Bat Habitat Delineation and Survey Suggestions for Bighorn Canyon National Recreation Area

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Executive Summary

The National Park Service (NPS) has proposed conducting a comprehensive inventory of bats in Yelowstone National Park, Grand Teton National Park, and Bighorn Canyon National Recreation Area (BCNRA). BCNRA and nearby federal lands may contain some of the highest bat diversity in the states of Wyoming and Montana. This project sought to identify potentially important bat habitat within BCNRA and conduct field reconnaissance to prioritize sites for future bat survey and monitoring efforts. This will facilitate the development of an effective survey, monitoring, and management strategy for the BCNRA and enable Park Service personnel to efficiently use limited funds to target key areas for bat conservation. There were two primary tasks required to meet the goals for this project. The first was to identify and compile geographically referenced electronic data on all features of BCNRA that might be useful in identifying important areas of bat use within and near BCNRA and to use this data to construct models that would identify critical bat habitat. The second was to visit some locations suggested by the accumulated habitat data and use acoustic bat detectors to determine the extent to which they were used by bats. Compiled information and field reconnaissance revealed an abundance of suitable bat habitat on BCNRA. The set of data resulting from my compilation efforts has been included on a CD-ROM accompanying this report for use in future biological monitoring efforts at BCNRA. As a test case, this information was used to generate a model predicting areas most likely to be used by Townsend's big-eared bat (*Corynorhinus townsendii*). This model showed the most suitable habitat in the central and southern portions of BCNRA due largely to proximity to caves. Similar models can be constructed for other groups of bats that have similar habitat requirements. Bat activity at all of the sites investigated with acoustic bat detectors was very high. Priority sites for bat inventory efforts should include selected portions of Layout Creek, Yellowtail Wildlife Habitat Management Area, Lockhart and Hillsboro Ranches, and caves off the recreation area (see Figure 5). The wealth of bats at BCNRA presents conservation opportunities for NPS that can be used to benefit the recreation area and its visitors.

Introduction

Bighorn Canyon National Recreation Area (BCNRA) was established in 1966, following the construction of the Yellowtail Dam, which created Bighorn Lake (Figure 1). Bighorn Lake extends 71 miles through Montana and Wyoming, 55 miles of which are held within Bighorn Canyon. The canyon itself is over 650 feet deep and carved from massive beds

of Madison Limestone. Limestone and dolomite extend throughout the area, outcropping frequently, and support many caves, including several large complexes that are among the longest known in either Montana, or Wyoming. When not contained by steep canyon walls, the broad riparian corridors around the Bighorn and Shoshone Rivers contain expansive wetlands with many open water ponds. The Recreation Area is composed of 70,000+ acres, which straddles the northern Wyoming and southern Montana borders. Upland habitat ranges from deciduous spring-fed riparian corridors, sagebrush and desert shrublands, and low-elevation juniper woodlands, to mid-elevation conifer forests (Figure 2).

This combination of geologic, hydrologic and vegetative features provides an abundant and diverse array of bat roosting habitat, including cliffs, caves, mines, buildings, and deciduous woodlands, all of which are proximate to wetland habitats used as foraging areas. This suggests that BCNRA and nearby federal lands may contain some of the highest bat diversity in the states of Wyoming and Montana. Twelve bat species have been documented in the area surrounding BCNRA, including Spotted Bat and Townsend's Big-eared Bat (Table 1), but knowledge of the fauna using the recreation area is limited.

The National Park Service (NPS) has recently begun a nationwide process to inventory and monitor the biological resources within its management areas. Recognizing the need for a cross-boundary, ecosystem approach to natural resource management, the system of national parks has been grouped into Cooperative Ecosystem Units to facilitate inventory, monitoring, and subsequent management decisions in ecologically meaningful areas. The Rocky Mountain Cooperative Ecosystem Studies Unit (RMU) includes Yellowstone and Grand Teton National Parks (YNP and GTNP) and BCNRA. A combined effort of biologists from these parks and regional wildlife experts has resulted in the recent release of a study plan for the RMU inventory and monitoring efforts (NPS, 2000). This document identified significant gaps in information on the species richness, abundance, and distribution of bat species within these parks. They have therefore proposed that the NPS conduct a comprehensive inventory of bats in these areas to establish a benchmark for future monitoring efforts and management actions.

This project sought to identify potentially important bat habitat within BCNRA and conduct field reconnaissance to prioritize sites for future bat survey and monitoring efforts. This will facilitate the development of an effective survey, monitoring, and management strategy for the BCNRA and enable Park Service personnel to efficiently use limited funds to target key areas for bat conservation.

Methods

There were two primary tasks required to meet the goals for this project. The first was to identify and compile geographically referenced electronic data on all features of BCNRA that might be useful in identifying important areas of bat use within and near BCNRA and to use this data to construct models that would identify critical bat habitat. The second was to visit some locations suggested by the accumulated habitat data to determine the extent to which they are actually used by bats.

Since biologically relevant geographic information system (GIS) data for BCNRA was not uniformly generated or centrally stored, much of my effort was expended identifying, rectifying, and compiling data leaving little time for formal GIS modeling. All GIS data deemed potentially relevant to bats was collected at WYNDD. It was immediately evident that most of this data was generated in ad hoc fashion and did not seem to precisely match standard projections. Therefore, all coverages were reviewed and corrected to match the map projection defined by digitally referenced graphics (DRG's) of relevant USGS 7.5 quadrangles of the area. Specifically, to the extent possible we corrected all data to match zone 12 of the Universal Transverse Mercator (UTM) projection based on the North American Datum of 1927.

As an example of what can be done with the compiled data, a simple habitat model was developed to predict the areas of BCNRA that where most likely to be used by Townsend's big-eared bat. This species was selected because it is among the most sensitive species on the list of those likely to occur in BCNRA and has been documented in the caves near the recreation area. The model was constructed from three GIS data layers: known caves in the Pryor Mountains, BCNRA vegetation data, and BCNRA wetlands data. Raster coverages of site suitability where created for each dataset, wherein each cell contained a categorical rank of relative suitability for Townsend's big eared bat, based on published habitat associations and behavioral data. Ranks were from 0 (unsuitable) to 3 (very suitable). For land cover data, each vegetation type was given a relative suitability rank (Table 3), while for caves, mines, and open water, ranks were assigned based on distance from the key habitat feature (Table 4). These ranks were combined additively, with somewhat more weight given to proximity to caves and mines, resulting in relative habitat suitability ranks ranging from 0 (unsuitable) to 10.5 (very suitable):

$$HS = 1.5*CDR + WDR + VR,$$

where HS = habitat suitability, CDR = cave and mine distance rank, WDR = water distance rank, and VR = vegetation rank. The resulting map was displayed in ArcView and used to give a rough idea of where the most suitable Townsend's big-eared bat habitat is within the recreation area.

Using information from my data compilation efforts, model, and personal communications with park personnel, I identified a short list of sites to investigate for bat use. At each of these sites, I placed a passively recording Anabat II acoustic bat detector (Figure 3). Detectors were connected to portable tape recorders, left operational overnight, and retrieved the following morning. Each tape was analyzed to determine the level of bat activity at that sight and filed for possible future analysis to identify calls of particular species. Relative bat activity was compared using the number of recorded files containing evidence of bat calls and the buffer size of those files (e.g., Britzke et al. 1999).

Results and Discussion

The first thing apparent from all analyses was a great abundance of suitable bat habitat on BCNRA and a great abundance of bats. The problem in conducting a bat inventory of BCNRA will not be locating areas of bat use, because bats probably use the vast majority of land in BCNRA and are therefore dispersed over a relatively broad area. Rather, the problem will be finding areas that concentrate bat use to the point where survey sampling is efficient.

The set of data resulting from my compilation efforts will be very useful to future survey efforts and, moreover, to other biological management in BCNRA. The enclosed CD-ROM contains 7 ArcView 3.2© shapefiles and 14 digital raster graphics files (DRG's) that delineate much of the wildlife habitat in the Recreation Area, with particular emphasis on bats (Table 2). All files come with an associated legend file (e.g., BCNRAvegetation.avl) that provides the same color-coding that appears in the figures of this report. The results of the habitat model for Townsend's big-eared bat (discussed below) are also included on the CD-ROM.

With the time and budget remaining following compilation of the resource data, I completed a basic bat habitat model for Townsend's big-eared bat. Time and budget constraints following data compilation precluded my addressing the full compliment of species possibly occurring in BCNRA, but I will generate new analyses should additional time and funds become available. GIS scoping studies are particularly valuable when it is necessary to focus surveys in large areas with a diversity of habitat that might not be suitable for bats (for example Yellowstone National Park). In this situation, the intersection of a suite of models (one for each species or, more efficiently, for a subset of species that is representative of the habitat use patterns of the complete bat fauna) would help focus survey efforts. In contrast, Bighorn Canyon national recreation area is a long, but relatively narrow strip of land with an abundance of habitat features that are valuable to bats of many species. Based on these characteristics, models for most species would likely encompass the majority of the recreation area in their highest habitat suitability category. Thus, in this case it is an appropriate strategy to survey readily accessible areas in and near BCNRA, whereby the vast majority of species present will be identified, but

also to model rare and habitat-limited species to make sure that areas at which they are most likely to occur are included in the survey.

With this in mind, the output of the model developed for Townsend's big-eared bat is presented in Figure 4. This model identifies areas that contain suitable habitat (based on published literature) that are proximate to caves or mines and open bodies of water. Two broad areas were identified as likely to be used by Townsend's big-eared bat; namely a strip of mixed shrubland and juniper woodlands in the central portion of the recreation area flanking Bighorn Lake, some of its tributaries (particularly Layout Creek), and adjoining wetlands, and a portion of the southern tip of BCNRA along the Bighorn River. Moreover, although no suitable caves have been documented on the recreation area, Townsend's bats are known to use caves immediately west, south, and east of the recreation. In particular, Kane Cave, Mystery Cave, and Horsethief Cave have been documented as day roosts and hibernacula and there are several other known, but unsurveyed, caves along the ridge to the west of Bighorn Canyon. Thus, it is highly likely that cave roosting bats forage within the park, and efforts to document this use should focus on surveys of small, open wetlands in these areas and, potentially, mist-netting the cave openings and radio or light-tagging bats to more explicitly follow their movements.

In general, bat activity at all of the scoping sites was very high, as expected by my preliminary habitat investigations. All cassette tapes from Anabat units (e.g., Figure 3), each of 45-minute duration, were completely filled with calls by midnight. Tapes had 245 ± 68 files (95% CI), and in all cases over 75% of these files showed evidence of bat activity. Further, the files containing bat calls had about 6% ± 0.5% of their buffers filled, which suggests that the sites were active, but that multiple calls were generally not overlapping in single files. For instance, Horse Thief Cave was the only site where multiple calls were regularly recorded in one file (largely due to the position of the detector with respect to the large cave entrance), and such files had buffers that were on the order of 15% full. Species composition at these sites was not investigated based on the Anabat Recordings, but calls were saved for future analyses. Preliminary evidence (i.e., visual observations of bats in flight, incidental observations of roosting bats, and coarse call characteristics) suggests that, at a minimum, little brown bats, big brown bats and possibly Lasiurus species were present at several sites. Also, Townsend's big-eared bats were seen at several cave entrances immediately off BCNRA and audible spotted bat calls were reported by local officials, but were not confirmed.

Conclusions

As with most initial species inventories, I recommend that a survey of Bighorn Canyon be conducted using a variety of methods in a variety of habitats designed to document use of the recreation area by all species that are present. One should consider the whole list of potential species and determine what locations and survey methods are best suited to document the presence of each of those species. This can be facilitated by the natural resource data compiled on the enclosed CD-ROM. As a first cut, I recommend placing priority on ponds in drainages in the central portion of the recreation area, where cave and cliff roosting species may be active, followed by portions of YWHMA, as presented in Figure 5. The final column of Table 1 also presents a few species-specific survey suggestions gleaned from my time at BCNRA, the habitat model I developed, and general knowledge of the species in question, but is by no means an exhaustive list. Rare species are almost by definition more difficult to detect than common ones, so surveying a given area is not a guarantee that such a species will be found, even if they do in fact occur their (Kunin and Gaston, 1997). Thus, to the extent possible, sites should be surveyed repeatedly, preferably over several years, using a combination of methods.

Bat use of buildings in BCNRA is site specific, but can be quite high. One abandoned building in the Yellowtail Wildlife Habitat Management Area has already been established as a "bat house" by the Wyoming Game and Fish Department. Other buildings in YWHMA are also likely to be used and I have further confirmed nighttime bat use of at least two abandoned buildings in the Hillsboro Ranch complex. Bats likely use these buildings during nights from roughly April through early October, after which they will migrate away from BCNRA or begin hibernation in nearby caves or mines. If archeological site management plans appear to conflict with bat use, a plan is likely available that will accommodate both the natural and cultural resources. For instance, Bat Conservation International has a "Bats in Buildings" program that provides guidelines for proper exclusion practices and also sells inexpensive bat houses that can be constructed in the vicinity to compensate for the loss of established roosting habitat (see "www.batcon.org" for more information). Also, the North American Bat House Research Project, created in 1993 by Bat Conservation International to advance the knowledge of artificial bat habitats, provides information on constructing and monitoring bat houses, particularly in areas of high bat diversity, like BCNRA.

From a biological perspective, BCNRA has a wealth of bat habitat and therefore is likely to have a wealth of bats (some of which, like the spotted bat, are quite charismatic), and it can potentially benefit from this unique natural resource. People are becoming increasingly aware of bats and their benefits to humans, not the least of which is the

consumption of vast quantities of insects. Many people I have met in my field excursions have been interested in learning about bats and are curious to see them in a controlled environment, so the potential for BCNRA to play a role in bat education is quite high. For instance, since much bat habitat in BCNRA is fairly assessable, a few survey stints (e.g., mist-netting of live bats) could easily be turned into interpretive sessions where visitors can learn about bats and see them up close.

Literature Cited

Britzke, E. R.; K. L. Murray; B. M. Hadley; and L. W. Robbins. 1999. Measuring Bat Activity with the Anabat II System. Bat Research News 40(1):1-3.

Knight, D. H.; G. P. Jones; Y. Akashi; and R. W. Myers. 1987. Vegetation Ecology in the Bighorn Canyon National Recreation Area: Wyoming and Montana. Report prepared by the Department of Botany, University of Wyoming, Laramie, Wyoming for the National Park Research Center, National Park Service,.

Kunin, W. E. and K. J. Gaston, eds. 1997. The Biology of Rarity: Causes and consequences of rare-common differences. Chapman and Hall, London.

Pierson, E. D. M. C. Wackenhut, J. L. Altenbach, P. Bradley, P. Call, D. L. Genter, C. E. Harris, B. L. Keller, B. Lenjus, L. Lewis, B. Luce, K. W. Navo, J. M. Perkins, S. Smith, and L. Welch. 1999. Species Conservation Assessment and Conservation Strategy for the Townsend's Big-Eared Bat (*Corynorhinus townsendii townsendii* and *Corynorhinus townsendii pallescens*). Idaho Conservation Effort, Idaho Department of Fish and Game, Boise, Idaho.

bat species likely to occur at BCNRA and pertinent survey tips

	Wyoming Conservation Status	Habitat Use			
		Roosts	**Hibernacula**	**Foraging**	**Survey Tips**
1B ive ive	High priority. Found rarely in northern and western Wyoming. Population status is uncertain. There are documented hibernacula in Pryor Mountains.	Summer roosts are in open areas of caves and mines and occasionally in buildings. Night roosts can be more varied, but are generally large open structures (e.g., caves, rock ledges, bridges, open buidings, large culverts.)	Likely do not migrate, but move deeper in caves and mines than summer roosts.	Foraging habitat varies across its range, but in the west *C. townsendii* is most likely to be found among shrublands, pinyon-juniper woodlands, and dry conifer forest. These bats may also forage in deciduous riparian woodlands and at forest edges, where they sometimes fly in the canopy and glean insects from vegetation. They can have a large foraging radius (potentially over 10 km).	Harp-trap cave and mi BCNRA) and mist net caves. This should be flyways, because *C. to* at avoiding nets. Poss some to determine use BCNRA. Difficult to bat detectors due to lo
1B ive ive	High priority. Found very rarely in northern and western Wyoming. Population status is uncertain. One of the few Wyoming specimens was from BCNRA.	Cliffs near permanent water.	Uncertain, but they may migrate south in winter.	Habitat use in Wyoming is unclear. Elsewhere they are found in Ponderosa pine and open shrublands. They have a moderate to large foraging radius (usually less than 5 miles). They imerge after dark and forage high above the ground. They show high fidelity to foraging sites, visiting the same locations night after night.	Consider auditory poi ridge-lines and ponde Acoustic bat detectors to sufficiently low fre They are under-repres because they forage w
3	Moderate priority. Uncommon throughout Wyoming. Population trends are uncertain.	Multiple roost types (abandoned buildings, hollow trees, loose bark, caves, mines, cliffs, and sink holes)	Uncertain in this area.	Generally found in conifer forest habitats with rock outcrops, but have been captured elsewhere, including sagebrush and semi-arid shrublands. Often fly low and forage over water holes and in treetops. Thought to emerge from day roosts at dusk to well after sunset.	Mist netting over wate woodlands or shurblan possibly harp-trap cav are sometimes difficul acoustic bat detectors calls and their foragin insects in "cluttered" v
1B	Moderate priority. Uncommon in Wyoming. Reported from the Green River basin in south central Wyoming and in the Pryor mountains west of BCNRA.	Multiple substrates, usually small rock crevices and buildings. Also caves, mines rock-piles, and tree cavities.	Uncertain in this area.	Generally found in lowland desert and grassland communities with cottonwood riparian corridors. Forage on the ground for large prey such as beetles, scorpions, and crickets. Emerge from day roosts about 1 hour after sunset and have a moderate foraging radius (~3 km from day roost).	Mist netting over wate arid habitats within BC
3	Moderate priority. Supposedly widespread in Wyoming and Montana, but uncommon where it occurs. Depends on fragmented, forest riparian corridors.	Solitary roosts in the foliage of deciduous trees, often at the edge of clearings. New evidence suggests they may also roost in some conifer trees.	Likely to migrate south in winter, but destination is uncertain.	Forage in aspen-pine forests, greasewood flats, and shortgrass prairies with access to deciduous riparian corridors. In summer, they emerge from day roosts lat in the evening (2-5 hours after sunset).	Hoary bats can be cau may be underrepresen sparsely distributed so foragers. They can be bat detectors due to th frequency call (althou Lasiurus species).
3	Moderate priority. Supposedly widespread in Wyoming, but uncommon where it occurs.	Deciduous trees under loose bark or in cavities. Sometimes in mines, caves, or buildings (especially open buildings).	Likely to migrate south in winter, and hibernate in buildings and rock crevasses.	Found in a variety of habitats, usually associated with riparian deciduous woodlamds. They are not clearly late or early fliers, emerging from day roosts at dusk or up to 2-3 hours after sunset. They are slow but strong flyers, foraging over woodland ponds at heights up to 7 m.	Siver-haired bats can b but may be underrepre solitary roosters and fo forage at heights abov nets.

teristics of bat species likely to occur at BCNRA and pertinent survey tips

	Priority and Nearby Status	Habitat Use			
		Roosts	Hibernacula	Foraging	Survey Tips
?	Moderate priority. Rare or transient in Wyoming. A specimen has been recovered near BCNRA.	Large colonial roosts in caves and mines.	Likely migrate to Central America in winter.	Could occur in the dry basins foraging in riparian zones and over isolated ponds. Often feed on insects over agricultural fields.	Mist net ponds in oper acoustic bat detection
?	Low-Moderate priority. There are very few confirmed records from Wyoming, but those records are from the Bighorn basin and there are records in bordering states.	Multiple substrates, especially buildings, but also rock crevases, hollow trees, and loose bark.	Likely not to migrate. Hibernate in caves and deep mines.	Found in low desert shrublands and woodlands, often foraging near the edges or tops stands of trees, over open water, or high above ground in open areas. Emerge from day roosts at sunset and activity peeks one hour later.	Mist net pathways in c shrublands and over p acoustic bat detection
1B?	Low-Moderate priority. This species is not yet documented in the BCNRA region, but could occur their based on known distribution and habitat preferences.	Day roost in bridges, buildings, and sometimes mines and caves. Night roost in abandoned buildings, attics, and porches. Maternity roost in buildings, caves, mines, and bridges.	Possibly migrates south in winter, but winter activity is uncertain.	Could occur in dry woodlands, shurblands and grasslands of Wyoming's basins, almost always near open water. They forage mainly along the surface of water. Emerge from day roosts just after sunset and return within 2 hours.	Mist net small ponds r and use active acoustic in the same areas.
3	Low priority. Common throughout Wyoming and Montana.	Crevases in rock faces and clay banks. Sometimes between boulders in talus fields, under tree bark, and in barns.	Likely not to migrate. Hibernate in caves and mines.	Seems to use a wide variety of habitats from montane to prairie zones, generally near rock outcrops, cliffs, talus fields, or steep clay buttes and cut riverbanks. Foraging begins at dusk or about 1 hour after sunset. Foraging occurs along cliffs and rocky slopes or over water when California myotis are not present. Often flies 1-3 m above the ground or water surface.	Mist net small ponds r and use active acoustic in the same areas.
3	Low priority. Common throughout Wyoming and Montana.	Various roost sites including caves, mines, trees, snags, rock crevices, and less frequently buildings.	May migrate south in winter (as they do in AZ and CA) or hibernate in local caves (as in KS, OK, TX).	Often found in mid-elevation conifer, mixed deciduous-conifer forests, arid floodplains, and rocky canyon lands. Often forage at tree-tops or beneath deciduous canopies. Emerge from day roosts at dusk.	Unattended acoustic b M. volans, do to their intensity call and mist- represent their abunda above typical net-level near foraging habitat a bat detection surveys i
5	Low priority. Common throughout Wyoming, Montana, and the rest of North America. Definitely occurs in YWHMA.	Buildings, and possibly rock crevices, caves, trees, and bridges. Maternity colonies are often in attics, barns, and bridges.	Likely hibernate in caves, deep mines, and underground structures.	Found in various habitats, often associated with humans, where they can be found foraging around lights, near tree-lined roads, and over open meadows. Can fly high (6-10 m) when en-route to foraging areas.	Mist net at the entranc show evidence of bat u near Yellowtail WHM acoustic bat detection areas.
5	Low priority. Common throughout Wyoming, Montana and the rest of North America. Definitely occurs in YWHMA.	Humid caves, buildings, and bat houses. Maternity colonies can be in hot attics. Solitary males can roost on many substrates. All roosts are usually near water.	May exhibit short-range migration to cave and mine hibernacula.	Uses a wide variety of habitats near water. Forages over water, along pond edges, along edge of tall vegetation. Emerges in early evening.	Mist net over water ho entrances to buildings bat use in Yellowtail V active acoustic bat det same areas.

Table 2: Description of compiled GIS data

File Name	Data Source	Description
BCNRAboundary	This file was provided by BCNRA. Its original source and projection information are unknown.	This is a line file delineating the legal boundary of Bighorn Canyon National Recreation Area.
Pondrivermarsh	See entries for "pond(wyndd)" and "BCNRAvegetation".	This file is a union of the "pond(wyndd)" shapefile and the wetland portion of the "BCNRAvegetation" shapefile. It divides wetlands into three basic classifications: ponds (small, still bodies of water identified by WYNDD from maps and field reconnaissance), marshes (vegetated wetlands delineated by Knight et al., 1987), and river (open, flowing wetlands delineated by Knight et al., 1987).
Pond(WYNDD)	This file was generated by WYNDD	This files was created by D. Keinath of WYNDD based on field reconnaissance in and near BCNRA and by digitizing mapped ponds from DRG's of the area. Pond boundaries are not exact, but are rather approximate locations derived from 24K topographic maps. Only a subset of these ponds were visited during this study, so the size and state of each may be different than indicated.
Topoboundaries	This file was provided by BCNRA. Its original source and projection information are unknown.	This file outlines the boundaries of each 7.5 minute quadrangle that contains part of BCNRA. Quadrangle map codes refer to the file names of the associated DRG files, which are designated using the standard index to topographic and other map coverages published for each state by the U.S. Geological Survey.
BCNRAvegetation	This file was provided by BCNRA. Its original source and projection information are unknown.	This file delineates the extent of major vegetation types in BCNRA. The base data is discussed by Knight et al. (1987), but it is not clear who created the GIS coverage, how they created it, or when it was done. It does not appear to precisely match the DRG's of the area, but no modifications were attempted since it is a large and complex file with no metadata. When precise locations of vegetation are important, users of this file should use caution and field-validate their data.
BCNRAroad&trail	This file was provided by BCNRA. Its original source and projection information are unknown.	This file delineates roads and 4WD trails in and near BCNRA. It appears to match roughly with roads found on the standard USGS 7.5 minute topographic quadrangles, with discrepancies seeming to be larger with respect to the Montana quadrangles than those from Wyoming. Since the date this file was generated is unknown, it is not known whether roads and trails presented here are current (although most seem to be based on limited field reconnaissance by WYNDD in the summer of 2001).
Lakeboundary	This file was provided by BCNRA. Its original source and projection information are unknown.	This is a line file delineating the boundary of the Bighorn River and Bighorn Lake in BCNRA. It corresponds fairly closely to the information presented on USGS 7.5 minute topographic quadrangles, with some inconsistencies floodplains and complex river bends. The lake margins in particular can fluctuate on a seasonal basis, so this file should only be taken as a rough guide.

Table 2 continued: Description of compiled GIS data

File Name	Data Source	Description
Topographic Quadrangle Digital Raster Graphics (DRG's): Montana (045108c1, 045107c8, 045108b3, 045108b2, 045108b1, 045107b8, 045108a3, 045108a2) Wyoming (44108h3, 44108h2, 44108h1, 44108g3, 44108g2, 44108g1)	DRG's for Wyoming Quadrangles where generated by Beartooth Mapping, Red Lodge, Montana. Montana DRG's were provided by BCNRA and their original source is unknown.	There are 14 DRG's, one for each USGS 7.5 minute topographic quadrangle that contains a portion of BCNRA. They can be viewed in ArcView© along with shapefiles, if the appropriate image processing extensions are loaded (i.e., Mr.SID Image Support for the Wyoming files and TIFF Image Support for the Montana files). The naming convention for these files follows standard USGS indexing format. The name of the proper DRG for a given area can be found by querying the "Topoboundaries" shapefile that is also included with this report.
coto_habsuit	This file was generated by WYNDD	This is an ArcInfo© grid coverage of the output of the habitat model generated for Townsend's big-eared bat. It is composed of 30 m cells, each of which has a value from 0 – 10.5, where 0 represents habitat that is unsuitable for the bat and 10.5 represents habitat that is highly suitable for the bat. This model can be used to identify approximate areas to conduct bat surveys. It should not be used to make direct management decisions or to determine the suitability of specific sites without field surveys. More details of model generation are provided in the text of this report.

Table 2 Notes:

1. All shapefiles are projected into Zone 12 of the Universal Transverse Mercator projection using the North American Datum of 1927. This is the same projection used in BLM 100K maps and standard USGS 7.5 minute topographic quadrangle maps. Where possible, files were altered to conform to digital raster graphics (DRG's) of 7.5 minute quadrangles provided by WYNDD and BCNRA.
2. Two coverages are conspicuously missing from this compilation, but potentially important to bat work at BCNRA. The first provides locations for underground openings (e.g., caves, abandoned mines), and the second provides aboveground human structures (e.g., abandoned buildings, mining cabins, barns, unused attics, etc.) that are potentially used by bats. There are not included here for the following reasons:
    a. Caves and Mines: The caves and mines file was purposefully not included in this report due to the sensitivity of several cave-roosting bats to disturbance (particularly the maternity roosts of Townsend's big-eared bat) and the associated concern of regional biologists that a compiled file of cave locations could facilitate visitation of those caves.
    b. Human Structures: Within and near BCNRA there are many buildings potentially used by bats, including those associated with historic ranch sites, homesteads, mines, prospects, and recreation area facilities. An exhaustive list would entail contacting numerous individuals and conducting extensive site validation, and was not within the scope of this pilot study. Some sites with known bat use include the Hillsboro Ranch Complex and several abandoned buildings in the Yellowtail Wildlife Habitat Management Area (see Figure 5). Compilation of such a buildings list should be one of the priorities of a formal bat inventory.

Table 3: Relative suitability ranks for vegetation at Bighorn Canyon National Recreation Area with respect to Townsend's big-eared bat.

Grid Code	Vegetation Class	Habitat Ranking
0	No Data	0
1	Marsh	0
2	Floodplain meadow or mudflat	0
3	Floodplain shrubland	2
4	Floodplain woodland	3
5	Creek woodland	3
6	Creek woodland	3
7	Mixed desert shrubland	2
8	Saltbush desert shrubland	2
9	Sagebrush desert shrubland	2
10	Mixed-grass prairie	0
11	Great Plaines shrubland	2
12	Basin grassland	0
13	Sagebrush steppe	2
14	Juniper woodland	2
15	Juniper - mountain mahogany woodland	2
16	Mountain mahogany shrubland	1
17	Limber pine woodland	3
18	Douglas fir woodland	1
19	Ponderosa pine woodland	3
20	Spruce - fir woodland	1
21	Wind - swept plateau (cushion plants)	0
22	Agricultural land	0
23	Human development	0
24	Open Water (River)	0
25	Unclassified (Unknown)	0

Table 4: Relative suitability ranks for proximity to caves, mines and open water with respect to Townsend's big-eared bat.

Distance From Cave		Distance from Water	
Dist.(km)	Rank	Dist.(km)	Rank
0-5km	3	0-1km	3
5-10km	2	1-2km	2
10-20km	1	2-5km	1
>20km	0	>5km	0