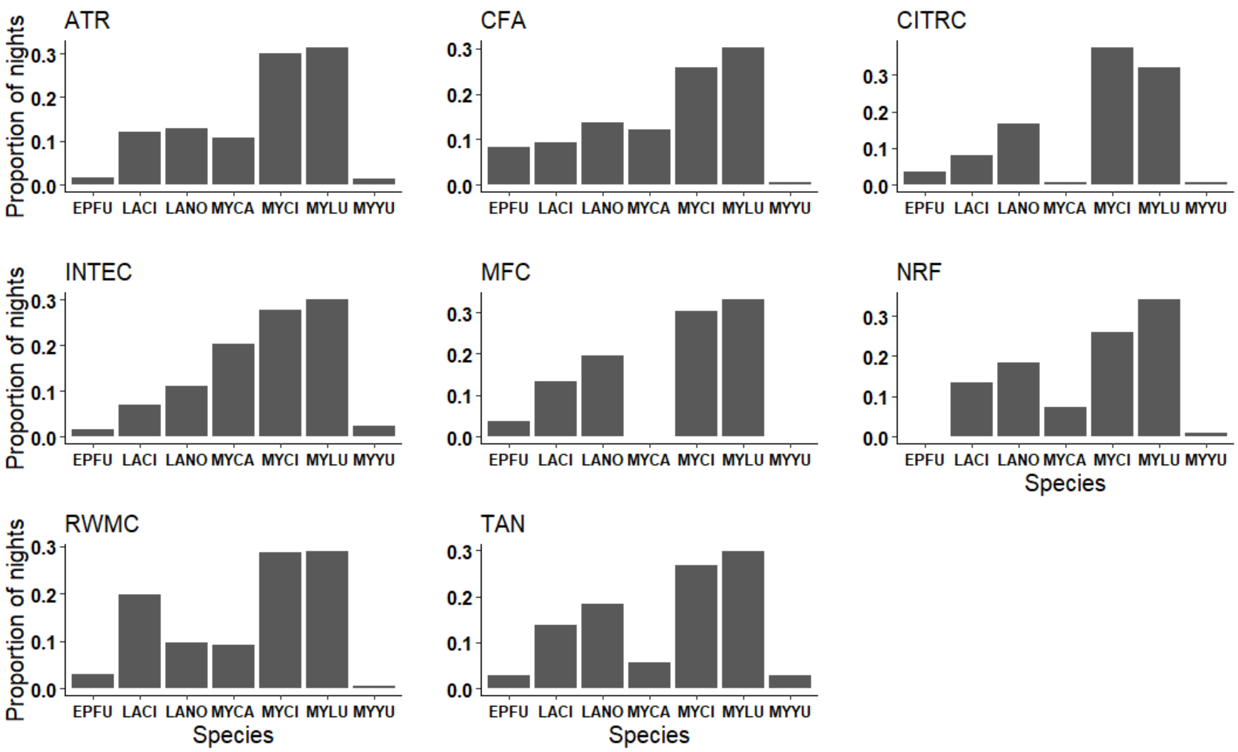

Figure 6. Proportion of nights bat species were documented at INL Site facilities during May to September from 2019 to 2021. Species are identified as the following: big brown bat (EPFU), hoary bat (LACI), silver-haired bat (LANO), California myotis (MYCA), western small-footed myotis (MYCI), little brown myotis (MYLU), and Yuma myotis (MYYU).

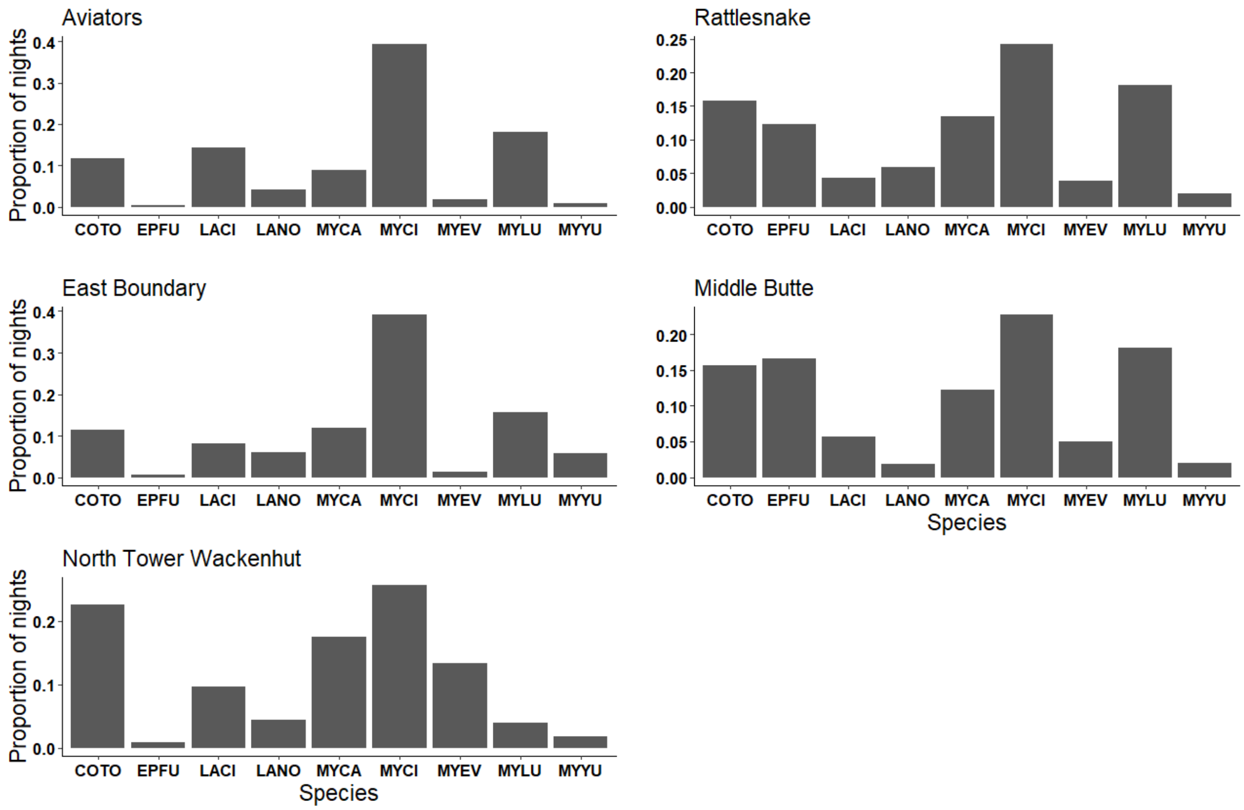

Figure 7. Proportion of nights bat species were documented at INL Site caves during May to September from 2019 to 2021. Species are identified as in the caption for Figure 6, along with Townsend's big-eared bat (COTO) and long-eared myotis (MYEV).

2.3 Participation in the North American Bat Monitoring Program (NABat)

The NABat program is a multiagency, multinational effort to standardize monitoring and management of bat species across several taxa (Loeb et al. 2015). NABat sampling and monitoring is divided across North America as a series of 10 × 10 km grid cells (Loeb et al. 2015). Grid cells are prioritized at a state level with the state's input. Each grid cell is subsequently split into four quadrants. Two grid cells are located on and near the INL Site, and a stationary acoustic survey point was identified within each of those quadrants (Loeb et al. 2015, Figure 8). Anabat detectors were set at eight locations on and near the INL Site during 2020 and 2021 (Figure 8). To document the occurrence of bat species at those locations, Kaleidoscope Pro version 5.4.8 was used for automated species identification (Clement et al. 2022, López-Baucells et al. 2021, Laverty et al. 2022). Under the signal parameter tab, the minimum and maximum frequency range was set to 14 to 120 kHz to minimize noise while still catching all the potential species. In the *Auto ID for Bats* tab, *Bats of North America 5.4.0* was selected, the default *0 Balanced (Neutral)* was selected from the drop-down list, and Idaho was selected in the *Select by region* drop-down list. Files were filtered by sampling location in Kaleidoscope, and the number of nights in which a species was present was quantified using the maximum likelihood estimator produced by Kaleidoscope.

During 2020, detectors functioned for two nights at each location; detectors recorded the presence of big brown bats, hoary bats, California myotis, western small-footed myotis, and little brown myotis at all eight locations. During 2021, detectors functioned for four nights at each of the eight locations. Detectors recorded the presence of big brown bats, Townsend's big-eared bats, hoary bats, silver-haired bats, western small-footed myotis, and little brown myotis at each location. These data have been sent to the Bat Hub at Oregon State University and to the IDFG to help with producing range-wide occupancy probability predictions for those bat species.

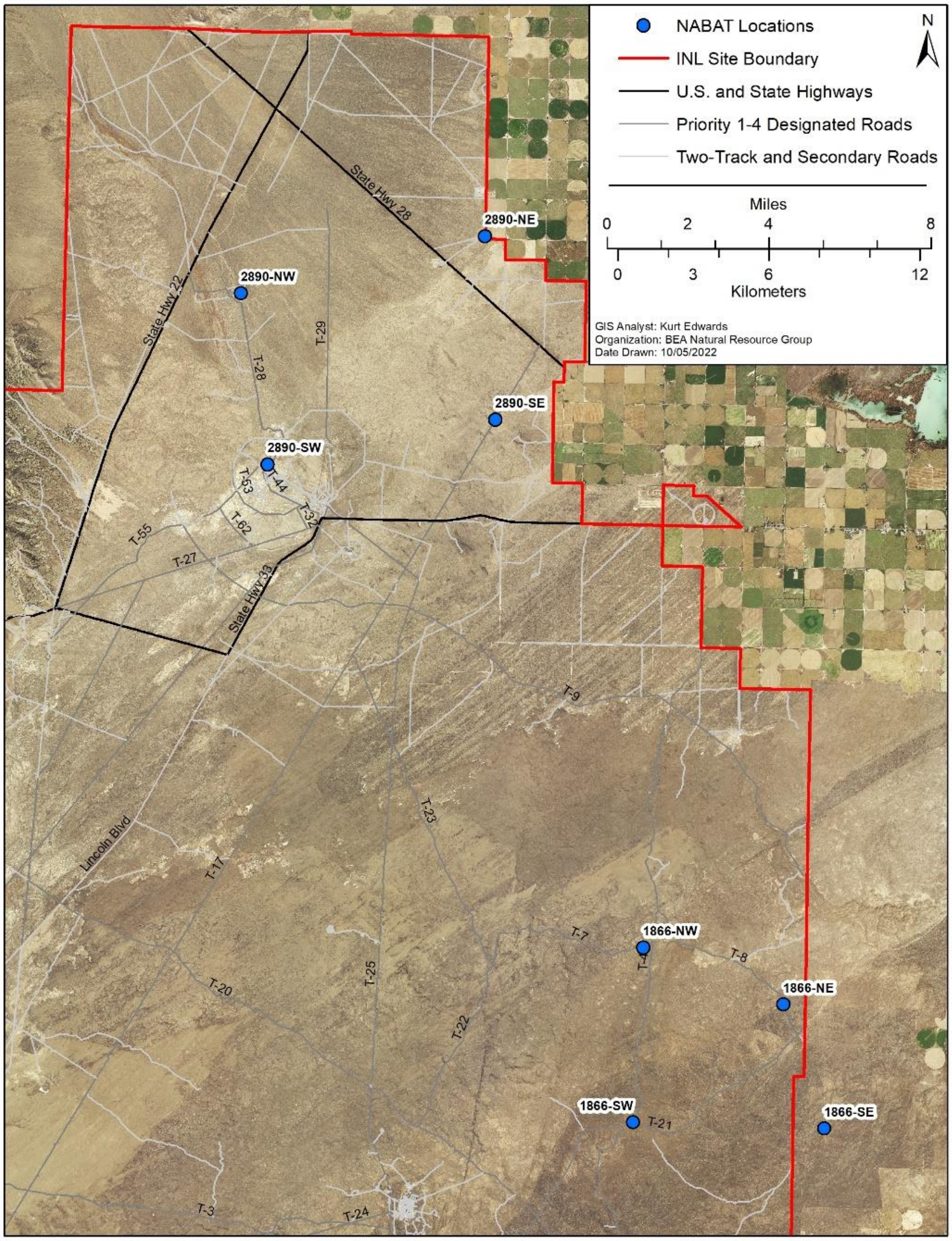

Figure 8. Locations of stationary detectors for NABat monitoring to document the occurrence of bat species on and near the INL Site during July and August 2020 and 2021.

2.4 White-Nose Syndrome Surveillance

WNS is a recent threat to many bats that hibernate in caves (Hoyt et al. 2021, Frick et al. 2010, Knudsen et al. 2013) and has killed over five million bats in seven species (Bernard et al. 2017, Hoyt et al. 2021). Many common bat species could be at risk of significant declines or extinction due to this disease (Hammerson et al. 2017). WNS has primarily been a disease occurring in the eastern U.S. (Ingersoll et al. 2016, Langwig et al. 2015, Reynolds et al. 2017), however, in 2016 a little brown myotis with WNS was found in King County, WA, (Lorch et al. 2016). In October 2021, *Pseudogymnoascus destructans*, the fungus that causes WNS, was documented in Minnetonka Cave in southern Idaho, which is about 118 miles (190 km) southeast of the INL Site. Under the direction of the IDFG, increased surveillance for the fungus and the disease will need to occur on the INL Site (Table 1).

Table 1. Bat species and potential for these species to be infected with the fungus *Pseudogymnoascus destructans* (*Pd*) that causes WNS.

Common name	Potential or confirmed WNS susceptible species
Big brown bat (EPFU)	Yes1
Hoary bat (LACI)	No1
Little brown myotis (MYLU)	Yes1
Silver-haired bat (LANO)	Pd positive1
Townsend's big-eared bat (COTO)	Pd positive1
Western long-eared myotis (MYEV)	Yes1
Western small-footed myotis (MYCI)	Pd positive1
California Myotis (MYCA)	Yes
Fringed Myotis (MYTH)	Yes1
Long-legged myotis (MYVO)	Yes1
Yuma myotis (MYYU)	Yes1
1 https://www.whitenosesyndrome.org/static-page/bats-affected-by-wns.	

2.4.1 Cave Temperature and Humidity

The growth of *Pseudogymnoascus destructans* is restricted by cave temperature and humidity (Torres-Cruz et al. 2019, Vanderwolf et al. 2012, Verant et al. 2012). Quantifying temperature and humidity in caves on the INL Site are important for understanding the potential for WNS to become established in caves on the INL Site. HOBO data loggers were placed in eight hibernacula on the INL Site from November 1, 2021, to March 31, 2022. Data loggers were placed in areas where bats had been observed previously during hibernacula surveys. HOBO loggers recorded temperature (°C) and humidity (% relative humidity) every 30 minutes. A mean, minimum, and maximum temperature for each month by cave was then computed. All caves on the INL Site had temperatures below the optimal growth for *Pseudogymnoascus destructans*, especially during January to March (Figure 9). The fungus also needs high levels of relative humidity for optimal growth (> 81%) (Torres-Cruz et al. 2019, Marroquin et al. 2017). College cave (94%) had humidity levels that would support optimal growth of the fungus. Middle Butte (78%), Moonshiner (78%), and North Tower Wackenhut (80%) caves had high humidity levels compared with the rest of the caves and could support limited growth of *Pseudogymnoascus destructans* (Marroquin et al. 2017). All other caves did not have humidity levels that would support growth of *Pseudogymnoascus destructans.*

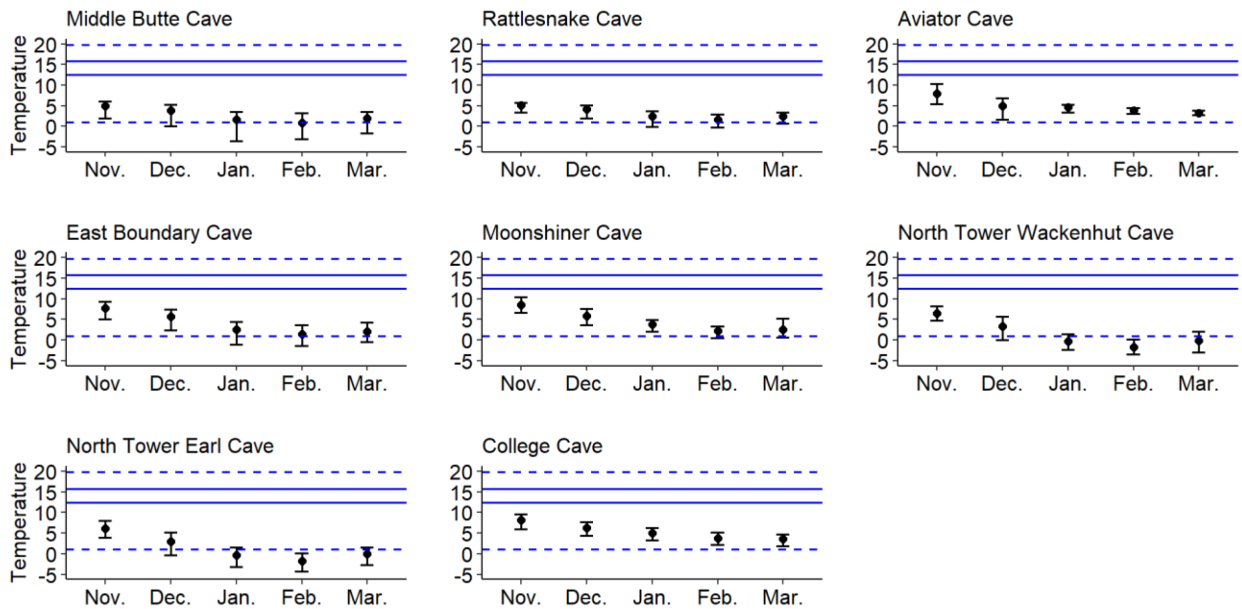

Figure 9. Mean (black dot), minimum, and maximum (error bars) temperatures (°C) by month in eight caves on the INL Site from November 2021 to March 2022. The solid blue lines represent the optimal range of temperatures for growth of *Pseudogymnoascus destructans*, while the dashed blue lines represent the range of temperatures for active growth of *Pseudogymnoascus destructans* (Verant et al. 2012).

2.5 Carcass Recovery and Assessment

Occasionally, fatigued and energetically stressed bats take refuge at INL Site facilities and subsequently die. Often INL Site workers discover a bat carcass on the floor or walls in facility buildings or outside in areas near facilities (Doering et al. 2018) and contact Environmental Monitoring and Natural Resource Services. When contacted, carcasses are collected and stored for future analysis (Doering et al. 2018). During 2020, 25 dead bats (two silver-haired bats, five western small-footed myotis, one long-eared myotis, nine little brown myotis, and eight unidentified bats) were collected. In 2021, 42 dead bats (two big brown bats, four silver-haired bats, 13 western small-footed myotis, 21 little brown myotis, one Yuma myotis, and one unidentified bat) were collected. Five or more bat carcasses of any species at the same time in a single location were never recorded, which would have been classified as a die-off, and would have triggered a notification to local and state biologists from the IDFG to begin investigating the cause of death (Doering et al. 2018).

Sixty-six bats collected from 2020 to 2021 were sent to GEL Laboratories (Charleston, South Carolina) to be analyzed for gamma-emitting radionuclides, specific alpha-emitting radionuclides, and for strontium-90, which is a beta-emitting radionuclide. The following radionuclides were detected in at least one sample during 2020 and 2021: cesium-137, colbalt-60, plutonium-238, plutonium-239/240, strontium-90, and zinc-65. Cesium-137 is ubiquitous in the environment because of fallout from historical nuclear weapons tests. Strontium-90 is another fallout radionuclide. Cobalt-60 and zinc-65, which are fission products, may indicate bats visited radioactive effluent ponds on the INL Site, such as at the ATR Complex ponds. Plutonium-238 and plutonium-239/240, which are present in radioactive waste, as well as in the environment from past weapons testing, were detected in samples collected in 2020 and 2021. The maximum dose received by bats in 2020 or 2021 at the INL Site was estimated to be 0.001 rad/d (0.01 mGy/d). The calculated dose was well below the threshold of 1 rad/d (10 mGy/d), and bats on the INL Site received an absorbed dose within the DOE standard established for terrestrial animals (DOE 2021, DOE 2022).

Since 2018, 81 bat carcasses collected at INL Site facilities were submitted to be analyzed for gamma-emitting radionuclides, specific alpha-emitting radionuclides, and for strontium-90. All the samples have come back with calculated doses within the DOE standard established for terrestrial animals. Other published studies have used fewer bats for sampling to test for contamination at water sources. For example, Warren et al. (2014) sampled 37 bats in Nevada and documented that dose rates to bats foraging and drinking at ponds was similar to doses measured in previous years, and that dose rates were less than the DOE limits and therefore did not pose a threat to bat populations. In future years, instead of submitting carcasses every year for contaminant testing, it is proposed to store specimens and then send randomly selected carcasses every three to five years for testing. It is also proposed that funding used for analyzing carcasses could be reallocated to tagging bats or for WNS sampling on the INL Site.

2.6 Relocating Live Bats

Live bats are occasionally located in buildings, sheds, or storage facilities on the INL Site, especially during summer when bat pups are becoming independent and during fall migration when bats are shifting from summer to winter habitats. When a bat was found in an area where it was safe and not creating a nuisance to INL Site workers or disrupting work, the bat was left alone and allowed to leave on its own accord. If a bat was found in an area where it was at risk of injury or was disrupting work, it was relocated from the area following approved guidelines (LI-1165 *Handling Nuisance Animals*, TPR-14607 *Preventing Disease From Rodents, Birds and Bats*, Doering et al. 2018, White-nose Syndrome Conservation and Recovery Working Group 2015). In 2020 and 2021, 14 bats were located in or near facilities. Six bats were in locations where they could be left alone and thus left on their own accord. In eight other instances, bats were relocated to vegetation outside of the building.

2.7 Public Outreach

Overall, three peer-reviewed papers were published and one manuscript is in preparation that were written in collaboration with professors at Brigham Young University-Idaho and Idaho State University. A poster and four presentations were presented at local and national scientific meetings. Two websites have discussed our work with bats. Presentations were given to over 250 people at the Idaho Falls Zoo Bat Night, over 400 students and teachers at STEM Day and at Zoo Camp. Bat ecology was taught in classrooms to 1,020 elementary students and 20 teachers at Museum and iSTEM camps about local bats and acoustic monitoring. A training on the basics of bat acoustic detectors was provided to 35 biology students at Brigham Young University-Idaho.

2.7.1 Publications

Published

Wackenhut, M. C., J. C. Whiting, and B. Doering, In Press. "Overwinter mass loss of Townsend's big-eared bats in multiple caves." *Northwest Naturalist.*

Whiting, J. C., B. Doering, and K. Aho. 2021. "Long-term patterns of cave-exiting behavior of hibernating bats in nine caves in western North America." *Scientific Reports* 11:8175. https://www.nature.com/articles/s41598-021-87605-0

Whiting, J. C., B. Doering, and K. Aho. 2022. "Can acoustic recordings of cave-exiting bats in winter estimate bat abundance in hibernacula?" *Ecological Indicators* 137:108755. https://www.sciencedirect.com/science/article/pii/S1470160X22002266

In Preparation

Whiting, J. C., B. Doering, and K. Aho. In preparation. "How many nights should acoustic detectors be set to estimate cave-exiting behavior of hibernating bats?" *Wildlife Research.*

2.7.2 Presentations

Whiting, J. C. 2021. "Ecology and Conservation of Bats in Southern Idaho." Idaho Falls Zoo Bat Night, Idaho Falls, ID.

Whiting, J. C. 2021. "Ecology and Conservation of Bats in Southern Idaho." Museum of Idaho, Idaho Falls, ID.

Whiting, J. C. 2022. "Bat Night 2022: Bat Conservation and a 'Chiropterarium'." at the Idaho Falls Zoo, Idaho Falls, ID.

Whiting, J. C. 2022. "Update on the Idaho National Laboratory Site Bat Protection Plan." Idaho Chapter of the Wildlife Society Annual Meeting, virtual meeting.

2.7.3 Posters

Whiting, J. C., B. Doering, and K. Aho. 2022. "Can acoustic recordings of cave-exiting bats in winter estimate bat abundance in hibernacula?" 50th North American Symposium for Bat Research an 19th International Bat Research Conference, Austin, TX.

2.7.4 Popular Press

Websites about bat work conducted on the INL Site:

https://idahoeser.inl.gov/Wildlife/bats.html

Bat Night at the Zoo | Idaho Falls, ID (idahofallsidaho.gov)

2.7.5 Idaho Falls Zoo

Two bat nights were organized in 2021 and 2022 for more than 250 people to discuss bat research, as well as bat acoustic monitoring and conservation at the Zoo, on the INL Site, and throughout Idaho.

2.7.6 Local Elementary and High Schools

All About Bats, *Idaho Ecology*, and *Green Energy* presentations were given to 1,020 students in classrooms from Rockland to Ashton and from Challis to Driggs. Those presentations also occurred during a summer Science, Technology, Engineering, and Math (STEM) Scholars Camp and at a workshop held in conjunction with the Museum of Idaho at Harriman State Park during the bat segment of the wildlife workshop.

2.7.7 Elementary and High School Teachers' Workshops

Twenty teachers were taught during Project Wild Workshops about local bats, conservation, and acoustic monitoring.

2.7.8 Collaboration with Local Universities

Training was provided on the basics of bat acoustic detectors to 35 biology students at Brigham Young University-Idaho. Fundamental skills were taught for analyzing bat call files using the Kaleidoscope software.

Collaboration was made with a student on a M.S. project at Idaho State University. Efforts included acoustically monitoring with stationary detectors from June to September along the South Fork of the Snake River and in the Sand Creek Desert, for little brown myotis, as well as for the other six bat species in that area—all of which are species of conservation concern in Idaho (IDFG 2017)—to quantify peaks and hot spots of bat activity using acoustical detectors (López-Baucells et al. 2021, Milchram et al. 2020). Data collected from those areas will be compared with similar data collected on the INL Site.

This project will initiate substantial monitoring of bat habitat use in southeastern Idaho and provide baseline data using activity indices in several habitats before the potential impact of WNS in this area. Data from those surveys will be provided to the IDFG, USFWS, DOE-ID, and other collaborators for the management and conservation of bats and their habitat. These data can then be used by those agencies to prioritize where, when, and how often to sample to detect the potential arrival of WNS in these areas.

3. Assess Conservation Measures for Bats

The INL Site Bat Protection Plan ensures protection of sensitive bat resources through adherence to recommended conservation measures. Conservation measures in the Bat Protection Plan were developed in collaboration with IDFG and USFWS bat biologists. Those measures have been considered during project planning and NEPA analysis on the INL Site. After the Bat Protection Plan was finalized in 2018, INL contractors began implementing management recommendations into planning and daily work activities. Procedural documents have utilized the Bat Protection Plan to provide guidance to INL managers and personnel regarding encounters with live or dead bats. Those documents also address seasonal activities that may affect summer roosts.

The Bat Protection Plan also provides guidance for activities proposed under recent NEPA evaluations. The Environmental Review Process at the INL determines the level of review for every proposed action and provides directions for compliance with all associated environmental aspects. Most proposed actions at the INL only meet the threshold for a categorical exclusion and are analyzed using an Environmental Compliance Permit (ECP). Each ECP is reviewed by Technical Points of Contacts to ensure all aspects relating to their field are addressed appropriately. The Natural Resources Technical Points of Contact who review ECPs, are responsible for including language associated with the conservation measures outlined in the Bat Protection Plan. Recent proposed actions that required review beyond that of an ECP (i.e., Environmental Impact Statement or Environmental Assessment) and supporting documents that cite the Bat Protection Plan and associated conservation measures included National Reactor Innovation Center.

4. RECOMMENDATIONS FOR ADDITIONAL STUDIES, MANAGEMENT ACTIONS, AND PLAN REVISIONS

4.1 Additional Studies

4.1.1 Hibernacula Surveys around Middle Butte

Acoustic detectors are effective at identifying bat species across habitat types (Britzke et al. 2000, Miller 2001), and these devices have been used extensively to study bat winter ecology (Bernard et al. 2017, Klüg-Baerwald et al. 2016, Whiting et al. 2022). Little is known about bat hibernation behavior, especially in natural, rock-crevice hibernacula (Johnson et al. 2017, White et al. 2020). Middle Butte is an elevated block of basalt flows (Spear and King 1982) that provides a diverse area of potential bat habitat and hibernation locations in the rock fall. The rock fall in the butte consists of large elevation and aspect gradients that may comprise temperature and humidity regimes that can be suitable for hibernation. In summer 2022, a search was conducted around Middle Butte for potential roosting and hibernation habitat for bats in the rock fall. Several areas were identified that could be used for roosting and hibernation sites on the north, northeast, and west sides of the butte. It is proposed to set Anabat detectors around Middle Butte during winter (November 1 to March 31) in those areas to document if the rock fall around the butte is used by hibernating bats. It is also proposed to set Anabat detectors around Middle Butte in those areas during maternity season (June 1 to August 31) to document if the rock fall around the butte is used by lactating females.

4.1.2 Setting Mist Nets at Facilities and Caves

Capturing bats in mist nets is an important way to gather information on species confirmation, richness, and diversity in an area, as well as to determine sex, age, and reproductive status of bats (O'Farrell and Gannon 1999, Francl et al. 2012). Mist netting for bats has occurred historically on the INL Site (Whiting et al. 2015). Current data for bat species occurring around facilities and caves are needed, this is especially true with the impending decision regarding little brown myotis and the potential for this species to be listed under the ESA. It is proposed to mist net around the eight facilities and three caves—Middle Butte, Rattlesnake, and Aviators caves (the three largest hibernacula on the INL Site). This trapping will occur from June 1 to August 31 on nights with suitable moon phase. When capturing bats, a determination will be made on sex, species, and if females are lactating (Gruver and Keinath 2006, Holloway and Barclay 2001, Krochmal and Sparks 2007). Doing such will provide important data for the different species occurring around facilities and caves and will help biologists at the INL Site understand the use of facilities and caves by lactating females.

4.1.3 Surveys of Bridges and Culverts

Bridges and culverts provide important roosting habitat for bats (Adams 2003). On August 24, 2022, preliminary surveys were conducted of 22 bridges and culverts for bats on the INL Site using protocols adopted by the USFWS (USFWS 2020). Bridges and culverts were searched for roosting bats, guano, discarded insect wings, and staining on the walls and ceilings of structures from urine and feces (USFWS 2020). Of the 22 structures surveyed, no roosting bats were observed, but six structures with guano, three structures with discarded insect wings, and one structure with staining on the walls and ceilings were observed. It is proposed to continue surveying those features where bat sign was documented in 2022. This surveying would include night-time visual surveys for roosting bats, deploying Anabat detectors near bridges and culverts, and potentially setting mist nets at these features.

4.2 Management Actions

With the impending, potential listing of the little brown myotis under the ESA, it is planned to produce an INL Site-wide communication regarding the basics of the ESA, the management regulations of a listed species under that Act, and the handling and transporting of little brown myotis that are found on the INL Site.

4.3 Plan Revisions

There are no major plan revisions proposed at this time.

5. REFERENCES

Adams, R. A., 2003, “Bats of the Rocky Mountain West: Natural History, Ecology, and Conservation,” *University Press of Colorado*, Boulder, CO, USA.

Bernard, R. F., and G. F. McCracken, 2017, “Winter behavior of bats and the progression of white-nose syndrome in the southeastern United States,” *Ecology and Evolution*, Vol. 7, No. 5, pp. 1487-96.

Bosworth, W. R., 1994, “Characteristics of winter activity in *Plecotus townsendii* in southeastern Idaho,” M.S. thesis, Idaho State University, Pocatello, ID, USA.

Britzke, E. R., E. H. Gillam, and K. L. Murray, 2013, “Current state of understanding of ultrasonic detectors for the study of bat ecology,” *Acta Theriologica*, Vol. 58, No. 2, pp. 109-17.

Britzke, E. R., B. A. Slack, M. P. Armstrong, and S. C. Loeb, 2010, “Effects of orientation and weatherproofing on the detection of bat echolocation calls,” *Journal of Fish and Wildlife Management*, Vol. 1, No. 2, pp. 136-41.

Britzke, E. R., and K. L. Murray, 2000, "A quantitative method for selection of identifiable search-phase calls using the Anabat system," *Bat Research News*, Vol. 41, No. 2, pp. 33-36.

Brooks, R. T., 2011, "Declines in summer bat activity in central New England 4 years following the initial detection of white-nose syndrome," *Biodiversity and Conservation*, Vol. 20, No. 11, pp. 2537-41.

Clement, M. J., J. A. Royle, and R. J. Mixan, 2022, "Estimating occupancy from autonomous recording unit data in the presence of misclassifications and detection heterogeneity," *Methods in Ecology and Evolution*, Vol. 13, pp. 1719–29.

DOE, 2021, "2020 Idaho National Laboratory Annual Site Environmental Report," U.S. Department of Energy Idaho Operations Office, Idaho Falls, ID, USA, DOE/ID-12082(20).

DOE, 2022, "2021 Idaho National Laboratory Annual Site Environmental Report," U.S. Department of Energy Idaho Operations Office, Idaho Falls, ID, USA, DOE/ID-12082(21).

Doering, B., J. C. Whiting, and B. Bybee, 2018, "Idaho National Laboratory Site Bat Protection Plan," U.S. Department of Energy Idaho Operations Office, Idaho Falls, ID, USA.

Dzal, Y., L. P. McGuire, N. Veselka, and M. B. Fenton, 2010, "Going, going, gone: the impact of white-nose syndrome on the summer activity of the little brown bat (*Myotis lucifugus*)," *Biology Letters*, Vol. 7, No. 3, pp. 392-94.

Ednie, G., D. M. Bird, and K. H. Elliott, 2021, "Fewer bat passes are detected during small, commercial drone flights," *Scientific Reports*, Vol. 11, No. 1, pp. 1-8.

Ellison, L. E., T. J. O'Shea, M. A. Bogan, A. L. Everette, and D. M. Schneider, 2003, "Existing data on colonies of bats in the United States: summary and analysis of the U.S. Geological Survey's Bat Population Database," in T. J. O'Shea and M. A. Bogan (Eds.), "*Monitoring trends in bat populations of the United States and territories: problems and prospects,"* U.S. Geological Survey, Biological Resources Discipline, Information and Technology Report, USGS/BRD/ITR--2003–0003, 274 p.

Francl, K. E., W. M. Ford, D. W. Sparks, and V. Brack Jr, 2012, "Capture and reproductive trends in summer bat communities in West Virginia: Assessing the impact of white-nose syndrome," *Journal of Fish and Wildlife Management*, Vol. 3, No. 1, pp. 33-42.

Fraser, E. E., A. Silvas, R. M. Brigham, and Z. J. Czenze, 2020, "Bat echolocation research: a handbook for planning and conducting acoustic studies," *Bat Conservation International*, Austin, TX, USA.

Frick, W. F., J. F. Pollock, A. C. Hicks, K. E. Langwig, D. S. Reynolds, G. G. Turner, C. M. Butchkoski, and T. H. Kunz, 2010, "An emerging disease causes regional population collapse of a common North American bat species," *Science*, Vol. 329, No. 5992, pp. 679-82.

Frick, W. F., 2013, "Acoustic monitoring of bats, considerations of options for long-term monitoring," *Therya*, Vol. 4, No. 1, pp. 69-78.

IDFG, 2017, "Idaho State Wildlife Action Plan," 2015. Idaho Department of Fish and Game, Boise, ID, USA.

Genter, D. L., 1986, "Wintering bats of the upper Snake River Plain: occurrence in lava-tube caves," *Great Basin Naturalist*, Vol. 46, No. 2, pp. 241-44.

Gillies, K. E., P. J. Murphy, and M. D. Matocq, 2014, "Hibernacula characteristics of Townsend's big-eared bats in southeastern Idaho," *Natural Areas Journal*, Vol. 34, pp. 24-30.

Gruver, J. C., and D. A. Keinath, 2006, "Townsend's big-eared bat (*Corynorhinus townsendii*): a technical conservation assessment," *USDA Forest Service*, Rocky Mountain Region, Lakewood, CO, USA.

Hammerson, G. A., M. Kling, M. Harkness, M. Ormes, and B. E. Young, 2017, "Strong geographic and temporal patterns in conservation status of North American bats," *Biological Conservation*, Vol. 212, pp. 144-52.

Haymond, S., and D. S. Rogers, 1999, "Habitat use by summer populations of bats in sagebrush-steppe." In *ESRF Annual Technical Report: Calendar Year 1998*, Idaho Falls, ID, USA.

Hein, C. D., and M. R. Schirmacher, 2016, "Impact of wind energy on bats: a summary of our current knowledge," *Human-Wildlife Interactions*, Vol. 10, No. 1, pp. 19-27.

Holloway, G. L., and R. M. R. Barclay, 2001, "*Myotis ciliolabrum*," *Mammalian Species*, Vol. 670, pp. 1-5.

Hoyt, J. R., A. M. Kilpatrick, and K. E. Langwig, 2021, "Ecology and impacts of white-nose syndrome on bats," *Nature Reviews Microbiology*, Vol. 19, pp. 196-210.

Ingersoll, T. E., B. J. Sewall, and S. K. Amelon, 2016, "Effects of white-nose syndrome on regional population patterns of 3 hibernating bat species," *Conservation Biology*, Vol. 30, No. 5, pp. 1048-59.

Johnson, J. S., J. J. Treanor, M. J. Lacki, M. D. Baker, G. A. Falxa, L. E. Dodd, A. G. Waag, and E. H. Lee, 2017, "Migratory and winter activity of bats in Yellowstone National Park," *Journal of Mammalogy*, Vol. 98, No. 1, pp. 211-21.

Klüg-Baerwald, B. J., L. E. Gower, C. L. Lausen, and R. M. Brigham, 2016, "Environmental correlates and energetics of winter flight by bats in southern Alberta, Canada," *Canadian Journal of Zoology*, Vol. 94, No. 12, pp. 829-36.

Knudsen, G. R., R. D. Dixon, and S. K. Amelon, 2013, "Potential spread of white-nose syndrome of bats to the Northwest: epidemiological considerations," *Northwest Science*, Vol. 87, No. 4, pp. 292-306.

Krochmal, A. R., and D. W. Sparks, 2007, "Timing of birth and estimation of age of juvenile *Myotis septentrionalis* and *Myotis lucifugus* in west-central Indiana," *Journal of Mammalogy*, Vol. 88, No. 3, pp. 649-56.

Langwig, K. E., J. R. Hoyt, K. L. Parise, J. Kath, D. Kirk, W. F. Frick, J. T. Foster, and A. M. Kilpatrick, 2015, "Invasion dynamics of white-nose syndrome fungus, midwestern United States, 2012-2014," *Emerging Infectious Diseases*, Vol. 21, No. 6, pp. 1023-26.

Lausen, C. L., and R. M. R. Barclay, 2006, "Winter bat activity in the Canadian prairies," *Canadian Journal of Zoology*, Vol. 84, No. 8, pp. 1079-86.

Laverty, T. M., and J. Berger, 2022, "Indirect effects of African megaherbivore conservation on bat diversity in the world's oldest desert," *Conservation Biology*, Vol. 36, No. 2, pp. e13780.

Loeb, S. C., T. J. Rodhouse, L. E. Ellison, C. L. Lausen, J. D. Reichard, K. M. Irvine, T. E. Ingersoll, J. T. H. Coleman, W. E. Thogmartin, and J. R. Sauer, 2015, "A plan for the North American bat monitoring program (NABat)," *Gen. Tech. Rep. SRS-208. Asheville, NC: US Department of Agriculture Forest Service,* Southern Research Station, Vol. 208, No. 1-100.

López-Baucells, A., N. Yoh, R. Rocha, P. E. D. Bobrowiec, J. M. Palmeirim, and C. F. J. Meyer, 2021, "Optimizing bat bioacoustic surveys in human-modified Neotropical landscapes," *Ecological Applications*, Vol. 31, No. 6, pp. e02366.

Lorch, J. M., J. M. Palmer, D. L. Lindner, A. E. Ballmann, K. G. George, K. Griffin, S. Knowles, J. R. Huckabee, K. H. Haman, C. D. Anderson, P. A. Becker, J. B. Buchanan, J. T. Foster, and D. S. Blehert, 2016, "First detection of bat white-nose syndrome in Western North America," *mSphere*, Vol. 1, No. 4, pp. e00148-16.

Marroquin, C. M., J. O. Lavine, and S. T. Windstam, 2017, "Effect of humidity on development of *Pseudogymnoascus destructans*, the causal agent of bat white-nose syndrome," *Northeastern Naturalist*, Vol. 24, No. 1, pp. 54-64.

Milchram, M., M. Suarez-Rubio, A. Schröder, and A. Bruckner, 2020, "Estimating population density of insectivorous bats based on stationary acoustic detectors: A case study," *Ecology and Evolution*, Vol. 10, No. 3, pp. 1135-44.

Miller, B. W., 2001, "A method for determining relative activity of free flying bats using a new activity index for acoustic monitoring," *Acta Chiropterologica*, Vol. 3, No. 1, pp. 93-105.

Nocera, T., W. M. Ford, A. Silvis, and C. A. Dobony, 2019, "Patterns of acoustical activity of bats prior to and 10 years after WNS on Fort Drum Army Installation, New York," *Global Ecology and Conservation*, Vol. 18, pp. e006333.

O'Farrell, M. J., and W. L. Gannon, 1999, "A comparison of acoustic versus capture techniques for the inventory of bats," *Journal of Mammalogy*, Vol. 80, No. 1, pp. 24-30.

O'Shea, T. J., P. M. Cryan, and M. A. Bogan, 2018, "United States bat species of concern: a synthesis," *Proceedings of the California Academy of Sciences*, Vol. 65, pp. 1-279.

Prendergast, J. A., W. E. Jensen, and S. D. Roth, 2010, "Trends in abundance of hibernating bats in a karst region of the southern Great Plains," *Southwestern Naturalist*, Vol. 55, No. 3, pp. 331-39.

Reynolds, D. S., K. Shoemaker, S. von Oettingen, and S. Najjar, 2017, "High rates of winter activity and arousals in two New England bat species: implications for a reduced white-nose syndrome impact?" *Northeastern Naturalist*, Vol. 24, No. B188-B208.

Reynolds, T. D., J. W. Connelly, D. K. Halford, and W. J. Arthur, 1986, "Vertebrate fauna of the Idaho National Environmental Research Park," *Great Basin Naturalist*, Vol. 46, No. 3, pp. 513-27.

Richardson, S. M., P. R. Lintott, D. J. Hosken, T. Economou, and F. Mathews, 2021, "Peaks in bat activity at turbines and the implications for mitigating the impact of wind energy developments on bats," *Scientific Reports*, Vol. 11, No. 1, pp. 1-6.

Safford, M., 1990, "Bat population study Fort Stanton Cave," *Bulletin of the National Speleological Society*, Vol. 51, No. 1, pp. 42-46.

Schwab, N. A., and T. J. Mabee, 2014, "Winter acoustic activity of bats in Montana," *Northwestern Naturalist*, Vol. 95, No. 1, pp. 13-27.

Sherwin, R. E., W. L. Gannon, and J. S. Altenbach, 2003, "Managing complex systems simply: understanding inherent variation in the use of roosts by Townsend's big-eared bat," *Wildlife Society Bulletin*, Vol. 31, No. 1, pp. 62-72.

Skalak, S. L., R. E. Sherwin, and R. M. Brigham, 2012, "Sampling period, size and duration influence measures of bat species richness from acoustic surveys," *Methods in Ecology and Evolution*, Vol. 3, No. 3, pp. 490-502.

Spear, D. B., and J. S. King, 1982, "The geology of Big Southern Butte, Idaho," *Cenozoic geology of Idaho: Idaho Bureau of Mines and Geology Bulletin*, Vol. 26, pp. 395-403.

Stahlschmidt, P., and C. A. Bruhl, 2012, "Bats as bioindicators - the need of a standardized method for acoustic bat activity surveys," *Methods in Ecology and Evolution*, Vol. 3, No. 3, pp. 503-08.

Torres-Cruz, T. J., A. Porras-Alfaro, N. A. Caimi, O. Nwabologu, E. W. Strach, K. J. H. Read, J. M. Young, D. C. Buecher, and D. E. Northup, 2019, "Are microclimate conditions in El Malpais National Monument caves in New Mexico, USA suitable for *Pseudogymnoascus* growth?" *International Journal of Speleology*, Vol. 48, No. 2, pp. 7.

USFWS, 2020, "Federal Transportation Agency/State Department of Transportation (DOT) Preliminary Guidelines for Using the Bridge/Structure Bat Assessment Form," https://www.fws.gov/sites/default/files/documents/appendix-d-bridge-structure-bat-assessment-form-guidance-april-2020.pdf.

Vanderwolf, K. J., D. F. McAlpine, G. J. Forbes, and D. Malloch, 2012, "Bat populations and cave microclimate prior to and at the outbreak of white-nose syndrome in New Brunswick," *The Canadian Field-Naturalist*, Vol. 126, No. 2, pp. 125-34.

Verant, M. L., J. G. Boyles, W. Waldrep, G. Wibbelt, and D. S. Blehert, 2012, "Temperature-dependent growth of *Geomyces destructans*, the fungus that causes bat white-nose syndrome," *PloS ONE*, Vol. 7, No. 9, pp. e46280.

Wackenhut, M. C., 1990, "Bat species overwintering in lava-tube caves in Lincoln, Gooding, Blaine, Bingham, and Butte counties, Idaho with special reference to annual return of banded *Plecotus townsendi*," M.S. Thesis, Idaho State University, Pocatello, ID, USA.

Warren, R. W., D. B. Hall, and P. D. Greger, 2014, "Radionuclides in bats using a contaminated pond on the Nevada National Security Site, USA," *Journal of Environmental Radioactivity*, Vol. 129, pp. 86-93.

Weller, T. J., T. J. Rodhouse, D. J. Neubaum, P. C. Ormsbee, R. D. Dixon, D. L. Popp, J. A. Williams, S. D. Osborn, B. W. Rogers, L. O. Beard, A. M. McIntire, K. A. Hersey, A. Tobin, N. L. Bjornlie, J. Foote, D. A. Bachen, B. A. Maxell, M. L. Morrison, S. C. Thomas, G. V. Oliver, and K. W. Navo, 2018, "A review of bat hibernacula across the western United States: Implications for white-nose syndrome surveillance and management," *PloS ONE*, Vol. 13, No. 10, pp. e0205647.

White, J. A., P. W. Freeman, H. W. Otto, and C. A. Lemen, 2020, "Winter use of a rock crevice by northern long-eared myotis (Myotis septentrionalis) in Nebraska," *Western North American Naturalist*, Vol. 80, No. 1, pp. 114-19.

White-nose Syndrome Conservation and Recovery Working Group, 2015, *Acceptable Management Practices for Bat Control Activities in Structures-A Guide for Nuisance Wildlife Control Operators,* S.S. Fish and Wildlife Service, Hadley, MA

Whiting, J. C., B. Doering, and K. Aho, 2021, "Long-term patterns of cave-exiting behavior of hibernating bats in nine caves in western North America," *Scientific Reports*, Vol. 11, pp. 8175.

Whiting, J. C., B. Doering, J. Lowe, D. K. Englestead, Justin A Frye, S. Earl, A. Earl, and B. Bybee, 2015, "Ecology, conservation, and management of bats in southeastern Idaho," Idaho Falls, ID, USA: U.S. Bureau of Land Managment.

Whiting, J. C., B. Doering, and D. Pennock, 2019, "Acoustic surveys for local, free-flying bats in zoos: an engaging approach for bat education and conservation," *Journal of Bat Research and Conservation*, Vol. 12, pp. 94-99.

Whiting, J. C., B. Doering, G. Wright, D. K. Englestead, J. A. Frye, and T. Stefanic, 2018a, "Bat hibernacula in caves of southern Idaho: implications for monitoring and management," *Western North American Naturalist*, Vol. 78, No. 2, pp. 165-73.

Whiting, J. C., B. Doering, G. Wright, D. K. Englestead, J. A. Frye, T. Stefanic, and B. J. Sewall, 2018b, "Long-term bat abundance in sagebrush steppe," *Scientific Reports*, Vol. 8, No. 1, pp. 12288.

Whiting, J. C., B. Doering, and K. Aho, 2022, "Can acoustic recordings of cave-exiting bats in winter estimate bat abundance in hibernacula?" *Ecological Indicators*, Vol. 137, pp. 108755.