Ecology and Management of Bats on the INL Site

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Introduction

Many bat species have important roles in ecosystem functions (i.e., insect control, plant pollination, and seed dissemination), and these mammals provide important ecosystem services (Kunz and Reichard 2010, Cryan 2011). For example, insectivorous bats are very effective at suppressing populations of nocturnal insects, and some authors estimate the value of bats to agricultural industry at roughly $22.9 billion each year (Boyles et al. 2011). Moreover, insectivorous bats are effective top-down predators of forest insects (Boyles et al. 2011). Potential declines in populations of bats could have far-reaching consequences across ecosystems and biological communities (Miller 2001, Adams 2003, Blehert et al. 2009).

Research and monitoring of bats have been conducted on the Idaho National Laboratory (INL) Site by contractors of the U.S. Department of Energy, Idaho Operations Office for several decades. During that time four theses, three reports, and seven publications have been produced by contractors, university researchers, and graduate students. The majority of that research and monitoring, however, occurred in the late 1980s and early 1990s. Currently, little is known regarding the distribution, abundance, movements, and use of habitat by bats on the INL Site. Our purpose was to organize and compile available information regarding bat research on the INL Site. Although not comprehensive, we have highlighted information from 14 studies that varied in their purpose (i.e., summer and winter habitat use, winter bat counts, winter activity, and thermal implications of roost site selection) and methods (e.g., mist netting, radio telemetry, echolocation surveys, as well as hibernacula and roost site surveys). We also provide conservation and management recommendations, as well as the details of a monitoring program that can answer critical questions for bat species and their habitats on the Site.

Ecology of Bats on the INL Site

Of the 14 known species of bats that occur in Idaho (Keller 1985), nine of those species are documented to occupy the INL Site during some part of the year (Table 1). Six of those species are likely migratory and use the Site seasonally; whereas, three are considered residents (Table 1). Many of these species are considered for different levels of protection by the U.S. Fish and Wildlife Service (FWS), U.S. Bureau of Land Management (BLM), Western Bat Working Group, and other conservation organizations (Table 1).

Currently, at least 17 out of 23 caves that are known to exist on the INL Site are used by several species of bats for winter hibernacula, as well as for summer day and night roosts (Tables 2, 3, and 4). Lava caves are also essential habitat during most of the year for three resident species (Tables 2 and 3). Indeed, much of the information concerning bats on the INL Site comes from research that has centered on counting and trapping individuals at caves. The highest number of resident bats counted during a winter survey was 464 Townsend's big-eared bats on 19 January 2007 in Middle Butte Cave, which is a dramatic increase from previous years (Table 2). In addition to being used as roost and hibernation areas, caves also provide habitat for concentrated patches of insect prey for these mammals. Additionally, preliminary surveys indicate that caves may be used as stop-over habitat during fall migrations by previously undocumented forest bats, such as the hoary bat and possibly the western or eastern red bat. Very little is known about the use of caves by migrating forest bats (Cryan 2011), and these areas may provide vital resources as bats traverse atypical habitats. Human access to caves on the INL Site has been restricted for over 50 years, and bat populations using these areas are relatively undisturbed compared with caves in the surrounding desert. For Townsend's big-eared bats on the INL Site, entrance into hibernacula begins around the last week of September and stabilizes by mid-November (Keller et al. 1993) (Fig. 1). Dispersal from hibernacula appears to begin in late April through early May (Keller et al. 1993) (Fig. 1).

Anthropogenic structures are also used as habitat by bats on the INL Site. Currently, there are at least 16 facilities on the INL Site, and many activities occur at these facilities—i.e., nuclear testing, research and development, and government defense programs. These areas, and their associated lands, occupy about 0.38% of the INL Site. Some of these facilities were constructed in the 1950s, and are surrounded by mature trees and waste-water ponds, which provide bats with vertical-structure habitat, water, and foraging areas. Indeed, during summer all resident and one migratory bat species use anthropogenic structures around facilities and near roads for roost sites (Tables 4, 5, and 6) (Keller et al. 1993, Haymond and Rogers 1997). Additionally, water troughs for livestock could be an important habitat component for bats on the INL Site (Bosworth 1996).

Not much is known regarding the movements and migration of bats on the INL Site. In one study during summer, two female Townsend's big-eared bats that were radio tagged moved 0.25 to 0.81 km from night roosts to foraging areas during an 11-day span (Haymond 1998). A third bat was followed for two nights and foraged in an area that was 20 km from the hibernaculum where it was captured (Haymond 1998). One female Townsend's big-eared bat that was radio-tagged during summer 1998 near the southeast corner of the INL Site moved northwest about 51.5 km to the Lemhi Mountains later that summer (Haymond and Rogers 1999). Banded bats have moved from Aviator to Rattlesnake Cave (8 km), from Rattlesnake to Middle Butte Cave (9 km), and from Rattlesnake to Moonshiner's Cave (8 km) (Keller et al. 1993). Additionally, 54% ($n = 53$) of Townsend's big-eared bats that were banded at Rattlesnake and Middle Butte Caves returned to the cave at which they were banded the following winter (Wackenhut 1990), and marked individuals occupied areas at or near the location of banding during summer and winter (Wackenhut 1990). No information exists regarding the movements of other bat species on the INL Site.

Several studies have documented the use of habitat and foraging areas by bats on the INL Site. Three radio-equipped Townsend's big-eared bats foraged at the interface of Utah juniper (*Juniperus osteosperma*) and sagebrush (*Artemisia* spp.) habitat types (Haymond 1998). Researchers using Anabat equipment documented western small-footed myotis in juniper woodland habitat and big-brown bats foraging at caves, along the Big Lost River, and in sagebrush habitat (Haymond 1998). Those bats also foraged more in caves and craters than in surrounding sagebrush habitat (Haymond and Rogers 1997). Also, summer roosts on the INL Site appear related to areas near stands of juniper (Bosworth 1996). Townsend's big-eared bats that were light tagged left cave craters for as long as 35 minutes to forage over sagebrush, occasionally dropping into vegetation to pursue insects (Keller et al. 1993). Two western small-footed myotis were detected in the sagebrush habitat near caves and craters. In June and July 1993 when water flowed in the Big Lost River, two *Myotis* spp. and one big brown bat were detected with acoustical equipment along the Big Lost River and one western small-footed myotis was captured at the Big Lost River Sinks (Keller et al. 1993). Additionally, researchers monitored the Big Lost River and eight of the waste-water ponds near facilities with an Anabat detector during summer 1996 to document foraging activity of bats. During those surveys, a big brown bat was detected along the Big Lost River, and bats occurred at all of the ponds except for the sewage lagoons at Central Facilities Area (CFA) (Table 6) (Haymond and Rogers 1997).

Current Threats to Bats

Recently, white-nose syndrome (WNS) has been identified as a major threat to many bats that hibernate in caves (Blehert et al. 2009, Kunz and Reichard 2010, Foley et al. 2011). WNS is a disease caused by a cold-adapted fungus (*Geomyces destructans*). Since its discovery in 2006, transmission of WNS has expanded 1,200 km (746 miles) from New York to Oklahoma, and researchers estimate that the spread of WNS syndrome will continue westward (Kunz and Reichard 2010). WNS has killed at least 5.5 to 6.7 million bats in seven species (Blehert et al. 2009, Foley et al. 2011). This disease has been labeled by some as the greatest wildlife crisis of the past century (Kunz and Reichard 2010), and many species of bats could be at risk of significant declines or extinction due to this disease (Kunz and Reichard 2010). Several species of bats on the INL Site could be affected by WNS (Table 1). One of these species (little brown myotis) has been petitioned for emergency listing under the Endangered Species Act (ESA) (Table 1). Two species that occur on the INL Site (western small-footed myotis and western long-eared myotis) are the western counterparts of the eastern small-footed myotis (*M. leibii*) and northern long-eared myotis (*M. septentrionalis*). The status of the latter two species is currently being reviewed for potential listing under the ESA.

Wind-energy development is expanding rapidly across the western USA, and researchers have been extremely surprised at the unprecedented mortality rate of bats at these facilities (Arnett et al. 2008, Cryan and Barclay 2009, Cryan 2011). The potential exists for development of wind energy on the INL Site. Additionally, many of the surrounding lands may be developed for wind-energy projects, which could affect negatively bats that use these lands, as well as areas on the INL Site. Currently, no continental-scale monitoring programs have been developed to assess bat fatalities at wind farms (Boyles et al. 2011); however, unprecedented numbers of bat species have been killed at wind-energy facilities (Cryan and Barclay 2009, Cryan 2011). Several species of bats that occupy the INL Site may be affected by development of wind energy (Table 1).

Recently, bats from numerous species have been declining across North America, mainly due to wind-energy development (Arnett et al. 2008, Cryan and Barclay 2009) and white-nose syndrome (Blehert et al. 2009, Foley et al. 2011); however, habitat loss and fragmentation is also a concern for bat populations (Adams 2003). Unfortunately, limited research has been conducted on this topic. In North America, logging has caused a 99% decline of old-growth forests (Adams 2003). The loss of these forests precipitates reduction of roosting and foraging habitat for some species of bats and their prey (Adams 2003). Many hibernacula, roost sites, and potential roost sites are destroyed with the closure of mines; thus bats potentially go elsewhere to roost. Some of these issues regarding habitat loss most likely affect bats on the INL Site (Bosworth 1996). For example, the closure of abandoned mines, alteration of water resources, and pesticide use on areas surrounding the INL Site may have caused a loss of foraging and roosting habitat, as well as prey base (Bosworth 1996, Haymond 1998), and large-scale fires that have burned sagebrush-steppe and juniper habitat most likely have affected bat species that have evolved in that system; however, further research needs to be conducted regarding these topics.

Hibernating and roosting bats may be affected by humans entering and exploring caves and abandoned mines (Wackenhut 1990, Haymond 1998, Adams 2003). These disturbances may include lights, noise, and an increase in the ambient temperature (Bosworth 1994, Haymond 1998). All of these disturbances can potentially cause bats to arouse or abandon their roosts and hibernacula (Adams 2003). For example, a human standing 10 feet below roosting bats can potentially emit enough heat to cause these mammals to arouse from hibernation, and entering a roost during maternity season (summer) can cause adults to abandon their young (Adams 2003). If bats are aroused during hibernation, this can result in individuals using needed fat reserves. This use of fat reserves may reduce survival among individuals during hibernation (Haymond 1998). On the INL Site, bats became more active when researchers were in caves for longer than 5 hours per visit (Bosworth 1994); these results indicate that caution must be used during certain times of the year when researchers enter hibernacula.

These disturbances can be minimized by entering the hibernaculum when the fewest number of bats are at or near the end of torpor, usually in January and February (Bosworth 1994).

Conservation and Management

More information is needed regarding the ecology of bats to properly manage these mammals on the INL Site (Genter 1986, Keller et al. 1993, Bosworth 1994, Doering 1996); indeed, although these mammals utilize the INL Site extensively they are one of the only suites of mammals that are not monitored regularly by the Environmental Surveillance, Education, and Research Program (ESER). Almost 20 years ago, researchers recommended some of the following ideas for monitoring bats on the INL Site (adapted from Keller et al. 1993):

1) Monitor the use of caves and waste-water ponds, as well as the Big Lost River and Big Lost River Sinks (if water is flowing in these areas) on the INL Site to determine which species use these areas, as well as when and how many of those species use these locations.
2) Document habitat requirements of Townsend's big-eared bats, including the microclimate of caves used by this species compared with caves that are not used by this species. Also, document daily and seasonal home ranges of Townsend's big-eared bats on the INL Site.
3) Produce an economical and efficient census technique for bats that can be used periodically to determine the status of these mammals on the INL Site.
4) Compare reliability of acoustic surveys for conditions at INL Site by mist netting.

Quantifying the relative abundance of nocturnal, solitary, and secretive species—such as bats—is oftentimes very difficult; however, recent advances in acoustic equipment (i.e., Anabat detectors) have allowed investigators to quantify and compare the activity of bats across sites, seasons, and species (Britzke et al. 1999, Britzke and Murray 2000, Miller 2001). Additionally, Anabat with its associated Analook software is likely the most cost-effective system for conducting long-term monitoring of multiple sites simultaneously, single sites over extended periods of time, or comparisons among differing habitat types (Miller 2001, Britzke et al. 2011). Below, we propose a monitoring program for the bat species that occupy the INL Site. Our monitoring plan will include passive (stationary detector, Fig. 2) and active (traversing a survey transect with a detector mounted to a vehicle) acoustical monitoring of important habitat features, counts of bats in winter hibernacula, and potentially capturing bats with mist nets to confirm species presence, monitor long-term trends of populations, and to develop an acoustic-call library for bats on the INL Site, as well as to conduct mark/re-sight studies of captured bats. This plan will incrementally address recommendations 1, 3, and 4. Recommendation 2 was investigated in previous studies (Doering 1996, Haymond 1998); however, current information may be needed to address these issues.

During winter 2012, we will establish permanent bat-monitoring stations at the eight facilities and at the three largest known hibernacula (Middle Butte, Aviator, and Rattlesnake Caves; Fig. 2). Anabat detectors will be set to record a least one half of an hour before and after sunrise and sunset. During summer 2012, we will randomly deploy the remaining 12 Anabat detectors at the 20 caves to determine if, and to what extent, these areas are utilized by bats across summer, autumn, and winter. Each detector will remain at a cave for 2 weeks, and subsequently we will randomly re-select placement of detectors at caves. Starting in 2013, we will deploy a subset of the 12 bat detectors at selected caves that are determined to be important for bats by our sampling in 2012. We will then deploy the remaining bat detectors passively and actively at important activity areas (i.e., juniper or sagebrush habitat, buttes, the

Big Lost River and Birch Creek Drainages, the Mass Detonation Area, as well as the Big Lost River Sinks). Recorded bat calls will be analyzed using Analook zero-crossing software, which can distinguish among the call sequences of species. We will produce an activity index for all bats and by species from the acoustical data (Miller 2001, Britzke et al. 2011), which we will use to compare bat activity at caves, facilities, and other important areas during certain seasons across the INL Site.

Cave surveys are an effective way to monitor hibernating colonies of bats on the INL Site, especially Townsend's big-eared bat because these mammals are highly visible during roosting and are concentrated in relatively few lava-tube caves (Bosworth 1996). Researchers have conducted winter surveys at 10 caves from 1984 to 2011, and 98% of the bats counted during those surveys occupied Rattlesnake, Aviator, and Middle Butte Caves. Each year, we will visit and count the number of bats occupying the three largest hibernacula on the INL Site (i.e., Middle Butte, Rattlesnake, and Aviator Caves) during 3 days from 1 January to 15 March (Bosworth 1994). At each cave, researchers will spend no more than 3 hours sampling a transect by stretching a metric tape from a designated location at the opening of the cave to the end of the cave. Biologists will then walk the transect line and identify and count the number of bats in each 10-m survey segment (e.g., 0 to 10, 10 to 20, etc.). In each 10-m section, we will also document if bats occur in clusters or as singles. At every 10 meters, researchers will record the relative humidity and the temperature at the ceiling and floor of the cave. We will follow all established guidelines and procedures for entering caves occupied by bats to minimize the spread of WNS. Conducting counts for bats in caves using this methodology will help us produce annual trends of bat populations that winter on the INL Site (Fig. 3).

Once we have an understanding of the use of caves and facilities by bats on the INL Site using acoustical monitoring, we will capture bats using mist nets during summer at caves or at other important habitat features (i.e., facilities or bridges) following the methods in Bosworth (1996) to confirm species presence, potentially monitor long-term trends of populations, and to develop an acoustic-call library for bats on the INL Site. In conjunction with the Idaho Department of Fish and Game (IDFG), we may weigh, identify sex, and band individuals for mark/re-sight studies. Thereafter, as we enter caves in the winter to count hibernating bats we will relocate marked bats. Doing such will provide estimates of the number of individuals occupying each cave, and will help us understand the movements and use of caves and other habitat features by bats on the INL Site.

Conclusion

WNS and wind-energy facilities have emerged in the past seven years as unprecedented threats to bat populations in North America (Cryan 2011). Additionally, the impact of habitat reduction and fragmentation on bat populations is not well understood (Adams 2003). With local and regional concern about bats increasing, a need exists to establish long-term monitoring of bats at a landscape-level scale (Miller 2001). More information is needed to properly manage bats on the INL Site (Genter 1986, Keller et al. 1993, Bosworth 1994, Doering 1996), especially as these mammals have not been monitored regularly by the ESER Program (e.g., breeding bird surveys). Previous researchers have indicated that surveys for bats should occur at all caves at least every other year to better understand movements, migration patterns, and population trends of these mammals on the INL Site (Wackenhut 1990, Keller et al. 1993). Despite this, only three of the 23 caves used by bats on the INL Site have been monitored sporadically since 1987. We will establish a monitoring program using acoustical surveys, which is the most efficient manner to gather such data (Miller 2001), counts of bats in caves during winter, and mist netting to better understand the use of the Site by bats.

The results of our monitoring program will provide critical information regarding bat ecology on the INL Site. Data from acoustical monitoring and mist netting will inform us of which areas, and when those areas, are used as foraging, roosting, and seasonal habitat for bats on the Site; as well as potentially indicating if caves on the INL Site are used as maternity roosts. Currently, there are no known maternity roosts on the INL Site (Bosworth 1996). Data from winter counts will provide important baseline information regarding trends of bats that use the three largest caves as hibernacula (Fig. 3). Our monitoring program will provide baseline information on population numbers and habitat use of these mammals prior to major threats potentially affecting these species on the INL Site, and will be similar to other ESER surveys conducted annually for wildlife. This information can be used for future project planning as well as National Environmental Policy Act requirements. Finally, this monitoring program will be a collaborative effort with the FWS, BLM, and the IDFG. Data collected concerning Townsend's big-eared bat will be provided to IDFG as they update their Comprehensive Wildlife Conservation Strategy for this species. Data we collect on use of caves by bats on the INL Site will provide information for a state-wide WNS program, which will be important in guiding the conservation and management of bats not only on the INL Site, but in Idaho.

Table 1. Bat species and the seasons and areas they occupy on the INL Site, as well as protection status and threats to thes e mammals (Genter 1986, Reynolds et al. 1986, Bosworth 1994, Doering 1996, Haymond 1998, Cryan 2011).

Common and Scientific Name	Distribution, Habitat, and Seasonal Occurrence	Protection Status	Affected by WNS	Affected by Wind Energy
Big Brown Bat (*Eptesicus fuscus*)†	Sitewide; buildings, caves, and lava tubes; year round	S4, Type 5	Yes	Yes
Hoary Bat (*Lasiurus cinereus*)*	Patchy; riparian and junipers; autumn	S4, Medium	No	Yes
Little Brown Myotis (*Myotis lucifugus*)*	Sitewide; roosts in buildings; summer and autumn	Currently petitioned for ESA listing	Yes	Yes
Pallid Bat (*Antrozous pallidus*)*	Patchy; shrub lands; autumn	S1	No	No
Red Bat (*Lasiurus blossevillii* or *L. borealis*)*	Patchy; caves; autumn	-	No	Yes
Silver-haired Bat (*Lasionycteris noctivagans*)*	Patchy; riparian and junipers; autumn	S4, Medium	No	Yes
Townsend's Big-eared Bat (*Corynorhinus townsendii*)†	Sitewide; caves and lava tubes; year round	G4, S3, Sensitive, Type 3, VU:A2c, High	Potentially	Potentially
Western Long-eared Myotis (*Myotis evotis*)*	Southeast and northwest INL Site; caves and junipers; summer and autumn	S3, Type 5, Medium	Yes	Potentially
Western Small-footed Myotis (*Myotis ciliolabrum*)†	Sitewide; buildings, caves, and lava tubes; year round	S4, Type 5, Medium	Yes	Potentially

†Resident species, *Migratory species
G4 (Global Natural Heritage and Conservation Data Center) = Not rare and apparently secure, but with cause for long-term concern.
S1 (State Natural Heritage and Conservation Data Center) = Critically imperiled because of extreme rarity or some factor of its biology makes it especially vulnerable to extinction; S3 = Rare or uncommon, but not imperiled; S4 = Not rare and apparently secure, but with cause for long-term concern.
Sensitive (USFS Regions 1 and 4) = Sensitive Species List (March 1999).
Type 3 (BLM) = Regional/State Imperiled Species; Type 5 (BLM) = Watch List.
VU:A2c (International Union for Conservation of Nature) = Vulnerable, threshold levels of population reduction in the past; reduction based on decline in area of occupancy, extent of occurrence, or quality of habitat.
Medium (Western Bat Working Group) = Medium priority indicates a level of concern, that should warrant closer evaluation, more research, and conservation actions of both the species and the possible threats; High = High priority species may be imperiled or at risk of imperilment.

Table 2. Location and date, as well as the number of bats observed in caves on the INL Site from 1984 to 2011 (Keller 1985, Genter 1986, Wackenhut 1990, Bosworth 1994). Names of caves are from Earl and Morris (1995).

Cave	Species		
	Townsend's Big-eared Bat	Big-brown Bat	Small-footed Myotis
Aviator Cave (East)			
2/15/1990	10	0	0
3/11/1993 - 3/18/1993	4	0	0
1/19/2007	6	0	0
Aviator Cave (West)			
2/15/1990	44	0	1
3/11/1993 - 3/18/1993	59	0	1
1/19/2007	79	0	0
2/10/2011	55	0	0
College Cave			
9/27/1992 - 10/3/1992	0	0	0
11/1/1992 - 11/7/1992	0	0	0
EBRII Cave IV			
12/12/1984 - 1/27/1985	7	0	0
Link Sausage Cave			
12/12/1984 - 1/27/1985	11	0	0
4/26/1988	3	0	0
1/24/1989	3	0	0
11/15/1992 - 11/21/1992	3	0	0
Lost Cave			
2/7/1993 -2/14/1993	0	0	0
Middle Butte Cave Complex			
12/12/1984 - 1/27/1985	15	0	9
10/17/1987	16	0	0
1/7/1988	21	0	1
4/11/1988	17	0	2
10/14/1988	20	0	1
1/26/1989	38	0	1
1/19/2007	464	0	10
3/11/2011	369	0	35
Middle Butte Cave (North)			
9/27/1992 - 10/3/1992	32	0	0
10/11/1992 - 10/17/1992	54	0	0
11/1/1992 - 11/7/1992	94	2	0
1/17/1993 - 1/23/1993	93	0	2
1/31/1993 - 2/6/1993	102	0	4

Table 2. Continued.

Cave	Species: Townsend's Big-eared Bat	Species: Big-brown Bat	Species: Small-footed Myotis
Middle Butte Cave (North) Continued			
3/3/1993 -3/10/1993	92	0	3
5/4/1993 -5/11/1993	33	0	2
Middle Butte Cave (Southeast)			
11/1/1992 - 11/7/1992	3	0	0
1/31/1993 - 2/6/1993	4	0	1
Middle Butte Cave (Southwest)			
9/27/1992 - 10/3/1992	1	0	0
Moonshiner Cave			
12/12/1984 - 1/27/1985	12	0	0
6/1/1987	1	0	0
11/22/1992 - 11/28/1992	2	0	0
4/3/1993 - 4/10/1993	3	0	0
North Tower Cave (Earl)			
11/15/1992 - 11/21/1992	4	0	0
North Tower Cave (Wackenhut)			
10/22/1987	3	0	0
1/7/1988	10	0	0
4/11/1988	6	0	0
10/14/1988	3	0	0
Rattlesnake Cave (East)			
12/12/1984 - 1/27/1985	0	0	4
3/26/1988	7	0	0
8/15/1988	1	0	0
1/19/1989	6	0	0
9/27/1992 - 10/3/1992	0	0	0
11/1/1992 - 11/7/1992	0	0	0
12/6/1992 - 12/12/1992	0	0	0
3/3/1993 - 3/10/1993	10	0	0
4/11/1993 - 4/18/1993	9	0	1
1/19/2007	1	0	0
2/11/2011	2	0	0
Rattlesnake Cave (West)			
12/12/1984 - 1/27/1985	132	0	41
10/17/1987	78	0	0
1/7/1988	127	0	14
3/26/1988	111	0	28
10/20/1988	87	0	3

Table 2. Continued.

Cave	Species Townsend's Big-eared Bat	Big-brown Bat	Small-footed Myotis
Rattlesnake Cave (West) Continued			
1/19/1989	138	0	21
10/23/1989	112	0	1
9/27/1992 - 10/3/1992	17	1	0
10/25/1992 - 10/31/1992	109	0	2
11/1/1992 - 11/7/1992	142	0	4
11/8/1992 - 11/14/1992	140	0	6
11/22/1992 - 11/28/1992	143	0	3
11/29/1992 - 12/5/1992	151	0	4
11/30/1992	126	no count	no count
12/4/1992	147	no count	no count
12/6/1992 - 12/12/1992	143	1	11
12/13/1992 - 12/19/1992	146	1	10
12/19/1992	158	no count	no count
1/3/1993 - 1/9/1993	141	0	13
1/8/1993	136	no count	no count
1/10/1993 - 1/16/1993	145	0	10
1/15/1993	141	no count	no count
1/31/1993 - 2/6/1993	143	0	14
2/2/1993	139	no count	no count
2/7/1993 -2/14/1993	134	1	23
2/12/1993	135	no count	no count
2/23/1993 - 3/2/1993	142	1	24
2/24/1993	132	no count	no count
3/3/1993 - 3/10/1993	139	2	28
3/5/1993	136	no count	no count
3/11/1993 - 3/18/1993	139	2	20
3/15/1993	127	no count	no count
3/27/1993 - 4/2/1993	136	0	15
3/29/1993	135	no count	no count
4/3/1993 - 4/10/1993	131	0	14
4/11/1993 - 4/18/1993	105	0	15
4/14/1993	97	no count	no count
4/19/1993 - 4/26/1993	57	0	11
4/23/1993	63	no count	no count
4/27/1993 - 5/3/1993	43	0	5
4/30/1993	34	no count	no count
5/4/1993 -5/11/1993	18	0	4

Table 2. Continued.

Cave	Species Townsend's Big-eared Bat	Big-brown Bat	Small-footed Myotis
Rattlesnake Cave (West) Continued			
5/10/1993	19	no count	no count
5/12/1993 - 5/19/1993	0	0	1
1/16/2004	175	0	37
1/19/2007	143	0	10
2/11/2011	140	0	47

Table 3. Location and bat species counted, caught with mist nets, or detected by Anabat equipment in caves during certain seasons on the INL Site from 1984 to 2011 (Genter 1986, Bosworth 1996, Haymond and Rogers 1997).

Cave	# of Studies	Species				
		Townsend's Big-eared Bat	Small-footed Myotis	Big Brown Bat	Long-eared Myotis	Unknown
Bachelor Roost						
Middle Butte Cave (North)	1	X				
Summer Day Roosts						
Flat Tire Cave	1	X				
Jensen's Cave	1	X				
Link Sausage Cave	1	X				
Middle Butte Cave (North)	3	X	X			
Moonshiner Cave	2	X	X			
North Tower Cave (Wackenhut)	1	X				
Pygmy Cave	1	X				
Rattlesnake Cave (West)	1		X			
Summer Night Roosts						
Barricade Shelter Cave	1					X
College Cave	2	X	X		X	
Coyote Cave	1	X				
Aviator Cave (East)	2	X				
East Boundary Cave	1	X	X			
East Deer Cave	1					X
Rattlesnake Cave (East)	1	X	X			
Flat Tire Cave	1	X				
Holy $*%@ Cave	1		X			
Jeep Trail Cave	1		X			
Jensen's Cave	2	X	X			
Lek Cave	1		X	X		
Link Sausage Cave	1	X				

Table 3. Continued.

Cave	# of Studies	Species				
		Townsend's Big-eared Bat	Small-footed Myotis	Big Brown Bat	Long-eared Myotis	Unknown
Summer Night Roosts Continued						
Lost Cave	2	X	X			
Middle Butte Cave Complex	3	X	X	X		
Moonshiner Cave	2	X	X		X	
North Tower Cave (Earl)	2	X	X			
North Tower Cave (Wackenhut)	2		X			X
Pygmy Cave	1	X				
Sandrift Cave	1					X
Aviator Cave (West)	2	X	X			
Rattlesnake Cave (West)	1	X				
Winter Roosts (Hibernacula)						
Aviator Cave (East)	1	X				
Rattlesnake Cave (East)	5	X	X			
EBRII Cave IV	1	X				
Link Sausage Cave	3	X				
Middle Butte Cave (North)	5	X	X	X		
Middle Butte Cave (Southeast)	1	X	X			
Middle Butte Cave (Southwest)	1	X				
Moonshiner Cave	3	X				
North Tower Cave	1	X				
Aviator Cave (West)	3	X	X			
Rattlesnake Cave (West)	6	X	X	X		

Table 4. Date and location, as well as the number of bat species captured by mist-nets on the INL Site from 1988 to 1999 (Wackenhut 1990, Keller et al. 1993, Bosworth 1996).

Location	Date	Length of Net (m) x Hours Set	Species	Sex	Number Captured
Aviator Cave Complex	9/28/1992	144	Townsend's Big-eared Bat	N/A	3
Aviator Cave Complex	7/25/1995	163	Western Small-footed Myotis	Male	4
Aviator Cave Complex	7/25/1995	163	Townsend's Big-eared Bat	Male	6
College Cave	7/17/1995	163	Western Small-footed Myotis	Male	3
College Cave	7/17/1995	163	Western Long-eared Myotis	Female	2
College Cave	7/17/1995	163	Townsend's Big-eared Bat	Male	2
College Cave	8/8/1995	163	Western Small-footed Myotis	Male	1
College Cave	8/8/1995	163	Western Small-footed Myotis	Female	1
Rattlesnake Cave (East)	3/26/1988	.	Townsend's Big-eared Bat	Male	2
Rattlesnake Cave (East)	3/26/1988	.	Townsend's Big-eared Bat	Female	5
Lek Cave	7/10/1999	.	Townsend's Big-eared Bat	Male	1
Lek Cave	7/10/1999	.	Townsend's Big-eared Bat	Female	3
Link Sausage Cave	7/6/1995	163	N/A	N/A	0
Lost Cave	7/26/1995	163	Townsend's Big-eared Bat	Male	5
Middle Butte Cave Complex	10/17/1987	.	Townsend's Big-eared Bat	Male	2
Middle Butte Cave Complex	10/17/1987	.	Townsend's Big-eared Bat	Female	5
Middle Butte Cave Complex	4/11/1988	.	Townsend's Big-eared Bat	Male	7
Middle Butte Cave Complex	4/11/1988	.	Townsend's Big-eared Bat	Female	9
Middle Butte Cave Complex	8/20/1992	192	Big Brown Bat	N/A	5
Middle Butte Cave Complex	8/20/1992	192	Western Small-footed Myotis	N/A	6
Middle Butte Cave Complex	8/20/1992	192	Townsend's Big-eared Bat	N/A	4
Middle Butte Cave Complex	9/7/1992	288	Townsend's Big-eared Bat	N/A	5
Middle Butte Cave Complex	9/7/1992	288	Silver-haired Bat	N/A	1
Middle Butte Cave Complex	7/8/1993	168	Big Brown Bat	N/A	1
Middle Butte Cave Complex	7/8/1993	168	Townsend's Big-eared Bat	N/A	4
Middle Butte Cave Complex	9/10/1993	192	Silver-haired Bat	N/A	1
Middle Butte Cave Complex	9/10/1993	192	Big Brown Bat	N/A	1
Middle Butte Cave Complex	9/10/1993	192	Western Small-footed Myotis	N/A	5
Middle Butte Cave Complex	9/10/1993	192	Western Long-eared Myotis	N/A	1

Table 4. Continued.

Location	Date	Length of Net Meter X Hours Set	Species	Sex	Number Captured
Middle Butte Cave Complex	9/10/1993	192	Townsend's Big-eared Bat	N/A	6
Middle Butte Cave Complex	7/12/1995	163	Western Small-footed Myotis	Male	1
Middle Butte Cave Complex	7/12/1995	163	Townsend's Big-eared Bat	Male	1
Middle Butte Cave Complex	8/9/1995	163	Western Small-footed Myotis	Male	8
Middle Butte Cave Complex	8/9/1995	163	Western Small-footed Myotis	Female	1
Middle Butte Cave Complex	8/9/1995	163	Townsend's Big-eared Bat	Male	2
Moonshiner Cave	7/20/1995	163	Western Small-footed Myotis	Male	3
Moonshiner Cave	7/20/1995	163	Western Small-footed Myotis	Female	2
Moonshiner Cave	7/20/1995	163	Western Long-eared Myotis	Male	1
Moonshiner Cave	7/20/1995	163	Townsend's Big-eared Bat	Male	1
Moonshiner Cave	8/10/1995	163	Western Small-footed Myotis	Male	4
Moonshiner Cave	8/10/1995	163	Western Small-footed Myotis	Female	8
Moonshiner Cave	8/10/1995	163	Western Long-eared Myotis	Male	2
Moonshiner Cave	8/10/1995	163	Townsend's Big-eared Bat	Male	4
Moonshiner Cave	7/3/1999	.	Western Small-footed Myotis	Male	1
Moonshiner Cave	7/9/1999	.	Western Small-footed Myotis	N/A	1
Moonshiner Cave	7/9/1999	.	Western Small-footed Myotis	Male	1
Moonshiner Cave	7/9/1999	.	Townsend's Big-eared Bat	Male	1
Moonshiner Cave	7/9/1999	.	Townsend's Big-eared Bat	Female	1
North Tower Cave (Earl)	7/18/1995	163	Western Small-footed Myotis	Male	1
North Tower Cave (Wackenhut)	10/22/1987	.	Townsend's Big-eared Bat	Female	3
North Tower Cave (Wackenhut)	4/11/1988	.	Townsend's Big-eared Bat	Male	1
North Tower Cave (Wackenhut)	4/11/1988	.	Townsend's Big-eared Bat	Female	5
North Tower Cave (Wackenhut)	6/8/1999	.	Townsend's Big-eared Bat	Female	1
North Tower Cave (Wackenhut)	7/8/1999	.	Townsend's Big-eared Bat	Male	1
Obscenity Snake Pit	7/19/1995	163	N/A	N/A	0
Rattlesnake Cave Complex	8/21/1992	192	N/A	N/A	0
Rattlesnake Cave Complex	7/11/1995	163	N/A	N/A	0
Rattlesnake Cave (West)	10/17/1987	.	Townsend's Big-eared Bat	Male	8
Rattlesnake Cave (West)	10/17/1987	.	Townsend's Big-eared Bat	Female	22

Table 4. Continued.

Location	Date	Length of Net Meter X Hours Set	Species	Sex	Number Captured
Rattlesnake Cave (West)	3/26/1988	.	Townsend's Big-eared Bat	Male	19
Rattlesnake Cave (West)	3/26/1988	.	Townsend's Big-eared Bat	Female	21
Rattlesnake Cave (West)	10/20/1988	.	Townsend's Big-eared Bat	Male	11
Rattlesnake Cave (West)	10/20/1988	.	Townsend's Big-eared Bat	Female	16
INTEC Sewage Ponds	8/13/1992	345	Little Brown Myotis	N/A	1
INTEC Sewage Ponds	8/30/1992	517	N/A	N/A	0
MFC Sewage Pond	8/12/1992	517	Western Small-footed Myotis	N/A	2
NRF Sewage Pond	8/18/1992	689	N/A	N/A	0

Table 5. Locations of summer night roosts and number of studies (acoustic and day surveys) conducted, as well as the bat species observed at anthropogenic structures on the INL Site (Haymond and Rogers 1997).

Location	Study Date	# of Studies	Species Townsend's Big-eared Bat	Small-footed Myotis	Big Brown Bat	Long-eared Myotis
Concrete bridge near rest stop on I-20	1996	1	X	X		
Metal culvert bridge at Lincoln Blvd./INTEC	1996	1		X		
Concrete bridge at Lincoln Blvd.	1996	1		X		X
Concrete bridge at MFC	1996	1	X	X		
Cinder block building at CFA-690	1996	1		X		
Aluminum siding building at CFA-1608	1996	1			X	
Aluminum siding building at CFA-696	1996	1		X		
Cinder block and glass building at CFA-662	1996	1		X		
Glass and brick building at CFA-689	1996	1			X	
Aluminum siding and stucco building at CFA-698	1996	1		X		

Table 6. Date, year, and locations of acoustic surveys conducted, as well as the bat species observed at caves on the INL Site from 1992 to 1996 (Keller et al. 1993, Haymond and Rogers 1997).

Location	Year	Date	Species Detected
Aviator Cave Complex	1992	9/27/1992	N/A
Middle Butte Cave Complex	1993	5/17/1993	Big Brown Bat
Middle Butte Cave Complex	1993	5/17/1993	*Myotis* spp.
Middle Butte Cave Complex	1993	6/16/1993	N/A
Middle Butte Cave Complex	1993	7/8/1993	*Myotis* spp.
Rattlesnake Cave Complex	1993	5/11/1993	Townsend's Big-eared Bat
Rattlesnake Cave Complex	1993	5/11/1993	*Myotis* spp.
Rattlesnake Cave Complex	1993	5/12/1993	Townsend's Big-eared Bat
Rattlesnake Cave Complex	1993	5/12/1993	*Myotis* spp.
Rattlesnake Cave Complex	1993	5/15/1993	Townsend's Big-eared Bat
Rattlesnake Cave Complex	1993	5/15/1993	*Myotis* spp.
Rattlesnake Cave Complex	1993	6/2/1993	*Myotis* spp.
CFA	1992	8/26/1992	N/A
CFA (sewage lagoons)	1996		N/A
INTEC (sewage ponds)	1993	6/12/1993	Big Brown Bat
INTEC (sewage ponds)	1993	6/12/1993	*Myotis* spp.
INTEC (sewage and waste lagoons)	1996		Big Brown Bat
INTEC (sewage and waste lagoons)	1996		Western Small-footed Myotis
INTEC (sewage and waste lagoons)	1996		*Myotis* spp.
MFC (sewage pond)	1992	8/12/1992	N/A
MFC (industrial waste pond)	1993	6/29/1993	Big Brown Bat
MFC (industrial waste pond)	1993	6/29/1993	*Myotis* spp.
MFC (sewage lagoons)	1996		Big Brown Bat
MFC (sewage lagoons)	1996		Western Small-footed Myotis
MFC (sewage lagoons)	1996		*Myotis* spp.
NRF (sewage pond)	1992	8/18/1992	N/A
RWMC (north pond)	1996		Big Brown Bat
RWMC (north pond)	1996		Western Small-footed Myotis
TAN (LOFT ponds; TAN pond)	1996		Big Brown Bat
TAN (LOFT ponds; TAN pond)	1996		Western Small-footed Myotis
TRA (sewage lagoons, waste ponds)	1996		Big Brown Bat
TRA (sewage lagoons, waste ponds)	1996		Western Small-footed Myotis

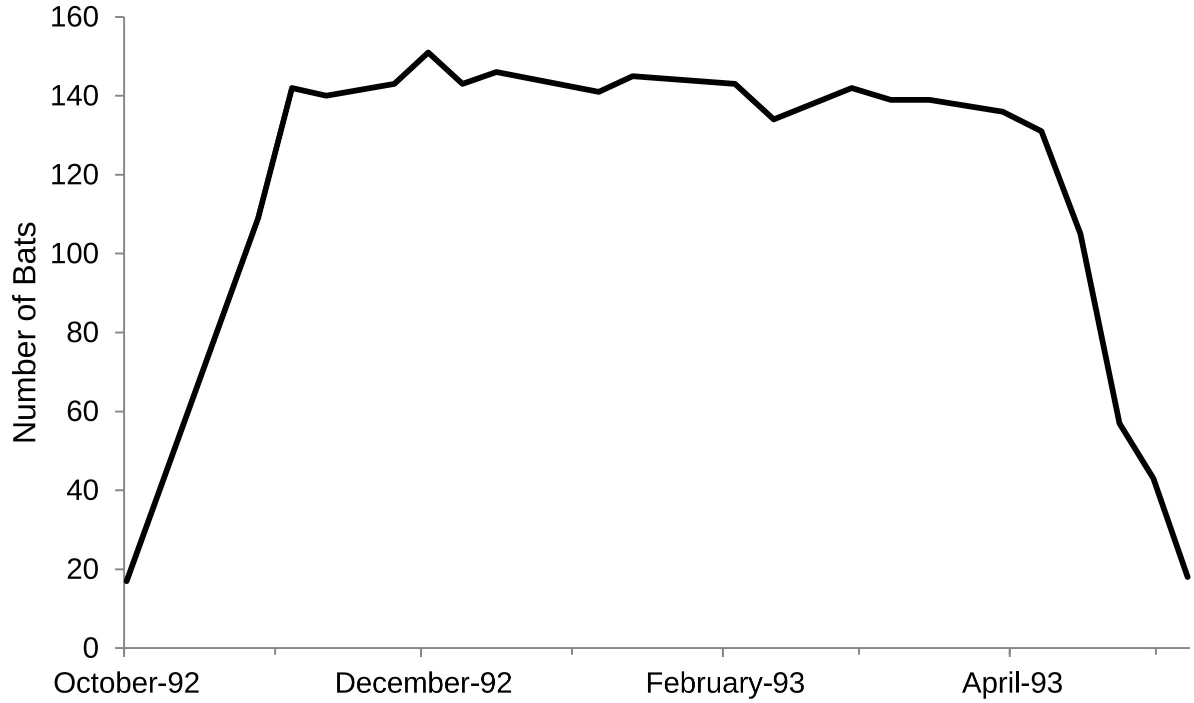

Figure 1. Counts (*n* = 22) of Townsend's big-eared bats during hibernation at West Rattlesnake Cave during 1992 and 1993 (Keller et al. 1993). The number of bats counted remained relatively stable from the first of November through the first week of April.

Figure 2. A passive-acoustical monitoring station for bats (about 10 ft.) with a microphone mounted at the top. A gray box (11 x 13 x 6 inches) is mounted to the pole about 3 ft. from the base (2 x 2 ft.). The gray box has a sign attached to it stating that the device is a bat-monitoring station and providing contact information. These devices record the calls of bats.

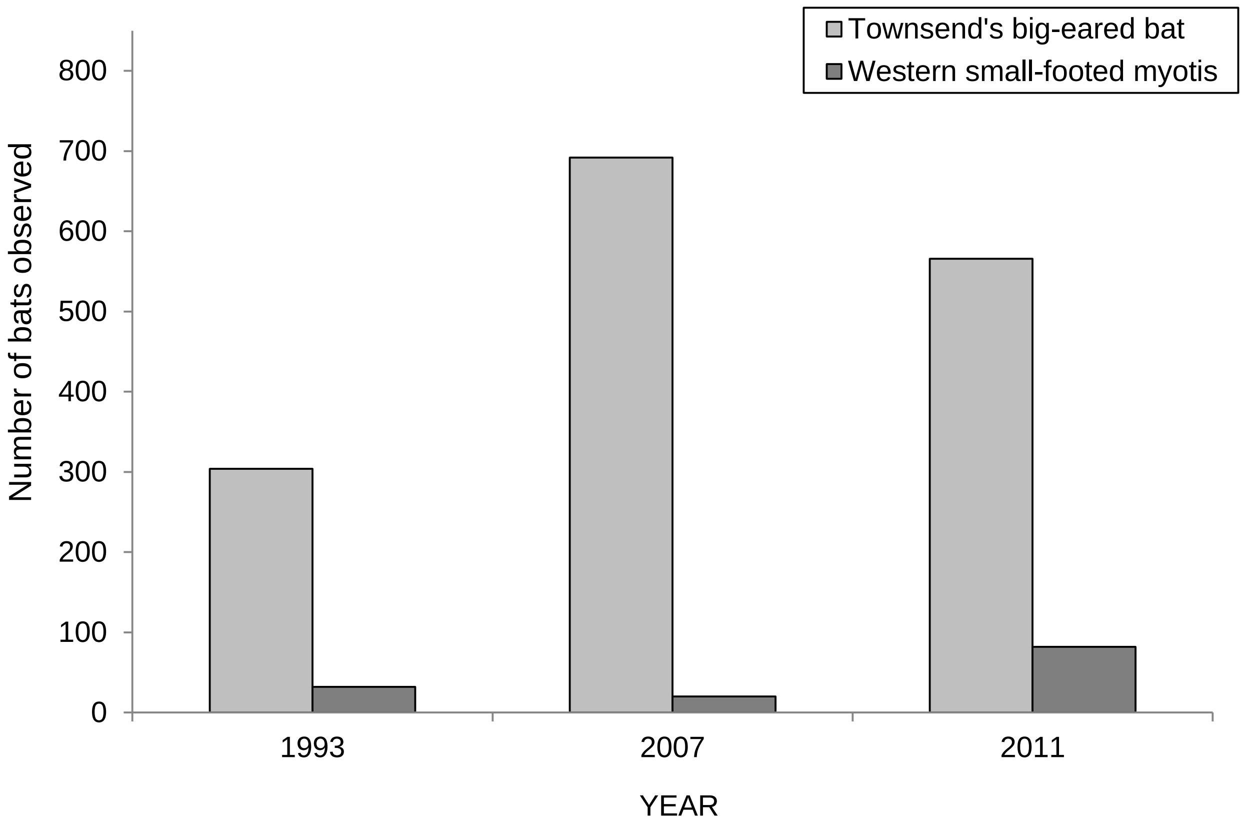

Figure 3. Summation of the number of two bat species counted at the three largest known winter hibernacula (Middle Butte, Rattlesnake, and Aviator Caves) in each year when consistent methodologies were used to survey those mammals. With several more years of surveys, such data can provide an index of the number of these species occurring at the three largest hibernacula on the INL Site during winter.

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