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Survey of Bats on the Mid-Columbia National Wildlife Refuge Complex and Little Pend Oreille National Wildlife Refuge, Washington, October 2011–May 2012

Open-File Report 2013-1120

U.S. Department of the Interior
U.S. Geological Survey

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By Joan C. Hagar, U.S. Geological Survey; Tom Manning, Oregon State University; and Jenny Barnett, U.S. Fish and Wildlife Service

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SALLY JEWELL, Secretary

U.S. Geological Survey
Suzette M. Kimball, Acting Director

U.S. Geological Survey, Reston, Virginia: 2013

Suggested citation:
Hagar, J.C., Manning, Tom, and Barnett, Jenny, 2013, Survey of bats on the Mid-Columbia River National Wildlife Refuge Complex and Little Pend Oreille National Wildlife Refuge, Washington, October 2011–May 2012: U.S. Geological Survey Open-File Report 2013-1120, 30 p.

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Conversion Factors

Inch/Pound to SI		
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
SI to Inch/Pound		
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
kilometer (km)	0.5400	mile, nautical (nmi)
meter (m)	1.094	yard (yd)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

°C=(°F-32)/1.8.

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

°F=(1.8×°C)+32.

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Introduction

Bats are diverse and abundant in many ecosystems worldwide. They perform important ecosystem functions, particularly by consuming large quantities of insects (Cleveland and others, 2006; Jones and others, 2009; Kunz and others, 2011). The importance of bats to biodiversity and to ecosystem integrity has been overlooked in many regions, largely because the challenges of detecting and studying these small, nocturnal mammals have rendered a paucity of information on matters as basic as species distribution and natural history attributes. Recently, concern for bats has arisen in response to recognition of large-scale threats, such as white-nosed syndrome (WNS; Turner and others, 2009; Frick and others, 2010) and mortality at wind energy facilities (Arnett and others, 2008), factors that are causing unprecedented population declines of bats (Boyles and others, 2011). WNS is a fungal disease that has killed more than 1 million cave-hibernating bats in eastern North America since being discovered in New York State in 2006 (U.S. Fish and Wildlife Service, 2012). WNS has spread rapidly from northeastern U.S., and as of August 2012 has been confirmed as far west as eastern Missouri(U.S. Fish and Wildlife Service, 2013*)*. Given the rapid spread of WNS, there is concern that the disease may soon affect western bat populations.

Hibernating bats are particularly vulnerable to the effects of WNS (Blehert and others, 2009). Refuges in eastern Washington, including the Mid-Columbia River National Wildlife Refuge Complex (MCRNWRC) and Little Pend Oreille National Wildlife Refuge, support many potential hibernacula. Sixteen species of bats potentially occur on these refuges, including one federally listed species of concern (Townsend's big-eared bat [*Corynorhinus townsendii*]; see table 1 for scientific names of bats), and 12 species that are of conservation concern in Washington and Oregon (table 1). However, little is known about bats on these refuges because few surveys have been done, and none have been done during winter. Refuge biologists are lacking even the most basic information, such as species presence, and location and status of hibernacula. In order to assess vulnerability and develop a strategy for management of WNS, refuge managers need to know where bats are hibernating, and which species are using each hibernaculum. The goal of this project was to provide information on the status of wintering bats to refuge biologists and managers in order to support decision-making that might minimize the threat of WNS in western bat populations. We conducted surveys of bat activity in winter and early spring as an initial step toward identifying bat species that may be over-wintering and locating potential hibernacula on these refuges. Our specific objectives were to identify bat species using the refuges, to identify areas of resident bat activity in autumn, winter, and early spring using acoustic bat detectors, and to try new methods for quick surveys of bat activity.

Study Area

The MCNWRC is comprised of seven refuges and one National Monument (NM) in eastern Washington and Oregon. At least four of these (Hanford Reach NM/Saddle Mountain National Wildlife Refuge (NWR), McNary, Umatilla, and Columbia) have potential hibernation habitat for bats, based on the availability of extensive cliff and rocky outcrop habitat. Sixteen species of bats potentially occur on the refuges (table 1). Nine species have been confirmed on Hanford Reach NM, where limited summer surveys have been conducted (Soll and others, 1999). Other refuges in the complex have never been surveyed.

Hanford Reach NM/Saddle Mountain NWR, McNary, Umatilla, and Columbia Refuges are located in the semi-arid shrub-steppe of the Columbia Basin Plateau and host shrub-steppe, riparian, wetland, and cliff, rimrock, and outcropping habitat. All but Columbia are adjacent to the Columbia River. Refuge riparian and wetland habitats provide potential foraging areas for bats, while cliffs and cliff crevices potentially support roost sites and hibernacula for some species (fig. 1). We conducted winter bat surveys in Columbia and Hanford/Saddle Mountain Refuges in December 2011 and January 2012. As a follow-up to winter surveys, we re-surveyed Columbia Refuge in April 2012.

Little Pend Oreille National Wildlife Refuge (LPO) is located in Stevens County, Washington, approximately 10 mi southeast of Colville (fig. 2). Located on the western slope of the Selkirk Mountain Range, it is dominated by mixed-conifer habitat types. As with MCNWRC, LPO lacked information about bats on the refuge, including a basic species list. The presence of abandoned mines on the refuge suggests the potential to support hibernating bats, as abandoned mines are often used as hibernacula by bats (Sherwin and others, 2009). A survey of abandoned mines conducted on LPO in 1996 (Block, 1996) to assess safety hazards and potential impacts to aquatic biota revealed a total of 11 mines on and adjacent to the refuge. During subsequent field work in 1995 and 1996, evidence of underground workings were found only at Bear Mountain Shaft (vertical passage) and Bear Mountain Adit (horizontal passage). The location of Bear Mountain Shaft (shaft) and Bear Mountain Adit (adit) was poorly documented, and had never been visited by current refuge staff. Although Block (1996) found no evidence of bat use during their brief survey of the Bear Mountain Adit, refuge staff wanted to locate the mine, precisely record the location with Global Positioning System (GPS) coordinates, and assess the shaft and adit for bat use and public safety issues. Both the shaft and adit are in remote, high elevation locations, accessed by jeep trails and walking. Access during winter would be made even more difficult by deep snow. The shaft is located on a ridge top and is approximately 4 m deep. Although the ridge is dominated by grass and shrub communities, the shaft itself is located in a small grove of conifer trees. In spring 2012, about 3 m of water was standing in the shaft, suggesting limited access to the mine (fig. 4). The adit is located on a steep, densely vegetated slope, approximately 190 m north of the shaft. The adit goes straight into the mountain side (fig. 4), beyond the 150 m surveyed by Block in 1996. Vegetation surrounding the adit is very dense, consisting of alder and coniferous forest.

Methods

We used Pettersson D500X detectors (Pettersson Elektronik, Uppsala, Sweden) for acoustic surveys. Each detector was powered by a 6-V gel-cell battery. Because we had only four detectors with which to sample a large area of potential habitat, we subjectively selected locations for detectors where we thought bat activity was most likely to occur. These locations included areas between rimrock cliffs (potential roosting habitat) and open water (potential foraging habitat) at Columbia Refuge, and near areas of open water, springs, or tree cover at Hanford. Detectors were deployed in waterproof housing, with microphone cables running through 2.4-m sections of 5.1-cm polyvinyl chloride (PVC) pipe, which were erected and stabilized with three guy lines attached to tent stakes (fig. 3). Microphones were oriented approximately 90 degrees from adjacent cliff faces to avoid echoes and capture calls of bats moving between cliff and water. The PVC poles were painted to blend in with the surroundings, to help minimize human interference.

We obtained raw weather data for a weather station near Columbia NWR (Warden Golf Weather Station) from the AgWeatherNet network (www.weather.wsu.edu). We determined air temperature (°F), relative humidity (percent), and wind speed (mph) for the closest 15-min interval on the range of dates during which acoustic detectors were deployed in winter, and used hourly records for the April survey at Columbia NWR.

Mine Shaft and Adit—Little Pend Oreille National Wildlife Refuge

On October 4, 2011, Inventory and Monitoring Biologist Jenny Barnett, Refuge Biologist Mike Munts, and former refuge manager, Steve Fowler, located the Bear Mountain mine shaft and deployed a bat detector. On October 17, 2011, the bat detector was moved from the shaft to the adit. Locations of both mine shaft and adit were documented with a GPS. Stationary detectors were again deployed at the same locations at Bear Mountain Shaft and Adit from May 9 to 15, 2012.

Winter Surveys—Columbia National Wildlife Refuge and Hanford National Monument/Saddle Mountain National Wildlife Refuge

Winter surveys were conducted at Columbia NWR and Hanford NM/Saddle Mountain NWR from December 5, 2011, to January 17, 2012. Originally, we intended to conduct preliminary surveys during the autumn, when pre-hibernation swarming can indicate the composition and numbers of species that use a site, particularly those species that may easily be missed during winter hibernation counts (Bat Conservation Trust, 2007). However, due to delays in funding, we were unable to begin field research until December 2011.

Stationary detectors were deployed at 16 sites at Columbia NWR (fig. 5) and 12 sites at Hanford NM/Saddle Mountain NWR (appendix 1). Detector settings were:

- Frequency: 500
- Pre-trigger: OFF
- Length: 1–3 s
- Input level: 80
- Trigger level: 80
- Interval: 0

Data from each detector were recorded on two compact flash (CF) cards. After 6 to 8 nights of data collection, data cards were downloaded and bat detectors were moved to a new location.

Driving transect surveys were conducted on 9 dates between December 13, 2011, and January, 12, 2012, beginning with 30 min of sunset (table 2). The observer drove an approximately 3-km-long route that passed within 0.4 km of deployed stationary detectors to allow for a comparison of detection rates between the two methods. At the beginning, end, and every 0.4 km along each transect, the observer stopped to deploy a hand-held acoustic detector for 10 min.

Spring Surveys—Columbia National Wildlife Refuge

We focused spring survey efforts on Columbia NWR to supplement the winter bat detections with more information about the species that were present and their activity locations. We conducted both stationary acoustic detection and driving-transect surveys at Columbia NWR in April 2012. In addition, several locations under bridges and in rimrock cliffs were visually inspected for signs of bat roosting. We operated acoustic bat detectors at seven sites (fig. 6) from April 17 to 27, 2012. The southern end of the refuge was not well sampled because there was very little rimrock in that area. We sampled for 1 to 5 nights at each site, for a total of 27 detector-nights across all sites. As in the winter, we placed detectors at subjectively selected locations where bat activity was most likely to be recorded, primarily between rimrock cliffs (roosting habitat) and water (foraging habitat). A further consideration for placement of detectors was to minimize disturbance by humans by selecting locations behind locked gates whenever possible.

Detectors were set to activate at 15 min before local sunset, and deactivate 30 min after local sunrise. Other detector settings were:

- Frequency: 500
- Pre-trigger: OFF
- Length: 5 s
- Input level: 80
- Trigger level: 80
- Interval: 0

Data from each detector were recorded on two CF cards of varying capacity (2–16 GB), and the CF cards were downloaded to a new folder each day. At each deployment, the detector was set to read all sectors on the fresh CF cards to ensure that the fresh cards had been re-formatted.

We modified the protocol for driving transects from that used in winter. We used Myotisoft Transect© and TransectPro© with Garmin™ and DeLorme GPS instruments, and SonoBat™ 3.05 to record and map acoustic transects from a moving vehicle. (See appendix 2, Recording and Displaying Bat Acoustic Transects, for protocol and detailed notes on using Myotisoft Transect© software in conjunction with GPS instruments).

Acoustic data were collected on 5 nights from three transects established along pre-determined routes. Transect surveys began 30 min after sunset (range of actual start times: 20:17 to 20:25), and ended 20–50 min later (range of actual end times: 20:45 to 21:02). We extended the detector's external microphone pointed toward the sky out the passenger window of the vehicle and drove at approximately 20 mi per hour. We recorded any time taken out of the survey for stops made along the way to open gates, etc. The longest transect was about 19 km, and the shortest transect was about 9 km.

Before starting each transect survey, the detector and GPS were synchronized as closely as possible (generally within 2 s error). Detector settings were the same as for stationary surveys (see above), and the external microphone, attached to the detector by a long cable extending from the same PVC pipe used in stationary surveys, was held in place by closing the passenger window of the vehicle on the pipe. The microphone was oriented vertically upwards and approximately 30 cm from the roof of the vehicle. Two GPS instruments were used for redundancy (a Garmin™ GPSmap 60, and a DeLorme Earthmate PN-40). Except for stopping to open and close gates, the observer drove at approximately 20 mph.

Processing Acoustic Data

All files from stationary detectors were processed with SonoBat™ Batch Scrubber 3 default settings (acceptable call quality=0.80, discriminant probability threshold=0.90) to remove files lacking signatures of bat calls. Files collected from transects were "scrubbed" of obvious noise files using the SonoBat™ D500X Attributer v. 2.2. We used SonoBat™ 3.02 Washington East to assign species identifications from call files. We manually examined every single call file and generally accepted the classification automatically assigned by SonoBat™. However, we overrode calls identified as Spotted Bat because they were obviously noise. Some files contained calls from two individual bats. In those cases, each bat was considered a separate call file. In cases where SonoBat™ did not classify obvious bat calls to species, we could often assign them to a call frequency group (table 1) based on visual inspection of the sonogram. Because the default criteria we used are fairly rigorous, our results may underestimate the number of bat calls actually recorded for both stationary detectors and transects.

To derive an index of bat activity, we summed the number of files recorded for each detector night, for each species and for all calls combined, and divided by the number of hours of detector operation.

Results

Mine Shaft and Adit—Little Pend Oreille National Wildlife Refuge LPO.— One bat call was recorded in October 2011 at Bear Mountain Shaft. It was not identifiable to species, but was classified in the 50 kHz group. A total of 216 call files were recorded at Bear Mountain Shaft in May 2012 (table 3). No bats were detected at the Bear Mountain Adit in either October 2011 or May 2012. The standing water in the mine shaft observed in the spring indicates that bats cannot access the mine through the shaft during the winter (fig. 4). Therefore, the shaft is unlikely to provide hibernating habitat for bats.

Winter Surveys—Columbia National Wildlife Refuge and Hanford National Monument/Saddle Mountain National Wildlife Refuge

We recorded nine bats on 6 nights out of 109 detector-nights at Columbia NWR (table 4). Bats were detected at four sites (fig. 5). No bats were recorded during 78 detector-nights at Hanford NM/Saddle Mountain NWR. We identified canyon bats and a myotis species from the acoustic data. All bats recorded were detected early in the night, between 17:28 and 19:56 hours. The average temperature (29.6°F) and wind speed (5.1 mph) for all dates from December 1, 2011 to January 21, 2012 for the hours between 17:00 and 20:00 were within two units of the averages recorded during times of bat detections (table 4). Average relative humidity (RH) for the entire period (77.6 percent) was 8.3 percent greater than the average RH recorded at times of bat detections. Seven of the nine bat detections were recorded before moon rise.

Stationary Detectors.—We identified 11 species out of a total of 2,846 bat calls recorded at Columbia NWR (table 5). Silver-haired bats were the most frequently detected species, comprising 44 percent of the recorded calls (fig. 7). The canyon bat, western small-footed myotis, and hoary bat each represented greater than 1 percent of the recorded calls. We recorded no more than 30 identifiable calls for the remaining 7 species (table 5). Two species that were infrequently detected, California myotis (four detections) and Townsend's big-eared bat (one detection), represented new species records for the MCNWRC.

We recorded bats on 25 of the 27 detector nights. One detector was set up differently and occasionally slipped down the pipe during the night; on one of those occasions (April 24–25 at Crescent Lake), no files were recorded. On April 26–27 at Goldeneye Lake, only a few noise files were recorded, likely due to equipment malfunction.

An index of bat calls per hour generally increased over the first 9 days of the 10-day sampling period (fig. 8). Nighttime temperatures were mild to warm, peaking near the middle of the sampling period on the night of April 22–23 (fig. 9). Bat activity did not clearly correspond with nighttime temperatures for the sampling period. However, it is possible that warm weather may have initiated a flush of emergence of aquatic insects, resulting in a subsequent period of heightened bat activity in response to increased prey abundance.

More than 80 percent of bat calls were recorded between 20:00 and 01:00 hours; detection rates decreased steadily between midnight and dawn (fig. 10). This activity pattern also was evident for individual species. In particular, 87 percent of canyon bat calls were recorded between 20:00 and 21:00 hours. All detectors were deployed by 19:40 hours, but the earliest recording was at 20:10 hours. Similarly, detectors were operated until after 06:20 hours, but no bats were recorded after 05:18 hours.

Transect Surveys.—We verified a total of six bats (four silver-haired bats, one canyon bat, and one unknown species from the 40 kHz Group) during five transect surveys (table 6). Bat calls from Transect 1 of a quality high enough to be classified by SonoBatch (a routine within SonoBat) included silver-haired bats and a single canyon bat. In addition to the calls classified by SonoBatch, the April 23 transect run had two obvious silver-haired bats and another possible canyon bat. Likewise, the April 24 run included six apparent silver-haired bats calls that were not classified by SonoBatch.

Visual Searches for Bat Roosts.—In addition to the acoustic surveys, an observer (T. Manning) spent some time searching for likely bat roosts at Columbia NWR in April 2012. Visual searches were conducted near Lower Crab Creek, Shiner Lake, and Blythe Lake by searching at the base of rimrock cliffs for accumulations of guano and peering into cracks with a flashlight. These searches did not provide any evidence that bats used cliffs in these areas.

T. Manning found a single bat roosting under a bridge where McManamon Road crosses Lower Crab Creek (NAD83, Zone 11T, 324515E 5196150N) on April 19, 2012. During daylight, T. Manning noticed obvious bat guano (fig. 11) in small amounts on the east creek bank, beneath the bridge. Bat foraging activity was detected the same evening (April 19, 2012) with a hand-held detector, and one bat was found roosting beneath the east side of the bridge. The bat roused and flew immediately in response to a flashlight beam. No bats were observed in subsequent visits to the bridge over the next several days and nights.

Discussion

Our winter survey effort was fairly cursory given the small area sampled by each detector deployment (less than 50-m radius) relative to the large area of potential habitat, particularly at Hanford NM/ Saddle Mountain NWR, and the low probability of detecting bats during winter. Nonetheless, we provided evidence of winter bat activity at Columbia NWR. The lack of detections of bats at Hanford NM/ Saddle Mountain NWR during the winter suggest the need for more extensive surveys, as we covered only a fraction of the potential habitat for a limited period of time.

Our acoustic data indicated the presence of canyon bats on Columbia NWR in the winter. Canyon bats have not previously been recorded north of the Columbia River along the Oregon-Washington State line outside of the breeding season, so our data provide evidence to extend the known winter range of this species. However, acoustic detections alone are often insufficient for conclusive identification of species presence (Barclay, 1999), so visual identification of this species during the winter would be helpful in confirming a range extension. One of the unknown bat species detected in winter at Columbia NWR may have been a little brown myotis, although the acoustical data provided only weak evidence for this identification because the signature was not conclusive. This species, along with at least three other myotis species (California, western small-footed , and Keen’s myotis) are year-round residents in the region. The wintering habits of other myotis species that potentially occur in the region, western long-eared, fringed, Yuma, and long-legged myotis are poorly understood. Additional study will be necessary to provide a more comprehensive inventory of wintering bats. One approach to obtaining such information is to monitor pre-hibernation and pre-migration bat activity by conducting surveys in the late summer and autumn to provide a more complete profile of seasonal activity patterns for all species that use the refuge.

Two species that were detected in April, California myotis (four detections) and Townsend’s big-eared bat (one detection), represented new species records for the MCNWRC. Both species are of conservation concern: the California myotis is listed as a State Vulnerable species in Oregon, and the Townsend’s big-eared bat is a Federal Species of Concern, as well as a State Candidate species in Washington (table 1). Townsend’s big-eared bats are year-round residents in the Pacific Northwest, from California to southern British Columbia. Based on hibernation locations on the upper Snake River Plain in Idaho (Genter, 1986) and in central Oregon (Dobkin and others, 1995), and our results indicating the presence of this species on Columbia NWR as early as mid-April, it seems likely that it over-winters on the refuge. Federally Endangered eastern subspecies of the Townsend's big-eared bat, Ozark big-eared bat (*Corynorhinus townsendii ingens*) and Virginia big-eared bat (*C. t. virginianus*) have not yet been documented as afflicted with white-nose syndrome (WNS), but it now occurs throughout much of their respective ranges. More surveys to better understand the seasonal distribution of Townsend’s big-eared bats on the MCNWRC would aid conservation planning for this special status species.

Two bat species and one close relative of a species present at Columbia NWR in April have been affected by WNS in eastern North America: big brown bat, little brown myotis, and eastern small-footed myotis (closely related to western small-footed myotis). All three species are reported to overwinter in the region. Because they may be among the most vulnerable to WNS, more information about the winter ecology, habitat use, and roost locations of these species is urgently needed to inform proactive management and effectively prioritize key hibernacula for their conservation. Using the locations where we recorded activity in both seasons (winter and spring) to deploy bat detectors from September through November may maximize the probability of detecting bats in the off-season. More intensive methods, such as tracking individual bats with radio-telemetry (Holland and Wikelski, 2009) and Passive Integrated Transponder (PIT) tag technology (see U.S. Geological Survey, 2013) may be helpful in locating winter roosts and estimating the numbers of bats using them.

Of the three survey methods we used, stationary acoustic detectors were the most efficient in winter and spring. In the April survey, the average detection rate for transects of 2.1 bat calls/hour was considerably lower than recorded by the stationary detectors, which had an average rate of 10 bat calls/hour for the same dates. If bat activity was localized near open water, transects that included stretches of upland habitat (appendix 3) probably were less likely to encounter bats than stationary detectors located in wetland habitat. Visual searches also proved inefficient for finding roosting bats, but could be helpful for pinpointing roosts in an area of cliff or rimrock habitat where bat activity has already been detected.

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Figure 1. Wetlands and rimrock habitat on Columbia National Wildlife Refuge, Washington.

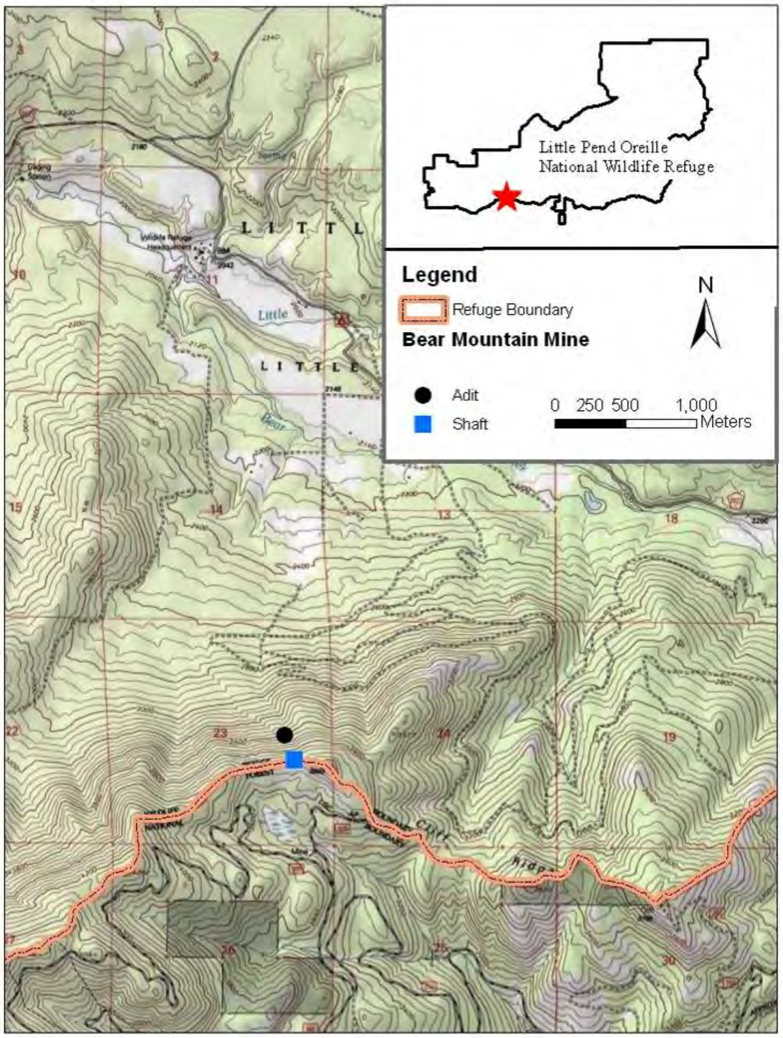

Figure 2. Location of Little Pend Oreille Refuge and Bear Mountain Mine Adit and Shaft, Washington.

Figure 3. Bat detector deployment at study sites. (A) Shiner Lake, Columbia National Wildlife Refuge, Washington. Detector is in the bag on the ground, and microphone is at the end of the horizontal piece of PVC pipe. (B) Bat detector deployment at Bear Mountain Mine Shaft, Little Pend Oreille National Wildlife Refuge, Washington. (C) Bat detector deployment at Bear Mountain Adit. Little Pend Oreille National Wildlife Refuge, Washington.

Figure 4. Bear Mountain Mine at Little Pend Oreille National Wildlife Refuge, May 2012. (A) Mine Shaft with standing water. (B) Adit.

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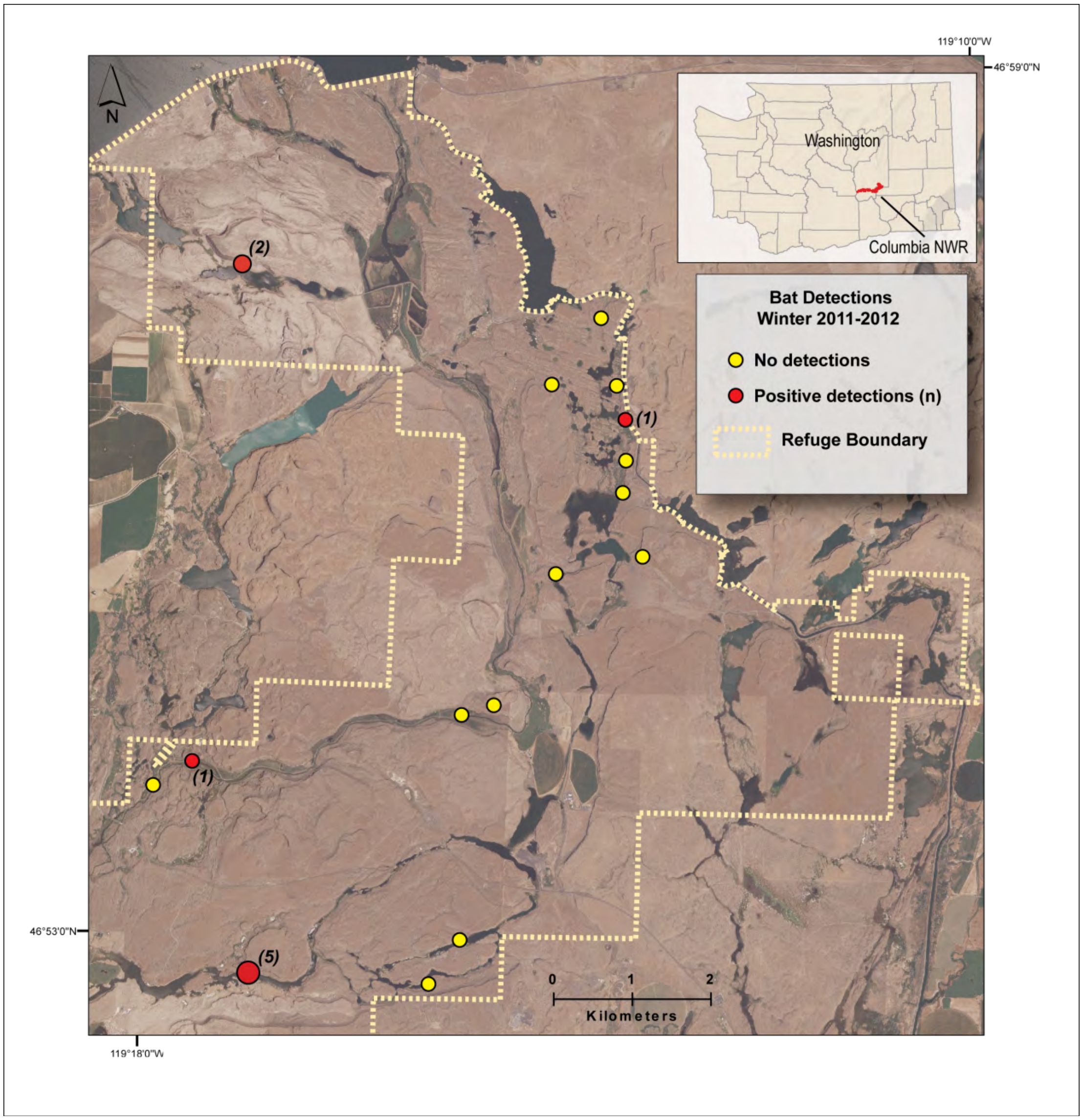


Figure 5. Acoustic bat detector deployment locations and number of bat detections (n) at Columbia National Wildlife Refuge, Washington, December 2011–January 2012.

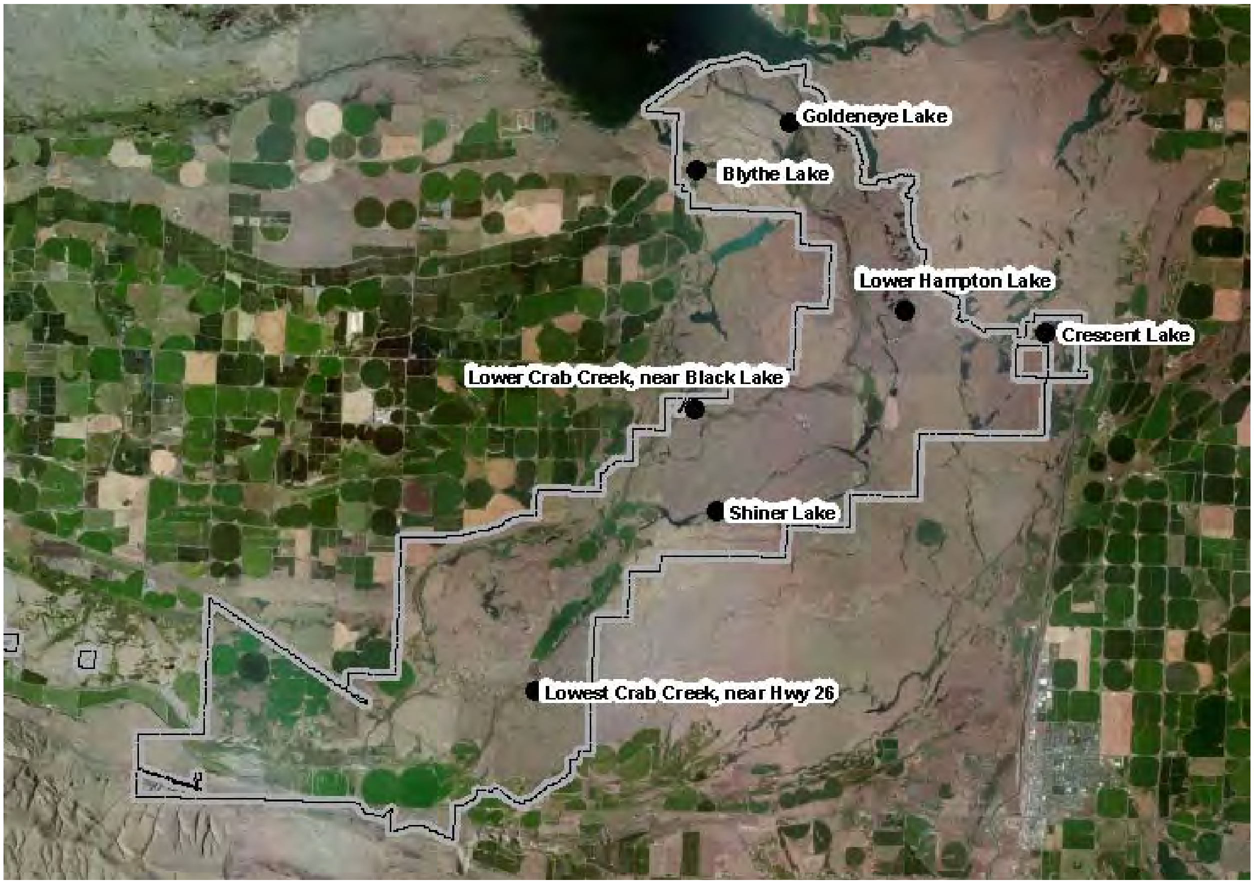


Figure 6. Location of stationary bat detectors deployed in April 2012, Columbia National Wildlife Refuge, Washington.

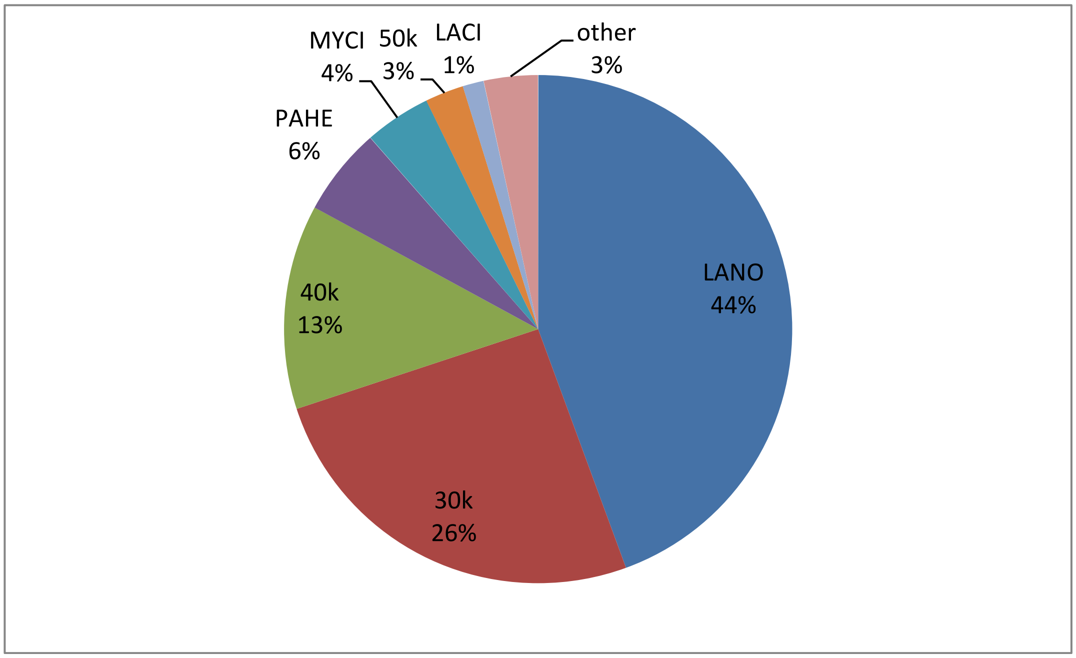


Figure 7. Species composition of bats detected at Columbia National Wildlife Refuge, Washington, April 17–27, 2012. Percentages represent relative frequency of calls detected. Species were silver-haired bat (LANO), unknown species in the 30-, 40-, and 50-kHz call frequency groups (see table 1), canyon bat (PAHE), western small-footed myotis (MYCI), and hoary bat (LACI). "Other" species each comprised less than 1 percent of detected calls: big brown bat, little brown myotis, Yuma myotis, California myotis, western long-eared myotis, pallid bat, and Townsend's big-eared bat.

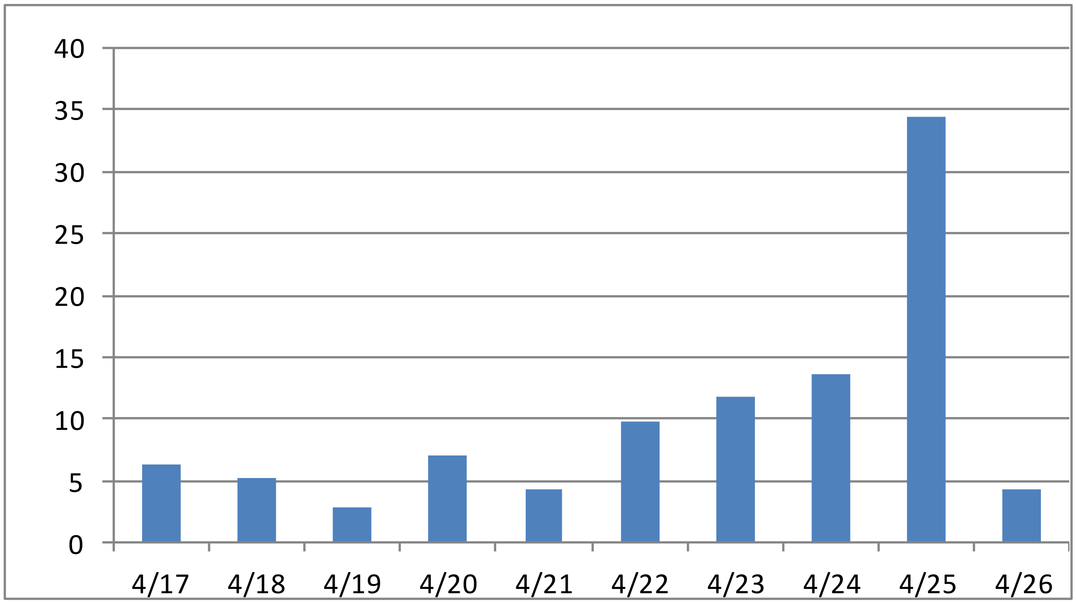


Figure 8. Index of bat activity (number of bats calls per hour) by date at Columbia National Wildlife Refuge, Washington, April 2012.

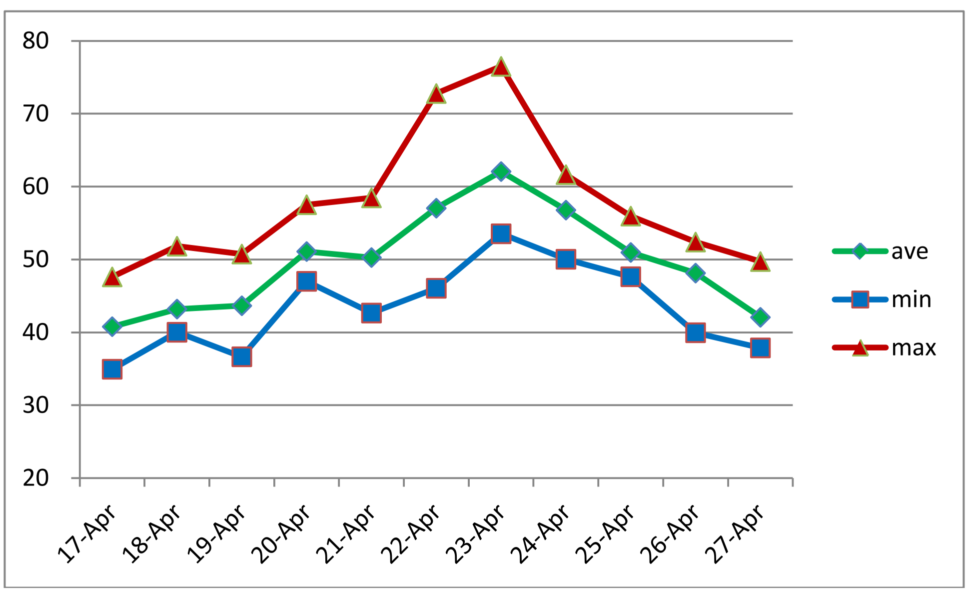


Figure 9. Average, minimum, and maximum nighttime temperatures (°F) on dates of bat detector deployments, Columbia National Wildlife Refuge, Washington, April 2012.

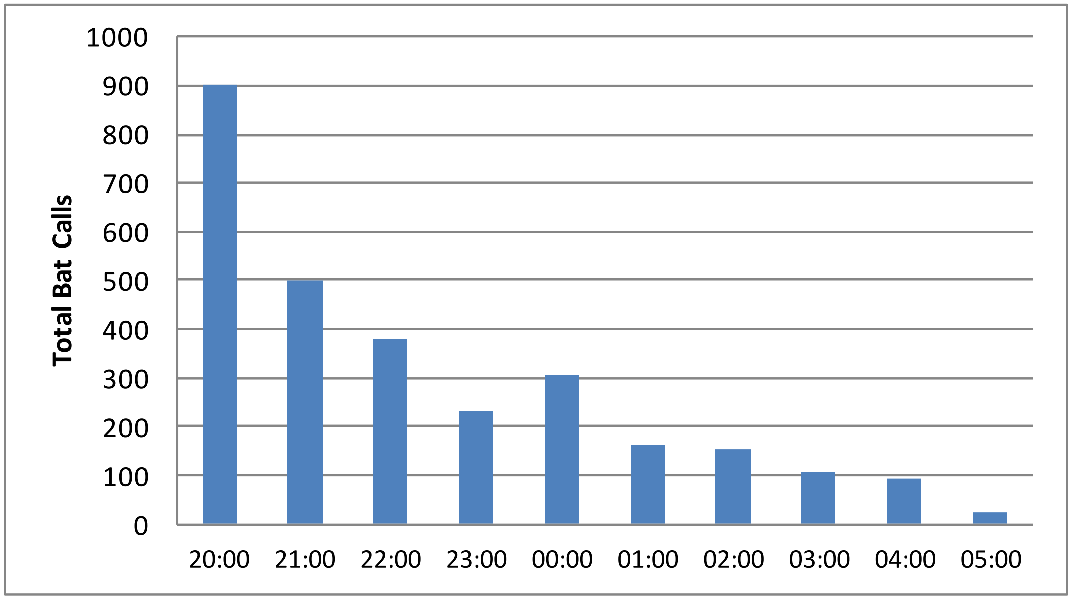


Figure 10. Total number of bat calls detected as a function of time of night, Columbia National Wildlife Refuge, Washington, April 17–27, 2012.

Figure 11. Bat guano found under bridge where McManamon Road crosses Lower Crab Creek, Columbia National Wildlife Refuge, Washington.

Table 1. Names, call frequency groupings, and conservation status of bat species that potentially occur on refuges of the Mid-Columbia National Wildlife Refuge Complex, Washington.

[Species of concern are those whose conservation status is of concern to the U.S. Fish and Wildlife Service, but more information is needed. kHz, kilohertz; OR, Oregon; WA, Washington]

Common name	Scientific name	Code	Call group	Conservation status
Big brown bat	*Eptesicus fuscus*	EPFU	30 kHz	None assigned
California myotis	*Myotis californicus*	MYCA	50 kHz	OR: Sensitive—Vulnerable
Canyon bat	*Parastrellus hesperus*	PAHE	50 kHz	WA: State monitored
Fringed myotis	*Myotis thysanodes*	MYTH	30 kHz	OR: Sensitive—Vulnerable; WA: State monitored
Hoary bat	*Lasiurus cinereus*	LACI	30 kHz	OR: Sensitive—Vulnerable
Keen's myotis	*Myotis keenii*	MYKE		WA: State candidate
Little brown yotis	*Myotis lucifugus*	MYLU	40 kHz	None assigned
Long-legged myotis	*Myotis volans*	MYVO	40 kHz	OR: Sensitive—Vulnerable; WA: State monitored
Pallid bat	*Antrozous pallidus*	ANPA	30 kHz	OR: Sensitive—Vulnerable; WA: State monitored
Red bat	*Lasiurus blossevillii*	LABL	40 kHz	WA: State monitored
Silver-haired bat	*Lasionycteris noctivagans*	LANO	30 kHz	OR: Sensitive—Vulnerable
Spotted bat	*Euderma maculatum*	EUMA	10 kHz	OR: Sensitive—Vulnerable; WA: State monitored
Townsend's big-eared bat	*Corynorhinus townsendii*	COTO	30 kHz	Federal: Species of Concern1; OR: Sensitive—Critical; WA: State candidate
Western long-eared myotis	*Myotis evotis*	MYEV	30 kHz	WA: State monitored
Western small-footed myotis	*Myotis ciliolabrum*	MYCI	40 kHz	WA: State monitored
Yuma myotis	*Myotis yumanensis*	MYYU	50 kHz	None assigned

Table 2. Dates, times, coordinates, and results of winter driving transects to detect bats at Columbia National Wildlife Refuge, Washington.

Date	Start time	End time	Start UTM E	Start UTM N	End UTM E	End UTM N	Bat detections
12/13/2011	16:13	17:56	332768	5198888	331075	5200445	None
12/14/2011	15:31	17:59	330194	5201664	331084	5200349	None
12/20/2011	15:33	17:48	329632	5198407	328324	5201981	Possible
12/21/2011	15:44	18:15	325422	5196943	329285	5197591	None
12/22/2011	16:38	18:02	296206	5148899	286274	5151408	None
12/28/2011	15:54	18:18	327533	5193961	329307	5195369	None
1/10/2012	16:02	17:40	325431	5203102	324247	5204350	None
1/11/2012	16:00	18:20	329624	5200220	332127	5198515	Possible
1/12/2012	16:00	18:29	302739	5174448	302995	5178752	None

Table 3. Total number of bats by species or call frequency group and detection rates (average calls/hour; based on 5 s recording length) at the Bear Mountain Shaft, May 9–15, 2012.

	Species	Number of detections	Detection rate
Bat species	Western long-eared myotis	71	2.90
	Silver-haired bat	10	0.41
	California myotis	5	0.20
	Western small-footed myotis	1	0.04
	Little brown myotis	1	0.04
	Yuma myotis	1	0.04
	Unknown bat spp.	31	1.27
Species group	40 kHz	53	2.16
	30 kHz	43	1.76
	Myo30 kHz	21	0.86
	50 kHz	12	0.49
Site total		216	10.08

Table 4. Bat species, and weather conditions at times of bat detections, December 2011–January 2012, Columbia National Wildlife Refuge.

[Climate data provided courtesy of Washington State University's AgWeatherNet©. Weather data represent conditions at time of bat detections, +/- 15 minutes]

Date	Species	Time	Temp (°F)	Relative humidity (percent)	Wind (mph)
12/05/2011	Canyon bat	17:53	30.1	77.1	3.2
12/27/2011	Canyon bat	18:48	43.7	76.5	8.9
01/11/2012	Unknown	17:53	25.6	62.9	4.3
01/12/2012	Unknown	17:33	25.5	77.2	2.4
01/12/2012	Unknown	17:51	26.1	75.2	2.3
01/14/2012	Unknown	19:49	29.7	64	9
01/14/2012	Canyon bat	19:56	29.6	65.7	13.1
01/17/2012	Myotis sp.	17:25	32.8	62.6	9.4
01/17/2012	Unknown	17:28	32.8	62.6	9.4
	Averages for weather:		30.66	69.31	6.89

Table 5. Total detection and detection rates (average calls/hour; based on 5 s recording length) of bats by species at seven sites on Columbia National Wildlife Refuge, Washington, April 17–27, 2012.

[Species are sorted by frequency of detection, from most to least]

	Blythe Lake	Crescent Lake	Goldeneye Lake	Lower Crab Creek	Lower Hampton Lake	Lowest Crab Creek	Shiner Lake	Species totals
Silver-haired bat	0	341	359	175	61	196	131	1,263
30KhZ group	0	196	248	153	15	30	85	727
40KhZ group	1	14	76	60	28	102	89	370
Canyon bat	0	0	5	11	2	101	41	160
Western small-footed myotis	0	6	34	8	23	16	33	120
50kHz group	0	0	7	13	3	31	16	70
Hoary bat	0	0	18	10	2	0	8	38
Unknown bat spp.	0	1	13	11	2	11	0	38
Big brown bat	0	0	20	6	0	1	3	30
Yuma myotis	0	0	4	8	0	0	2	14
Little brown myotis	0	1	4	0	0	1	2	8
California myotis	0	0	0	0	1	2	1	4
Western long-eared myotis	0	0	0	0	0	1	1	2
Pallid bat	0	0	0	0	0	0	1	1
Townsend's big-eared bat	0	0	0	0	0	0	1	1
Site totals	1	559	788	455	137	492	414	2,846
Bats/hour	0.1	26.0	18.1	8.3	2.5	15.2	7.4	10.4

Table 6. Locations, dates, times, and results of acoustic transect surveys for bats in Columbia National Wildlife Refuge, Washington, April 2012.

Transect #	Date	Start Time	Total time	Start UTM E	Start UTM N	End UTM E	End UTM N	Weather	Bats
Transect 1	4/21	20:17	0:38	328398	5205596	324293	5197084	Clear, still, 54°F, new moon.	40 kHz
Transect 1	4/23	20:21	0:37	328398	5205596	324293	5197084	72°F, cloudy.	1 PAHE, 2 LANO
Transect 1 in reverse	4/24	20:22	0:40	324293	5197084	328398	5205596	Clear, still, 56°F; young moon.	1 LANO
Transect 2	4/25	20:23	0:38	324251	5204632	332783	5198882	Cloudy, breezy, 55°F.	Noise
Transect 3	4/26	20:25	0:20	328250	5197417	332804	5198861	Windy, 45°F.	1 LANO

Appendix 1. Dates and Locations of Deployments of Acoustic Bat Detectors at Columbia, Hanford NM/Saddle Mountain, and Little Pend Oreille National Wildlife Refuges, Winter 2011–2012

Date deployed	Date retrieved	Time deployed	Refuge	Site name	UTM (Zone 11, NAD 83) Easting	Northing
10/04/2011	10/17/2011	12 days	LPO	Bear Mountain Shaft	446549	5364250
10/17/2011	10/28/2011	2 days[a]	LPO	Bear Mountain Adit	446473	5364420
12/01/2011	12/08/2011	7 days	Columbia		330901	5200355
12/01/2011	12/08/2011	7 days	Columbia		330932	5201285
12/08/2011	12/14/2011	6 days	Columbia		330940	5200765
12/08/2011	12/14/2011	6 days	Columbia		330823	5201719
12/14/2011	12/21/2011	7 days	Columbia		330624	5202579
12/14/2011	12/21/2011	7 days	Columbia		329996	5201734
12/21/2011	12/28/2011	7 days	Columbia		324926	5196639
12/21/2011	12/28/2011	7 days	Columbia		325422	5196943
12/28/2011	01/06/2012	9 days	Columbia		329259	5197653
12/28/2011	01/06/2012	9 days	Columbia		328850	5197528
01/06/2012	01/11/2012	5 days	Columbia		328427	5194104
01/06/2012	01/11/2012	5 days	Columbia		328825	5194664
01/11/2012	01/19/2012	8 days	Columbia		326134	5194247
01/11/2012	01/26/2012	15 days	Columbia		326059	5203272
01/20/2012	01/25/2012	4 days	Columbia		330047	5199324
12/16/2011	12/22/2011	6 days	Hanford	Rattlesnake Springs	292339	5153702
12/16/2011	12/22/2011	6 days	Hanford	Sniveley Homestead	291515	5147919
12/22/2011	12/29/2011	7 days	Hanford	Bobcat	295965	5147525
12/22/2011	12/29/2011	7 days	Hanford	Sniveley Canyon	291026	5148719
12/29/2011	01/05/2012	7 days	Hanford		312420	5139464
12/29/2011	01/05/2012	7 days	Hanford		294070	5153687
01/05/2012	01/12/2012	7 days	Hanford	Saddle	313341	5185075
01/05/2012	01/12/2012	7 days	Hanford	Canal Bridge	311178	5182141
01/12/2012	01/18/2012	6 days	Hanford		303090	5173178
01/12/2012	01/18/2012	6 days	Hanford		306405	5177396
01/20/2012	01/26/2012	6 days	Hanford		318796	5171631
01/20/2012	01/26/2012	6 days	Hanford		326437	5153106
04/17/2012	04/18/2012	11 h 39 min	Columbia	Shiner Lake	325931	5194309
04/18/2012	04/19/2012	11 h 8 min	Columbia	Shiner Lake	325931	5194309
04/19/2012	04/20/2012	11 h 5 min	Columbia	Shiner Lake	325931	5194309
04/20/2012	04/21/2012	11 h 2 min	Columbia	Shiner Lake	325931	5194309
04/21/2012	04/22/2012	10 h 59 min	Columbia	Shiner Lake	325931	5194309
04/22/2012	04/23/2012	10 h 55 min	Columbia	Goldeneye Lake	327771	5204246
04/23/2012	04/24/2012	10 h 53 min	Columbia	Goldeneye Lake	327771	5204246
04/24/2012	04/25/2012	10 h 50 min	Columbia	Goldeneye Lake	327771	5204246
04/25/2012	04/26/2012	10 h 47 min	Columbia	Goldeneye Lake	327771	5204246
04/26/2012	04/27/2012	malfunction	Columbia	Goldeneye Lake	327771	5204246
04/19/2012	04/20/2012	11 h 5 min	Columbia	Lower Crab Creek	325422	5196943
04/20/2012	04/21/2012	11 h 2 min	Columbia	Lower Crab Creek	325422	5196943
04/21/2012	04/22/2012	10 h 59 min	Columbia	Lower Crab Creek	325422	5196943
04/22/2012	04/23/2012	10 h 55 min	Columbia	Lower Crab Creek	325422	5196943
04/23/2012	04/24/2012	10 h 53 min	Columbia	Lower Crab Creek	325422	5196943
04/24/2012	04/25/2012	10 h 50 min	Columbia	Lowest Crab Creek	321335	5189756

Date deployed	Date retrieved	Time deployed	Refuge	Site name	UTM (Zone 11, NAD 83)	
04/25/2012	04/26/2012	10 h 47 min	Columbia	Lowest Crab Creek	321335	5189756
04/26/2012	04/27/2012	10 h 44 min	Columbia	Lowest Crab Creek	321335	5189756
04/19/2012	04/20/2012	11 h 0 min	Columbia	Blythe Lake	325445	5203011
04/19/2012	04/20/2012	11 h 5 min	Columbia	Lower Hampton Lake	330716	5199444
04/20/2012	04/21/2012	11 h 2 min	Columbia	Lower Hampton Lake	330716	5199444
04/21/2012	04/22/2012	10 h 59 min	Columbia	Lower Hampton Lake	330716	5199444
04/22/2012	04/23/2012	10 h 55 min	Columbia	Lower Hampton Lake	330716	5199444
04/23/2012	04/24/2012	10 h 53 min	Columbia	Lower Hampton Lake	330716	5199444
04/24/2012	04/25/2012	malfunction	Columbia	Crescent Lake	334306	5198891
04/25/2012	04/26/2012	10 h 47 min	Columbia	Crescent Lake	334306	5198891
04/26/2012	04/27/2012	10 h 44 min	Columbia	Crescent Lake	334306	5198891
05/9/2012	05/17/2012	7 days	LPO	Bear Mountain Shaft	446549	5364250
05/9/2012	05/17/2012	7 days	LPO	Bear Mountain Adit	446473	5364420

[a] Data cards filled with noise on the third night of deployment effectively terminating data collection.

Appendix 2. Recording and Displaying Bat Acoustic Transects

Documentation and instruction on how to produce displayable transect files from GPS track data and bat call detection files are not readily available from the developer of the Myotisoft™ programs. We documented the following protocol to make it easier for future users. These directions pertain specifically to Garmin™ and DeLorme GPS instruments, and SonoBat™ 3.05 acoustic software.

To successfully record all data needed for a displayable transect:

1. Be sure you know how your particular GPS records track data, and how to download the track data, including time data for each trackpoint. Without time data for each individual trackpoint, Myotisoft Transect© or TransectPro© software cannot produce a transect file to display. Also, be sure that it is possible to convert a GPS track file to a GPX file, because that's the format used by Myotisoft software.

   For instance, with a Garmin™ GPSmap 60, the instrument is by default set to record a waypoint on the track every 100 meters. By changing the set-up, it is possible to record one waypoint per some-given-time-interval (we used 10 s). This is apparently the only way to get time data for a track. At the completion of each transect, the "active log" must be downloaded from that track to some outside data storage. This "active log" file appears to be the only place where the time data are stored, and the active log is temporary, that is, it gets replaced in the GPS (that is, lost) when a new track is started. Files saved as tracks alone, without the active log, **will not include time data**. Later, the downloaded active log can be opened on a computer with the Garmin™ software or EasyGPS software and saved as a GPX file with extension ".gpx". The GPX file is input for the Myotisoft program.

   The procedure is different with a DeLorme Earthmate PN40 GPS. In this case, it appears the default is to create tracks with time data included, and the file saved as a "track" apparently has the time data needed to produce a transect display. That is, there is no additional "active log;" thus, the track can simply be saved within the GPS, and the track can be downloaded to a computer later (using the DeLorme software supplied with the instrument) and exported as a GPX file.

2. Before starting a transect, make sure that the GPS and bat detector are synchronized as closely as possible (generally within 2 s error), so that accurate locations of bat calls are recorded.
3. Use a standardized transect datasheet and checklist to make sure no essential data are omitted and that all pertinent data are recorded, such as temperature, weather conditions, start and stop times, start and stop locations, route details, etc.
4. Remember to save and download GPS and call data at the end of each transect. Remember that with some GPS instruments it is necessary to download the "active log" after each transect to get usable time data that is synchronized with position data.

5. We recommend testing these procedures before running a transect to collect real data, to make sure that

   A) track points are associated with time data,

   B) it is possible to save and/or download trackpoints, and

   C) it is possible to convert or export to the GPX format.

To display transect data using the Myotisoft Transect© or TransectPro©:

1. To get recorded bat acoustic data ready for the Myotisoft program, run the SonoBat™ File Attributer to scrub out the majority of the non-bat noise files, then run the SonoBat™ Suite for the appropriate geographic region in batch mode (SonoBatch) to make preliminary classifications of the bat call files.

   Be sure to set the batch processor to “append spp. to filenames” (button at bottom right of SonoBatch window). Doing this will attach a standard four-letter species acronym to each file of sufficient quality to classify. For instance,

   “CMB_Transect 1-24Apr12-20,40,58”

   becomes

   “CMB_Transect 1-24Apr12-20,40,58-Lano”

   This signifies that the call file has been classified as a silver-haired bat (*Lasionycteris noctivagans*). The Myotisoft program will need this to label bat calls on the final transect display.

   Note that this extra label is attached to the actual batcall files in the transect data, not to the text file that results from the SonoBatch routine; the text file is NOT used in the Myotisoft program.

   Also, be aware that the scrubbing and classifying processes described in this step may take many hours of processing, depending on computer speed and the number of call files. Although much of this process is automated by SonoBat™ and takes little input from the user, the batch classification of bat call files by SonoBat™ is preliminary and should be verified by an expert.

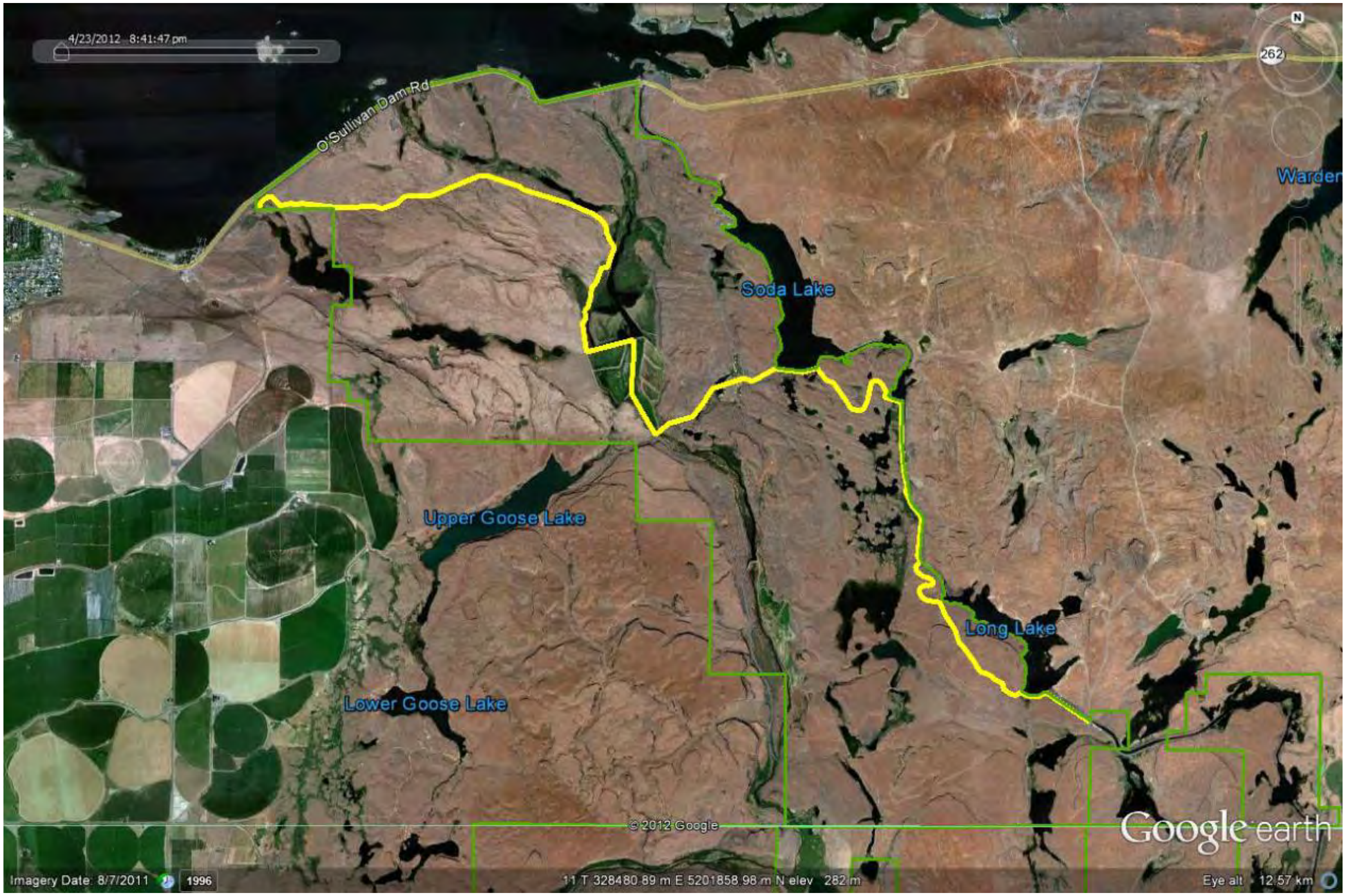
2. The GPX file should be checked to make sure it includes time data and geographic coordinates also check bat call files to verify that at least some have species acronyms attached. Start Myotisoft Transect© (to display transects using Google Earth™) or TransectPro© (to display transects using ArcGIS) and follow the prompts to tell the program where GPX and batcall data are to be stored, and where results files are to be saved.

3. If no error message is displayed, the transect and results should be displayable. Look for a file with extension .kmz (for Transect to use in Google Earth™) or .shp (for TransectPro© to use in ArcGIS) in the location specified for results output. To view a transect on a computer loaded with Google Earth™, simply double-click the file icon and it should open Google Earth™ and display the transect automatically. Bat icons are displayed at the locations where acoustic files were recorded. Classified calls are labeled with their species acronym, and noise files or poor bat call files will display as "Unknown." The "Unknown" labels can be turned off (unchecked) using the sidebar in Google Earth™.

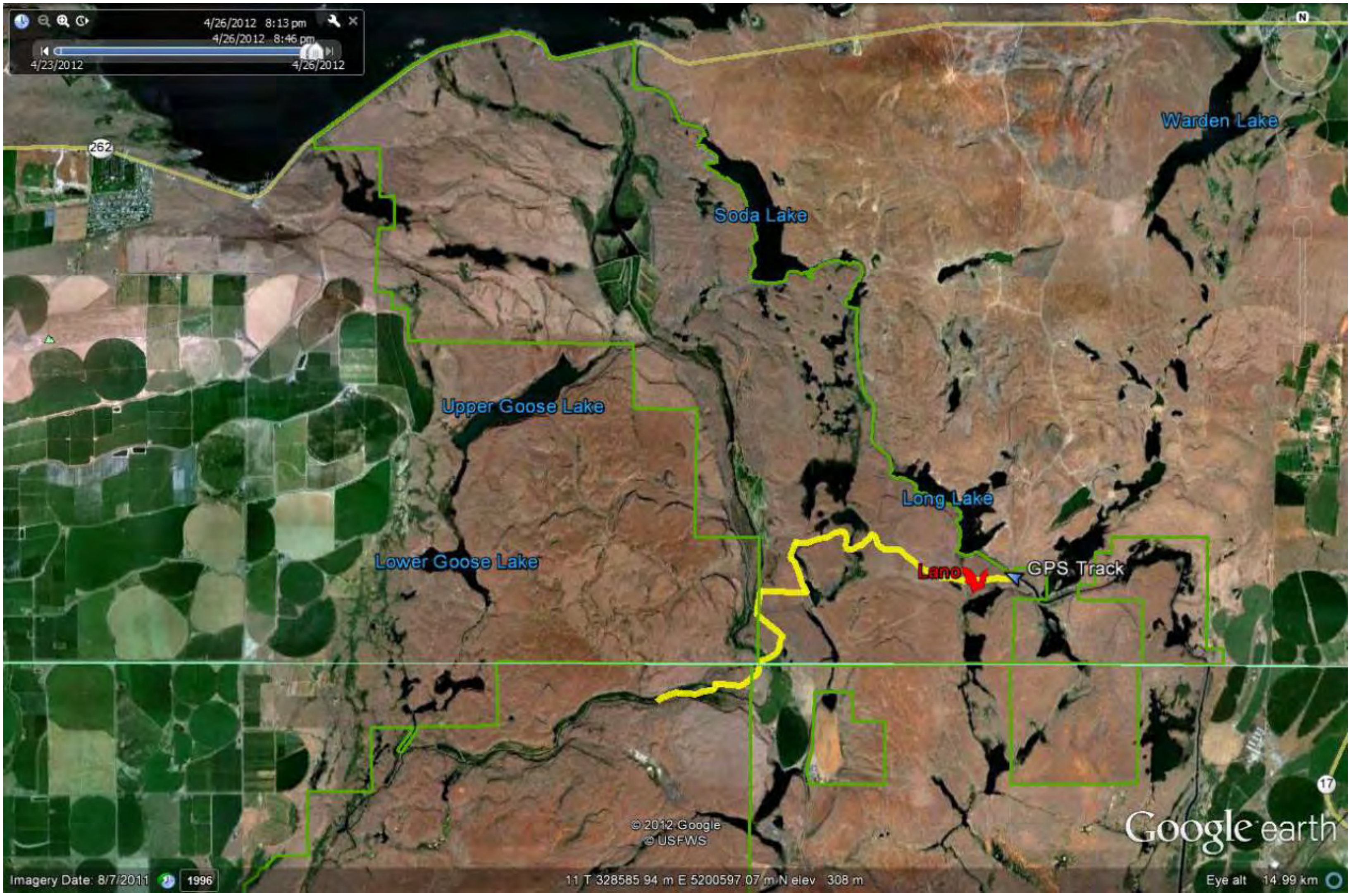
Appendix 3. Bat Survey Transect Routes and Bats Detected, Columbia National Wildlife Refuge, Washington, April 2012

Bat Survey Transect 1 at Columbia National Wildlife Refuge, April 23, 2012. One canyon bat (PAHE; *Parastrellus hesperus*) and two silver-haired bats (LANO; *Lasionycteris noctivagans*) were detected.

Bat Survey Transect 2 at Columbia National Wildlife Refuge, April 25, 2012. No bats were detected.



Bat Survey Transect 3 at Columbia National Wildlife Refuge, April 26, 2012. One silver-haired bat (LANO; *Lasionycteris noctivagans*) was detected.



Publishing support provided by the U.S. Geological Survey
Publishing Network, Tacoma Publishing Service Center

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