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June 19, 2006
PN 1664.002.001

CHIROPTERAN RISK ASSESSMENT

PROPOSED BEECH RIDGE WIND ENERGY GENERATION FACILITY GREENBRIER AND NICHOLAS COUNTIES, WEST VIRGINIA

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1.0 INTRODUCTION

Beech Ridge Energy LLC proposed construction of the 186 MW Beech Ridge wholesale wind energy generation facility along approximately 23 miles (37 km) of forested Appalachian Mountain ridgelines in Greenbrier County, West Virginia (Figure 1). The project will consist of a maximum of 124 1.5-MW turbines placed in a single row along Beech Ridge, Big Ridge, Cold Knob (but not on Cold Knob), Ellis Knob, Old Field, Nunly Mountain, Rockcamp Ridge, and Shellcamp Ridge, at an average elevation of approximately 3,800 ft (1160 meters) above msl. These ridgelines trend northwest-southeast, east-west, north-south, and northeast-southwest (Figure 2a). The project area is located approximately 5 miles (8 km) northwest of the town of Trout, approximately 7 miles (11 km) north-northwest of Williamsburg, and approximately 9 miles (14.5 km) northeast of downtown Rupert, West Virginia. In addition, a transmission line corridor 100 feet wide will extend approximately 8.4 miles (13.5 km) northwest from the turbine strings and into Nicholas County, West Virginia.

The primary easement zones for the turbine strings are owned entirely by MeadWestvaco. Alternative easement areas are under other/mixed ownership. Land use agreements have not been completed in alternate easement zones (Figure 2a). Approximately 6.5 miles (10.5 km) of this corridor are currently forested, and will be cleared of trees for construction of the transmission line (Figure 2b).

Each turbine would include an 80-meter (262 ft) (hub height) tubular tower, and a 77-meter (253 ft) diameter rotor that would turn at a typical operating speed of 17 rpm. Approximately one-third of turbines would be lit with red or white strobes as required by the Federal Aviation Administration. Lighting will be limited to the minimum required by the FAA.

Collisions between bats and manmade structures are well documented. Numerous impacts with television towers, other communication towers, large buildings, powerlines, and fences have been reported, but collisions with wind energy turbine blades appear to occur, in some instances, at much higher rates. Hypotheses concerning the reason(s) for these escalated collision rates were summarized in Arnett (2005):

Linear corridor hypothesis Many species of bats (especially red bats and hoary bats) are known to use linear corridors during migration and while foraging. Wind farms in forested regions can be developed along natural corridors such as ridge tops, or corridors are created when access roads are constructed. Risk of collisions may increase if bats use corridors where wind turbines are located.

Acoustic failure hypothesis Either migrating or foraging bats may fail to acoustically detect wind turbines, particularly moving blades. If the smooth cylindrical turbine masts are not detected by echolocating bats, bats may be killed by collisions with these structures. The functional range of echolocation by North American bats typically varies from 3–5 meters. Migrating bats flying at a velocity of 5 meters/second would have less than a second to respond to the presence of a wind turbine/turbine blade.

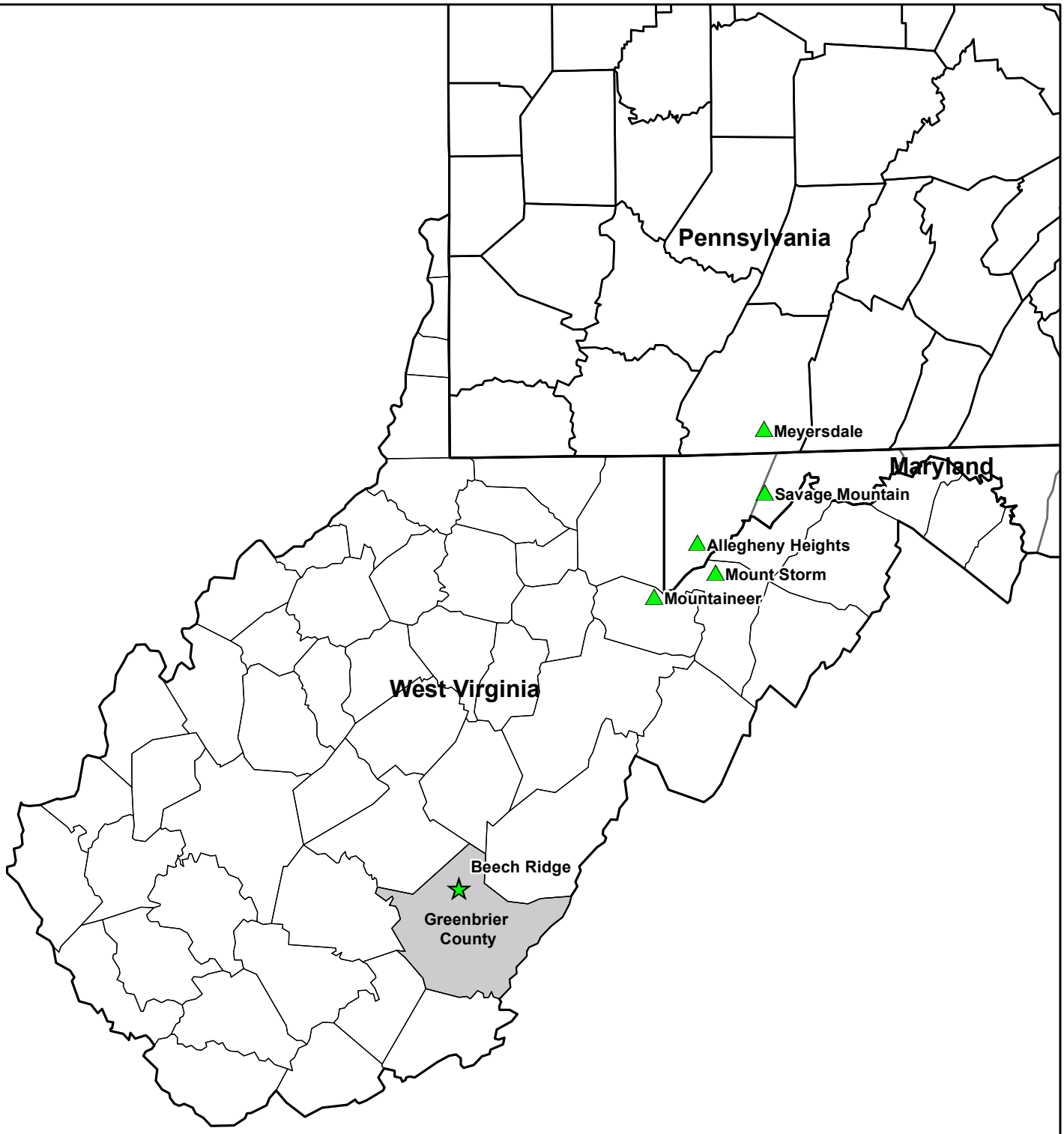

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Figure 1: Allegheny Heights, Beech Ridge, Meyersdale, Mountaineer, Mt. Storm, and Savage Mountain Windfarms, Located in Pennsylvania and West Virginia.

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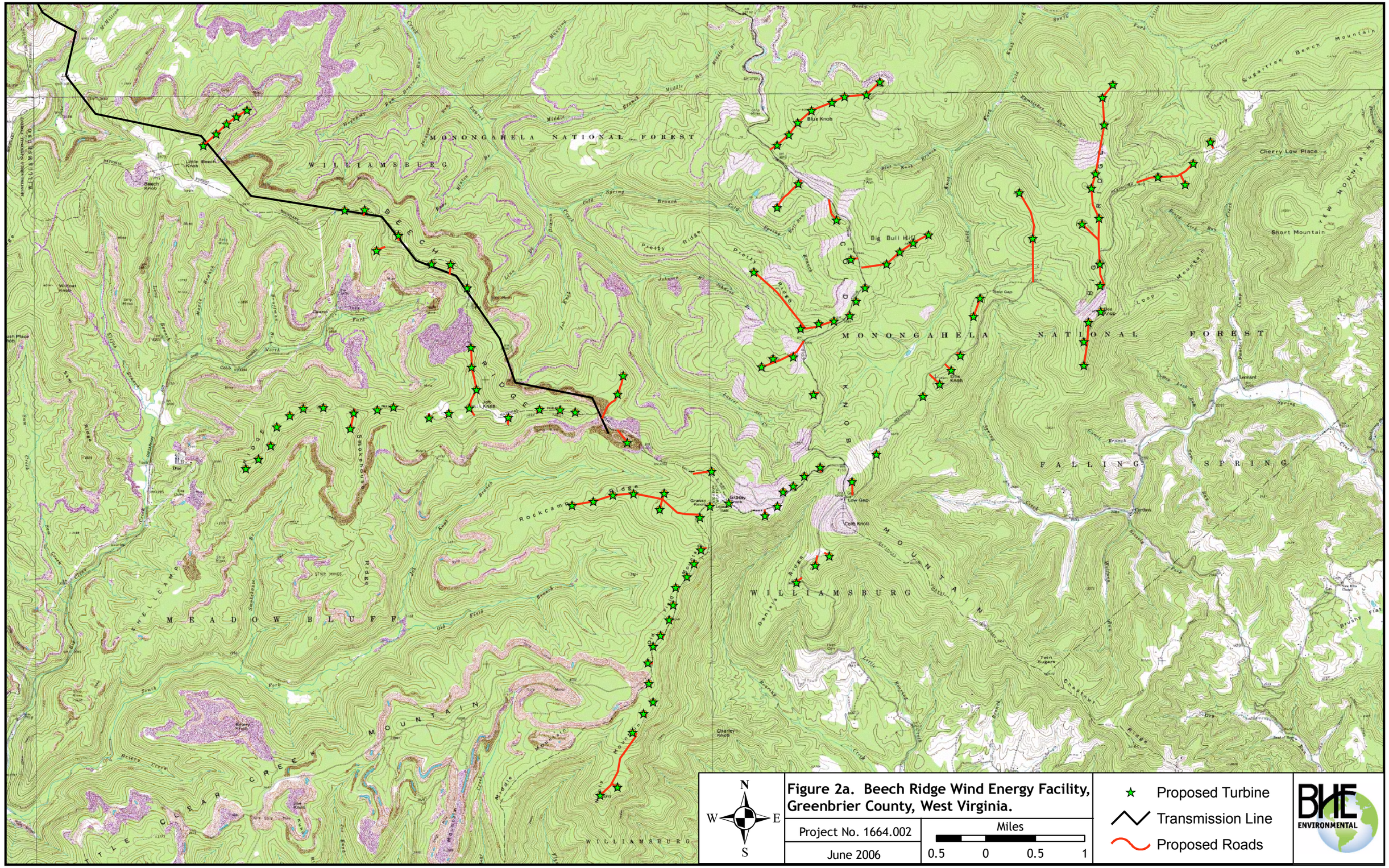
MONONGAHELA NATIONAL FOREST
WILLIAMSBURG
BEECH RIDGE
Little Beech Knob
Beech Knob
Wildcat Knob
Joe Knob
Smokehouse Ridge
Rockcamp Ridge
Grassy Knob
Blue Knob
Big Bull Hill
Pretty Ridge
Reid Gap
Blue Knob
Low Gap
Cole Knob
Daniels Ridge
Charley Knob
Twin Sugars
Cherry Low Place
Short Mountain
Sugartree Bench Mountain
FALLING SPRING
MEADOW BLUFF MOUNTAIN
LITTLE CLEAR CREEK
Turbyfill
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Figure 2a. Beech Ridge Wind Energy Facility, Greenbrier County, West Virginia.
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Miles
0.5 0 0.5 1
Proposed Turbine
Transmission Line
Proposed Roads
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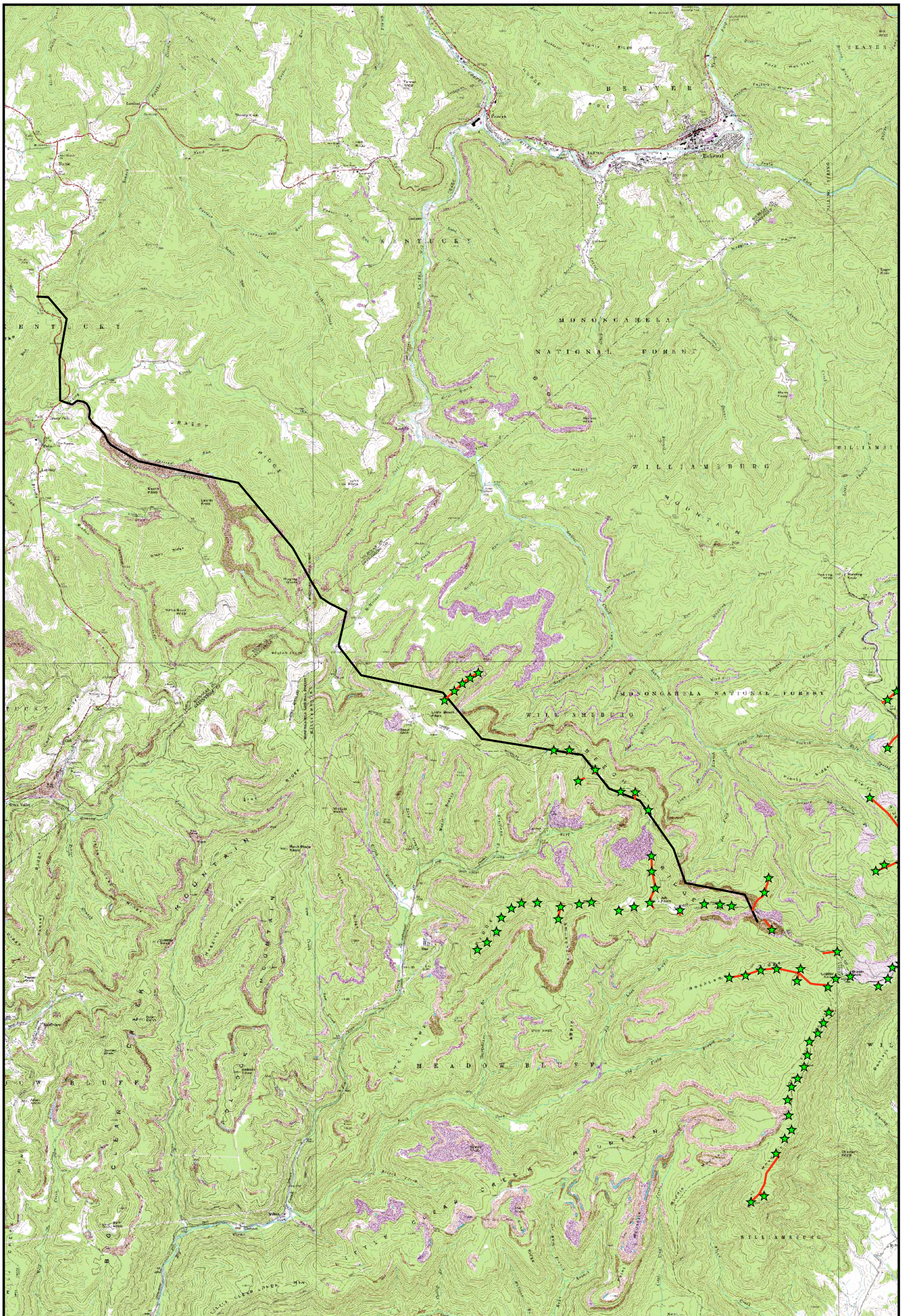

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Figure 2b. Beech Ridge transmission line corridor, Greenbrier and Nicholas counties, West Virginia.

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Miles

0.75 0 0.75 1.5

Proposed Turbine

Transmission Line

Proposed Roads

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Visual failure hypothesis Rotating rotor blades are subject to motion smear, thus making them difficult for organisms to see and respond appropriately. Bats utilize vision and may fail to visually detect wind turbine rotor blades.

Roost attraction hypothesis Bats may be attracted to wind turbines because the tall, white turbine masts are perceived as potential roosts. During migration in late summer and fall, bats seek shelter during the day, following nighttime travel. Bats may mistake the large, white turbine masts for potential tree roosts, and thus increase their susceptibility to collision at turbines.

Light attraction hypothesis Bats may be attracted to the lights placed on wind turbines. Currently, these lights range from red lights or stroboscopic lights placed on alternate turbines, as recommended by the Federal Aviation Administration. Recent data appear to contraindicate this hypothesis.

Acoustic attraction hypothesis Bats may be attracted to audible and/or ultrasonic sound produced by wind turbines. The uniform constant sounds made by the turbine generator and/or the variable "swishing" sounds made by rotating blades may attract bats and increase their risk of collision.

Motion attraction hypothesis Curious bats may be attracted to the movement of rotating turbine blades. By investigating the moving blades, bats increase their risk of collision.

Insect concentration hypothesis Flying insects rise in altitude with warm daily air masses and may become concentrated, particularly along ridge tops on certain nights. If the activity of migrating and locally foraging bats increases in response to high insect concentrations, the bats increase their exposure to turbine collisions.

Insect attraction hypothesis Flying insects may be attracted to the white turbine masts at night and get trapped in the downstream wake of the rotors. Bats respond to these concentrations of insects in the wake and collide with the turbine blades in the process of feeding.

In evaluating the risk of bat mortality at the Beech Ridge site, it is useful to consider mortalities at other operating utility-scale wind energy facilities on Appalachian ridgelines. The 66 MW Mountaineer site in Tucker County, West Virginia (the only operating wind facility in the state) and the 30 MW Meyersdale site in Somerset County, Pennsylvania are owned and operated by FPL Energy and are within 91 miles (146 km) and 143 miles (230 km) respectively of the Beech Ridge site (Figure 1).

The Buffalo Mountain site is on Tennessee Valley Authority land in Anderson County, Tennessee, approximately 252 miles (406 km) southwest of the proposed Beech Ridge facility. The proposed 186 MW Beech Ridge site is considerably larger than other operating sites on Appalachian ridgelines in regard to number of turbines, acreage, and in total rotor swept area. The highest levels of bat mortality at North American windfarms have been recorded at the three operating sites on forested Appalachian ridgelines.

Three other wind energy sites, significantly smaller than the proposed 186 MW Beech Ridge site, are located nearby in Pennsylvania: Somerset wind farm (six turbines) and Garret Mountain Energy (eight turbines) in Somerset County, and Mill Run in Fayette County. During internet and literature searches, no bat mortality data were discovered for these sites.

A number of other wind power generation sites are permitted in this portion of the Allegheny Mountains (Figure 1):

- a 300 MW New Power site and a 250 MW U.S. Wind Force Site at Mount Storm in Grant County, West Virginia,
- the 67-turbine, 101 MW Allegheny Heights project proposed by Clipper Windpower in Garrett County, Maryland, and
- the 25-turbine, 40 MW Savage Mountain site proposed by U.S. Wind Force in Allegany and Garrett counties, Maryland.

This report documents aspects of the proposed project and similar projects, provides a review of information pertaining to bat mortality at existing wind energy sites, and based upon these data, qualitatively estimates the risk of effects to listed bat species and other bats. We discuss three primary means whereby bats may be affected at the site.

2.0 PROJECT DESCRIPTION

2.1 TURBINES

Beech Ridge proposes installation of up to 124, 1.5 megawatt turbines manufactured by General Electric (model FLE). These turbines have a nominal "cut-in speed" of 3.5 m/s (7.9 mph). That is, winds of 3.5 m/s contain sufficient energy to support the generation of electric power by the turbine. At wind speeds below 3.5 m/s, as measured by an anemometer atop each nacelle, the turbine "primary brake" is applied (i.e., the turbine blades are feathered by orienting the primary surface of each blade parallel to the wind direction). With the primary brake applied the blades will not rotate around the hub, or will rotate very slowly (less than one revolution per minute). Control systems allow the cut-in wind speed to be set independently at each turbine. Wind speeds above 3.5 m/s will result in blade speeds of 17 rpm. If wind speeds at an operating (spinning) turbine drop below the cut-in speed, the primary brake is applied and the blades come to a stop within approximately one minute.

2.2 REGIONAL ECOLOGY AND PHYSIOGRAPHY

The following text describes the ecological region in which the Beech Ridge project occurs. This description is useful in understanding the nature of the area, and in comparing important ecological aspects of the Beech Ridge site to the two other nearby operating wind energy sites - Meyersdale and Mountaineer.

The Beech Ridge project area lies entirely within the Central Appalachian Broadleaf Forest-Coniferous Forest–Meadow Ecological Subregion of the United States (McNab and Avers 1994). Within this Subregion, the proposed project is located in Ecological Section M221B—the

Allegheny Mountains. The Mountaineer and Meyersdale windfarms (as well as the Mount Storm windfarms) are also within the Allegheny Mountain Subregion (Figure 3).

Section M221B comprises part of the Appalachian Plateaus geomorphic province and is a maturely dissected plateau characterized by high, sharp ridges, low mountains, and narrow valleys. Bedrock is covered by residuum on the ridges and mountain tops, colluvium on the slopes, and alluvial materials in the valleys. Devonian shale and siltstone, Mississippian carbonates and sandstones, and Pennsylvanian shale, sandstone, and coal form the bedrock in Section M221B. Sandstone and sturdy carbonates support upland areas and weaker carbonates and shale underlie valleys (USFS 2005).

Ultisols, Inceptisols, and Alfisols are the dominant soil types in Section M221B. The vegetation of Section M221B-Allegheny Mountains can be placed in four broad groups and is influenced by elevation and aspect: red spruce (*Picea rubens*), northern hardwoods, mixed mesophytic, and oak. Red spruce is characteristic above 3,500 ft (1,060 m) and can be interspersed with American beech (*Fagus grandifolia*) and yellow birch (*Betula alleghaniensis*). Beech is more common on northerly aspects, and yellow birch on southerly. The northern hardwood forests include sugar maple (*Acer saccharum*) occurring with beech and black cherry (*Prunus serotina*). Mixed mesophytic forest forms the transition to drier forest types and dominant species include red oak (*Quercus rubra*), basswood (*Tilia americana*), white ash (*Fraxinus americana*), and tulip poplar (*Liriodendron tulipifera*) (USFS 2005).

Precipitation typically averages 45 to 60 in (1,140 to 1,520 mm) per year, approximately 20% to 30% of this being snowfall. Mean annual temperature is approximately 39 to 54°F (4 to 12°C). The growing season ranges from 140 to 160 days, with local variation (USFS 1994).

Within the project area, the predominant soil types belong to the Dekalb-Gilpin very stony complex (Gorman et al. 1972). The project area lies near the center of a larger property that is actively managed for commercial timber. Of the 48,000 acres within 1 km of the site, approximately 79% is characterized as timber greater than 26 years old, 19% is characterized as timber less than 26 years old, and 2% is non-forested (e.g., roads, surface mines). The project area itself is largely forested, with notable exceptions being areas cleared for roads, and other areas affected by commercial timber harvest activities, and historic mining activities. Dominant species include oaks, sugar maple, black cherry, and white ash. Mountain maple (*A. spicatum*) is a common understory/midstory species. Approximately three-quarters of Greenbrier County West Virginia is forested.

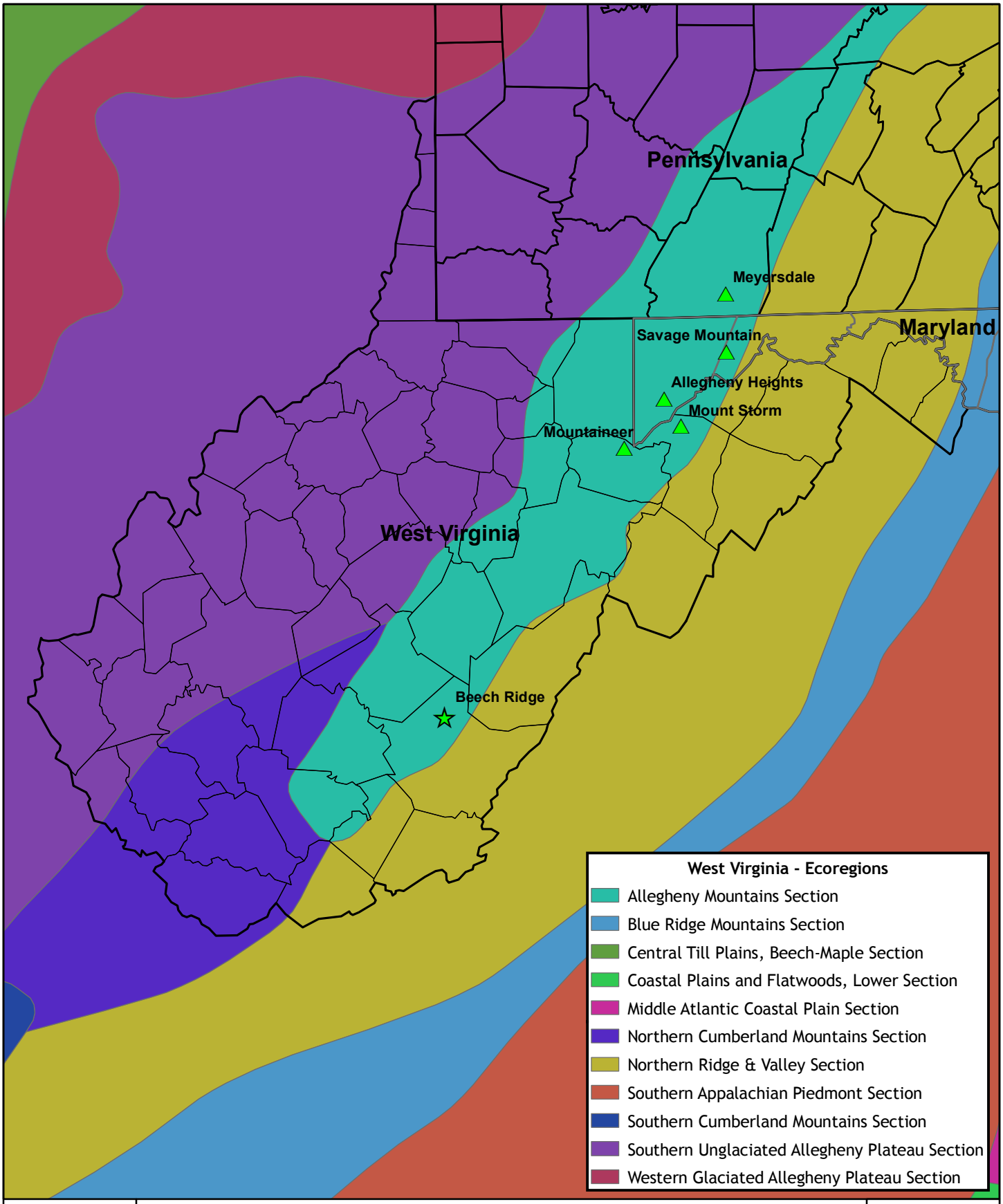

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Figure 3. Ecoregion Sections in West Virginia, southwest Pennsylvania, and western Maryland.

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2.3 BATS

Fourteen species of bats have been documented within West Virginia (Table 1). Except for the gray bat (*Myotis grisescens*), Rafinesque's big-eared bat (C*orynorhinus rafinesquii*), Seminole bat (*Lasiurus seminolus*), and the evening bat (*Nycticieus humeralis*), each of the species has potential to occur in the proposed project area.

The gray bat is extremely rare in West Virginia, which is outside the species' home range (BCI 2005a, WVDNR 2005). There is one record of two gray bats in Hellhole Cave in Pendleton County (WVDNR 2005, Garton et al. 1993), but there are no other summer or winter records of the species in West Virginia. Gray bat occurrences are considered "accidental" within the state.

Only summer populations, apparently all of them bachelor colonies, are known in Virginia (VDGIF 2005). In August 1977, this species was reported from Scott and Lee counties (VDGIF 2005), in the extreme southwest portion of Virginia, over 150 miles (241 km) southwest of the project area. In 1988, a summer colony of about 3,000 gray bats was discovered in Washington County (VDGIF 2005), approximately 110 miles (177 km) southwest of the proposed project area. No winter hibernacula have been identified in Virginia.

Rafinesque's big-eared bats are also rare in West Virginia. The species has been recorded in Fayette and Wayne counties (Natureserve 2005) and in Collison Cave in Nicholas County (Garton et al. 1993). The species is classified as "S1" in West Virginia, indicating five or fewer documented occurrences, or very few individuals remaining in the state. While it has been documented in West Virginia, Kentucky, and Tennessee, and potential habitat exists in caves in southwestern Virginia, the Rafinesque's big-eared bat has not been found in Virginia (VDGIF 2005).

The Seminole bat is represented by a single known occurrence in West Virginia. A specimen was captured in Pendleton County, West Virginia. The species is considered "accidental" in the state.

The evening bat is classified by the WVDNR as S1 (five or fewer documented occurrences, or very few individuals remaining in the state). Some range maps for the species exclude West Virginia, with records of the species in the state considered isolated or questionable (BCI 2005b, C. Stihler pers. comm.).

In Virginia, evening bats are known only from the eastern part of the state in the Coastal Plain and lower Piedmont Provinces (VDGIF 2005). The Virginia Department of Game and Inland Fisheries (VDGIF) indicates known or likely occurrence of the evening bat in Montgomery County, approximately 50 miles (80 km) southeast of the project area; other known or likely occurrences are more distant from Greenbrier County, West Virginia.

Table 1. Bats potentially present in the proposed Beech Ridge project area during summer, winter, and spring/fall migration.

Species	Status	Anticipated Seasonal Presence within Five Miles of Proposed Turbine Strings			Previously Identified in Greenbrier Co.?*
		Summer	Winter	Migration	
Indiana bat (*Myotis sodalis*)	Fed: E WV: S1; VA: E	Yes	No	Yes	Winter
Virginia big-eared bat (*Corynorhinus townsendii virginianus*)	Fed: E WV: S2; VA: E	No	No	Unlikely**	No
Northern long-eared bat (*Myotis septentrionalis*)	None	Yes	Yes	Yes	Summer, winter
Eastern small-footed bat (*Myotis lebii*)	Fed: none WV: S1	Yes	Yes	Yes	Summer, winter
Little brown bat (*Myotis lucifugus*)	None	Yes	Yes	Yes	Summer, winter
Eastern pipistrelle (*Pipistrellus subflavus*)	None	Yes	Yes	Yes	Summer, winter
Big brown bat (*Eptesicus fuscus*)	None	Yes	Yes	Yes**	Summer, winter
Eastern red bat (*Lasiurus borealis*)	None	Yes	No	Yes	Summer
Hoary bat (*Lasiurus cinereus*)	None	Yes	No	Yes	Summer
Silver-haired bat (*Lasyonycteris noctivagans*)	Fed: none WV: S2	No	Yes	Yes	Winter
Gray bat (*Myotis grisescens*)	Fed: E WV: SA	No	No	No	No
Rafinesque's big-eared bat (*Corynorhinus rafinesquii*)	Fed: none WV: S1	No	No	No	No
Seminole bat (*Lasiurus seminolus*)	SA	No	No	No	No
Evening bat (*Nycticeius humeralis*)	Fed: none WV: S1	Unlikely	No	Unlikely	No

*Absence of records in the county may reflect lack of surveys rather than absence of the species.
**Species is a local migrant.
West Virginia NWNHP Rank:
S1 = Five or fewer documented occurrences, or very few individuals remaining in the state. Extremely rare and critically imperiled, or because of factor(s) making the species vulnerable to extirpation.
S2 = Six to twenty documented occurrences, or few individuals remaining in the state. Very rare and imperiled, or ranked because of factor(s) making the species vulnerable to extirpation.
SA = Species occurrences considered accidental or adventive.
Virginia Rank: **E** = Endangered

The other 10 bat species in West Virginia include year-round residents as well as species with potential presence only during certain seasons (Table 1). The Indiana bat (*M. sodalis*) and Virginia big-eared bat (*Corynorhinus townsendii virginianus*) are federally listed as endangered. The remaining eight species are not federally listed as threatened or endangered, are not proposed for listing, and are not Candidate species. The West Virginia Nongame Wildlife and Natural Heritage Program (NWNHP) tracks populations of rare species, however the state of West Virginia does not list species as threatened or endangered. The Indiana bat and Virginia big-eared bat are listed as endangered by the State of Virginia. None of the other bat species potentially present in the project area is listed by the State of Virginia. Descriptions of each species potentially present in the proposed project area are below. In coordination with the USFWS and the West Virginia Department of Natural Resources (WVDNR), BHE surveyed the portion of the project area in which the turbine strings are proposed for the presence of bats during the summer maternity season. Mist nets were erected at 15 sites from July 22 to July 26, 2005, with the survey consisting of 62 net-nights (BHE 2005). Survey procedures followed Indiana Bat Recovery Plan guidelines (USFWS 1999), and the number of survey sites investigated was approved by the USFWS prior to the initiation of field studies.

A total of 78 bats (excluding two individuals which escaped before they could be identified), representing six common species, was captured. No federally listed species were captured during the survey:

- little brown bats (*Myotis lucifugus*, n = 22; 28%),
- big brown bats (*Eptesicus fuscus*, n = 17; 22%),
- red bats (*Lasiurus borealis*, n = 13; 16%),
- eastern pipistrelles (*Pipistrellus subflavus*, n = 10; 13%),
- northern long-eared bats (*Myotis septentrionalis*, n = 10; 13%), and
- hoary bats (*Lasiurus cinereus*, n = 6; 8%).

2.3.1 Indiana Bat (*Myotis sodalis*)

The Indiana bat was listed by the federal government as endangered on March 11, 1967. Populations across the species range (as recorded from counts in hibernacula) have declined since the late 1950s. A principal cause of decline is destruction of hibernacula from collapse, flooding, or vandalism by humans. Suspected contributing factors include loss of suitable summer habitat and contamination by pesticides (USFWS 1999). A recovery plan for Indiana bats was developed in 1983 (USFWS 1983), and revised in 1999 (USFWS 1999).

The Indiana bat is a migratory species found in West Virginia and Virginia year-round (Appendix A). In winter (mid-November through March) Indiana bats hibernate in caves and mines. For the remainder of the year, Indiana bats roost in trees (Barbour and Davis 1969). In April and again in August-September, Indiana bats migrate between winter and summer habitat. Some individuals may travel 300 to 400 miles (483 to 644 km) between summer and winter roosts (USFWS 1999). Others, particularly males, may roost in trees near hibernacula in summer. In Pennsylvania and New York, radiotelemetry studies indicate Indiana bats migrate between 30 and 60 miles (48 and 97 km) (Johnson and Strickland 2004). In Pennsylvania, none of the bats appeared to travel mountain ridge tops, although each of the bats crossed over ridges (Johnson and Strickland 2004). The migrating bats traveled along powerline and pipeline rights-of-way, along highways, and along stream courses (Johnson and

Strickland 2004). Limited recovery records of banded Indiana bats from the Midwest indicate females and some males migrate north in the spring upon emergence from hibernation (USFWS 1999). Migration distances and routes are unknown for Indiana bats inhabiting West Virginia (C. Stihler pers. comm.)

In spring, Indiana bats migrate from hibernacula to forested habitats. Upon emergence from hibernation, Indiana bats are active near the hibernaculum during a period called staging. Spring staging occurs from approximately mid-April through early May. During staging, Indiana bats emerging from hibernation roost in trees, and forage near hibernacula. In Missouri, staging male and female Indiana bats traveled between 1.2 and 6.4 miles (1.9 and 10.3 km) from their hibernaculum nightly (Rommé et al. 2002). Females typically leave caves before males (Humphrey 1978, LaVal and LaVal 1980). Following mid-May emergence from hibernation, a single radio-marked male followed for two weeks traveled 10 miles (16 km) in western Virginia (Hobson and Holland 1995).

Indiana bats typically arrive in summer habitat in early to mid-May. This species roosts under exfoliating bark or in cavities of trees. Pregnant females form maternity colonies that may consist of up to 100 adult bats (USFWS 1999). Male Indiana bats tend to roost singly or in small all-male groups (USFWS 1999). Males may occur in summer anywhere throughout the range of the species, including near hibernacula.

Adults of this species feed exclusively on flying insects. Indiana bats forage most frequently in upland and riparian forests, but they also may forage along wooded edges between forests and croplands, and over fallow fields (Brack 1983, LaVal and LaVal 1980). They frequently use open space over streams as travel corridors.

In August, Indiana bats begin to leave summer habitat and migrate to hibernacula. Autumn swarming occurs from approximately mid-August through September. During swarming, numerous bats fly in and out of cave entrances from dusk to dawn, while relatively few roost in caves during the day (Cope and Humphrey 1977). Indiana bats periodically use tree roosts during fall swarming (Menzel et al. 2001). In Missouri, swarming Indiana bats traveled up to 4 miles (6.4 km) from roost sites (Rommé et al. 2002). In Kentucky, male Indiana bats radiotracked during October traveled up to 1.7 miles (2.7 km) from their roost sites. Kiser and Elliot (1996) found males roosted in trees between 0.5 and 1.5 miles (0.8 and 2.4 km) from the hibernaculum (Kiser and Elliot 1996).

A study by Brack et al. (2002) indicated that potential bat habitat may not be suitable when occurring at higher elevations and latitudes. Higher latitudes and elevations are cooler and wetter than areas at lower latitudes and elevations. Further, daily and seasonal temperatures are more variable at higher latitudes and elevations. These weather-related and climatic characteristics add significantly to the cost of reproduction to individual bats (Brack et al. 2002). As such, bat habitat located at higher latitudes or elevations, such as that found within the project area, may be of a lower quality than otherwise expected.

In West Virginia, most records of Indiana bats are from winter hibernacula (Figure 4). Priority III hibernacula (containing less than 500 Indiana bats) are located in Greenbrier, Monroe, Mercer, Pendleton, Pocahontas, Preston, Randolph, and Tucker counties in West Virginia

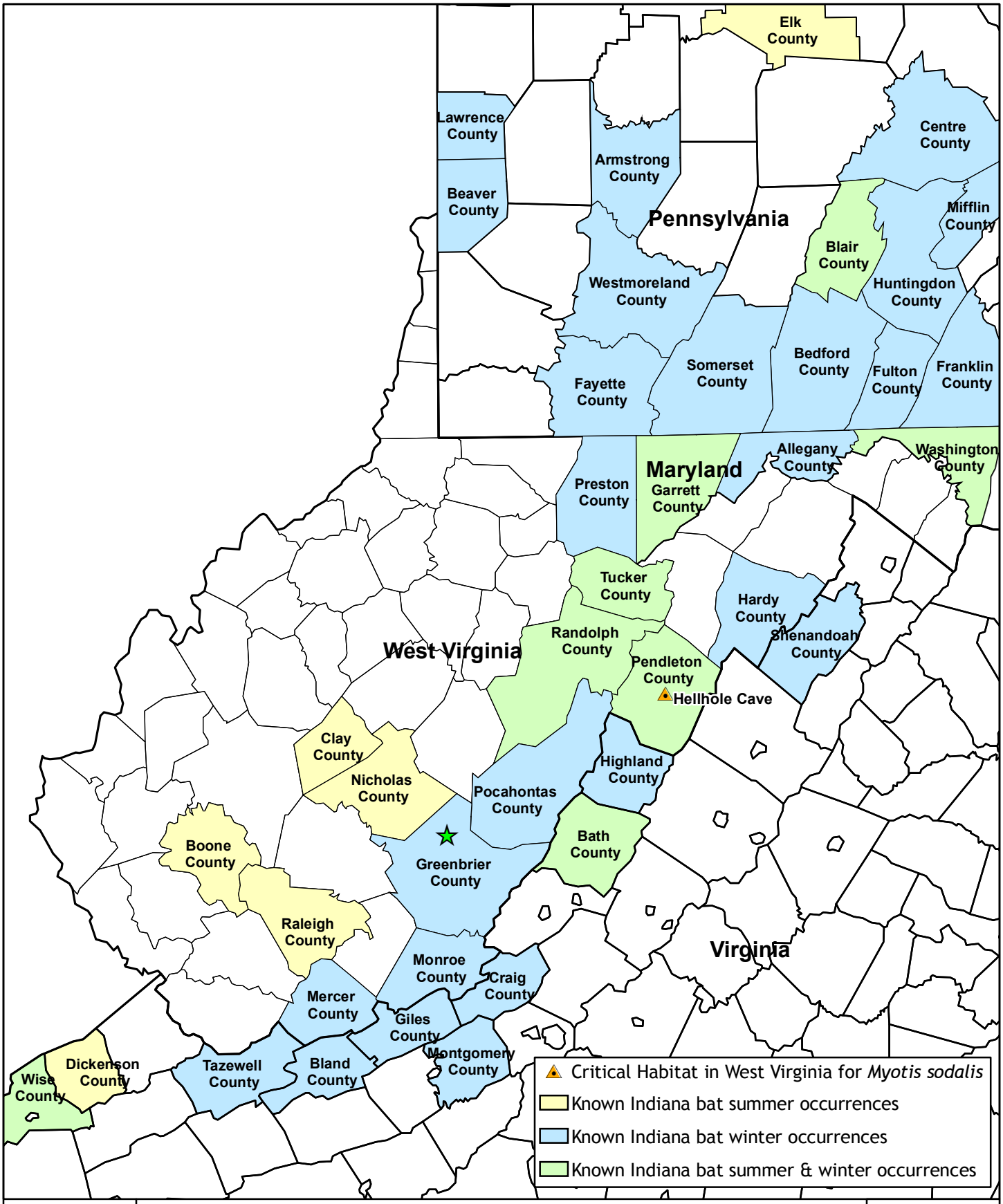

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Figure 4. Counties in which the Indiana bat (*Myotis sodalis*) occurs near the Beech Ridge site.

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(USFWS 1999). There is an historic record of wintering Indiana bats in Hardy County (C. Stihler pers. comm.).

In Greenbrier County, less than 100 Indiana bats have been found in Bob Gee, Organ, Piercy's, and General Davis caves (Garton et al. 1993); potential exists for additional wintering Indiana bats in the many un-surveyed caves within the county.

Only four caves within 10 miles of the proposed turbine sites are know to have, or do support Indiana bats. Bob Gee Cave is the only known (historic) hibernaculum within 5 miles of the proposed turbine sites. This cave is approximately 2.5 miles (4 km) southeast of the nearest proposed turbine site (Figure 5). Nine Indiana bats were found in this cave in 1984, six in 1988, and three in 1990. The most recent surveys in Bob Gee Cave occurred in 2006 and 2002; no Indiana bats were observed. All caves suitable as hibernacula within 5 miles of proposed turbine sites, with exception of one entrance to the Friar's Hole system, were surveyed for the presence of endangered bats in early March 2006. No Indiana bats or other listed bat species were present.

The best available information at this time indicates three caves located between 5 miles and 10 miles from the turbine sites support hibernating Indiana bats. Marthas Cave, located approximately 9 miles northeast of the nearest turbine, contained 196 Indiana bats in the most recent survey (2004). The 2004 count was about 30% lower than the maximum count of 285 documented in 1996. McFerrin Cave was last surveyed in the winter of 1981, when two Indiana bats inhabited the cave. A maximum of 39 Indiana bats have been documented utilizing the cave. McFerrin cave is approximately 6.75 miles south of the nearest proposed turbine site. Snedegars Cave is part of the extensive Friar's Hole Cave System which has over 40 miles of known passages. The most recent survey (2004) found 193 hibernating Indiana bats (Table 2).

There is a museum record for an Indiana bat in Higginbothams Cave No. 1, however the species apparently no longer utilizes the cave. Indiana bats were not present in the cave during any recent surveys (1976, 1981, and 1998). Higginbothams Cave No. 1 is approximately 9 miles southeast of the nearest proposed turbine.

Table 2. Proximity of Indiana bat hibernacula to proposed Beech Ridge turbine sites, and characteristics of Indiana bat populations utilizing the cave.

Cave	Approximate Distance from Nearest Proposed Turbine (miles)	Maximum Population	Maximum Population since 1960	Most Recent Population
Bob Gee Cave	2.75	9 (1984)	9 (1984)	0 (2002)
Snedegars Cave	6	193 (2004)	193 (2004)	193 (2004)
McFerrin Cave	6.75	39 (1952)	2 (1981)	2 (1981)
Marthas Cave	9	285 (1996)	285 (1996)	196 (2004) 181 (2002)

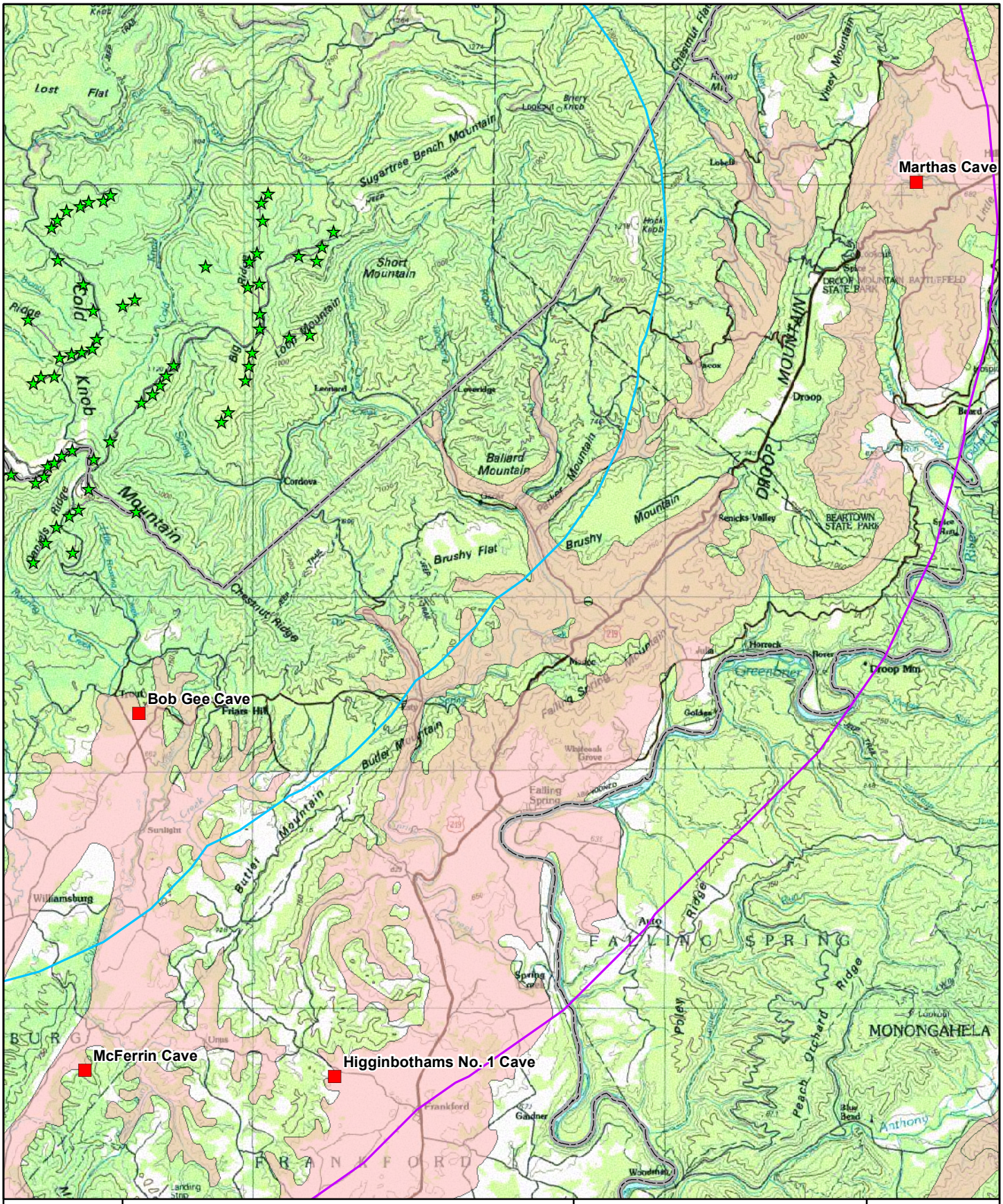

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Figure 5. Indiana bat hibernacula near the Beech Ridge site, Greenbrier County, West Virginia.

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Miles

0.875 0 0.875 1.75

★ Proposed Turbines

BHE ENVIRONMENTAL

Summer occurrences of Indiana bats in West Virginia have been documented in seven counties, including Nicholas and Clay counties northwest of the proposed turbine sites. These occurrences are of particular interest because these counties are proximate to Greenbrier County, and because the Beech Ridge project is located between these occurrences and the area of karst/caves in central Greenbrier County. The known presence of Indiana bats in Nicholas County and in Clay County is limited to only one male Indiana bat in each county. The Clay County record dates back to 1999, and the Indiana bat in Nicholas County was captured in 2004. Indiana bats captured during summer in Pendleton, Tucker, and Raleigh counties were adult males as well.

Designated Critical habitat for the Indiana bat in West Virginia and Virginia is limited to Hellhole Cave in Pendleton County, approximately 75 miles (121 km) northeast of the project area (Figure 4). Approximately 9,000 Indiana bats, nearly 90% of all Indiana bats inhabiting the state, utilize this hibernaculum (WVDNR 2005).

Indiana bats occur in winter and summer in Tucker, Pendleton, and Randolph counties, West Virginia (USFWS 1999). In 1999, a post-lactating female Indiana bat was captured in Randolph County (Owen et al. 2001). Between 2003 and 2005, reproductive female Indiana bats have been captured in Boone County and tracked to roost trees, providing the first records of Indiana bat maternity colonies in West Virginia (B. Sargent pers. comm.). Boone County is approximately 50 miles (80 km) west of the proposed project area. A reproductive female Indiana bat was also tracked to a roost tree in Tucker County in 2004 (B. Sargent pers. comm.). Tucker County is approximately 70 miles (113 km) north of the project area.

In Virginia, a single Priority III hibernaculum is present in Bath, Montgomery, and Shenandoah counties, and a Priority II hibernaculum is located in Lee and Wise counties in the western tip of Virginia (USFWS 1999). A reproductive female Indiana bat was captured in Lee County, and an individual was captured during summer in Bath County (USFWS 1999). Indiana bats were recently identified during winter in Highland, Craig, Giles, Bland, and Tazewell counties (Indiana Bat Recovery Team pers. comm.).

2.3.2 Virginia Big-Eared Bat (*Corynorhinus townsendii virginianus*)

Virginia big-eared bats were federally listed as endangered in 1979 due to their limited distribution and small population size. A recovery plan for the Ozark big-eared bat and Virginia big-eared bat was approved by the USFWS in 1984 and revised in 1995 (USFWS 1995).

The species is identified as very rare and imperiled in West Virginia. The number of Virginia big-eared bats declined sharply from 1950 through the early 1980s. Much of the decline is attributed to human disturbance at cave roosts. The majority of the population hibernates in only three caves, which makes them highly susceptible to human disturbance (USFWS 1995). However, recent trends suggest a stable or slightly increasing population (Stihler 2003). Range-wide, the total population is estimated at 20,000 (C. Stihler pers. comm.).

The Virginia big-eared bat inhabits a small range centered in northeast West Virginia (Appendix A), including Fayette, Grant, Hardy (historic only), Pendleton, Preston (historic only), Randolph, and Tucker counties, as well as nearby Rockingham, Highland, Bath, Pulaski, Bland, and Tazewell counties in Virginia (Figure 6).

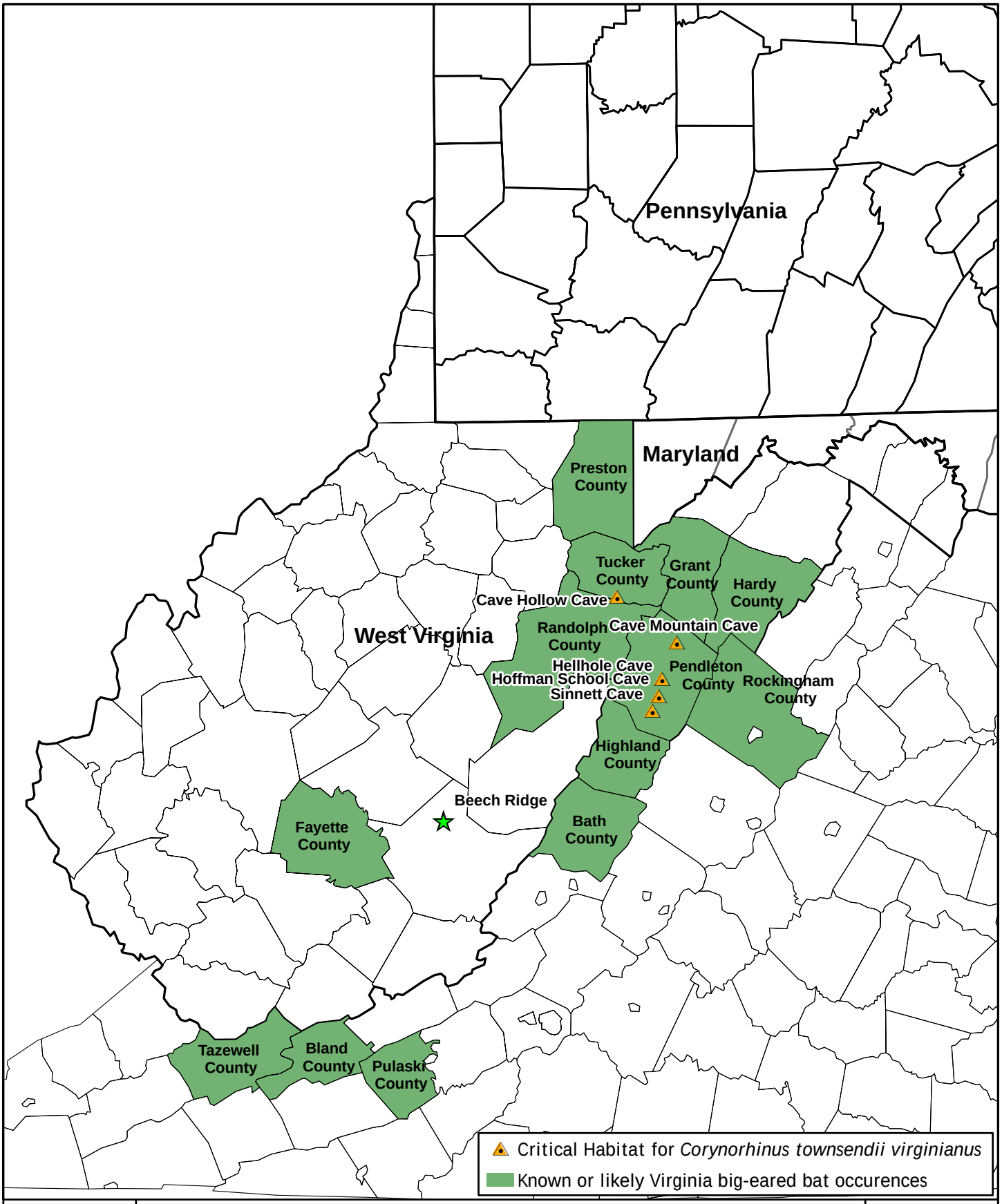

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Figure 6. Counties in which the Virginia big-eared bat (*Corynorhinus townsendii virginianus*) occurs or is likely to occur near the Beech Ridge site.

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Five caves in Tucker and Pendleton counties, West Virginia have been designated as Critical Habitat for this species (Figure 6). The largest known concentration of this species is in Hellhole Cave in Pendleton County, approximately 75 miles (121 km) northeast of the proposed project area. In 2002, 8,566 Virginia big-eared bats were identified in Hellhole Cave (Stihler 2003).

Several males and females were identified during autumn in Fayette County at mine portals approximately 30 miles west-northwest of the proposed turbine sites. Historic records of Virginia big-eared bats hibernating in Hardy and Preston counties exist, but the species has not been identified recently in winter in those counties (C. Stihler pers. comm.).

Virginia big-eared bats have been captured during summer in Pendleton, Tucker, Randolph, Grant, Hardy, and Fayette counties (C. Stihler pers. comm., BHE 1999).

In Virginia, this species has been identified during summer in three caves in Tazewell County, and in another cave in Highland County, and during winter in caves in Bland, Highland, Bath, and Tazewell counties (VDGIF 2005).

Virginia big-eared bats reside year-round in West Virginia and Virginia. They hibernate in colder or well-ventilated parts of caves closest to entrances. Virginia big-eared bats are non-migratory and may use the same cave for winter and summer roosting habitat, although they have been known to travel up to 40 miles (64 km) between seasonal roosts (Barbour and Davis 1969). Caves with known occurrences in Virginia are all located above 1500 feet (457 meters) in elevation (VDGIF 2004). Virginia big-eared bats have also been observed roosting in rock shelters, cracks, and fissures with large entrances and deep passages (Lacki et al. 1993). In 2002, approximately 28 Virginia big-eared bats were observed in the New River Gorge, approximately 30 miles from the project area. During a July 2005 mist net survey conducted to inventory bats where proposed turbines will be located, no Virginia big-eared bats were captured (BHE 2005).

Mating occurs during the fall. In spring, females give birth and raise their young in maternity colonies. Virginia big-eared bats have a high degree of roost site fidelity with females returning to the same maternity colony year after year. Most males roost singly during the summer months (Whitaker and Hamilton 1998), although bachelor colonies have been documented (Stihler 2003). Virginia big-eared bats do not leave their roosts to forage until late in the evening. They have been known to temporarily roost in sheds, trees, and under bridges during the night.

Virginia big-eared bats forage over the forest canopy, along cliff lines, and over grassy fields and pastures (Burford and Lacki 1995, WVDNR 2005, Craig Stihler, pers. comm.). The species has also been captured in mist nets within non-forested rights-of-way through forested areas (e.g., corridors for buried pipelines). A large proportion of their diet consists of small moths and beetles. Radio-telemetry studies indicate these bats travel up to 6.5 miles (10.5 km) from the cave roost to feed. Individual bats often return to the same feeding area night after night.

2.3.3 Northern Long-Eared Bat (*M. septentrionalis*)

The northern long-eared bat ranges from southern Canada and the central and eastern U.S. through northern Florida (Appendix A). It is abundant throughout West Virginia and Virginia and is a year-round resident in both states (Harvey 1992, VDGIF 2005).

The northern long-eared bat is migratory, but usually does not migrate long distances (Whitaker and Hamilton 1998). Northern breeding populations generally move south to winter hibernacula, typically occupying winter habitat beginning in mid-October (Natureserve 2005). In winter (October/November through March/April), this species hibernates in caves and mines. It may hibernate in caves occupied by several other species. Northern-long eared bats occasionally emerge from hibernation and briefly fly around (Whitaker and Hamilton 1998).

In summer, this species typically roosts in trees (under exfoliating bark or in crevices and hollows) and in manmade structures (Harvey 1992, Foster and Kurta 1999). Foster and Kurta (1999) identified northern long-eared bats roosting singly or in small groups that averaged 17 individuals. This species forages along forested hillsides and ridges, often through dense vegetation (Harvey et al. 1999). In Randolph County, West Virginia, northern-long eared bats foraged in upland forests and along road corridors (Owen et al. 2003). The mean home range of reproductive female *M. septentrionalis* was 160 acres (Owen et al. 2003).

This species has been identified in eleven caves in West Virginia, primarily during winter, but occasionally during warmer months (Garton et al. 1993). Northern long-eared bats have been identified in caves in Berkeley, Greenbrier, Pendleton, Randolph, and Tucker counties (Garton et al. 1993). This species is one of the most abundant captured during summer mist net surveys of forested areas, and is abundant at cave entrances during the autumn swarming period (Stihler 2003). The northern long-eared bat has been captured in Greenbrier and Pendleton counties during summer (BHE 1999). In July 2005, 10 northern long-eared bats were captured during a mist net survey conducted within the proposed Beech Ridge site (BHE 2005).

2.3.4 Eastern Small-Footed Bat (*M. leibii*)

The eastern small-footed bat is distributed along the Appalachian Mountains from Southern Maine, Vermont, and New Hampshire to northern Alabama, and west to northern Arkansas (Appendix A). Eastern small-footed bats appear to be sparsely distributed throughout their range, including in West Virginia and Virginia (Barbour and Davis 1969, WVDNR 2005, VDGIF 2005). It occurs in Fayette, Grant, Greenbrier, Hardy, Mercer, Monongalia, Monroe, Morgan, Nicholas, Pendleton, Pocahontas, Preston, Randolph, Tucker, and Webster counties (Natureserve 2005). Eastern small-footed bats have been identified in caves in Greenbrier, Monroe, and Pendleton counties (Garton et al. 1993), and captured during summer in Greenbrier County (BHE 1999). During a July 2005 mist net survey conducted within the Beech Ridge project area, no eastern small-footed bats were captured (BHE 2005). In Virginia, the eastern small-footed bat occurs throughout all counties along the eastern third of the state (VDGIF 2005).

Little is known about the habits of this species. The eastern small-footed bat typically occurs in mountainous regions at elevations ranging from 787 to 3690 feet (240 to 1125 meters). They often are found in eastern deciduous and coniferous forests (Best and Jennings 1997). In summer, eastern small-footed bat may be found roosting in buildings, caves, rock outcrops, and mines (Harvey et al. 1999). This species is often found in late summer with other migrating bats, but migratory behavior of the eastern small-footed bat is not well known (Best and Jennings 1997). In winter, this species hibernates in caves and mines, often in the coldest locations near the entrance (Harvey 1992). The eastern small-footed bat begins hibernation later, and emerges from hibernation earlier, than most other species (Best and Jennings 1997). Hibernation begins late in the fall (mid-November) and individuals usually leave hibernation by March, although it has been noted that they may remain active throughout the winter months (Best and Jennings 1997).

2.3.5 Little Brown Bat (*M. lucifugus*)

The little brown bat is abundant throughout forested areas of the U.S. as far north as Alaska (Appendix A). The species range includes all of West Virginia, and Virginia. It is a year-round resident in both states. Little brown bats are commonly found hibernating in West Virginia caves. Greater than 129,000 little brown bats were counted during hibernacula surveys between 2000 and 2003 (Johnson and Strickland 2004). Little brown bats also utilize other caves in Pendleton County, and caves in Berkeley, Grant, Greenbrier, Monroe, Monongalia, Randolph, and Tucker counties (Garton et al. 1993). Among the counties in which little brown bats have been captured during summer are Greenbrier and Pendleton (BHE 1999). In July 2005, 22 little brown bats were captured during a mist net survey conducted within the Beech Ridge project site (BHE 2005).

This species is especially associated with humans, often forming nursery colonies in buildings, attics, and other manmade structures (Harvey et al. 1999). These colonies are often close to a lake or stream. Males are likely solitary in the summer months (Harvey et al. 1999). In late August and early September, little brown bats prepare for hibernation, and may swarm at the entrance of caves or mines (Whitaker and Hamilton 1998). Migration between summer and winter roosts may be short distances or several hundred miles (Fenton and Barclay 1980, Whitaker and Hamilton 1998). The timing of migration and hibernation depends upon local weather conditions, with northern populations hibernating from September to early May, and southern populations hibernating from November to March (Fenton and Barclay 1980). Little brown bats typically hibernate in caves and mines, and hibernacula are typically not used as summer roosts (Harvey et al. 1999, Whitaker and Hamilton 1998).

Little brown bats often forage over water where their diet consists of aquatic insects, including mosquitoes, mayflies, midges, and caddisflies. Foraging also occurs over forest trails, cliff faces, meadows, and farmland where they consume a wide variety of insects (Harvey et al. 1999).

2.3.6 Eastern Pipistrelle (*Pipistrellus subflavus*)

The eastern pipistrelle occurs in the eastern U.S., including all of West Virginia and Virginia (Barbour and Davis 1969, VDGIF 2005). This species appears abundant throughout its range. Summer and winter ranges are identical. The eastern pipistrelle is present year-round throughout West Virginia and Virginia. It is frequently found in West Virginia caves, though

rarely in large numbers (Garton et al. 1993). The eastern pipistrelle has been identified in caves in Berkely, Grant, Greenbrier, Jefferson, Mercer, Mineral, Monongalia, Monroe, Pendleton, Pocahontas, Preston, Randolph, and Tucker counties (Garton et al. 1993). Among the counties in which eastern pipistrelles have been captured in summer is Greenbrier County (BHE 1999). In July 2005, 10 eastern pipistrelles were captured during a mist net survey conducted within the proposed site (BHE 2005). In summer, eastern pipistrelles have been found roosting in foliage and, rarely, in buildings. They may roost singly or in colonies of up to 30 bats (Barbour and Davis 1969). In winter, eastern pipistrelles hibernate in mines, quarries, caves, and rock crevices.

2.3.7 Big Brown Bat (*Eptesicus fuscus*)

The big brown bat is common throughout North America (Appendix A). It ranges throughout the United States from Alaska and Canada to Mexico and South America. Big brown bats do not migrate; there appears to be no difference in range from summer to winter (Barbour and Davis 1969). The big brown bat is found throughout West Virginia and Virginia year-round (Harvey 1992, VDGIF 2005). It roosts in rock crevices, expansion joints of bridges and dams, hollow trees, and manmade structures. Big brown bats have been found in caves in Greenbrier, Hardy, Monroe, Pendleton, Tucker, and Randolph counties, West Virginia (Garton et al. 1993). Maternity colonies containing several hundred individuals have been recorded from attics, barns, and other manmade buildings (Harvey 1992). Among the West Virginia counties in which big brown bats have been captured during summer are Greenbrier and Pendleton (BHE 1999). In July 2005, 17 big brown bats were captured during a mist net survey conducted within the proposed site (BHE 2005).

2.3.8 Red Bat (*Lasiurus borealis*)

The red bat is found from southern Canada, throughout the U.S., to Mexico and Central America (Barbour and Davis 1969). It is common in the midwest and central states, and is present throughout West Virginia and Virginia (Appendix A, Harvey 1992, VDGIF 2005, Whitaker and Hamilton 1998). During winter, male red bats are more commonly found in northern areas, while females are more often found in southern areas (Cryan 2003). There is no clear segregation of the genders during summer (Cryan 2003).

Red bats are migratory; however, migration patterns are poorly understood. Red bats inhabiting the eastern U.S. are likely to move south in the fall. In winter, red bats may hibernate in tree foliage for short periods, but arouse and forage during warm nights. Red bats have been captured in Greenbrier County in summer (BHE 1999). In July 2005, 13 red bats were captured during a mist net survey conducted within the proposed site (BHE 2005). No winter records of red bat occurrences were available, but it is likely red bats are present throughout West Virginia and the western portion of Virginia during winter.

Like most lasiurids, *Lasiurus borealis* typically roosts in tree foliage. Individual red bats may use several roost sites. Red bats hang from branches or leaf petioles and are camouflaged by leaves. Adults are solitary, but females and young roost together until young become volant.

2.3.9 Hoary Bat (*L. cinereus*)

The hoary bat is widespread throughout the U.S., but in eastern regions, the species distribution varies seasonally (Whitaker and Hamilton 1998). Breeding individuals are known from Canada south to Arkansas, Louisiana, and Georgia (Barbour and Davis 1969). The range of the hoary bat includes all of West Virginia (Harvey et al. 1999). Maps of hoary bat distribution in Virginia vary, but the species is consistently depicted in the western third of the state (Whitaker and Hamilton 1998, VDGIF 2005). It appears that the genders are separate during summer, with females inhabiting the northeast region (Cryan 2003, Whitaker and Hamilton 1998). Reproductive females are found in the northeast as far south as Pennsylvania and Indiana (Whitaker and Hamilton 1998). Female hoary bats give birth between mid-May and early July (Cryan 2003). Hoary bats have been captured in Greenbrier County in summer (see BHE 1999). In July 2005, six hoary bats were captured during a mist net survey conducted within the proposed site (BHE 2005).

In August, this species moves south to winter habitat in southeastern and southwestern states, the Caribbean, and Central and South America (Cryan 2003, Whitaker and Hamilton 1998). In the eastern U.S., hoary bats winter in northern Florida and southern Georgia, Alabama, Louisiana, and South Carolina (Whitaker and Hamilton 1998). Hoary bats apparently migrate in groups, with large numbers passing through an area over several nights in spring and fall (Whitaker and Hamilton 1998, Natureserve 2005). Females precede males in spring migration. In the north, some may hibernate rather than migrate (Whitaker 1980). Hoary bats migrate north from March through April (Whitaker and Hamilton 1998).

Hoary bats roost in foliage of deciduous or coniferous trees (Barbour and Davis 1969). The species generally is solitary except during migration and when young accompany females (Mumford and Whitaker 1982).

2.3.10 Silver-Haired Bat (*Lasyonycteris noctivagans*)

The silver-haired bat is common in forested areas throughout much of North America, although it is characterized as a northern species (Whitaker and Hamilton 1998). In the east, the silver-haired bat occurs from Maine and Wisconsin south to Mississippi, Alabama and Georgia (Whitaker and Hamilton 1998). However, the species is migratory and this range includes both summer and winter habitat. This species is typically found in parts of its range containing older stands of coniferous or mixed coniferous and deciduous forests (BCI 2002). Silver-haired bats are found primarily along the mountainous eastern border of West Virginia, in Pendleton, Pocahontas, Randolph, Tucker counties, and in Wayne County on the western boarder (Natureserve 2005). No silver-haired bats were captured during the July 2005 mist net survey in the project area (BHE 2005). This species may be found throughout Virginia (VDGIF 2005).

In spring, silver-haired bats in the eastern U.S. disperse east and north from winter habitat (Cryan 2003). Silver-haired bats roost almost exclusively in tree cavities, often switching roosts throughout the maternity season (BCI 2002). In the east, young are born primarily in Canada, Michigan, and the northeastern states (Whitaker and Hamilton 1998). Silver-haired bats typically are solitary, but may congregate in small maternity colonies usually numbering fewer than 10 individuals (Whitaker and Hamilton 1998).

Silver-haired bats migrate south in September and October and winter primarily south of the Ohio River in southeastern and eastern states, including West Virginia and Virginia (Whitaker and Hamilton 1998). Females are thought to migrate farther than males, and it is possible males remain in winter habitat year-round (Whitaker and Hamilton 1998). During migration, silver-haired bats were found roosting in trees along a ridge (Whitaker and Hamilton 1998). Typical winter roosts for this species include trees, buildings, wood piles, and rock crevices (Harvey et al. 1999). Occasionally silver-haired bats will hibernate in caves or mines, especially in northern regions of their range. Silver-haired bats have been found in caves in Greenbrier and Pendleton counties (Garton et al. 1993).

Though they are highly dependent upon older forest areas for roosts, silver-haired bats feed predominantly in disturbed areas such as small clearings and along roadways or streams (BCI 2002, Whitaker and Hamilton 1998). The silver-haired bat typically leaves the roost and begins to forage relatively late, with major foraging activity peaks 3 and 7 to 8 hours after sunset (Natureserve 2005). In southeastern Virginia and northeastern North Carolina, silver haired bats were active throughout the year, including during winter evenings when air temperature was 13ºC or more (Natureserve 2005).

2.4 CAVES

Between March 2 and March 7, 2006, BHE surveyed caves near the proposed Beech Ridge wind energy site (BHE 2006). Methods and results of our surveys were described in a report provided to Invenergy, the USFWS, and the West Virginia DNR (BHE 2006), and are summarized here. Prior to field work, BHE queried available literature, in particular: Davies, W. 1965. *Caverns of West Virginia*. West Virginia Geological and Economic Survey, Morgantown, WV; and Storrick, G. 1992. *The Caves and Karst Hydrology of Southern Pocahontas County and the Upper Spring Creek Valley*. West Virginia Speleological Survey, Reston, VA; coordinated with the West Virginia DNR; the Natural Resources Analysis Center at West Virginia University; and Mr. Bill Balfour, a speleological authority in the project area. BHE developed a GIS database identifying approximately 140 known caves within 5 miles of proposed turbine locations. We report this number as an approximation because our compilation of data from numerous sources may include undetected duplications. We focused our attention on caves within 5 miles of turbine locations because previous studies indicate Indiana bat activity during swarming (prior to hibernation) and staging (after hibernation) is concentrated within 5 miles of hibernacula. All caves within 5 miles of the project site occur in a southwest to northeast trending band, south and east of the proposed turbine locations.

Based upon information available prior to our field survey, we concluded 115 (82%) of the 140 caves within 5 miles of the turbine sites did not provide suitable winter habitat for Indiana bats or Virginia big-eared bats. These caves are less than 100 feet in length, and presumably, temperatures in these small caves would closely reflect ambient air temperatures, fluctuating too widely to support hibernating bats. Additionally, these caves would reach temperatures below freezing, which are fatal to hibernating bats. Twenty-four caves were evaluated in the field. One cave was not evaluated.

Of the 24 caves evaluated in the field, the entrances and/or portions of the interiors of 12 caves were inspected and found to be unsuitable for use by Indiana bats or Virginia big-eared bats. Entrances to these caves were blocked, or the caves exhibited evidence of flooding to the ceiling:

1. DePriest Cave No. 2
2. Roadside Cave
3. Jarvis Collapsed Dome Cave
4. Mashed Finger Well
5. Hanging Tree Cave
6. Little Bird Cave
7. McCoy Thunderdome Cave
8. Bore Hole
9. Wolfe's Blowhole
10. Dogwood Sink Cave
11. McCoy's Thunderdome South
12. Miller's Cave No. 1

Twelve other caves, including Bob Gee Cave, a historic Indiana bat hibernaculum, were surveyed and data were collected including number and species of bats present, characteristics of the cave entrance, floor and ceiling temperatures, nature of air flow, and amount of water within the cave.

1. Bob Gee Cave
2. Thrasher Cave
3. Roaring Creek Cave
4. Carr Branch Cave
5. Ben's No. 5/Smokehole Cave
6. Williamson Cave No. 2
7. Windmill Water Cave
8. Bransford's Cave
9. Casteret Cave
10. Portal Cave
11. Knight Saltpeter Cave
12. Cadle Cave

The timing of our survey, although later than the more typical December or January hibernacula survey window, was appropriate given the purpose of the survey. Temperatures at cave entrances ranged from -4ºC to 7ºC, and ceiling temperatures at the back of surveyed caves ranged from -1ºC to 10ºC. The torpid nature of bats we encountered was typical of bats observed during winter surveys.

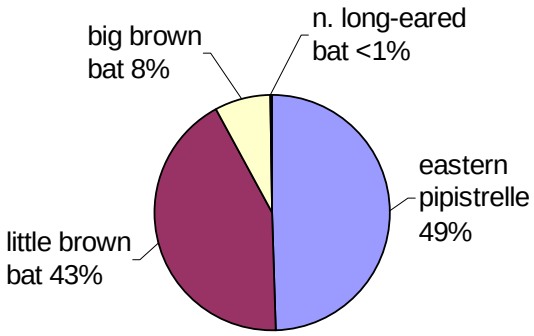
The Friar's Hole Cave System has nine known primary entrances, only one of which is within 5 miles of proposed turbine locations (approximately 4.5 miles). Indiana bats are not known to inhabit the cave near this entrance, commonly called the "Friar's Hole Entrance." In the last 16 years (since 1990) a maximum of 193 Indiana bats has been identified in the Friar's Hole system, in the portion known as Snedegar's Cave. Two entrances to Snedegar's Cave are identified, one between 5 and 6 miles from proposed turbine sites, and one between 6 and 7 miles from the locations.

Four entrances to the Friar's Hole Cave System are between 5 and 6 miles from the turbine sites, and four are between 6 and 7 miles from the sites. Investigations of the cave interior using any of the nine entrances requires passage through water and other difficult caving conditions. We have not confirmed which, if any, of these passages flood to the ceiling. The system includes nearly 45 miles of mapped passage, including some areas as much as 618 feet

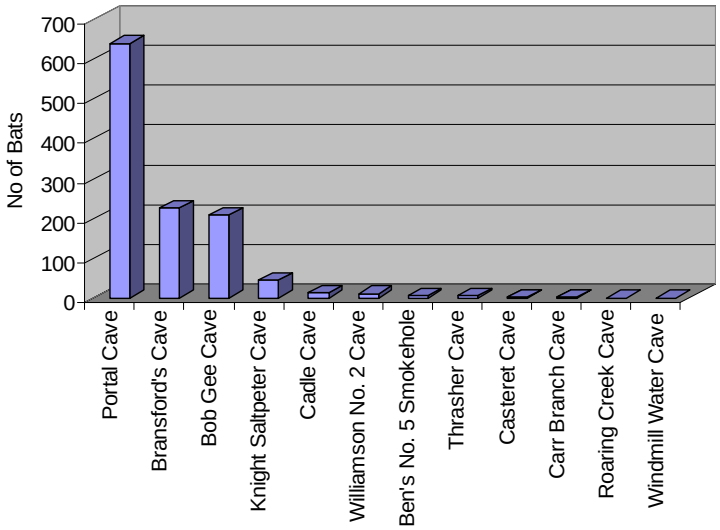
below ground surface. Survey of the massive system for the presence of Indiana bats or Virginia big-eared bats was not completed during our survey.

No Indiana bats, Virginia big-eared bats, or other federally-listed or otherwise rare or uncommon species were identified in any of the 12 caves surveyed in March 2006. Four bat species were observed (in descending order of occurrence):

- eastern pipistrelle (n=566),
- little brown bat (n=490),
- big brown bat (n=86), and
- northern long-eared bat (n=3).



Of the 12 caves BHE surveyed intensively, Portal Cave, located between 4 and 5 miles from the nearest proposed turbine location, contained the greatest number of bats (n=637); followed by Bransford's Cave (located between 3 and 4 miles from turbine locations, n=224); and Bob Gee Cave (located between 2 and 3 miles from turbine locations, n=206). Seven caves contained 50 or fewer bats and no bats were found in two of the 12 caves.



In summary, all caves within 5 miles of the nearest proposed turbine site which we believed to have at least some potential to support hibernating bats (with the exception of the Friar's Hole entrance to the Friar's Hole Cave System) were surveyed during early March 2006. Only common bat species were present in the caves. No Indiana bats were present in Bob Gee Cave during our 2006 survey (nor during the previous survey completed in 2002).

3.0 POTENTIAL EFFECTS OF THE BEECH RIDGE FACILITY TO BATS

Construction and operation of the Beech Ridge wind energy facility presents concerns regarding impacts to bats through three primary avenues:

- Bats may be killed by colliding with moving turbine blades.
- Construction of the turbines and associated appurtenances may degrade habitat quality through the removal of trees.
- Bats may be disturbed to the extent of being displaced by operating turbines.

3.1 BAT MORTALITY AT WIND ENERGY SITES

Much of the information available regarding mortality caused by collisions with moving turbine blades is contained in technical reports completed for wind site owners/developers, is

unpublished, and often difficult to obtain. Anecdotal information can be found in numerous studies intended to address avian impacts, although these data are suspect in that study methods were not designed to detect bat mortality.

As of winter 2004, studies conducted specifically to investigate bat mortality had been conducted at six wind energy facilities across the United States: four studies in the Northwest, two in the Rocky Mountains, four in the upper Midwest, and three in the East. Average mortality ranged from 1.2 to 47.5 bats killed per turbine per year. Methods used in these studies varied; mortality estimates were adjusted in many cases for the biases presented by searcher efficiency and removal of carcasses by scavengers. Bat mortality has been anecdotally recorded at other wind sites as well.

Documented bat kills at North American wind energy sites have been highest in the east (Appalachian Mountains), moderate in the Midwest, and lowest in the western states. In most cases, documented mortality was low – less than five bats per turbine per year. Mortality exceeding 10 bats per turbine per year has been identified at only four sites: Mountaineer (West Virginia), Meyersdale (Pennsylvania), Buffalo Mountain (Tennessee), and Top of Iowa (Iowa). Nationwide, more than 99% of fatalities documented as of the winter of 2004 (Johnson 2004) have been of six species in the United States, with hoary bats accounting for nearly one-half of all mortality:

- hoary bat (47.1%),
- eastern red bat (25.4%),
- silver-haired bat (11.8%),
- eastern pipistrelle (7.7%),
- little brown bat (5.6%), and
- big brown bat (1.8%).

So called "migratory bats" or "tree bats" (hoary bat, eastern red bat, silver-haired bat) account for over 84% of known fatalities. Bats that roost (winter and or summer) caves, sometimes referred to as "cave bats," comprise the remaining approximately 16%.

Although mortality has been documented in all months when bats are not hibernating, a significant majority of mortality has been documented in mid July through mid October during the post-maternity dispersal from summer habitat to winter habitat. Documented mortality is highest between approximately July 15 through September 15. The near absence of mortality during the spring migration period is unexplained. Similarly, mortality is very low during the summer maternity period, even when substantial numbers of bats are present at wind energy sites. In a study in Minnesota, researchers found bat activity as measured by ultrasound detectors was not correlated with bat mortality (Johnson et al. 2003a).

The sites at which the highest mortality has been documented occur at approximately 2760 ft (840 m) above msl (Meyersdale), and 3363 ft (1025 m) above msl (Mountaineer). Both of these sites are on forested Appalachian Mountain ridgelines. At this time the greatest risk of bat mortalities is expected at sites on forested Appalachian Mountain ridgelines.

The presence of FAA-approved lighting on towers has been the subject of speculation regarding bat mortality. Studies completed in 2004 at Mountaineer found no significant difference in mortality at lit and unlit towers. Similar results were documented at the Klondike wind facility in Washington State (Johnson et al. 2003b).

Most of the 10 species of bats likely to be present during some portion of the year at Beech Ridge have been killed at one or more operating wind energy sites. No fatalities of federally listed bat species have been documented at wind energy sites in the United States. Based upon results of mortality monitoring completed to date, we expect hoary bats and eastern red bats to account for the majority of bat kills at Beech Ridge. These two species accounted for most of the mortality in turbine searches conducted in 2004 at Meyersdale (73%), and Mountaineer (58%), and in 2003 at Mountaineer (61%).

Concurrent studies at Meyersdale and Mountaineer in 2004 showed a positive correlation in the timing of bat fatalities, indicating a regional phenomenon such as weather may affect mortality. Nights with average wind speeds exceeding 6 meters per second [13.4 mph]) were associated with extremely low observed bat fatalities, while the highest fatality rates were associated with low wind speed (less than 4 meters per second [8.9 mph]). High mortality rates were also associated with low relative humidity, higher temperature, and higher barometric pressure; conditions documented after weather fronts passed through the study areas (Arnett 2005).

Little information exists upon which to base conclusions regarding the biological significance of bat mortality at wind energy facilities. For instance, do the numbers of bats killed represent a meaningful proportion of the populations of these bat species? Unfortunately, total population estimates do not exist for any of the species killed at wind sites to date.

Reasonably accurate estimates exist for the federally endangered Indiana bat, one of the most uncommon North American species. No federally listed bat species has been identified during bat mortality studies at wind sites; we mention the size of the population of this species for context only. The most current censuses (2005) yielded a range wide population of 458,000 Indiana bats in existence. The population of Virginia big-eared bats is also reasonably well known, and was recently estimated at approximately 18,400 individuals (Currie 2000), and at 20,000 individuals (C. Stihler pers. comm.). Populations of species that have been killed at wind energy sites are much more common than these two listed species, and may be one or more orders of magnitude higher.

3.2 BAT COLLISION MORTALITY AT BEECH RIDGE

Specific pre-construction techniques/protocols that accurately predict chiropteran mortality at wind sites do not exist. Post construction mortality monitoring remains the best source for these data. However, comparison of the Beech Ridge site to other nearby similar sites with known mortality is a useful approach.

The highest levels of bat mortality documented to date have occurred at the two wind energy sites nearest Beech Ridge. There are substantial similarities in the Ecoregion, topography, elevation, geographic location, and other aspects of the Mountaineer, Meyersdale, and Beech Ridge sites (Table 3). Wind energy sites with lower mortality (e.g., the Lincoln site in Kewaunee County, Wisconsin; the Buffalo Ridge site in Minnesota; or the Foote Creek Rim site in Wyoming) are located in midwest or western states, are commonly located on flat terrain, and have been constructed in agricultural areas or other non-forested sites (e.g., short grass prairie/sagebrush, pasture).

Based upon published and unpublished information available at this time, the similarities in the projects discussed in Table 3, and the anticipated similarity in the behavior of bats at these same sites, we believe it likely mortality at the Beech Ridge site will be similar to that at the Mountaineer and Meyersdale sites. Studies completed between July 31 and September 13, 2004 at the Mountaineer and Meyersdale sites found a daily kill rate of 0.9 bats and 0.6 bats per turbine, respectively. These kill rates are representative of the peak period of mortality (fall migration period) rather than the entire year. Application of the mean of these daily kill rates, adjusted for rotor swept area, yields a predicted daily kill rate for the Beech Ridge site *during fall migration* of 0.9 bats per turbine, or a daily facility-wide total *during fall migration* of 112 bats (0.9 bats per turbine x 124 turbines).

If *annual* kill estimates (47.53 bats per turbine) based upon post-construction monitoring in 2003 at the Mountaineer site (FPL Energy 2004) are applicable to the Beech Ridge site, *annual* facility-wide mortality at Beech Ridge, adjusted for rotor swept area, can be predicted at 6746 bats. Due to the proposed number of turbines at Beech Ridge (124) relative to Meyersdale (20) and Mountaineer (44), the Beech Ridge facility may have a larger annual kill than the two other facilities combined.

Other than the two federally listed species that may occur in the project area, bat species that may suffer mortality at Beech Ridge are widely dispersed in the United States and a substantial portion of each species population will not forage in, roost in, travel through, or migrate over the Beech Ridge site.

The proposed Beech Ridge site originally presented the potential for concern in that it was thought to be proximate to Indiana bat and/or Virginia big-eared bat hibernacula, and was assumed to be located in an area used by Indiana bats and Virginia big-eared bats in the summer (Figure 7). However, surveys completed during the summer and winter (BHE 2005, BHE 2006) did not detect local presence of either species.

Table 3. Attributes of the Beech Ridge and Mountaineer, West Virginia; and Meyersdale, Pennsylvania wind energy sites.

Feature	Beech Ridge (Greenbrier Co., WV)	Mountaineer (Tucker Co., WV)	Meyersdale (Somerset Co., PA)
EcoRegion (Section)	Allegheny Mountains	Allegheny Mountains	Allegheny Mountains
Topographic position	Ridgelines	Ridgeline	Ridgeline
Approximate average elevation (above msl)	1160 m (3,800 ft)	1025 m (3,363 ft)	840 m (2,756 ft)
Vegetative cover	Towers to be placed in openings cleared in forest cover	Towers placed in openings cleared in forest cover	Towers placed in openings cleared in forest cover
No. of turbines	124 (1.5-MW)	44 (1.5-MW)	20 (1.5-MW)
Turbine string(s)	Single string on ~37 km of numerous ridgelines oriented primarily NW to SE, E to W, N to S, and NE to SW	Single 8.8 km string along generally SW to NE crest of Backbone Mountain	Single 3.8 km string generally SW to NE along ridgeline
Hub height	80 m (262 ft)	70 m (230 ft)	80 m (262 ft)
Rotor diameter	77 m (253 ft)	72 m (236 ft)	72 m (236 ft)
Max. rotor height	119 m (390 ft)	106 m (343 ft)	116 m (381 ft)
Min. rotor height	42 m (138 ft)	34 m (112 ft)	44 m (144 ft)
Rotor swept area	4,657 m^2 per turbine 577,468 m^2 total	4,071 m^2 per turbine 179,124 m^2 total	4,071 m^2 per turbine 81,420 m^2 total
Rotor RPM	17	17	17
Turbine cut in speed	3.5 meters per second (8 miles per hour)	4 meters per second (9 miles per hour)	4 meters per second (9 miles per hour)
Lighting	Red or white strobes on one third of turbines	L-864 red strobes on one third of turbines	L-864 red strobes on one third of turbines
Bat species in the region (bats listed for Mountaineer and Meyersdale are those species detected in mortality searches. Percent of total detected mortality is indicated).	Hoary bat Eastern red bat Eastern pipistrelle Big brown bat Silver-haired bat Little brown bat N. long-eared bat Eastern small-footed bat Indiana bat Virginia big-eared bat	Hoary bat (33.7%) Eastern pipistrelle (24.6%) Eastern red bat (24.1%) Little brown bat (9.8%) Silver-haired bat (4.8%) Big brown bat (2.5%) Unidentified sp (0.5%)	Hoary bat (45.4%) Eastern red bat (27.5%) Eastern pipistrelle (8.0%) Big brown bat (6.9%) Silver-haired bat (5.7%) Little brown bat (2.7%) N. long-eared bat (0.7%) Unidentified Myotis (0.5%)

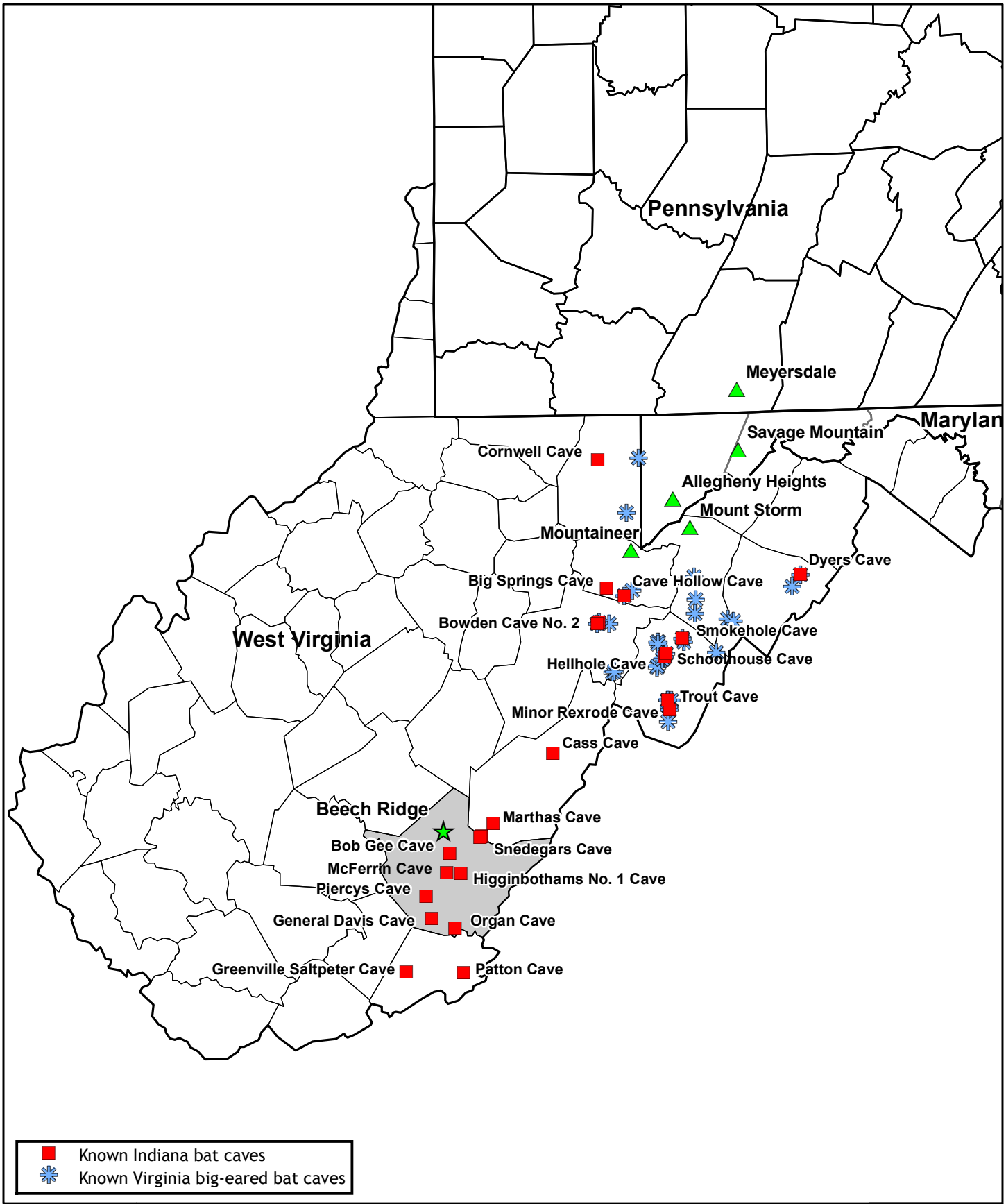


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Figure 7. Indiana bat hibernacula and Virginia big-eared bat caves in West Virginia near the Beech Ridge site.

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The Beech Ridge site is within a group of counties, generally extending southwest to northeast, in which Indiana bats hibernate. Counties in which summer occurrences of the species have been documented are immediately west and east of Greenbrier County (Figure 4). Summer occurrences have been documented in Randolph, Tucker, and Pendleton counties north of Beech Ridge. With Indiana bat hibernacula in Greenbrier County (Figure 5), and in other nearby counties (Figure 7) male Indiana bats may be present in the county during summer. Considering known proximate locations of summer and winter occurrences of Indiana bats, it is reasonable to presume individuals of this species move through Greenbrier County in spring and fall. It is unlikely female and juvenile Indiana bats will occupy the project area during summer. Thermal conditions in the project are less than ideal, and may be entirely unsuitable, for use by females and young (Brack et al. 2002).

The chance of collisions between Indiana bats and turbine blades during the summer is low. Indiana bats, even if present, are likely to be rare in the project area, and are likely to be active at heights largely below the rotor swept area. Studies completed to date have documented very low mortality during summer months, even when concurrent mist net surveys and or ultrasound acoustic detection devices indicate the presence of substantial numbers of bats. Chances of mortality during migration, especially during the fall, may be higher.

Virginia big-eared bats do not migrate, or migrate locally - with movements between summer and winter caves generally less than 40 miles (64 km). Most of Fayette County, West Virginia and most of Bath County, Virginia, in which the species has been documented, is within 40 miles (64 km) of the Beech Ridge project site. If the species utilizes caves near the project area, for instance in the area of karst south of the site, Virginia big-eared bats may occur in the project area during spring or fall. No signs of summer or winter presence of Virginia big-eared bats were identified in caves within 5 miles of the nearest turbine during surveys completed in early 2006 (BHE 2006).

The chance of fatalities of this species is considered very low. Surveys completed during the summer and winter (BHE 2005, BHE 2006) did not detect local presence of the species. The species has not been documented in Greenbrier County.

3.3 HABITAT DEGRADATION AT BEECH RIDGE

The USFWS is routinely consulted regarding potential impacts to federally listed bat species associated with a wide variety of projects in the eastern United States. Their concerns commonly focus upon habitat modifications near hibernacula and maternity caves, and modification of forested habitat in nearly any location within the range of potentially affected species. Where such habitat modifications occur, the Service recommends project-specific consultation.

Removal of forested habitat may affect summer maternity habitat of the Indiana bat, and the Service routinely requires mist net surveys to characterize the summer presence of this species in project areas. If forest removal in occupied Indiana bat summer habitat occurs, there is commonly substantial concern regarding the potential for direct mortality. A single maternity tree may support 100 or more adult female Indiana bats and their young.

Trees within approximately 55 meters (180 ft) of each tower will be cleared, yielding approximately 2.3 acres (0.9 ha) of cleared area per tower, and 285 acres (115 ha) at tower sites project-wide. Pre-construction presence/absence surveys were completed in 2005 along the proposed turbine sites; no Indiana bats were captured. Similar surveys will be completed at 12 mist net sites in summer 2006 along forested portions of the proposed transmission corridor. As during previous surveys of the project area, the survey intensity for this effort has been coordinated and approved by the USFWS.

The transmission line corridor extending northwest from the turbine strings will require the clearing of approximately 128 forested acres. For purposes of the conclusions in this document, we have assumed mist net surveys along the transmission corridor will not detect the presence of Indiana bats or Virginia big-eared bats.

In terms of forest habitat utilized by other bat species that may utilize the project area, it is important to consider this project in the context of forest habitat present in the local area. Greenbrier County includes approximately 1023 mi^2, 75% of which is forested (Griffith and Widmann 2003). The proposed project will remove approximately 400 acres of forest (less than 0.08% of the forest in the county) and is therefore exceedingly unlikely to constitute a significant loss in the habitat available to bats that utilize forested habitat.

Based upon the best available information, including almost exclusively negative results of summer mist net surveys for Indiana bats in West Virginia, and the elevation of the Beech Ridge site, the likelihood of an Indiana bat maternity colony in the project area is very low. However, considering the proximity of the project area to known and potential hibernacula, there is perhaps potential for presence of male Indiana bats roosting and or foraging within the project area during summer, and migrating/staging/swarming individuals utilizing the project area during spring and fall. There is one historic hibernaculum within 5 miles (8 km) (Bob Gee Cave), three active hibernacula (McFerrin Cave, Martha's Cave, and Snedegars Cave) between 5 and 10 miles (8 and 16 km) of the site, and one historic hibernaculum (Higginbotham Cave No. 1) between 5 and 10 miles (8 and 16 km) of the site. The site generally lies within a band of counties in which Indiana bats occur in the winter (or winter and summer), and is just to the east of two, and northeast of two West Virginia counties in which Indiana bats occur in the summer (Figure 4). These summer occurrences are limited to a single male Indiana bat in each county.

Virginia big-eared bats have not been identified utilizing caves within 10 miles (16 km) of the project site, or anywhere in Greenbrier County. Because these bats travel up to approximately 6.5 miles (10.5 km) from their roost cave to feed, and because there are no caves utilized by this species near the project area, the likelihood of Virginia big-eared bats being present in the project area in the summer is very low. Removal of forest vegetation as proposed for this project is unlikely to affect this species.

3.4 DISTURBANCE AND DISPLACEMENT OF BATS AT BEECH RIDGE

Speculations have been made concerning the potential disturbance of bats by operating wind energy facilities, and the potential for resulting displacement from otherwise suitable habitat. Data do not exist to dismiss the risk of such disturbance or displacement, but preliminary information now available supports the conclusion that wind turbines and their blades do not substantially disturb/displace bats. In 2004 at the Mountaineer and Meyersdale wind sites, bats were commonly observed foraging in forest openings at turbine sites. Thermal imaging equipment was used to investigate bat behavior near wind towers. Bats landed on towers, foraged near rotating blades, pursued rotating blades, and flew in patterns that appeared to indicate purposeful collision avoidance. The presence of bats near operating turbines was also documented at the Buffalo Ridge site in Minnesota (Johnson et al. 2003a), and the Buffalo Mountain site in Tennessee.

4.0 POST CONSTRUCTION MONITORING AND ADAPTIVE MANAGEMENT TESTING

Beech Ridge Energy LLC is proposing post-construction bat mortality monitoring, and the testing of adaptive management techniques to mitigate this mortality. This monitoring and integrated testing of adaptive management strategies would be completed over a three-year period, and would be comprised of (1) an initial one-year baseline monitoring program including standardized carcass searches, scavenging assessments, observer-bias evaluations. Additionally, the studies will include the collection of meteorological data to assess correlations between wind speed, wind direction, other meteorological factors, and bat fatality. The year of baseline data collection will be followed by two-years of continued monitoring coupled with testing of adaptive management strategy(s).

As part of this effort, Beech Ridge Energy LLC will form a Technical Committee, the purpose of which will be to provide ongoing technical input throughout the development and implementation of the Post Construction Monitoring Plan and the Adaptive Management Plan. Membership on the Technical Committee may be filled by Beech Ridge Energy LLC personnel, and a representative of the Public Service Commission, the USFWS, the WVDNR, the Bat Wind Energy Cooperative, and an established state-wide environmental organization. It is the intention of Beech Ridge Energy LLC to share post construction bat mortality data, exclusive of proprietary information, with members of the Technical Committee.

5.0 LITERATURE CITED

Arnett, E.B. (ed). 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas.

Barbour, R.W. and W.H. Davis. 1969. Bats of America. University Press of Kentucky, Lexington. 286 pp.

Bat Conservation International, Inc. (BCI). 2002. Silver-haired bat: Lasionycteris noctivagans. Accessed at http://www.batcon.org/discover/species/lnoctiv.html on July 20, 2004.

Bat Conservation International, Inc. (BCI). 2005a. Gray bat: Myotis grisescens. Accessed at http://www.batcon.org/discover/species/mygris.html on June 20, 2005.

Bat Conservation International, Inc. (BCI). 2005b. Evening bat: *Nycticieus humeralis*. Accessed at http://www.batcon.org/discover/species/mysept.html on June 22, 2005.

Best, T. and J. Jennings. 1997. *Myotis leibii*. Mammalian Species 547:1-6.

BHE Environmental, Inc. (BHE). 2006. April 6 letter from Russ Rommé, BHE Environmental, Inc. to Dave Groberg, Invenergy LLC describing 2006 survey for hibernating bats in caves within 5 miles of proposed turbine sites at the Beech Ridge wind site in Greenbrier County, West Virginia. 3 pp + attachments and map.

BHE Environmental, Inc. (BHE). 2005. Mist net surveys at the proposed Beech Ridge Wind Farm, Greenbrier County, West Virginia. Unpublished report submitted to Beech Ridge Energy LLC, Olney, Maryland. 12pp + appendices.

BHE Environmental, Inc. (BHE). 1999. Mist net survey for bats in Areas 8, 9, and 10 of the Marlinton/White Sulphur and Cheat/Potomac Ranger Districts, the Monongahela National Forest in Greenbrier and Pendleton Counties, West Virginia. Unpublished report submitted to USDA Forest Service, Monongahela National Forest, Greenbrier Ranger District. 25pp + appendices.

Brack, V., Jr. 1983. The nonhibernating ecology of bats in Indiana with emphasis on the endangered Indiana bat, *Myotis sodalis*. Unpublished Ph.D. dissertation, Purdue University, West Lafayette, Indiana. 280 pp.

Brack, V., C. Stihler, R. Reynolds, C. Butchkoski, and C. Hobson. 2002. Effect of climate and elevation on distribution and abundance in the mideastern United States *in:* Kurta A., and J. Kennedy (eds.) The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International, Austin, Texas. p 21-28.

Burford, L.S. and M.J. Lacki. 1995. Habitat use by *Corynorhinus townsendii virginianus* in the Daniel Boone National Forest. American Midland Naturalist 134:340-345.

Cope J. and S. Humphrey. 1977. Spring and autumn swarming behavior in the Indiana bat, *Myotis sodalis*. Journal of Mammalogy 58(1):93–5.

Cryan, P.M. 2003. Seasonal distribution of migratory tree bats (*Lasiurus* and *Lasionycteris*) in North America. Journal of Mammalogy 84(2):579-593.

Curry, R. 2000. Federally listed threatened and endangered species of importance to mining. Pages 51-58 *in* Vories, K. and D. Throgmorton (eds.), Proceedings – Bat Conservation and Mining: A Technical Interactive Forum. USDI, Office of Surface Mining, Alton, Illinois and Coal Research Center, Carbondale, Illinois.

Fenton, M.B. and R. Barclay. 1980. *Myotis lucifugus*. Mammalian Species 142:1-8.

Foster, R.W. and A. Kurta. 1999. Roosting ecology of the northern bat (*Myotis septentrionalis*) and comparisons with the endangered Indiana bat (*Myotis sodalis*). Journal of Mammalogy 80:659–672.

FPL Energy. 2004. A study of bird and bat collision fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: annual report for 2003. Juno Beach, Florida.

Garton, E.R., F. Grady, and S.D. Carey. 1993. The vertebrate fauna of West Virginia Caves. West Virginia Speleological Survey Bulletin 11. 107 pp.

Gorman, J.L., L.S. Newman, W.W. Beverage, and W.F. Hatfield. 1972. Soil Survey of Greenbrier County, West Virginia. Published by the United States Department of Agriculture, Soil Conservation Service, in cooperation with the West Virginia Agricultural Experiment Station.

Griffith, D. and R. Widmann. 2003. Forest Statistics for West Virginia: 1989 and 2000. US Department of Agriculture, Newton Square, Pennsylvania.

Harvey, M.J. 1992. Bats of the Eastern United States. Arkansas Game and Fish Commission. 46 pp.

Harvey, M.J., J.S. Altenbach, and T.L. Best. 1999. Bats of the United States. Arkansas Game and Fish Commission. 64 pp.

Hobson C. and J. Holland. 1995. Post-hibernation movement and foraging habit of a male Indiana bat, *Myotis sodalis* (Chiroptera: Vespertilionidae), in western Virginia. Brimleyana 23:95-101.

Humphrey, S.R. 1978. Status, winter habitat, and management of the endangered Indiana bat, *Myotis sodalis*. Florida Scientist 41:65-76.

Johnson, G. 2004. Overview of available bat mortality studies at wind energy projects. Presentation at November 3-4, 2004 Wildlife Interactions Research meeting, National Wind Coordinating Committee, Lansdowne, Virginia.

Johnson, G. and M.D. Strickland. 2004. Biological assessment for the federally endangered Indiana bat (*Myotis sodalis*) and Virginia big-eared bat (*Corynorhinus townsendii virginianus*). Unpublished report prepared for NedPower Mount Storm LLC. Chantilly, Virginia.

Johnson, G., W. Erickson, M. Strickland, M. Shepherd, D. Shepherd, and S. Saparro. 2003a. Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota The American Midland Naturalist 150:332-342.

Johnson, G., W. Erickson, J. White, and R. McKinney. 2003b. Avian and bat mortality during the first year of operation at the Klondike Phase I wind project, Sherman County, Oregon. Draft report prepared for Northwestern wind power, Goldendale, Washington.

Kiser J.D. and C.L. Elliott. 1996. Foraging habitat, food habits, and roost tree characteristics of the Indiana bat (*Myotis sodalis*) during autumn in Jackson County, Kentucky. A Report Submitted to the Nongame Program Kentucky Department of Fish and Wildlife Resources.

Lacki, M.J., M.D. Adam, and L.G. Shoemaker. 1993. Characteristics of feeding roosts of Virginia big-eared bats in Daniel Boone National Forest. Journal of Wildlife Management 57:539–543.

LaVal R. and M.L. LaVal. 1980. Ecological studies and management of Missouri bats, with emphasis on cave-dwelling species. Missouri Department of Conservation, Terrestrial Series 8:1-52.

McNab, W.H. and P.E. Avers. 1994. Ecological Subregions of the United States. USDA Forest Service, Washington, DC.

Menzel M., J. Menzel, T. Carter, M.W. Ford, and J. Edwards. 2001. A review of forest habitat relationships of the Indiana bat. Newtown Square, Pennsylvania: USDA Forest Service, Northeastern Research Station. General Technical Report NE-284.

Mumford, R.E. and J.O. Whitaker, Jr. 1982. Mammals of Indiana. Indiana University Press, Bloomington. 537 pp.

Nicholson, C. 2003. Buffalo Mountain windfarm bird and bat mortality monitoring report, October 2001 to September 2002. Report submitted to the Tennessee Valley Authority, Knoxville. 15 pp.

NatureServe. 2005. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.4. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer (accessed June 13-22, 2005).

Owen, S.F., M.A. Menzel, W.M. Ford, B.R. Chapman, K.V. Miller, J.W. Edwards, and P.B. Wood. 2001. First summer record of a female Indiana bat, *Myotis sodalis*, in West Virginia. Journal of the Elisha Mitchell Scientific Society 117(2):132-134.

Owen, S.F., M.A. Menzel, W.M. Ford, B.R. Chapman, K.V. Miller, J.W. Edwards, and P.B. Wood. 2003. Home-range size and habitat use by the northern long-eared myotis (*Myotis septentrionalis*). The American Midland Naturalist 150:352-359.

Rommé R., A. Henry, R. King, T. Glueck, and K. Tyrell. 2002. Home range near hibernacula in spring and autumn *in*: Kurta A. and J. Kennedy (eds.). The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International, Austin, Texas. p 153-158.

Stihler, C. 2003. Shedding light on West Virginia's cave-dwelling bats. West Virginia Wild Magazine http://www.wvdnr.gov/wildlife/magazine/Archive/03Summer/Shedding_Light.shtm

U.S. Fish and Wildlife Service (USFWS). 1983. Recovery Plan for the Indiana Bat. U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 82 pp.

U.S. Fish and Wildlife Service (USFWS). 1995. Ozark Big-eared Bat Revised Recovery Plan. Tulsa, Oklahoma. 51pp.

U.S. Fish and Wildlife Service (USFWS). 1999. Agency Draft: Indiana bat (*Myotis sodalis*) revised recovery plan. Region 3 U.S. Fish and Wildlife Service, Ft. Snelling, Minnesota. March 1999.

U.S. Forest Service (USFS). 1994. Ecological Subregions of the United States. U.S. Department of Agriculture, Washington, DC.

Virginia Department of Game and Inland Fisheries (VDGIF). 2005. Virginia's Wildlife. http://www.dgif.state.va.us/wildlife/va_wildlife/index.html (accessed June 23, 2005).

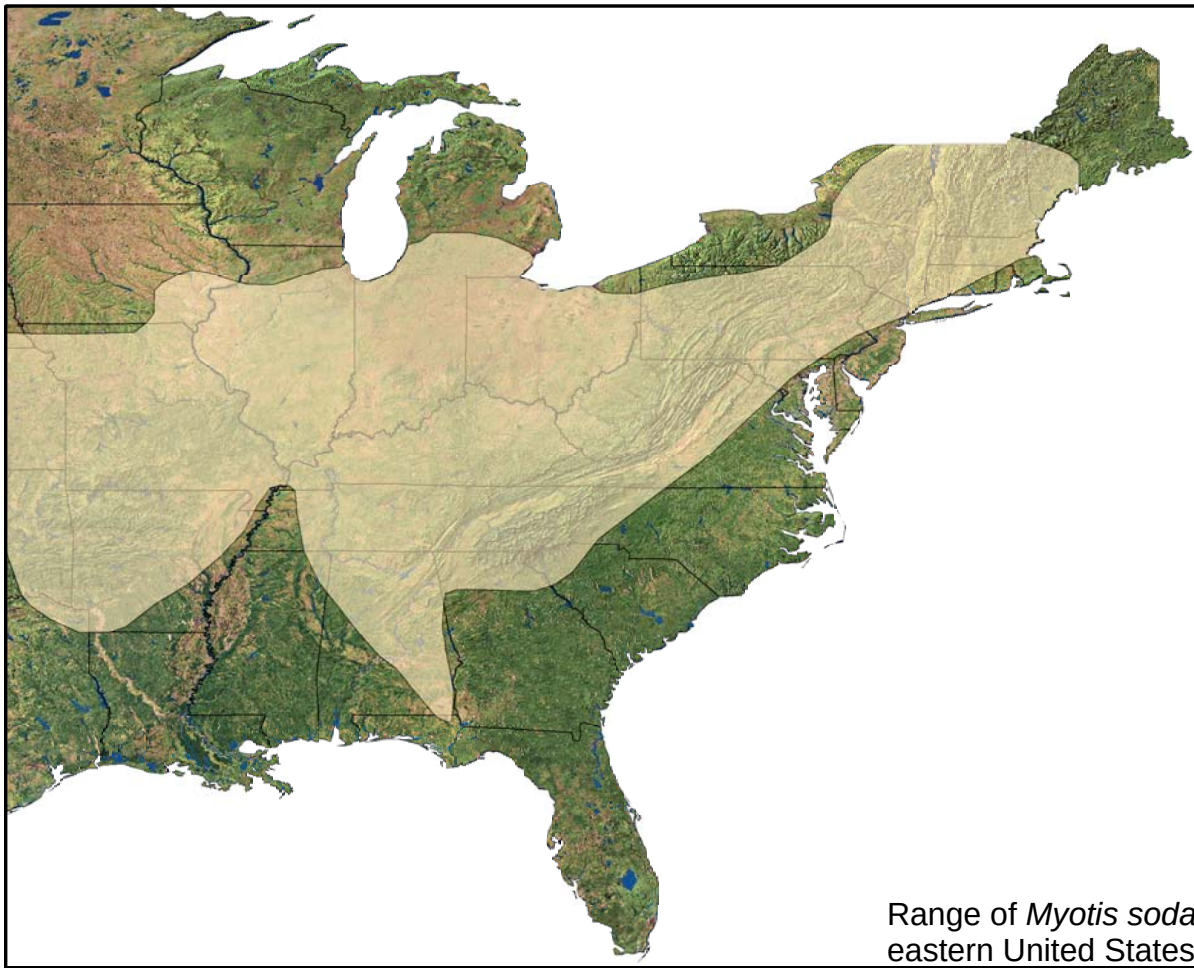
West Virginia Division of Natural Resources (WVDNR). 2005. http://www.dnr.state.wv.us/wvwildlife/endangered.htm (accessed June 15-24 2005).

Whitaker, J.O., Jr. 1980. The Audubon Society Field Guide to North American Mammals. Alfred A. Knopf, New York. 745 pp.

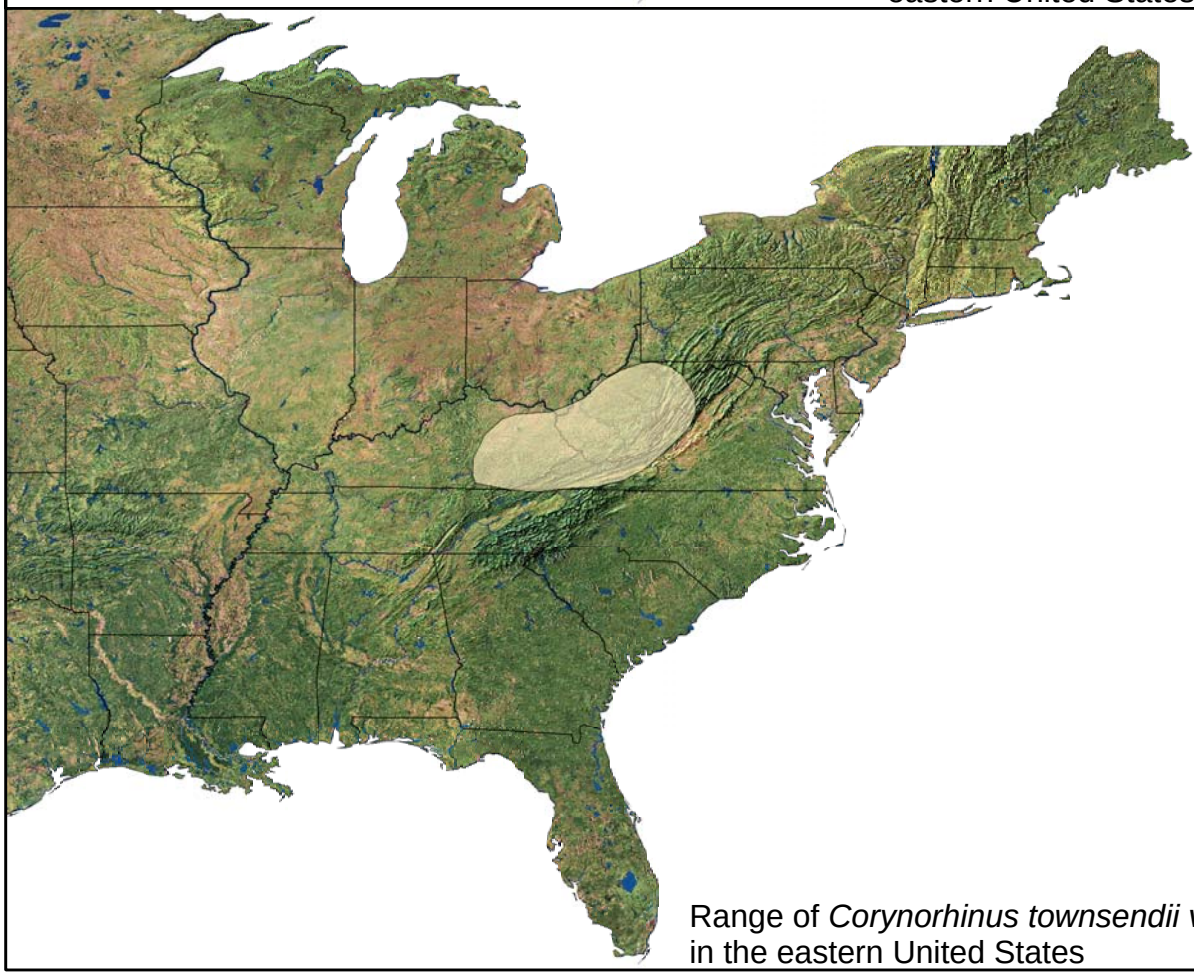
Whitaker, J.O., Jr. and W.J. Hamilton, Jr. 1998. Mammals of the Eastern United States. Third edition. Cornell University Press, Ithaca, New York. 583 pp.

APPENDIX A

Bats of the Beech Ridge Project Area – Range Maps



Range of *Myotis sodalis* in the eastern United States



Range of *Corynorhinus townsendii virginianus* in the eastern United States

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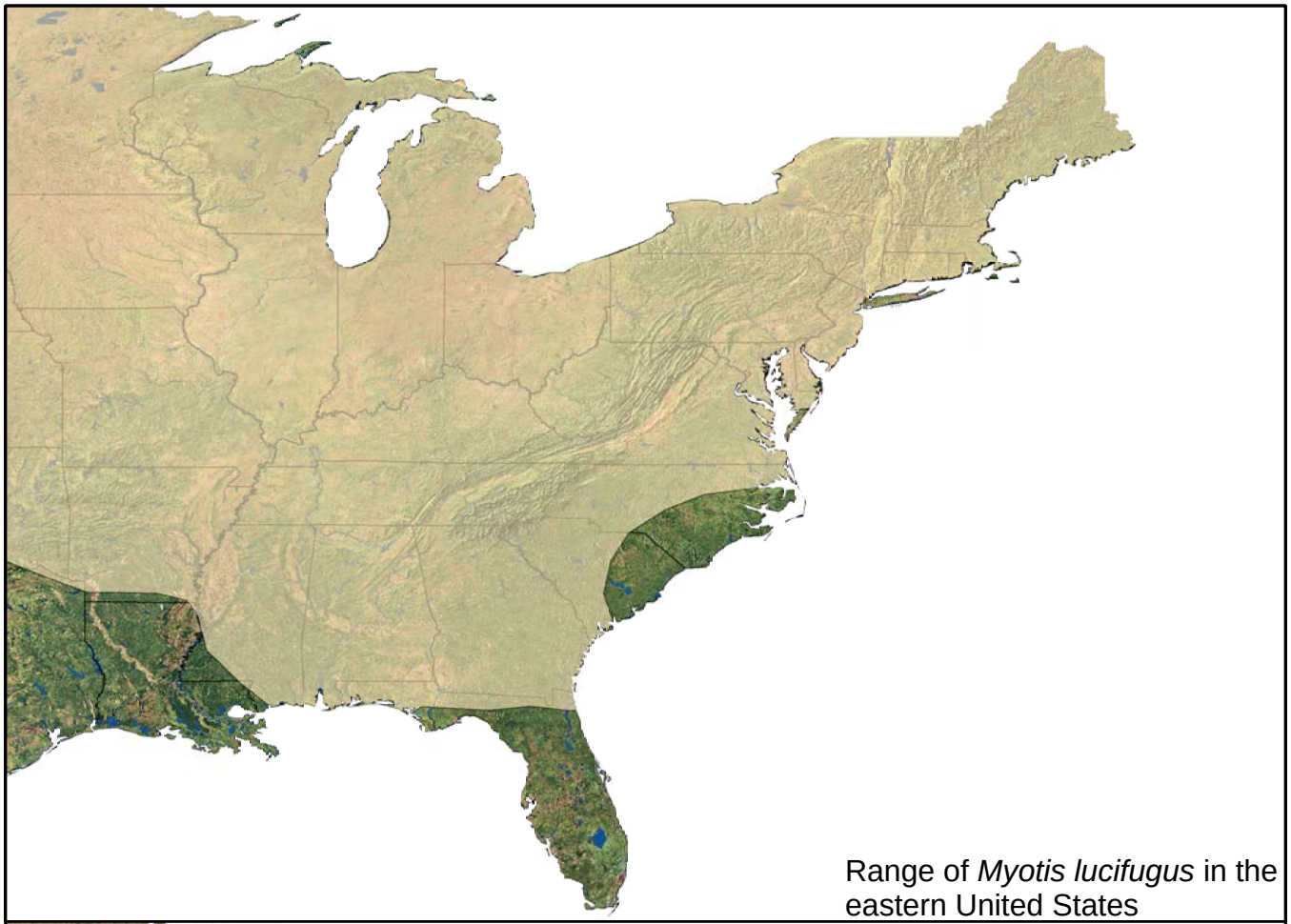
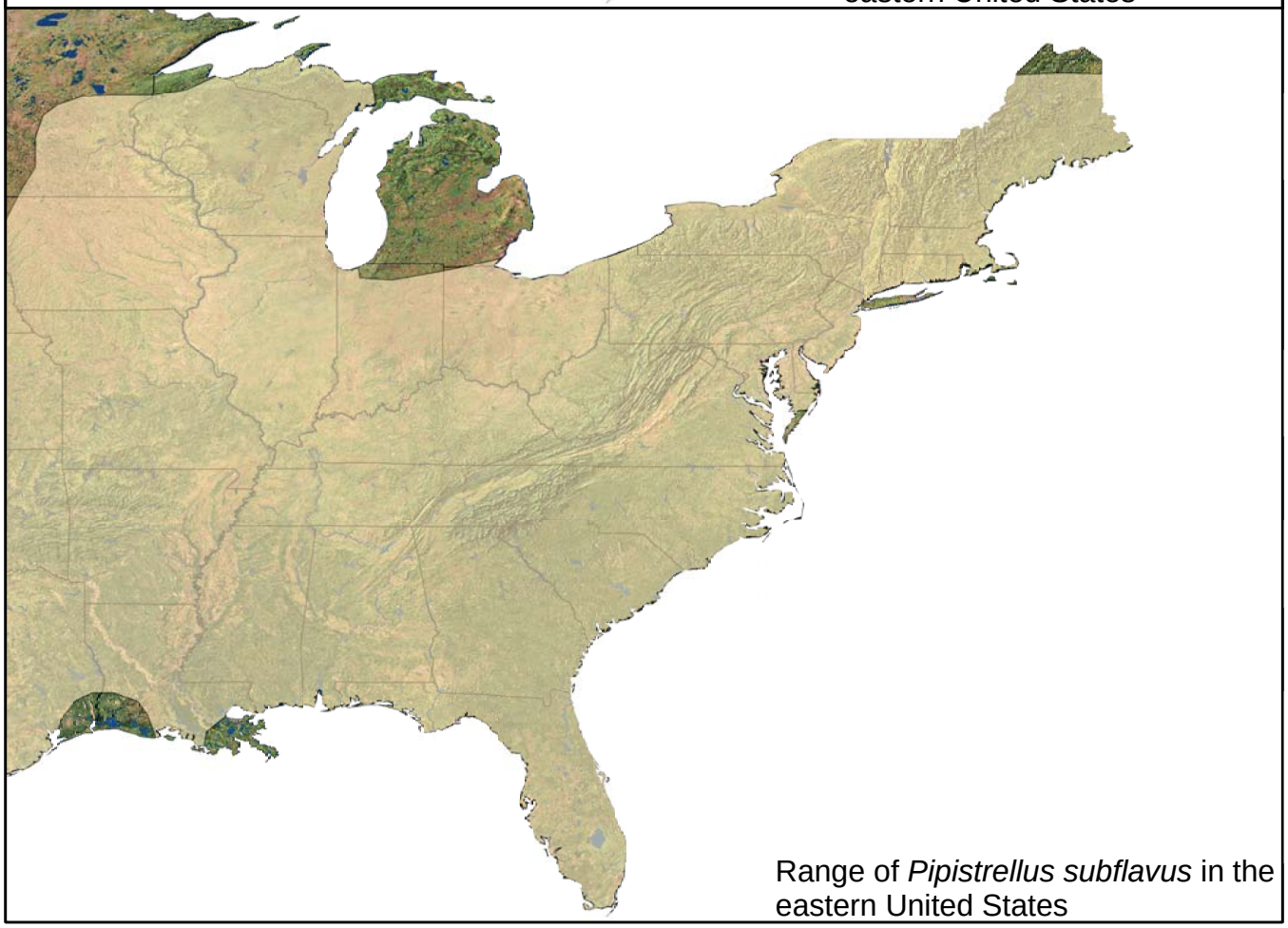
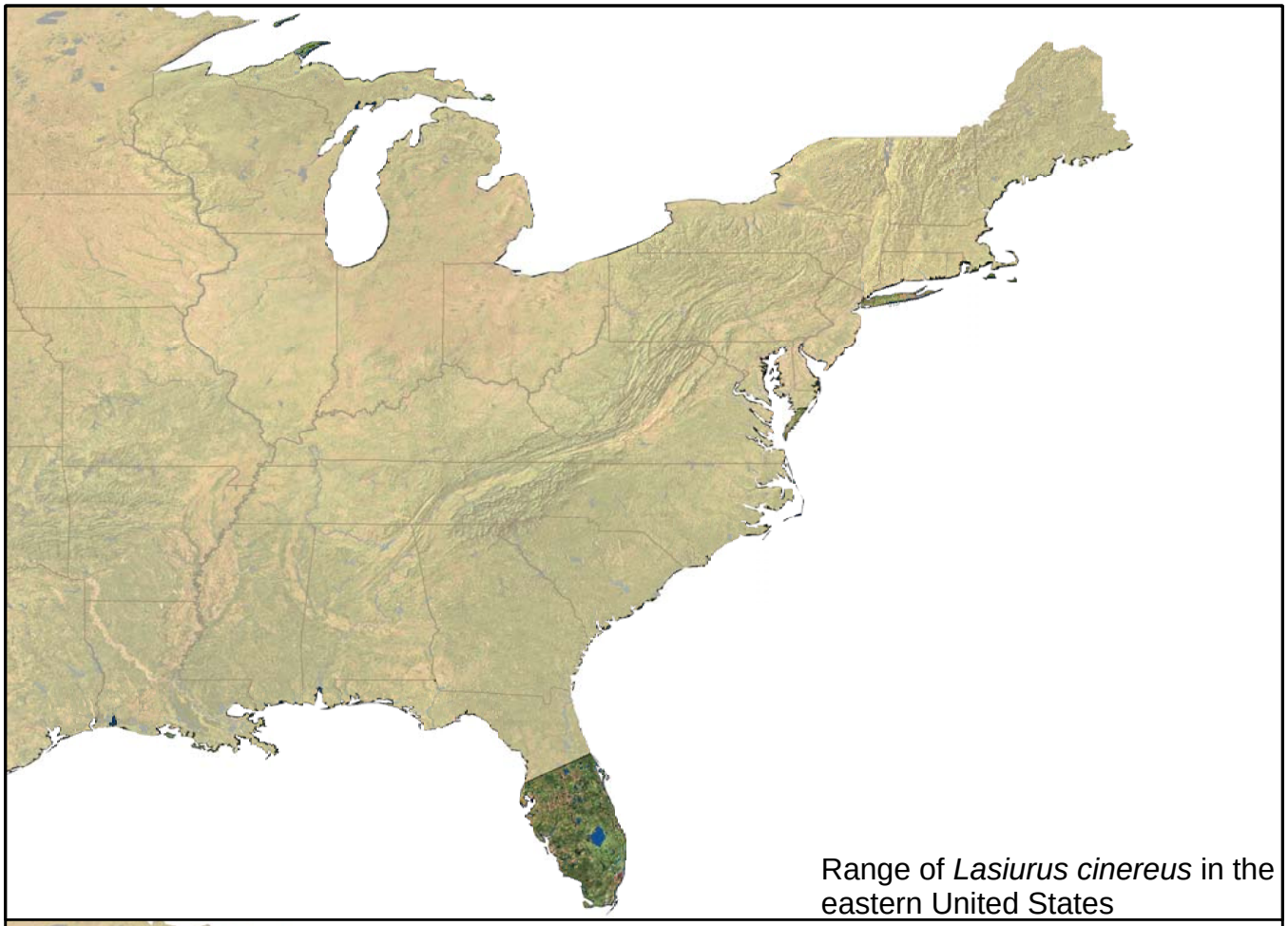


Range of *Myotis lucifugus* in the eastern United States

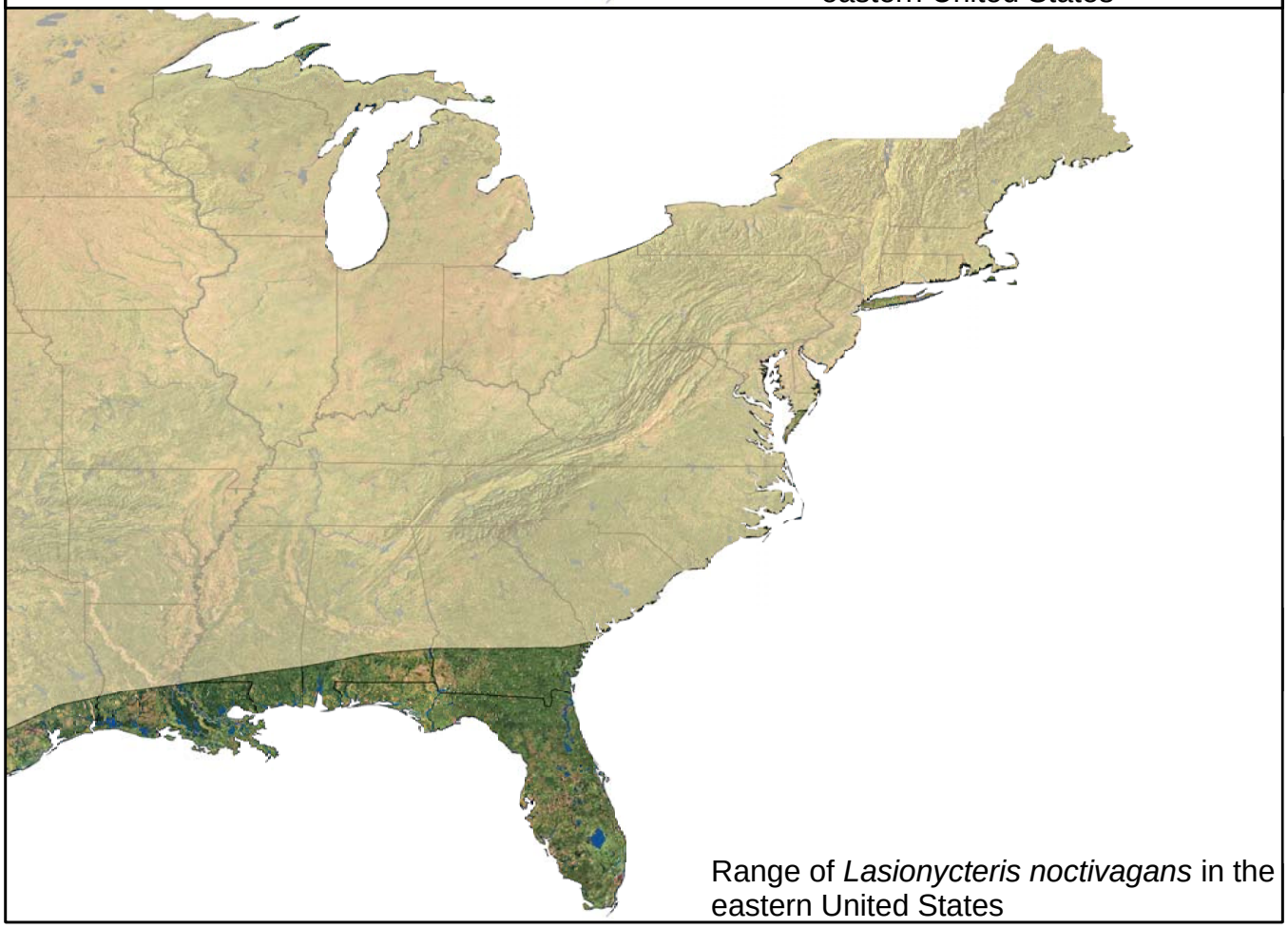


Range of *Pipistrellus subflavus* in the eastern United States

Bat Range data obtained from - http://www.natureserve.org/getData/mammalMaps.jsp (06/21/2005)

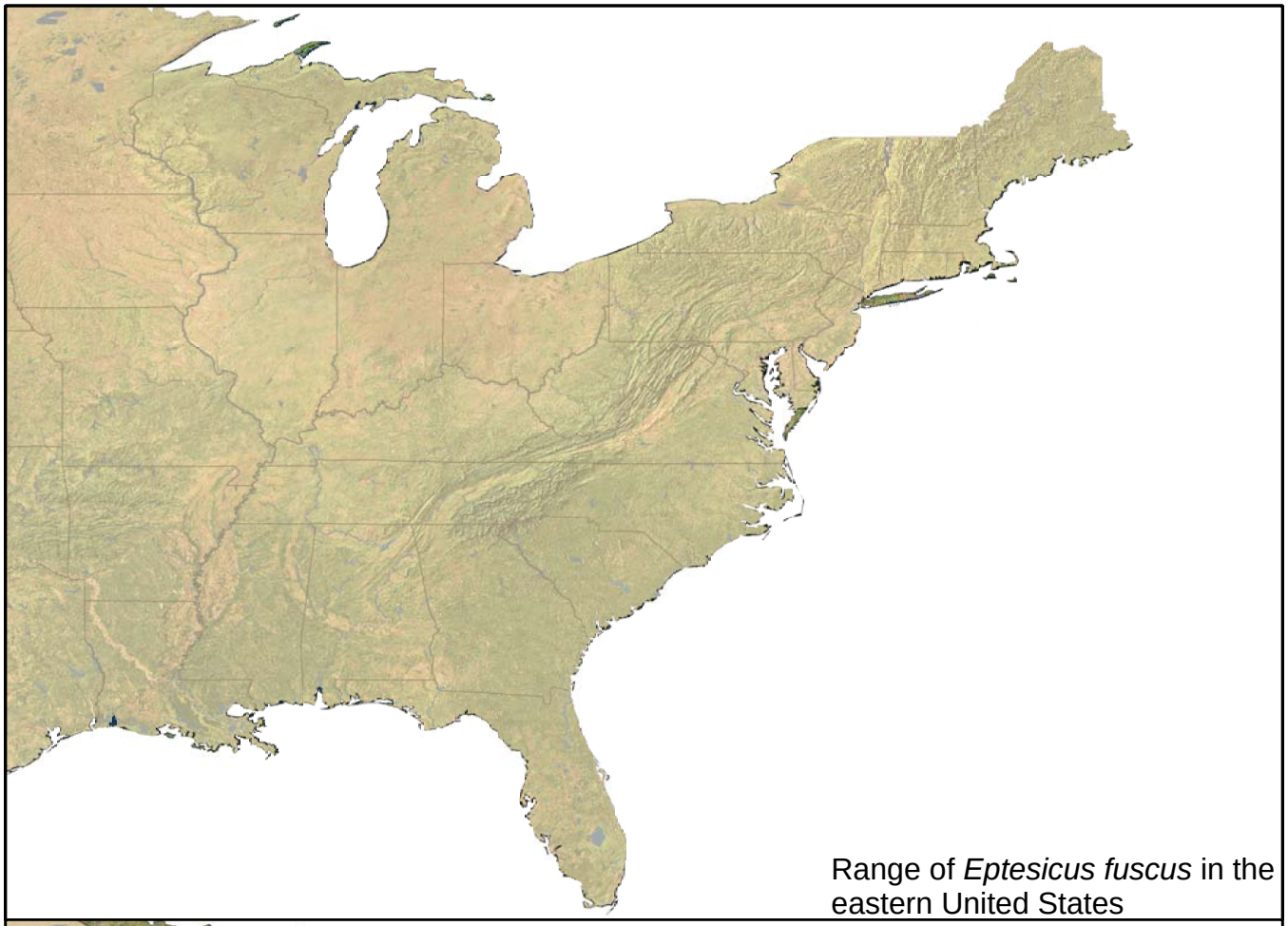


Range of *Lasiurus cinereus* in the eastern United States

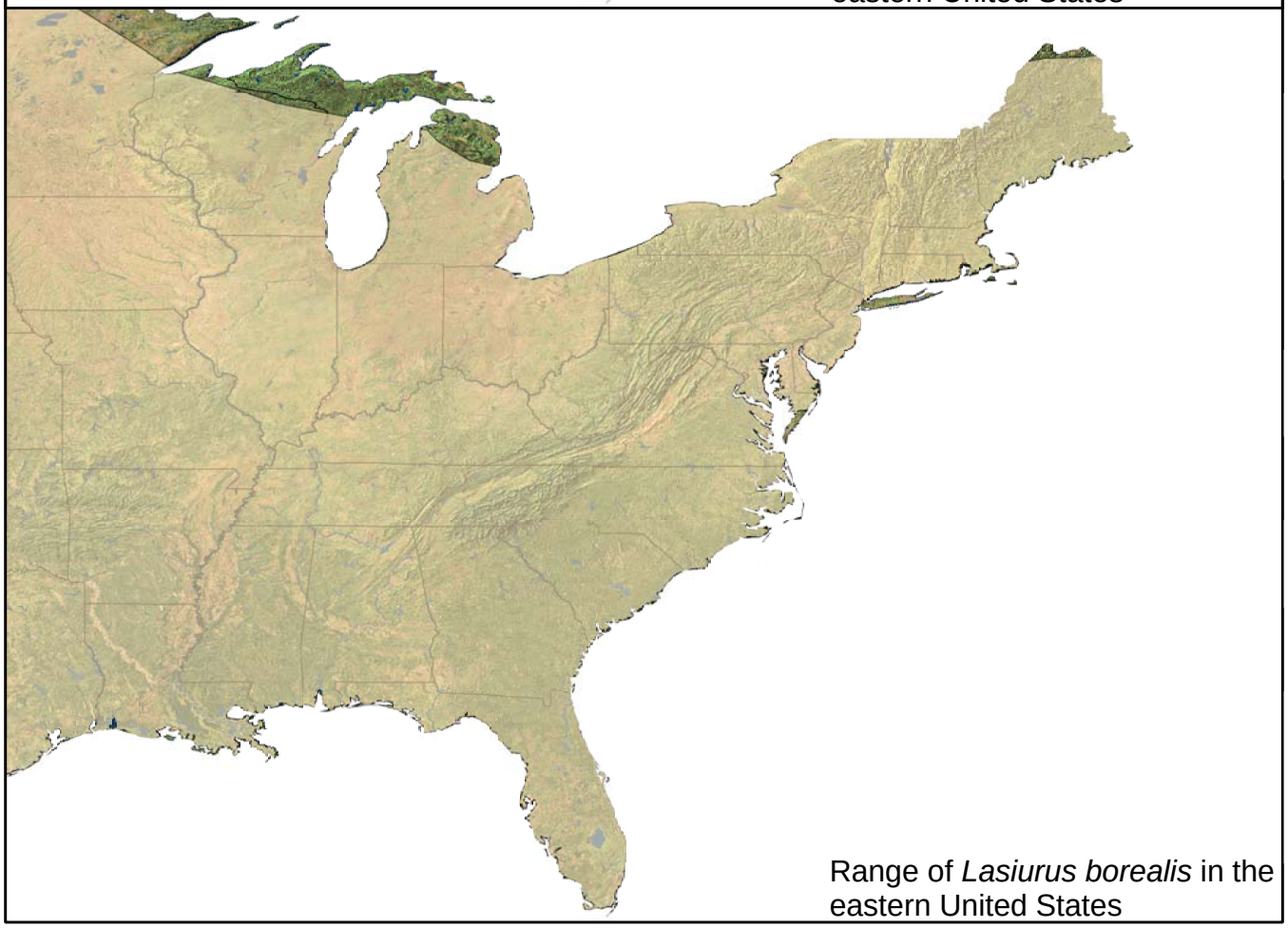


Range of *Lasionycteris noctivagans* in the eastern United States

Bat Range data obtained from - http://www.natureserve.org/getData/mammalMaps.jsp (06/21/2005)

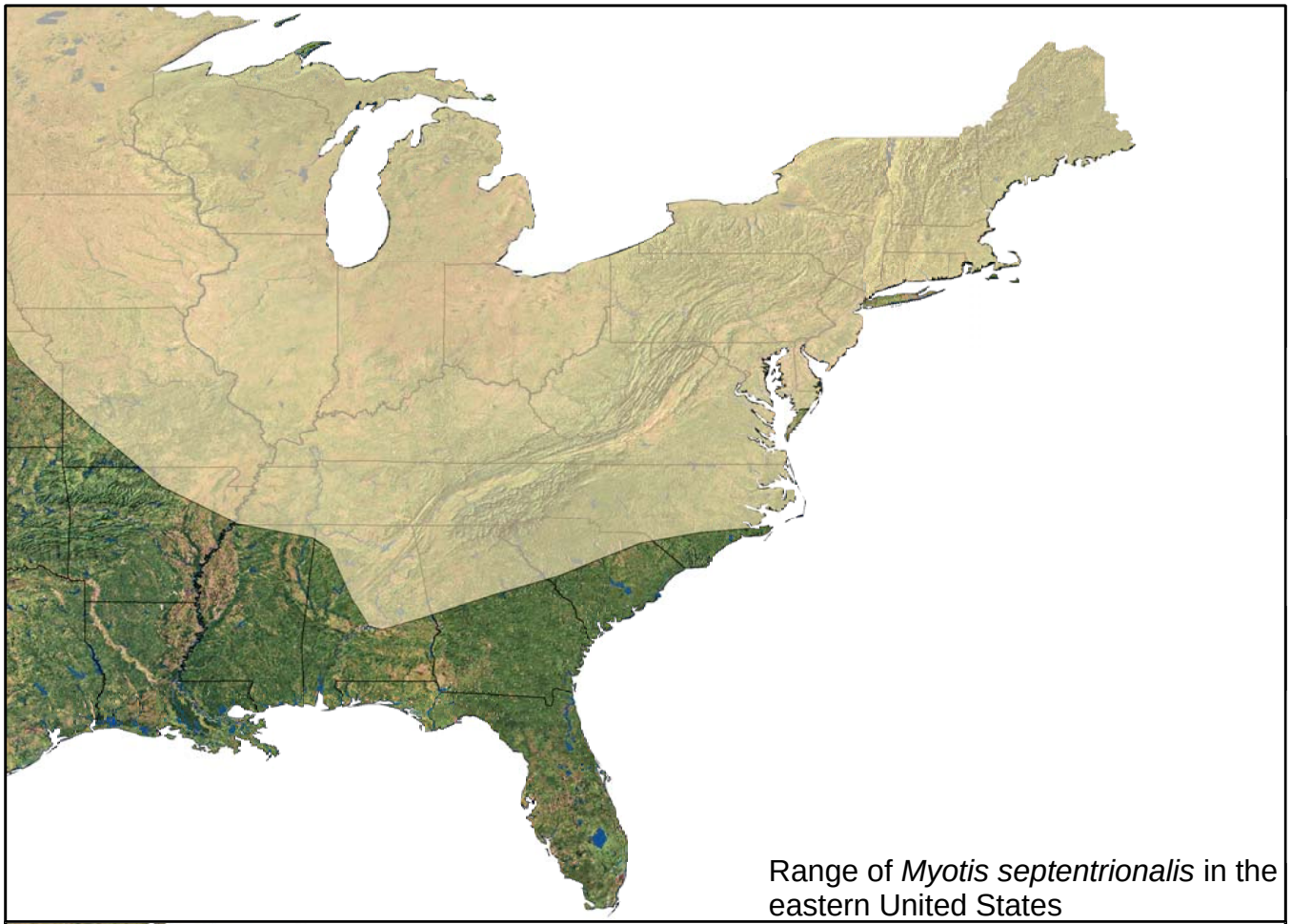


Range of *Eptesicus fuscus* in the eastern United States

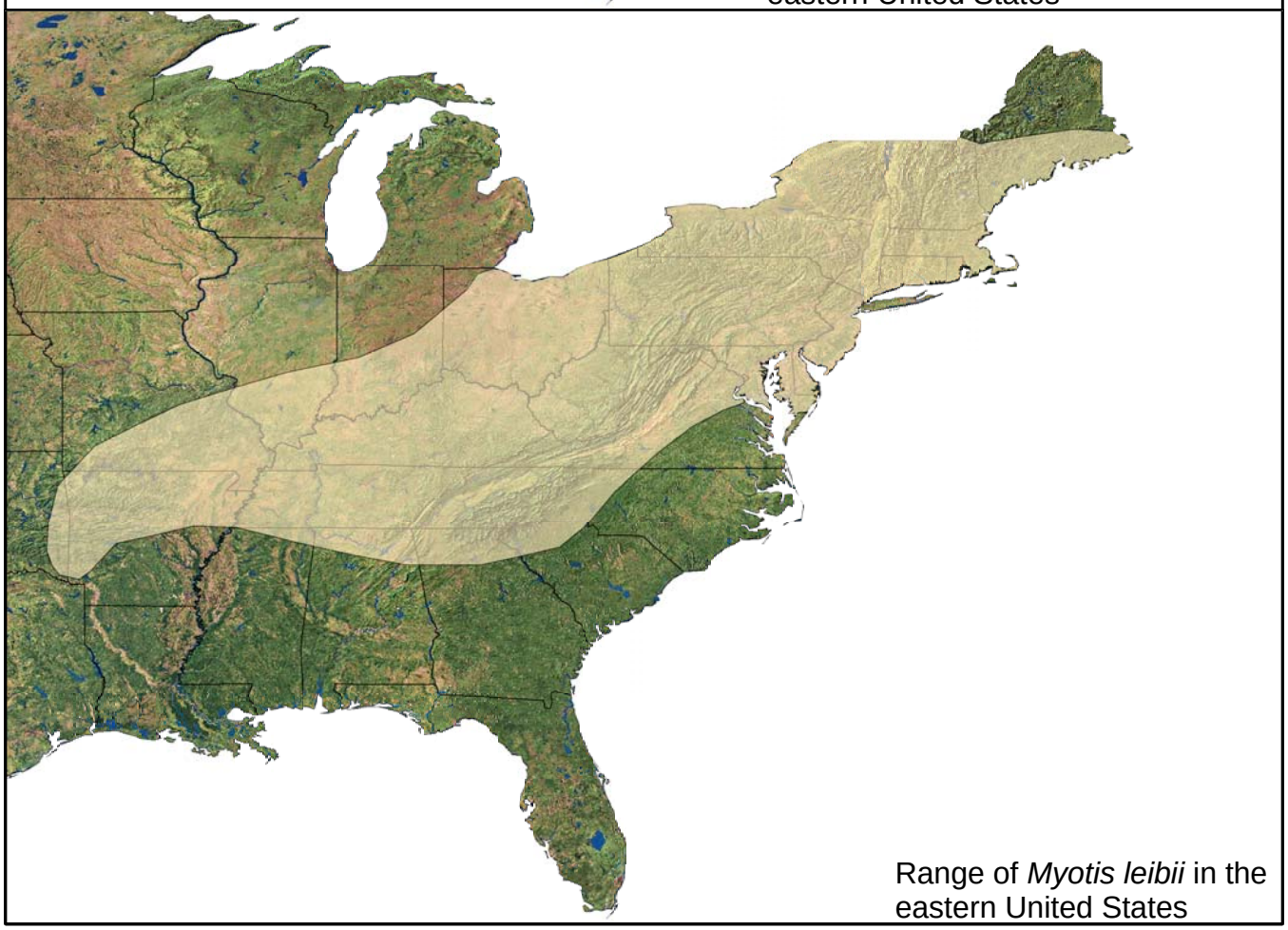


Range of *Lasiurus borealis* in the eastern United States

Bat Range data obtained from - http://www.natureserve.org/getData/mammalMaps.jsp (06/21/2005)



Range of *Myotis septentrionalis* in the eastern United States



Range of *Myotis leibii* in the eastern United States

Bat Range data obtained from - http://www.natureserve.org/getData/mammalMaps.jsp (06/21/2005)