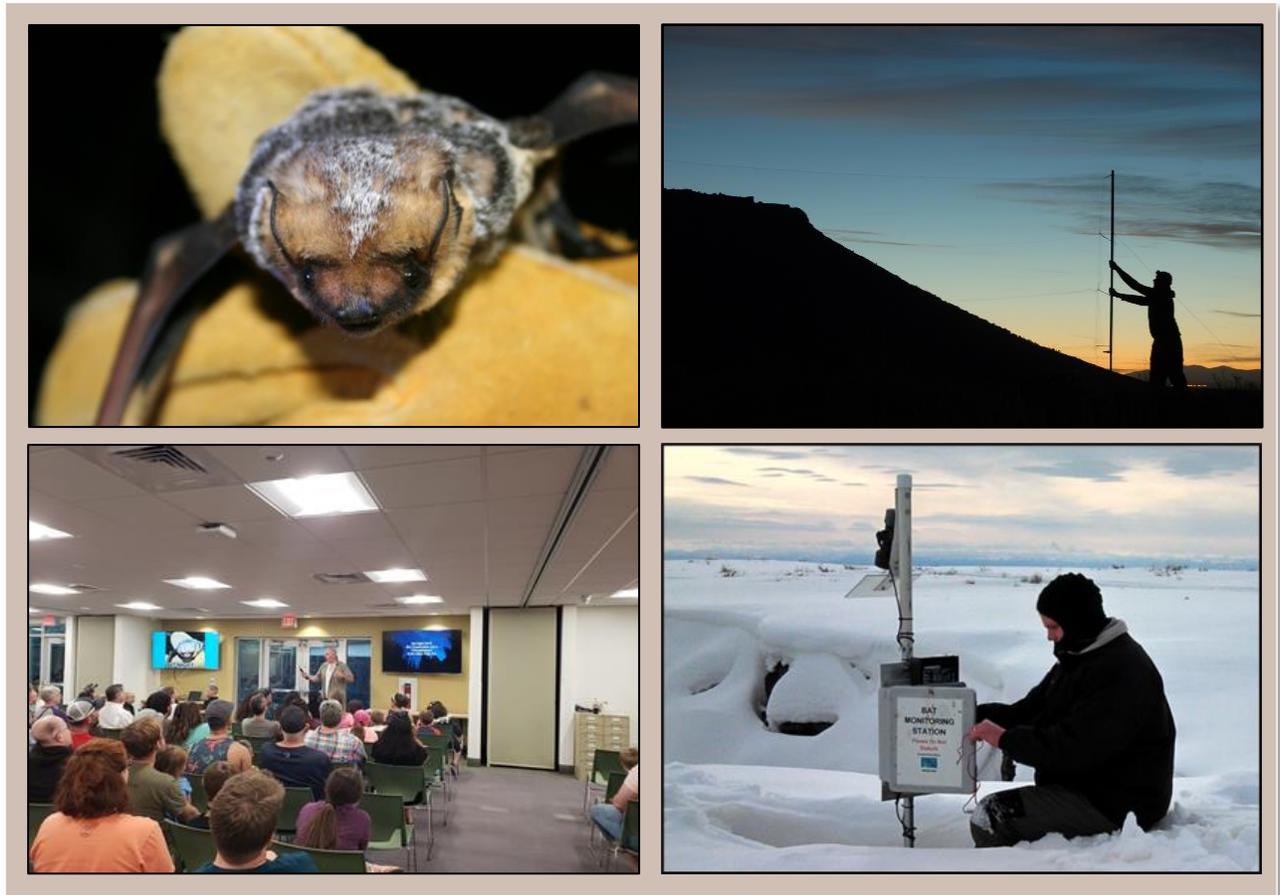


Idaho National Laboratory Site Bat Protection Plan Update

18 November 2020



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Acronyms

BLM	Bureau of Land Management
DOE-ID	U.S. Department of Energy, Idaho Operations Office
ESA	Endangered Species Act
ESER	Environmental Surveillance, Education, and Research
IDFG	Idaho Department of Fish and Game
INL	Idaho National Laboratory
NEPA	National Environmental Policy Act
NSTR	National Security Test Range
USFWS	U.S. Fish and Wildlife Service

1.0 Introduction

The Idaho National Laboratory (INL) Site is a U. S. Department of Energy, Idaho Operations Office (DOE-ID) reservation encompassing 890 mi² (230,509 ha) on the eastern Snake River Plain approximately 25 mi (40 km) west of Idaho Falls (Reynolds et al. 1986, Doering et al. 2018). The INL Site is federal property administered by the DOE-ID. The DOE-ID oversees operations at the INL Site (Doering et al. 2018). Support for land management and natural resources decisions for the INL Site is provided through the Environmental Surveillance, Education, and Research (ESER) Program operating under contract with the DOE-ID. The ESER Program conducts ecological monitoring on the INL Site to provide support to the DOE-ID for land-management and natural resource issues (Doering et al. 2018).

Bats are important ecosystem components on the INL Site (Whiting et al. 2015, Doering et al. 2018) 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 6 with heightened conservation concern (Whiting et al. 2015, Idaho Department of Fish and Game 2017, Doering et al. 2018). Since the early 1980s, the DOE-ID has supported bat monitoring on the INL Site (Genter 1986, Doering 1996, Haymond and Rogers 1999). 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 USA for the conservation of bats and their habitat (Genter 1986, Doering et al. 2018, Whiting et al. 2018a).

Over the past decade, the emergence of white-nose syndrome and large-scale, commercial wind-energy development have caused wide-spread mortality in bats (Hein and Schirmacher 2016, Ingersoll et al. 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 United States (Knudsen et al. 2013, O'Shea et al. 2016, O'Shea et al. 2018). In light of these conservation concerns for bats, in 2018 the DOE-ID produced a bat protection plan for the INL Site (Doering et al. 2018). Doering et al. (2018) indicated that 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 the 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 to facilitate the biological assessment and biological opinion process required by the Endangered Species Act (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 the 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 our monitoring program with biologists from the USFWS, Idaho Department of Fish and Game (IDFG), the Bureau of Land Management (BLM), 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; and
- 6) Tier bat conservation actions at the INL Site to the Idaho State Wildlife Action Plan.

2.0 Bat Protection Plan Update

This update will ensure that the USFWS, IDFG, and other collaborators have current information concerning bats on the INL Site. This update will also provide the following required information (Doering et al. 2018):

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

This plan update will be appended to revisions of the Bat Protection Plan (Doering et al. 2018). In conjunction with this update, the ESER contractor, DOE-ID, USFWS, and IDFG will meet to discuss changes in any section of the plan (e.g., fluctuations in trends of bat abundance on the INL Site), 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).

3.0 Describe Objectives, Methods, Results, and Interpret Findings from Monitoring Data

3.1 Hibernacula Counts

Estimation of long-term, population changes of bats is central for targeting management and providing important information for habitat management (Ingersoll et al. 2013, Whiting et al. 2018b). 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. 2018b). We conducted counts of hibernating bats on the INL Site between November 1 and March 31 using established protocols and care to minimize disturbing bats (Doering et al. 2018, Whiting et al. 2018b). We used counts from 2013 to 2018 conducted in all 8 known hibernacula on the INL Site, except Link Sausage Cave, to document number of Townsend's big-ear bats and western small-footed myotis by year (Whiting et al. 2015, Doering et al. 2018). We also used counts from 1993 to 2018 that were conducted using consistent methods to provide an historical view of population changes of bats in Middle Butte, Rattlesnake, and Aviators caves (the three largest hibernacula on the Site and the caves that have been consistently surveyed for the longest time on the INL Site).

From 2013 to 2018, for 24 surveys of hibernacula on the INL Site, the mean (\pm *SD*) number of investigators that entered caves and counted bats was 3 ± 1 investigator (range = 2 to 5 investigators). During those years, researchers counted 1,878 Townsend’s big-eared bats and 101 western small-footed myotis (Figure 1). In Middle Butte, Rattlesnake, and Aviators caves, during 18 hibernacula surveys from 1993 to 2018 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 (Figures 2 and 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 (Wackenhut 1990, Bosworth 1994, Whiting et al. 2018b) and because of variation in use of areas in hibernation sites, which influences observers seeing and counting those species (Safford 1990). Our counts of these species in 2018 fall within the normal variation of historical population counts on the INL Site (Figures 1, 2, and 3), which indicates that there is 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 animals (Ingersoll et al. 2013, Whiting et al. 2018b). Our data 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 white-nose syndrome 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).

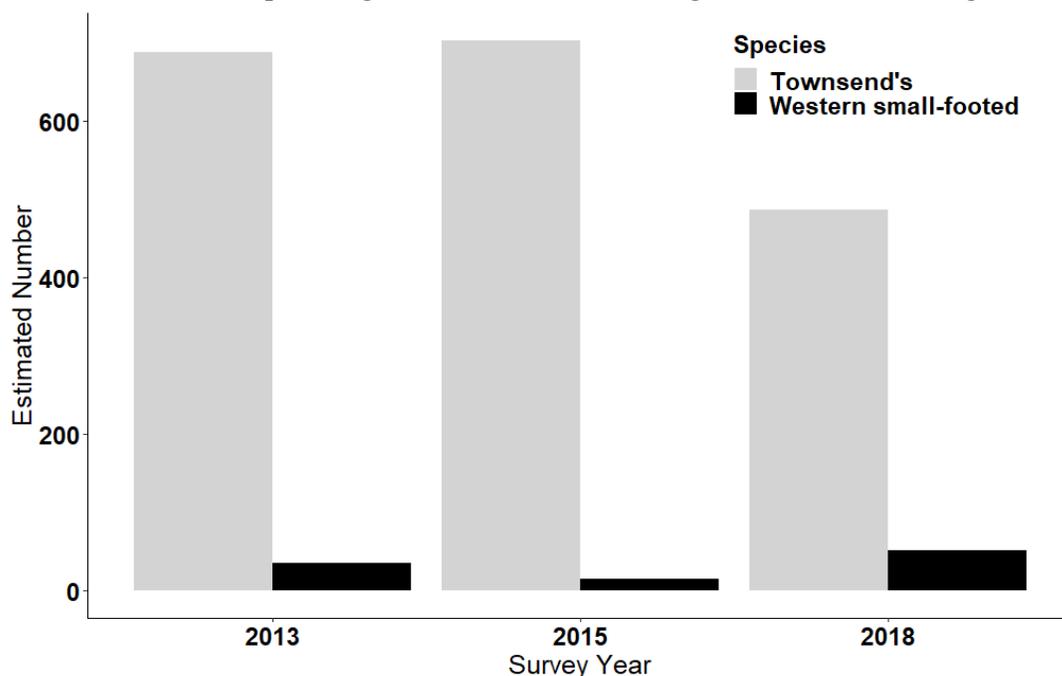


Figure 1. Number of bats counted in 8 caves on the INL Site in each year when consistent methods were used for surveys.

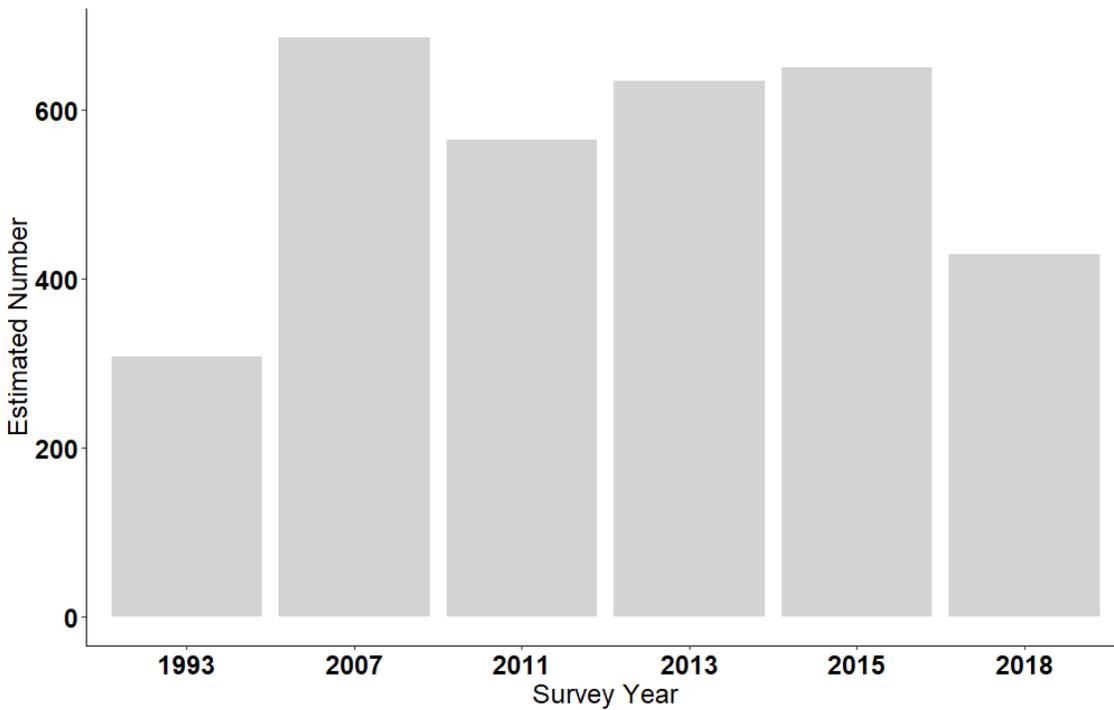


Figure 2. Number of Townsend's big-eared bats counted in Middle Butte, Rattlesnake, and Aviators caves on the INL Site in each year when consistent methods were used for surveys.

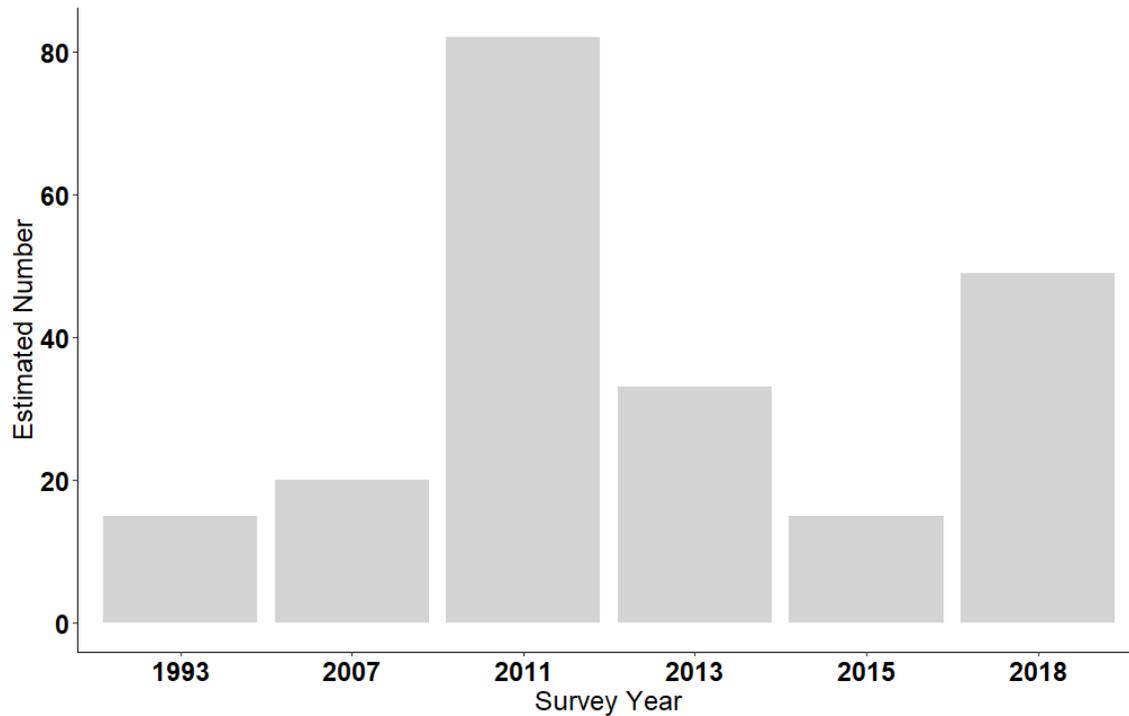


Figure 3. Number of western small-footed myotis counted in Middle Butte, Rattlesnake, and Aviators caves on the INL Site in each year when consistent methods were used for surveys.

3.2 **Passive Acoustic Monitoring**

3.2.1 **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 (O'Farrell et al. 1999, Britzke and Murray 2000, Miller 2001). These devices have been used extensively to study bat winter ecology (Lausen and Barclay 2006, Klüg-Baerwald et al. 2016, Bernard and McCracken 2017). Little is known about bat hibernation behavior in the western USA prior to the arrival of white-nose syndrome (Knudsen et al. 2013, Schwab and Mabee 2014, Weller et al. 2018). We set Anabat SD1 and SD2 detectors at 9 hibernacula on the INL Site during winter (1 November to 31 March) from 2011 to 2018. Detectors were powered by external batteries and solar panels (Lausen and Barclay 2006, Schwab and Mabee 2014, Reynolds et al. 2017). Each unit was equipped with a BatHat to reduce damage to equipment from rain, snow, and freezing temperatures (Britzke et al. 2010); Anabat units also had reflector plates oriented at 45° angle from the center axis of the microphone (Britzke et al. 2010, Skalak et al. 2012, Reynolds et al. 2017). Detectors were programmed to record at least from sunset to sunrise (Miller 2001, Johnson et al. 2017, Nocera et al. 2019), and the division ratio was set at eight (Skalak et al. 2012). We adjusted the sensitivity to exclude ambient noise (O'Farrell et al. 1999, Britzke et al. 2013, Whiting et al. 2019).

We placed microphones about 3 m above the ground and positioned them so the center axis of the zone of reception was approximately 15° above the horizon (Schwab and Mabee 2014, Klüg-Baerwald et al. 2016, Johnson et al. 2017). We oriented microphones to maximize detection near cave entrances while trying to avoid recording near-ground noise and echoes (O'Farrell et al. 1999, Britzke et al. 2010, Schwab and Mabee 2014). When triggered by bats flying outside of hibernacula, detectors created one, ≤ 15 sec. call file, labeled with a date and time stamp. We filtered call files for bat search-call phases by species in AnaLookW (Lausen and Barclay 2006, Britzke et al. 2013, Klüg-Baerwald et al. 2016). Additionally, B. Doering who has > 25 years of experience vetting bat calls in the western USA manually verified species for all files that passed filters. In our analyses, we used files per night containing at least one search-phase echolocation sequence of ≥ 2 echolocation pulses as our response variable (Britzke et al. 2010, Schwab and Mabee 2014, Klüg-Baerwald et al. 2016, Bernard and McCracken 2017). Weather data were collected from the National Oceanic and Atmospheric Administration weather station at MFC every 5 min. from ½ hour before sunset to ½ hour after sunrise each day (Whiting et al. In preparation).

From 2011 to 2018 at 9 caves, Anabat units recorded 2,204 nights equaling 17,243 files (Townsend's big-eared bat = 4,160 files, western small-footed myotis = 13,083 files). Mean (\pm *SD*) number of files recorded per night across caves for Townsend's big-eared bats was 2 (\pm 8.3, range = 0 to 220 files) and for western small-footed myotis was 6 (\pm 24.0, range = 0 to 570 files). We recorded Townsend's big-eared bats and western small-footed myotis in each month of winter, and western small-footed myotis were recorded on average 3 times more than Townsend's big-eared bats in winter, except December (Figure 4).

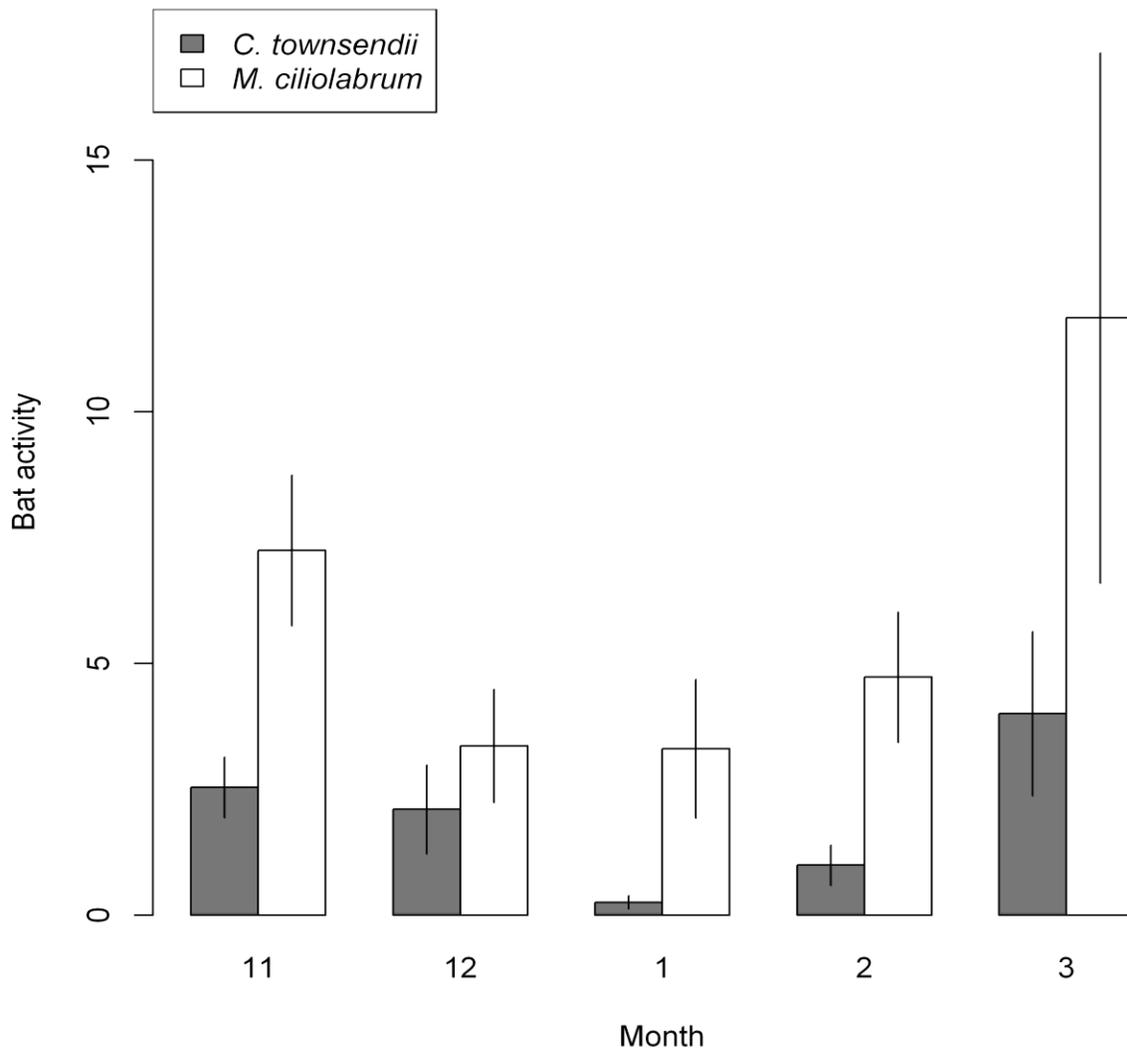


Figure 4. Mean cave-exiting activity (number of files \pm 95% CIs) averaged across 9 hibernacula for Townsend's big-eared bats (*Corynorhinus townsendii*) and western small-footed myotis (*Myotis ciliolabrum*) by month on the INL Site from 2011 to 2018.

During winter, temperature, wind speed, barometric pressure, and number of hibernating bats were the strongest predictors of bat activity for both species (Figure 5). Western small-footed myotis were more active at cold temperatures, high wind speeds, and higher change in barometric pressure than Townsend's big-eared bats (Figure 5a-d). At 0°C, predicted bat activity was 1.9 files/night for Townsend's big-eared bats and 5.9 files/night for western small-footed myotis (Figure 5a). At 10°C, predicted activity increased to 8.5 files/night for Townsend's big-eared bats and 31.7 files/night for western small-footed myotis (Figure 5a). Western small-footed myotis were more active with higher numbers of conspecifics than Townsend's big-eared bats (Figure 5d).

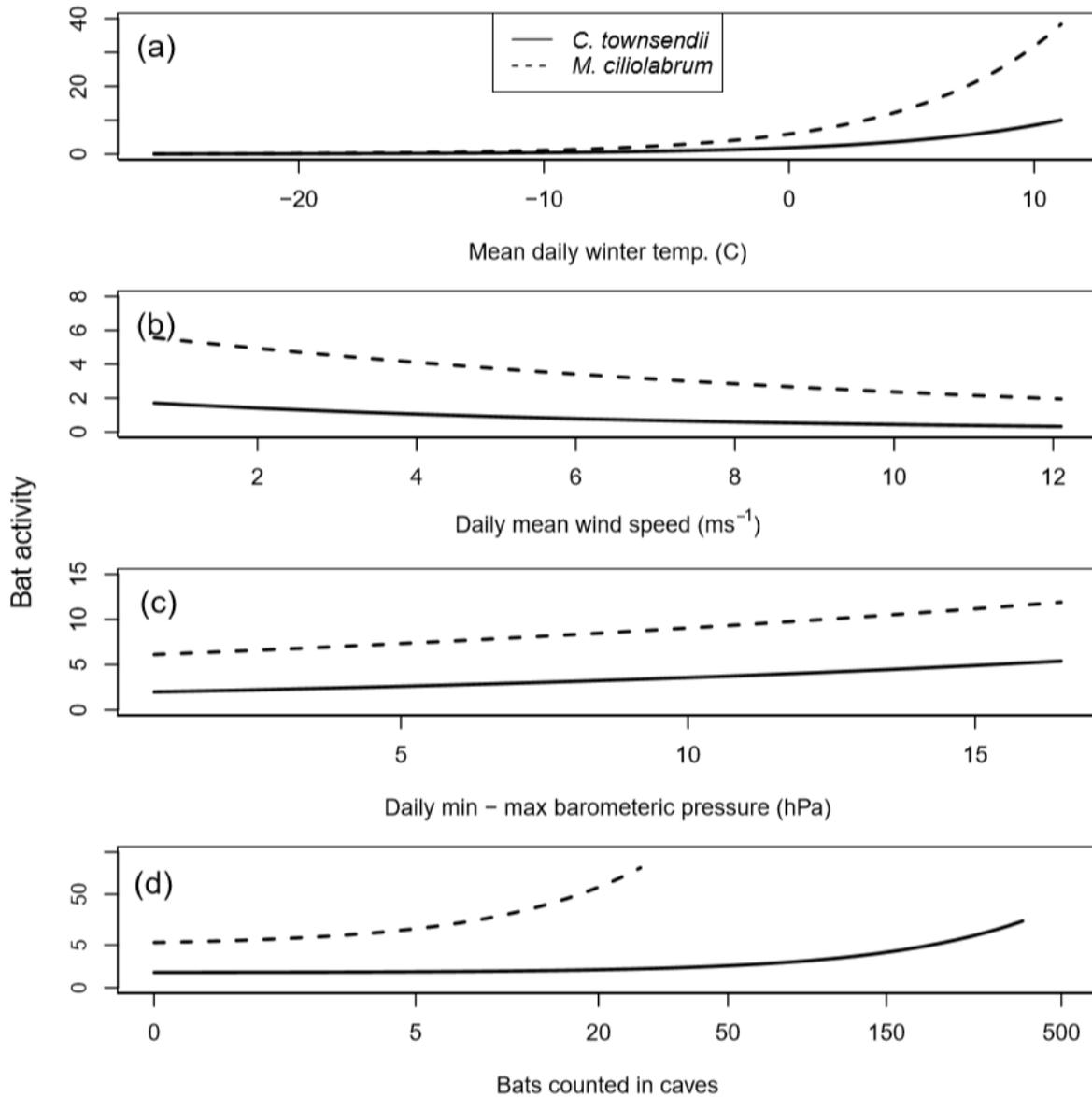


Figure 5. Cave-exiting activity (number of files/night) across 9 hibernacula for Townsend's big-eared bats (*Corynorhinus townsendii*) and western small-footed myotis (*Myotis ciliolabrum*) by (a) temperature, (b) wind speed, (c) barometric pressure, and (d) number of bats counted during hibernacula surveys on the INL Site from 2011 to 2018.

Much interest exists in developing long-term acoustic monitoring of bats (Dzal et al. 2010, 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 white-nose syndrome in the western North America (Lorch et al. 2016), it is important to understand cave-exiting behavior of bats (Johnson et al. 2012, Hayman et al. 2017). Our results provide insight into cave-exiting behavior of Townsend's big-eared bats and western small-

footed myotis and what environmental variables are important for that behavior. Our data also provide a long-term baseline dataset of that behavior, which can be used in future analyses to quantify the potential impact of white-nose syndrome on these species when this disease arrives on the INL Site (Whiting et al. In preparation).

3.2.2 Spring, Summer, and Autumn Passive Acoustic Monitoring

Monitoring bats throughout the year acoustically is important and can provide data for how white-nose syndrome and other stressors affect bat populations (Dzal et al. 2010, Brooks 2011, Francl et al. 2012). We set Anabat SD2 detectors from 2011 to 2019 at 8 facilities, 4 caves (Middle Butte, Rattlesnake, East Boundary, and Aviators caves), 1 around Middle Butte, and 1 in a random location around the INL Site to document occurrence of bat species and activity during the non-hibernation season (May to October). Each detector was programmed to record at least from sunset to sunrise (Miller 2001) and the division ratio was set at eight. We adjusted the sensitivity of Anabat detectors to exclude the ambient noise (Britzke et al. 2013). When triggered by a bat call, detectors created one, ≤ 15 sec file, labeled with a unique date and time stamp. For facility acoustic monitoring, we oriented detectors 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, we oriented microphones 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. We analyzed bat calls during summer the same way as our most recent winter data analysis (Whiting et al. In preparation).

For the monitoring summary analysis presented here, data from the years 2017 through 2019 were used. This represented data collected from completion of the final draft of the Bat Protection Plan up to the cut-off for this analysis. A total of 1,742,867 files were collected, with 1,033,057 of those containing identifiable bat echolocation calls or fragments. Ultimately, a total of 731,075 files were identified to species. During bat activity seasons (May through October) from 2017 to 2019 across all 8 facilities, Anabat units recorded 534,592 bat files. During that same period at Middle Butte, Rattlesnake, and Aviators caves (the main three bat caves), Anabat units recorded 498,465 bat files. We recorded 9 total species at facilities (Figure 6) and the mean ($\pm SD$) number of species recorded at each facility was 6 (± 1 species). Number of species detected at facilities ranged from four at NRF to seven at CFA, CITRC, and INTEC. We also recorded 9 species at caves (Figure 6), and the mean ($\pm SD$) number of species recorded at each cave was 8 (± 1 species). Little brown myotis and western small-footed myotis had the highest frequency of occurrence at facilities, while western small-footed myotis had the highest frequency of occurrence at caves (Figure 6). Tree bats (hoary and silver-haired bats) had a higher frequency of occurrence at facilities than caves (Figure 6).

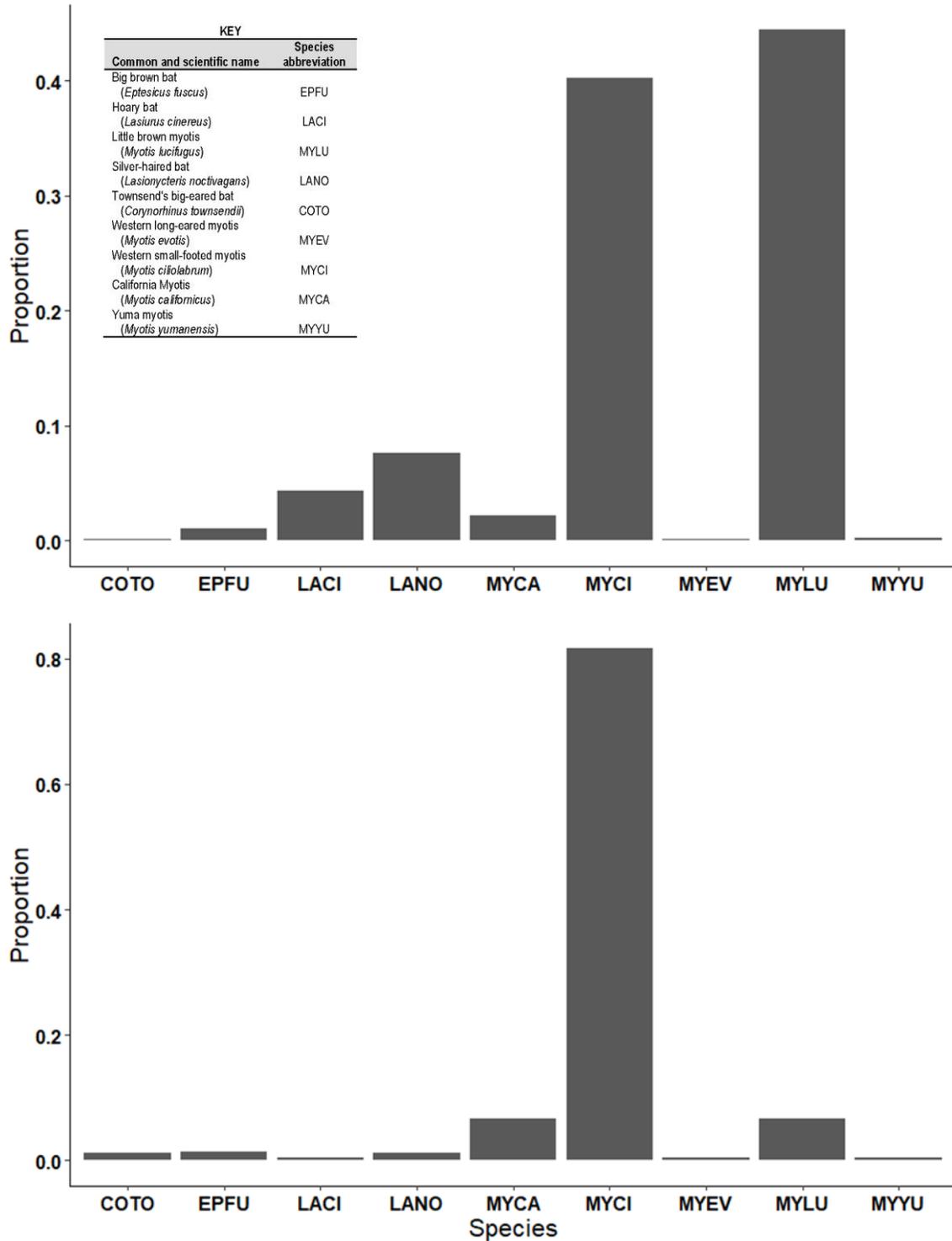


Figure 6. Proportion of call files of bat species documented at INL Site facilities (top) and at Middle Butte, Rattlesnake, and Aviators caves (bottom) during May to October from 2017 to 2019.

3.3 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). Active acoustic monitoring for bats along drivable transects is part of that monitoring effort (Loeb et al. 2015). In conjunction with the IDFG, BLM, USFWS, and U.S. Forest Service; the ESER Program developed two preliminary driving transects on the INL Site that followed methods described in the NABat protocol (Figure 7, Loeb et al. 2015). We drove those routes once a month, June through September, and followed established methods described in Loeb et al. (2015) to document bats. After surveys, all files were manually reviewed in AnaLookW to determine species. In 2018, we discontinued surveys along the Buttes Route, because we were not able to safely follow the methods for those surveys (i.e., driving speed). During that year, on the Lincoln Route we recorded 17 bat files (June = 1, July = 2, August = 2, and September = 12) 77% of those were of big brown bats and silver-haired bats. In 2019, we surveyed the Lincoln Route and recorded 54 bat files (June = 3, July = 2, August = 30, and September = 19). Again, 94% of those files were big brown bats and silver-haired bats. These data indicate that driving transects may not be as applicable on the INL Site as stationary detectors at caves and facilities. These data have been sent to the Bat Hub at Oregon State University and to the IDFG to help establish NABat sampling in Idaho.

3.4 White-nose Syndrome Surveillance

White-nose syndrome is a recent threat to many bats that hibernate in caves (Blehert et al. 2009, Frick et al. 2010) and has killed over five million bats in seven species (Bernard and McCracken 2017). Many common bat species could be at risk of significant declines or extinction due to this disease (Hammerson et al. 2017). Primarily a disease occurring in the eastern USA (Ingersoll et al. 2013, 2016), white-nose syndrome is now in the western USA (Lorch et al. 2016). In some areas of southern Idaho, the general conditions of humidity and temperature exist in caves for growth of *Pseudogymnoascus destructans*, the fungus that causes white-nose syndrome (Knudsen et al. 2013, Gillies et al. 2014). With the arrival of this disease in the western USA, it is important to understand which bats on the INL Site that could be affected by this disease (Table 1, Whiting et al. 2018a).

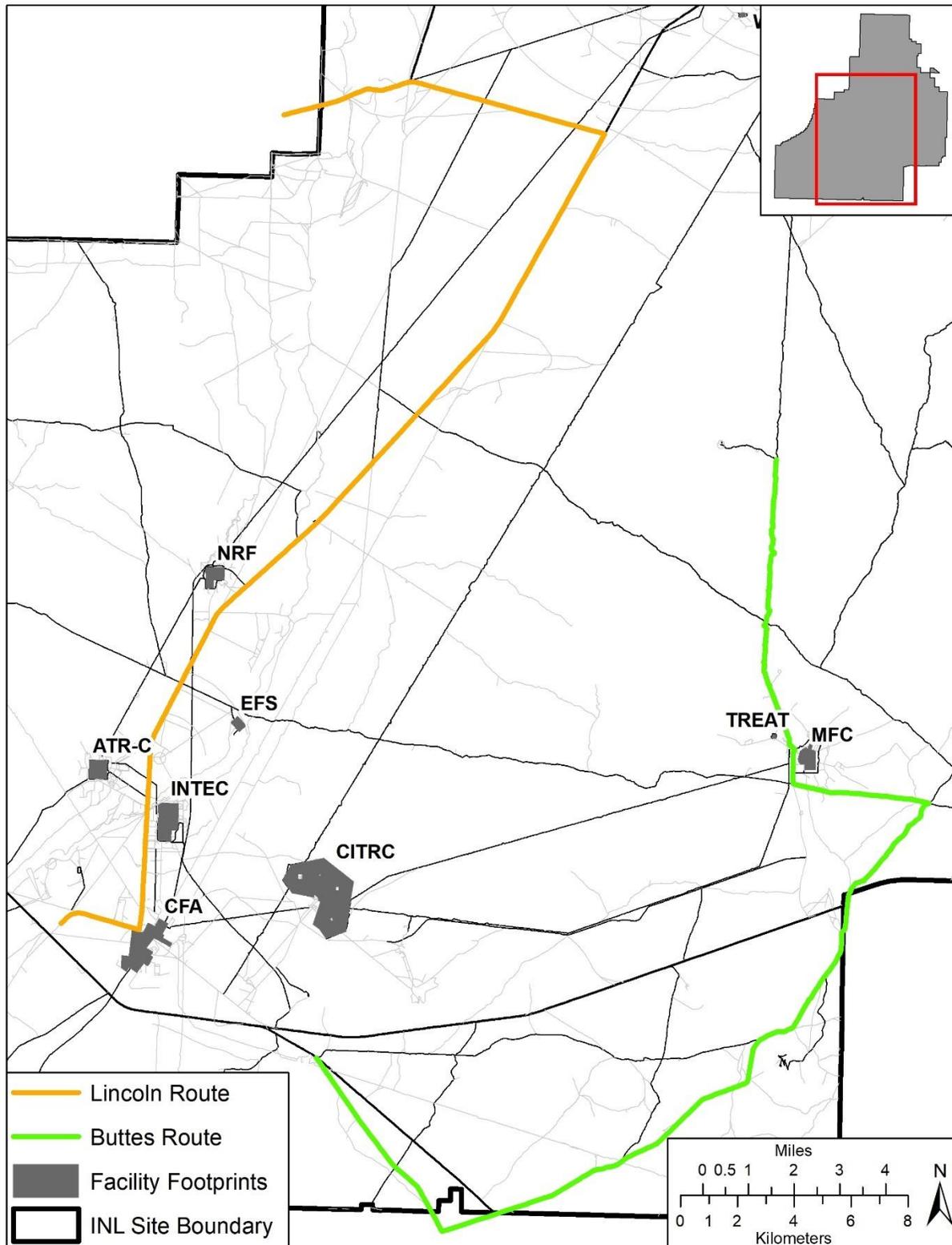


Figure 7. Preliminary driving routes for NABat transects established in 2014 to monitor bats on the INL Site. These routes were approximately 30 miles (48 km) long.

Table 1. Bat species and potential for these species to be infected with, or carriers of, the fungus *Pseudogymnoascus destructans* that causes white-nose syndrome.

Common name	Potential or confirmed white-nose syndrome susceptible species
Big brown bat	Yes ¹
Hoary bat	No ¹
Little brown myotis	Yes ¹
Silver-haired bat	Carrier of fungus ^{1,2}
Townsend's big-eared bat	Carrier of fungus ^{1,2}
Western long-eared myotis	Yes ¹
Western small-footed myotis	Carrier of fungus ¹
California Myotis	Yes
Fringed Myotis	Yes ¹
Long-legged myotis	Yes ¹
Yuma myotis	Yes ¹

¹<https://www.whitenosesyndrome.org/static-page/bats-affected-by-wns>

²Bernard et al. (2015)

3.4.1 Cave Temperatures and Humidity

The growth of the fungus that causes white-nose syndrome—*Pseudogymnoascus destructans*—is restricted by cave temperature and humidity (Vanderwolf et al. 2012, Verant et al. 2012, Torres-Cruz et al. 2019). Quantifying temperature and humidity in caves on the INL Site are important for understanding the potential for white-nose syndrome to become established in caves on the Site. We placed HOBO data loggers in 8 hibernacula on the INL Site from 2014 to 2015. Data loggers were placed in areas where bats had been observed previously. Those devices recorded temperature (°C) and humidity (% relative humidity) every 15 minutes beginning November 1. We then averaged temperatures by caves across days for each hibernation month, as well as for minimum and maximum temperatures for each month. Because of a malfunctioning data logger, we were not able to gather data from College Cave. All caves, except Middle Butte and College caves had humidity levels that would not support *Pseudogymnoascus destructans*. Middle Butte Cave had several intervals through the winter where condensing humidity conditions existed (i.e., dewpoint equal to ambient temperature). All caves on the INL Site had temperatures that were below the optimal growth for *Pseudogymnoascus destructans*, especially during January to March (Figure 8).

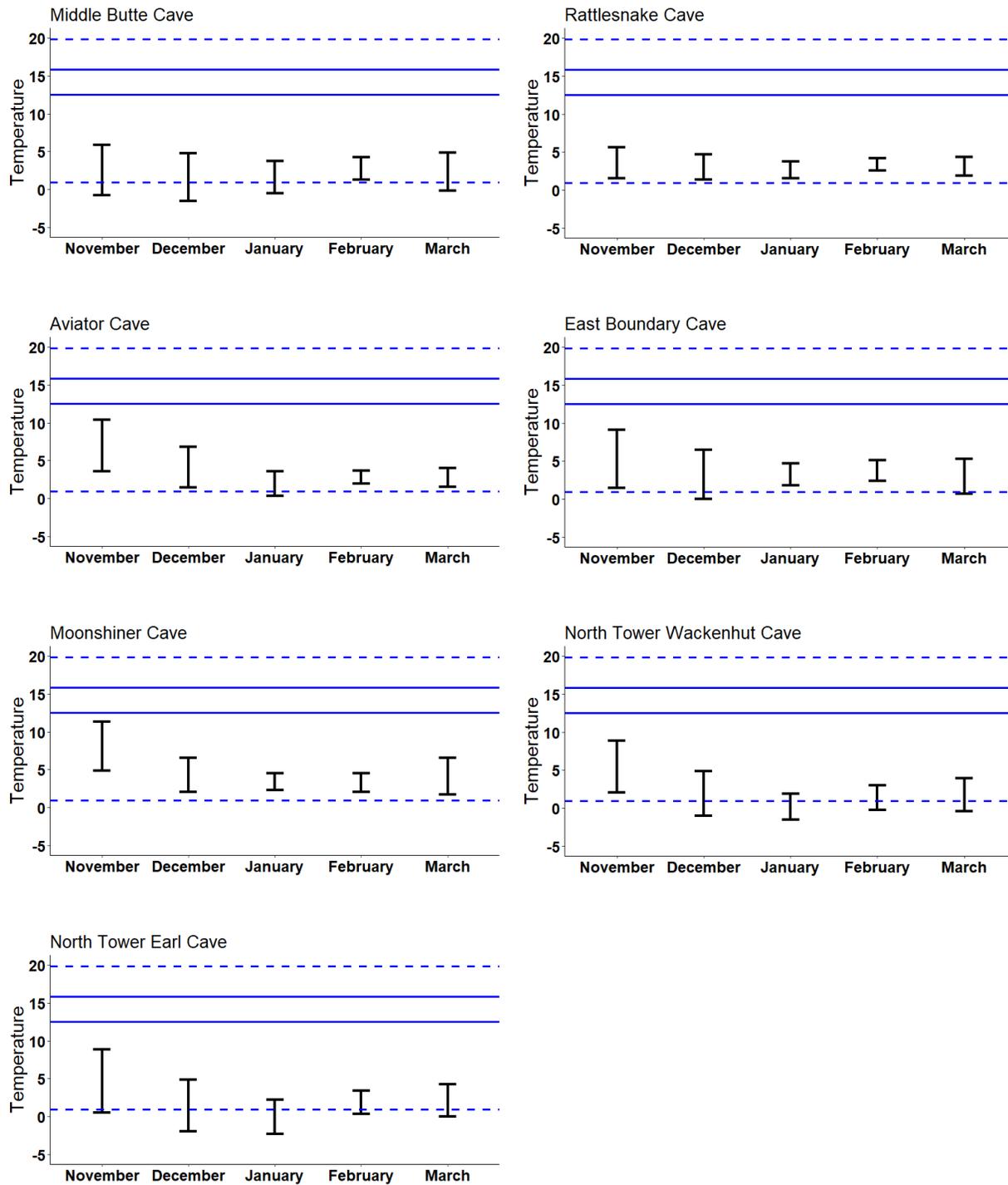


Figure 8. Average range of temperatures (°C) by month in 7 caves on the INL Site from November 2014 to March 2015. The solid blue lines represent the optimal range of temperatures for growth of *Pseudogymnoascus destructans*, while the dashed blue lines represent the range of temperatures for active growth of *Pseudogymnoascus destructans* (Verant et al. 2012).

3.4.2 Capturing Bats in Mist Nets

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, Kunz et al. 2009). We set mist nets at the runoff pond west of MFC on July 30 and August 1, 2019 during the new moon. We arrived at the selected site before sunset. Nets were set and opened around sunset and remained open until bat activity subsided (Miller 2005). Three bat detectors (Anabat SD2) were set on poles along the pond's perimeter to record bat calls and allow researchers to hear bat activity around the pond. We observed bats flying along the shore and over the water but did not capture any bats on the days we set mist nets. MFC facility lights illuminated the area brightly and made nets clearly visible to us and presumably the bats.

3.5 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). We were notified on each occasion when a bat carcass was found and collected and stored those carcasses for future analysis (Doering et al. 2018). We collected 35 dead bats (1 big brown bat, 8 silver-haired bats, 4 Yuma myotis, 11 western small-footed myotis, and 11 little brown myotis) in 2018 and 29 dead bats (1 long-eared myotis, 5 silver-haired bats, 11 western small-footed myotis, and 12 little brown myotis) in 2019. We never recorded five or more bat carcasses of any species at the same time in a single location, which would have been classified as a die-off, and would have triggered us calling local and state biologists from the IDFG to begin investigating the cause of death (Doering et al. 2018). We sent 15 bats collected from 2018 to 2019 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. Of those samples, none were above background levels for americium-241, cesium-137, cobalt-60, plutonium-238, plutonium-239, strontium-90, and zinc-65.

3.6 Relocating Live Bats

Live bats occasionally are found 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 was not a nuisance to INL Site workers or disrupting work, we left the bat alone and allowed it to leave on its own volition. If a live bat was found in an area where it was at risk of injury or was disrupting work, we may have relocated it from the area following approved guidelines (Doering et al. 2018). In 2018 and 2019, we were contacted around 10 times about live bats. Most of the bats were in locations where they could be left to leave on their own volition. At ATR, however, there was a western small-footed myotis that we relocated to the trees just south of the building.

3.7 Public Outreach 2016 to 2020

Overall, we published 4 peer-reviewed papers and have 2 manuscripts in preparation that were written in collaboration with professors at Brigham Young University-Idaho, Idaho State University, and Temple University, as well as with biologists from the Bureau of Land Management, Idaho Department of Fish and Game, Craters of the Moon National Monument and Preserve, and the Idaho Falls Zoo. We presented 5 posters and 3 presentations at local and national scientific meetings. Two articles in the popular press were also written about bats on the INL Site. One Twitter feed, 1 video, and 3 websites have discussed our work with bats. We also presented to > 2,500 people at the Idaho Falls Zoo, including 420 students and 56 teachers at STEM Day and at Zoo Camp. We also taught about bats in classrooms to 9,110 elementary students and taught 37 teachers at Museum and iSTEM camps about local bats and acoustic monitoring. Some of these accomplishments were completed by 3 female and 3 male undergraduate students studying to become wildlife biologists at BYU-Idaho.

3.7.1 Publications

Published

Call, R. S., J. C. Whiting, B. Doering, J. Lowe, D. K. Englestead, J. A. Frye, T. Stefanic, and G. Wright, 2018, Maternity roosts of Townsend's big-eared bats in lava tube caves of southern Idaho. *Northwest Science* 92:158-165. <https://bioone.org/journals/northwest-science/volume-92/issue-2/046.092.0201/Maternity-Roosts-of-Townsend's-Big-Eared-Bats-in-Lava-Tube/10.3955/046.092.0201.short>

Whiting, J. C., B. Doering, G. Wright, D. K. Englestead, J. A. Frye, T. Stefanic, and B. J. Sewall, 2018, Long-term bat abundance in sagebrush steppe. *Scientific Reports* 8:12288. <https://www.nature.com/articles/s41598-018-30402-z>.

Whiting, J. C., B. Doering, G. Wright, D. K. Englestead, J. A. Frye, and T. Stefanic, 2018, Bat hibernacula in caves of southern Idaho: implications for monitoring and management. *Western North American Naturalist* 78:165-173. <https://bioone.org/journals/western-north-american-naturalist/volume-78/issue-2/064.078.0207/Bat-Hibernacula-in-Caves-of-Southern-Idaho--Implications-for/10.3398/064.078.0207.short>

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* 12:94-99. http://secemu.org/wp-content/uploads/2020/01/Whiting_et_al_2019.pdf

In preparation

Wackenhut, M. C., J. C. Whiting, and B. Doering, In review, Overwinter mass loss of Townsend's big-eared bats in multiple caves. *Mammal Research*.

Whiting, J. C., B. Doering, and K. Aho, In review, Long-term patterns of cave-exiting behavior of hibernating bats in nine caves. *Scientific Reports*.

3.7.2 Posters

Twede, B., N. Zenger, J. C. Whiting, D. Pennock, and D. Englestead, 2019, Summer entry by humans into bat roosts in the Sand Creek Desert. *Idaho Chapter of the Wildlife Society Annual Meeting*, Boise, ID.

Twede, B., N. Zenger, J. C. Whiting, D. Pennock, and D. Englestead, 2020, Summer entry by humans into bat roosts in the Sand Creek Desert. *Idaho Chapter of the Wildlife Society Annual Meeting*, Moscow, ID.

Whiting, J. C., B. Doering, D. K. Englestead, and J. A. Frye, 2019, Cave-exiting behavior of hibernating bats in 12 Idaho caves. *99th Annual Meeting of the American Society of Mammalogists*, Washington D.C.

Whittle, D., N. Royston, B. Abel, J. C. Whiting, and B. Doering, 2017, Bat mortalities at wind-energy facilities in Southern Idaho. *Idaho Chapter of the Wildlife Society Annual Meeting*, Boise, ID.

Whittle, D., N. Royston, B. Abel, J. C. Whiting, and B. Doering, 2017, Bat mortalities at wind-energy facilities in Southern Idaho. *Western Bat Working Group Biennial Meeting*, Fort Collins, CO.

3.7.3 Presentations

Whittle, D., N. Royston, B. Abel, J. C. Whiting, and B. Doering, 2017, Bat mortalities at wind-energy facilities in Southern Idaho. *Idaho Department of Fish and Game Symposium*, Idaho Falls, ID.

Whiting, J. C., B. Doering, G. Wright, D. K. Englestead, J. A. Frye, T. Stefanic, and B. J. Sewall, 2018, Long-term trends of hibernating bat abundance in Southern Idaho: implications for conservation and management. *Western Bat Working Group Biennial Meeting*, Fort Collins, CO.

Twede, B., N. Zenger, J. C. Whiting, D. Pennock, and D. Englestead, 2019, Summer entry by humans into bat roosts in the Sand Creek Desert. *Idaho Department of Fish and Game Symposium*, Idaho Falls, ID.

3.7.4 Popular Press

Articles about our bat work on the INL Site

Menser, P. 2016. Bats don't spook INL archaeologist, Bat central: as extinction threats mount, eastern Idaho offers refuge, prime habitat. INL Public Affairs & Strategic Initiatives. <https://inl.gov/article/bat-central-as-extinction-threats-mount-eastern-idaho-offers-refuge-prime-habitat/>.

Menser, P. 2019. Environmental monitoring is a team effort at INL Site. INL Public Affairs & Strategic Initiatives. <https://inl.gov/article/environmental-monitoring-is-a-team-effort-at-inl-site/>.

Twitter feed

<https://twitter.com/INL/status/791269375445602304>

Video about our bat work on the INL Site

<https://www.youtube.com/watch?v=TiMZWnqGZlw>

Websites about our bat work on the INL Site

<http://www.idahooser.com/LandManagement/batcount.html>

<http://www.idahobatwatch.org/index.html>

<https://www.idahofallsidaho.gov/1312/Bat-Night-at-the-Zoo>

3.7.5 Idaho Falls Zoo from 2018 to 2019

- Presented to 10 groups of children about bat research in southern Idaho.
- Taught 2,000 people about bat conservation at informal booths.
- Held 6 bat nights for more than 500 people to discuss our bat research, as well as bat acoustic monitoring and conservation in Idaho.
- Taught 420 students about bats and bat genetics at STEM Day and 56 teachers at Zoo Camp

3.7.6 Local Elementary Schools from 2018 to 2019

- Presented *All About Bats* in classrooms to 9,110 students from Rockland to Ashton and from Challis to Driggs.

3.7.7 Elementary and High School Teachers' Workshops from 2018 to 2019

- Taught 37 teachers at Museum and iSTEM camps about local bats and acoustic monitoring.

4.0 Assess Conservation Measures and Mitigation for Bats on the INL Site

The INL Site Bat Protection Plan ensures protection of sensitive bat resources through adherence to a number of recommended conservation measures. Conservation measures developed in the Bat Protection Plan were developed in collaboration with IDFG and USFWS bat biologists and were considered during project planning and NEPA analysis. 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. They also address seasonal activities that may affect summer roosts.

The Bat Protection Plan also provides guidance for activities proposed under NEPA. Recent NEPA evaluations, such as the Versatile Test Reactor Environmental Impact Statement cited the Bat Protection Plan in reference to species use of the INL, and Power Grid Test Bed Environmental Assessment specifically addressed bat monitoring on the INL Site and white-nose syndrome.

To support the proposed National Security Test Range (NSTR) expansion, bat acoustic surveys were conducted near lava outcrops along the eastern margin of the project area in areas with apparent deep fissures and vertical extent most likely to support bat summer roosts. A total of six detector nights of data were collected in three locations during midsummer when resident bat species should have established maternity roosts. Of 341 call files collected, all identifiable bat call sequences appeared to be from western small-footed myotis except for one big brown bat. Timing and level of activity did not suggest the presence of significant summer roosts in the NSTR area surveyed. Western small-footed myotis is considered the most abundant bat on the INL Site during summer, and the results were consistent with Site-wide bat monitoring. Townsend's big eared bat was not detected during NSTR bat surveys.

NSTR operations involve the use of explosives. Bat protection planning and the potential impacts to bats from construction and operation of the project were considered during the environmental impact analysis process under NEPA. Conservation measure number four in the Bat Protection Plan recommends avoiding blasting within a 0.75-mile (1.2-km) radius of hibernacula and important summer roosts. The 0.75-mile blasting buffer was arrived at through the review of numerous resource agency documents outlining conservation strategies to protect roosting bats from blasting associated with mining, highway construction, and similar massive earth moving activities. The closest bat hibernation cave to the NSTR project area is 6 miles (9.7 km), well outside the recommended blasting buffer distance. Acoustic surveys conducted in closer proximity to the NSTR project area did not indicate the presence of important summer roosts or suitable habitats that would support such roosts within the recommended 0.75-mile buffer. Impact to bats from explosives use was raised during NEPA scoping and public comments.

5.0 Recommendations for Additional Studies, Management Actions, and Plan Revisions

5.1 Additional Studies

5.1.1 Hibernacula Surveys around Middle Butte

Acoustic detectors are effective at identifying bat species across habitat types (O'Farrell et al. 1999, Britzke and Murray 2000, Miller 2001), and these devices have been used extensively to study bat winter ecology (Lausen and Barclay 2006, Klüg-Baerwald et al. 2016, Bernard and McCracken 2017). Little is known about bat hibernation behavior, especially in natural, rock-crevice hibernacula (Lausen and Barclay 2006, 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 butte consists of large elevation and aspect gradients that may comprise temperature and humidity regimes that can be suitable for hibernation. We propose to set Anabat detectors around the Middle Butte during winter (1 November to 31 March) to document if the rock fall around the butte is used by hibernating bats.

We will set Anabat detectors powered by external batteries and solar panels (Lausen and Barclay 2006, Schwab and Mabee 2014, Reynolds et al. 2017) at random areas and elevations around the butte. Each unit will be equipped with a BatHat to reduce damage to equipment from rain, snow, and freezing temperatures (Britzke et al. 2010); Anabat units will also have reflector plates oriented at 45° angle from the center axis of the microphone (Britzke et al. 2010, Skalak et

al. 2012, Reynolds et al. 2017). Detectors will be programmed to record at least from sunset to sunrise (Miller 2001, Johnson et al. 2017, Nocera et al. 2019), and the division ratio will be set at eight (Skalak et al. 2012). We will also adjust the sensitivity of the detectors to exclude ambient noise (O'Farrell et al. 1999, Britzke et al. 2013, Whiting et al. 2019).

This project will initiate monitoring of bat winter-habitat use around Middle Butte and provide baseline data using activity indices in that area, which would document another important winter hibernaculum on the INL Site. Data from these surveys will be provided to the IDFG, USFWS, and other collaborators for the management and conservation of bats on the INL Site and in southeastern Idaho.

5.1.2 White-nose Syndrome Surveys in Southeastern Idaho

ESER biologists are collaborating with biologists from the Upper Snake Field Office of the BLM, Idaho State University, IDFG, and Brigham Young University-Idaho to monitor for white-nose syndrome in southeastern Idaho. Southeastern Idaho consists of the largest, contiguous volcanic pseudokarst in the USA (Veni 2002), which provides essential winter and summer bat habitat (Genter 1986, Gillies et al. 2014). The Sand Creek and Big deserts have one of the highest densities of hibernacula for Townsend's big-eared bats and western small-footed myotis (Whiting et al. 2018a, Whiting et al. 2018b), as well as one of the highest densities of maternity roost sites for Townsend's big-eared bats in the western USA (Call et al. 2018). Additionally, the South Fork of the Snake River has large areas of exceptional bat habitat and the highest recorded number of captures of little brown myotis in southeastern Idaho (Whiting et al. 2015). Little brown myotis have suffered catastrophic declines from white-nose syndrome (Frick et al. 2010) and western small-footed myotis likely will be affected by this disease (Knudsen et al. 2013).

In light of the imminent arrival of white-nose syndrome and the importance of southeastern Idaho for bat conservation and management in western North America, we have identified the following two objectives to document baseline activity levels of bats before the arrival of white-nose syndrome:

- 1) Acoustically monitor with stationary detectors from June to September in and near King's Bowl to quantify activity levels of little brown myotis, Townsend's big-eared bats, and western small-footed myotis, as well as other bat species;
- 2) Acoustically monitor with stationary detectors from June to September along the South Fork of the Snake River for little brown myotis, as well as for the other 6 bat species in that area (Whiting et al. 2015)—all of which are species of conservation concern in Idaho (Idaho Department of Fish and Game 2017)—to quantify peaks and hot spots of bat activity using acoustical detectors and activity indices (Miller 2001, Skalak et al. 2012, Britzke et al. 2013).

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 white-nose syndrome in this area. Data from these surveys will be provided to the IDFG, USFWS, INL Site, 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 white-nose syndrome in this area.

5.2 Management Actions

In 2021, ESER biologists will present a training on handling and transporting bats that are found on the INL Site.

5.3 Plan Revisions

There are no recommended plan revisions proposed at this time.

6.0 Literature Cited

- Bernard, R. F., J. T. Foster, E. V. Willcox, K. L. Parise, and G. F. McCracken, 2015, Molecular detection of the causative agent of white-nose syndrome on Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) and two species of migratory bats in the southeastern USA. *Journal of Wildlife Diseases* 51:519-522.
- 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* 7:1487-1496.
- Blehert, D. S., A. C. Hicks, M. Behr, C. U. Meteyer, B. M. Berlowski-Zier, E. L. Buckles, J. T. H. Coleman, S. R. Darling, A. Gargas, R. Niver, J. C. Okoniewski, R. J. Rudd, and W. B. Stone, 2009, Bat white-nose syndrome: an emerging fungal pathogen? *Science* 323:227-227.
- Bosworth, W. R., 1994, *Characteristics of winter activity in Plecotus townsendii in southeastern Idaho*. M.S. Thesis. Idaho State University, Pocatello, Idaho.
- 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* 58:109-117.
- 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* 41:33-36.
- 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* 1:136-141.
- 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* 20:2537-2541.
- Call, R. S., J. C. Whiting, B. Doering, J. Lowe, D. K. Englestead, J. A. Frye, T. Stefanic, and G. Wright, 2018, Maternity roosts of Townsend's big-eared bats in lava tube caves of southern Idaho. *Northwest Science* 92:158-165.

- Doering, B., J. C. Whiting, and B. Bybee, 2018, *Idaho National Laboratory Site Bat Protection Plan in U.S. Department of Energy, Idaho Operations Office*, editor., Idaho Falls, ID.
- Doering, R. W., 1996, *Thermal implications of roost site selection in hibernating Plecotus townsendii*. M.S. Thesis. Idaho State University, Pocatello, Idaho.
- 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* 7:392-394.
- 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*. Pages 127-237 in T. J. O'Shea and M. A. Bogan, editors. Monitoring trends in bat populations of the United States and territories: problems and prospects. United States Department of Interior.
- Francel, 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* 3:33-42.
- Frick, W. F., 2013, Acoustic monitoring of bats, considerations of options for long-term monitoring. *Therya* 4:69-78.
- 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* 329:679-682.
- Genter, D. L., 1986, Wintering bats of the upper Snake River Plain: occurrence in lava-tube caves. *Great Basin Naturalist* 46:241-244.
- 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* 34:24-30.
- 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* 212:144-152.
- Hayman, D. T., P. M. Cryan, P. D. Fricker, and N. G. Dannemiller, 2017, Long-term video surveillance and automated analyses reveal arousal patterns in groups of hibernating bats. *Methods in Ecology and Evolution* 8:1813-1821.
- Haymond, S., and D. S. Rogers, 1999, *Habitat use by summer populations of bats in sagebrush-steppe*. ESRF-033.
- Hein, C. D., and M. R. Schirmacher, 2016, Impact of wind energy on bats: a summary of our current knowledge. *Human-Wildlife Interactions* 10:19-27.

- Idaho Department of Fish and Game, 2017, *Idaho State Wildlife Action Plan*, 2015. Sponsored by the U.S. Fish and Wildlife Service, Wildlife and Sport Fish Restoration Program, Boise, ID.
- Ingersoll, T. E., B. J. Sewall, and S. K. Amelon, 2013, *Improved analysis of long-term monitoring data demonstrates marked regional declines of bat populations in the eastern United States*. PloS one 8: e65907. doi:65910.61371/journal.pone.0065907.
- 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* 30:1048-1059.
- Johnson, J. S., M. J. Lacki, S. C. Thomas, and J. F. Grider, 2012, *Frequent arousals from winter torpor in Rafinesque's big-eared bat (Corynorhinus rafinesquii)*. PloS one 7.
- 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* 98:211-221.
- 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* 94:829-836.
- 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* 87:292-306.
- Kunz, T. H., R. Hodgkison, and C. D. Weise, 2009, Methods of capturing and handling bats. Pages 3-35 in T. H. Kunz and S. Parsons, editors. *Ecological and behavioral methods for the study of bats*. The John Hopkins University Press, Baltimore, Maryland.
- Lausen, C. L., and R. M. R. Barclay, 2006, Winter bat activity in the Canadian prairies. *Canadian Journal of Zoology-Revue Canadienne De Zoologie* 84:1079-1086.
- Loeb, S. C., T. J. Rodhouse, L. E. Ellison, C. L. Lausen, J. D. Reichard, K. M. Irvine, T. E. Ingersoll, J. T. 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. 208:1-100.
- 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 1(4):e00148-16. doi: 10.1128/mSphere.00148-16.
- Miller, B. W., 2001, A method for determining relative activity of free flying bats using a new activity index for acoustic monitoring. *Acta Chiropterologica* 3:93-105.

- Miller, K., 2005, *South Fork of the Snake River bat survey project: final report*. Idaho Department of Fish and Game, Idaho Falls, Idaho
- 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* 18.
- O'Farrell, M. J., and W. L. Gannon, 1999, A comparison of acoustic versus capture techniques for the inventory of bats. *Journal of Mammalogy* 80:24-30.
- O'Farrell, M. J., B. W. Miller, and W. L. Gannon, 1999, Qualitative identification of free-flying bats using the Anabat detector. *Journal of Mammalogy* 80:11-23.
- 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* 65:1-279.
- O'Shea, T. J., P. M. Cryan, D. T. Hayman, R. K. Plowright, and D. G. Streicker, 2016, Multiple mortality events in bats: a global review. *Mammal Review* 46:175-190.
- 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* 55:331-339.
- 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* 24: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* 46:513-527.
- Safford, M., 1990, Bat population study Fort Stanton Cave. *Bulletin of the National Speleological Society* 51:42-46.
- Schwab, N. A., and T. J. Mabee, 2014, Winter acoustic activity of bats in Montana. *Northwestern Naturalist* 95:13-27.
- 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* 31:62-72.
- 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* 3:490-502.
- 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* 26:395-403.

- 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* 3:503-508.
- Torres-Cruz, T. J., A. Porras-Alfaro, N. A. Caimi, O. Nwabologu, E. W. Strach, K. J. 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* 48:7.
- 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* 126:125-134.
- Veni, G., 2002, Revising the karst map of the United States. *Journal of Cave and Karst Studies* 64:45-50.
- 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 7.
- 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 townsendii.* M.S. Thesis. Idaho State University, Pocatello, Idaho.
- 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 13.
- 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* 80:114-119.
- Whiting, J. C., B. Doering, and K. Aho, In preparation, Long-term patterns of cave-exiting behavior of hibernating bats in nine caves in western North America. *Scientific Reports*.
- Whiting, J. C., B. Doering, J. Lowe, D. K. Englestead, J. A. Frye, S. Earl, A. Earl, and B. Bybee, 2015, *Ecology, conservation, and management of bats in southeastern Idaho.* U.S. BLM report, Idaho Falls, ID.
- 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* 12:94-99.
- 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* 78:165-173.

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* 8:12288.