PRE-CONSTRUCTION BAT RISK ASSESSMENT

Greenskies Solar Array Project
New London County, Connecticut

Prepared for:

Greenskies Renewable Energy

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EXECUTIVE SUMMARY

The Greenskies Solar Array Project is a proposed 6.0 MW ground-mounted photovoltaic solar array covering approximately 50 acres of habitat on a deforested knoll (Pigeon Hill) near East Lyme, Connecticut. As part of the environmental assessment of this proposal, North East Ecological Services (‘NEES’) was contracted to conduct a risk assessment to determine the impact of the construction and operation of the solar array to bats that live or migrate through the project area. The assessment consisted of a 1) desktop risk analysis ("Phase I Risk Assessment") that summarizes the literature to determine the likelihood of direct or indirect effects to bats from the construction and operation of the project, 2) an on-site habitat assessment that looked for site characteristics and microhabitat features (such as roosting habitat, foraging habitat, and hibernacula) that may be predictive of bat usage patterns, and 3) informal consultation with appropriate state wildlife officials to determine the potential presence of protected species or hibernacula near the project site.

Consultation with Connecticut Department of Energy and Environmental Protection (‘CT DEEP’) suggests that there are no specific concerns about the impact of the Greenskies project on the local bat community, including the federally-endangered Indiana myotis (*Myotis sodalis*) which is not considered likely to occur in eastern Connecticut. An on-site habitat evaluation conducted by NEES in April 2013 documented the presence of both immature and mature forests (primarily deciduous with some conifers) within the project site. There was also evidence of both current and abandoned agricultural habitat throughout the project area and several buildings that could be used as maternity roost sites by commensal bat species. NEES was unable to document any exposed rock habitat that could be utilized by eastern small-footed myotis (*Myotis leibii*). The forested habitat was generally early- to mid-successional with relatively low snag density and therefore does not appear to be likely primary roosting habitat for forest-roosting bats. The presence of several large bodies of water and substantial tracts of mixed forest habitat in the vicinity of the project area suggests the proposed habitat alterations on the project site would not impair the ecological viability of the bats in the New London County area.

Based on the desktop analysis and on-site habitat assessment, NEES makes the following recommendations:

1) Deforestation activity on the project site should be limited to the winter months to minimize impact of project construction on bat roosting habitat
2) If deforestation activities need to occur outside of the winter months, acoustic monitoring should be conducted at these potential roost trees to confirm the absence of maternity colonies before the trees are removed.
3) Demolition activity of buildings on the project site should not be conducted until their status as maternity colonies has been established, or these activities should be limited to the winter months to minimize the potential for direct impact to roosting bats.
4) Construction activities near the man-made pond habitat are unlikely to impact bat foraging activity given the large volume of open water habitat within 3.0 km of the project site.
5) In the event that the Greenskies Solar Array project is approved and developed, a post-construction bat activity survey should be conducted to determine whether the solar array has any indirect impacts on bat activity at the project site.

INTRODUCTION

Greenskies Renewable Energy (‘Greenskies’) is proposing to develop a 6-megawatt ground-mounted photovoltaic solar array at a 50 acre parcel located between Walnut Hill and Grassy Hill Road (‘the project site’) in East Lyme, Connecticut. Greenskies contracted North East Ecological Services (‘NEES’) to conduct a desktop analysis and site survey for the purpose of estimating the potential impact of constructing and operating a solar array facility on bats at this location. To complete the desktop analysis, NEES reviewed existing information regarding bats in Connecticut, conducted a literature review for additional information, and relied on our extensive experience studying the impact of renewable energy projects on bats. The purpose of this study was to provide Greenskies with a document that identified ongoing conservation issues regarding bats in Connecticut and to identify potential risks to bats that would need to be addressed or mitigated during construction of the solar array facility.

The Resource Inventory and Impact Assessment (‘Impact Assessment’) conducted by Environmental Planning Services (EPS, 2012) suggested that eight of the nine species of bats found in the northeastern United States could be considered potential site inhabitants based on the presence of suitable habitat within the project site (Table 1). To our knowledge, none of these species were observed at the project site during the multiple site surveys conducted by EPS.

SITE DESCRIPTION

NEES relied on the Impact Assessment (EPS, 2012) to conduct the desktop analysis of the project site. Site-specific details were then verified by an on-site survey to document specific habitat features that may be relevant for bats. The Greenskies project site is located within the Eastern Uplands physiographic province underlain by rocks assigned to the Avalonian Terrane (Merguerian and Sanders, 2010). According to USGS topographic maps (UCONN MAGIC, 2013), the project site is located on a gently sloping knoll, with an elevation ranging from 200 ft (61.5m asl) at the Walnut Hill Road up to 320 ft (98.5m asl) at the highest point on Pigeon Hill. The area immediately surrounding the project area is primarily mixed woodland forest and agricultural habitat with substantial suburban development within a 2.0 km radius of the project site. The Impact Assessment revealed that the project area is primarily upland habitat containing hayfields, successional fields, and mixed hardwood and coniferous forest stands. The Impact Assessment further identified areas of forested landscape and wooded wetlands within the project site that could be used as roosting locations for summer resident bats.

Analysis of the project area using Google Earth ™ revealed four large bodies of surface water within 3.0 km of the project site (Davis Pond, Darrow Pond, Lake Konomoc, and Powers Lake) and one small pond (< 3.0 acres) within 1.0 km of the project site. In addition, the Impact Assessment identified multiple wetland areas within the project site, six vernal pools, one man-made pond, and at least one surface water feature (Cranberry Meadow Brook) that could be used as foraging or drinking sites by summer resident bats.

STATE AND FEDERAL AGENCY CONSULTATION

Consultation with Connecticut Department of Energy and Environmental Protection ('CT DEEP') revealed relatively little information was available concerning the presence of protected species within the vicinity of the project site (Kate Moran*,* CT DEEP *pers. comm*.). The lack of federally-endangered species in the vicinity of the project area precluded any federal nexus that would require involvement with the regional office of the U.S. Fish and Wildlife Service.

ON-SITE HABITAT SURVEY

NEES conducted an on-site habitat survey on 27 April, 2013. I approached the project site from the southern corner of the project area and walked from an access road connected to Walnut Hill Road. The wooded trail went east and then due north along the project boundary. There were several abandoned buildings and sheds in this area but none of them showed any external sign of bat usage or activity. The habitat in this section of the project area was primarily mixed deciduous forest with several small old field clearings that were in the early stages of succession. I continued north to the top of Pigeon Hill where the forested habitat transitioned to open field habitat along a stone wall border. I turned west back down the hill towards Walnut Hill Road, travelling through forested habitat (primarily oaks and beech) and several housing lots before reaching a small clearing with an evergreen border. I returned to the top of Pigeon Hill and travelled north along the property line until I reached an abandoned barn. An exterior survey of the barn revealed no evidence of house-roosting bat activity. From the barn location, I walked back down Pigeon Hill towards Walnut Hill Road to an area of forested wetlands identified by the EPS Impact Assessment. At this location, there were several large (> 36 dbh) oak trees with broken limbs and crevices that could be used by roosting bats.

I walked east back up to the peak of Pigeon Hill and followed the stone wall lining the northeastern border of the project area. The entire length of the stone wall had a wind break of deciduous trees. I continued east down off of the peak of Pigeon Hill towards the artificial pond and vernal pool habitat identified by EPS in their site survey. East of this area, the habitat was primarily successional forest habitat with dense undergrowth, although there were several emergent trees of large size that could be used as potential roost trees. I continued south through this mixed habitat and the red cedar stand identified in the Impact Assessment until reaching the southeast corner of the project area. The habitat is this area, particularly southeast of the project area, had less undergrowth and more maintained trails, that had ample evidence of wildlife usage. I continued southwest up Pigeon Hill through successional forest habitat dominated by white oak. There were few trails or openings in this area that could be used by commuting bats in this section of the project area.

Overall, there were several areas that contained large diameter trees that could be used as maternity roosts by summer resident bats. The large oak trees in the northwestern section of the project area had the best overall features but were located on the bottomland habitat on the west side of Pigeon Hill. Therefore it is unlikely that they received adequate insolation to be used as maternity roosts. There were several large emergent trees in the overgrown field habitat in the eastern section of the project area that receive adequate insolation to be used as maternity roosts (see Appendix Two, Greenskies 08). The field habitat along the top of Pigeon Hill also had a few larger diameter trees that were dispersed across the landscape that could be used as maternity roosts. There was no evidence (urine staining, guano accumulation) that any of the human structures on the project area (one barn, one abandoned house, and multiple sheds) were being used by bats.

The walking survey revealed no evidence for exposed rock, talus habitat, or rock outcrops that would be required to provide roosting habitat for the eastern small-footed myotis. The project site did have numerous trails, roads, and field edge habitat that could be used by commuting bats maneuvering across the landscape. Similarly, it is likely that summer resident bats would use the man-made pond on the project site to drink water. However, a driving survey of the surrounding habitat suggests that none of these habitats are unique or limited in the areas adjacent to the project area.

THE BATS IN CONNECTICUT

There are nine species of bats whose distributional range reaches within the state of Connecticut (Table 1). All the bats found in Connecticut are insectivorous, but vary in the types of insects eaten, the methods employed to capture insects, and the habitats they utilize. All bats in the eastern United States navigate using a combination of vision and acoustic orientation ('echolocation'), and many of these 'acoustic signatures' can be used to identify species in the field. One species (the Indiana myotis, *Myotis sodalis*) is federally-endangered. Three species of migratory tree bats (eastern red bat, hoary bat, and silver-haired bat) are state listed as *Species of Special Concern* in Connecticut. The bats found throughout the summer months in Connecticut follow two major winter phenologies; 'hibernating bats' move from their summer habitat to hibernate in geological formations throughout the winter and 'migratory bats' move to more southern latitudes and remain active throughout the winter months. All three migratory tree bats found in Connecticut are listed as Species of Special Concern because of our lack of knowledge about their basic biology and geographic distribution throughout the state.

Table 1. List of Potential Bat Species at the Project Site

Common Name	**Species Name**	**Conservation Status**
Little brown myotis	*Myotis lucifugus*	
Northern myotis	*Myotis septentrionalis*	
Indiana myotis	*Myotis sodalis*	***FE***
Eastern small-footed myotis	*Myotis leibii*	
Big brown bat	*Eptesicus fuscus*	
Eastern tri-colored bat	*Perimyotis subflavus*	
Eastern red bat	*Lasiurus borealis*	***SC***
Hoary bat	*Lasiurus cinereus*	***SC***
Silver-haired bat	*Lasionycteris noctivagans*	***SC***

FE = Federally Endangered Species List
SC= Species of Special Concern (CT DEEP, 2012)

The Indiana Myotis, *Myotis sodalis*

The U.S. Fish & Wildlife Service listed the Indiana myotis as federally-endangered in 1967 because of dramatic population declines and destruction of key maternity roosts and hibernacula (Trombulak et al., 2001; Clawson, 2002). Despite almost forty years of protection, Indiana myotis populations continue to decline in their core range, although the cause of the decline is unknown (Clawson, 2002). In their core range, the distribution pattern of Indiana myotis is associated with cavernous limestone areas (Thomson, 1982: Kurta et al., 1993), with most of the known population existing in one of nine Priority I hibernacula in Indiana, Kentucky, and Missouri (Menzel et al., 2001). In the last eight years, an emergent fungal disease called White-Nose Syndrome ('WNS') has caused a massive regional decline in this species, but current estimates suggest the overall population has not declined significantly due to increases in other parts of the range (Thogmartin et al., 2012). However, as WNS continues to spread into the core of their range, it is likely that the increases we have seen in this species over the last thirty years will be negated in less than five years. The Indiana myotis was considered extirpated from the state of Connecticut since the 1950s but a winter survey in 1997 documented one Indiana myotis hibernating in Connecticut and radiotelemetry projects from eastern New York suggested that some Indiana myotis were spending part of the summer in the state (Krukar, 2008). Given that the source hibernacula for these bats have been decimated by WNS, it is unlikely that Indiana myotis continue to exist within the state of Connecticut.

During the reproductive season, Indiana myotis have a life history similar to other *Myotis* bats. Upon emergence from their hibernacula in the spring, Indiana myotis migrate to their summer range. Indiana myotis are known to migrate up to 532 km to reach their summer territory (Kurta & Rice, 2002). However, most populations of Indiana myotis appear to migrate much shorter distances (Griffin, 1970; Hicks, 2003). This appears to be particularly true for males, which often live near the hibernacula all summer (Fenton & Downes, 1981; Hicks, 2003). Upon reaching their summer range, adult females form reproductive colonies to raise their young. These 'maternity' colonies remain relatively intact from June through August and are generally located under exfoliating bark or in tree cavities (Kurta & Rice, 2002). Although Indiana myotis are known to use man-made structures (Butchkowski & Hassinger, 2002), including bathouses (Carter et al., 2001; 2002), most maternity colonies are formed in tree roosts. Roost trees are generally located in riparian, floodplain and bottomland forest habitat. Indiana myotis roosts appear to have key characteristics that are generally independent of the tree species (Scherer, 1999). Specifically, roost trees are large (greater than 36 cm dbh), tall, near water, and in direct sunlight most of the day (Kurta et al., 1993: Menzel et al., 2001: Kurta & Rice, 2002). Within these roosts, each female within the colony (5 – 45 females) raises a single pup that is born by the end of June and reaches adult size by the end of August. During the summer months, females use multiple roosts and appear to switch between them on a regular basis (Hicks, 2003). During the summer months, adult males are believed to live alone or in small groups under exfoliating bark (Ford et al., 2002). Foraging by the Indiana myotis is generally concentrated in riparian habitat. Although Indiana myotis were historically considered to forage primarily over water (USFWS, 1999), there is a considerable amount of research that suggests they are more diverse in habitat selection (Kurta et al., 1993: Menzel et al., 2001: Carroll et al., 2002).

The Little Brown Myotis, *Myotis lucifugus*

The little brown myotis occurs throughout most of North America (Fenton and Barclay, 1980), and has historically been one of the most common species encountered throughout its range. In late spring and early summer, females form maternity roosts which are commonly located in human structures (e.g. barns, attics, bat houses). These 'commensal' colonies can be small (under 100 individuals), but also may reach sizes of several thousand bats, with the largest known colonies in the eastern United States (Butchkoski & Hassinger, 2002). Where commenal roosts are not available, little brown myotis are known to use tree hollows for maternity colonies (Barclay & Cash, 1985). Little brown myotis are found in a wide variety of habitats, but are most commonly captured along streams, lakes, and ponds (Fenton & Bell, 1979), and will even use woodland vernal pools (Francl, 2005). Although little brown myotis are captured over streams and rivers, they are generally found foraging in pools rather than in riffles where the noise of the water interferes with their echolocation (von Frenckell & Barclay, 1987; Mackey & Barclay, 1989). Given the flexibility of little brown myotis in their prey selection, they have a relatively small foraging home range (30 ha: Henry et al., 2002) and seldom travel far from their roosts to foraging areas (Henry et al., 2002).

Little brown myotis migrate seasonally from their summer home range to their hibernacula, spending the fall season in transitional roosts (Fenton & Thomas, 1985). Data from banded bats suggest that these migratory events are more related to geology than latitude; little brown myotis travel to available caves and abandoned mines. The distance that little brown myotis will migrate is highly variable, but can reach up to 455 km (Humphrey, 1971). Prior to the outbreak of White-Nose Syndrome, it is likely that little brown myotis were the most abundant bat species in the state of Connecticut. Given the level of mortality seen in this species, Frick et al. (2010) anticipates that the little brown myotis, the most abundant bat species in the eastern United States, will be regionally extinct by 2020. The failure to capture any little brown myotis during the CT DEEP summer surveys in 2007 (Krukar, 2008) suggests that the impact of WNS was already being felt in the state at that time.

The Eastern Small-footed myotis, *Myotis leibii*

The eastern small-footed myotis has an extensive distribution (from Ontario to New England, southward to Georgia and Westward to Oklahoma), although it is not considered common anywhere within its range. Taxonomic confusion has most likely played a significant role in the lack of federal protection afforded to this species, considering the eastern small-footed myotis is one of the rarest bats in North America (Griffin, 1940) and 'without doubt the least known of all northeastern bat species' (Thomas, 1993). Although small-footed myotis are not federally protected, they do have special status in many of the New England states. They do not have any conservation status in the state of Connecticut.

Because of the sparse distribution, the eastern small-footed myotis has proven difficult to research in significant numbers, and therefore most of our knowledge of this species comes from individual captures and hibernaculum counts. These data suggest that reproductive groups (females and their offspring) tend to use rocky hillsides as maternity roosts during the summer months (Fenton et al., 1980). Although this is typical habitat in mountainous regions, they appear to be more versatile throughout their range, using rock slabs, hollow trees, exfoliating bark, abandoned tunnels, and even human structures (Thomas, 1993; Best, 1997). Summer populations of small-footed myotis appear to be patchy throughout their range, and activity is often concentrated around hibernacula (Thomas, 1993). Summer records of reproductive small-footed myotis are quite rare, and recent capture data (post-1980) are generally limited to small numbers of individuals (LaGory & Reynolds, 2002; Gannon and Sherwin, 2001; Jaycox, 2003; Hicks, 2003). There are no summer or winter records of eastern small-footed myotis from Connecticut and recent surveys in the state found no evidence for eastern small-footed myotis (Krukar, 2008).

Northern myotis, *Myotis septentrionalis*

The northern myotis ranges throughout the eastern United States and much of the lower Canadian provinces (Caceres & Barclay, 2000). During summer, female northern myotis form small maternity colonies (usually less than 30 bats) within tree hollows, crevices, or under exfoliating bark (Foster and Kurta, 1999; Menzel et al., 2002; Owen et al., 2003). Unlike Indiana myotis, northern myotis typically use living trees as roosts (Foster & Kurta, 1999). Tree species used as roosts are highly variable but are predominantly deciduous. Like most tree-roosting bats, the roost trees of northern myotis are taller and wider than randomly selected trees (Owen et al., 2002; Ford et al., 2006; Perry & Thill, 2007). Owen et al. (2003) found that the majority of roost trees used by northern myotis were located in intact forests (70-90 year old forests with no timber harvest activity within 10-15 years), often close to open water (Larson et al., 2003). Less is known about the summer ecology of male northern myotis, although they are known to use tree roosts (more likely under exfoliating bark than in cavities: Perry & Thill, 2007), bat houses (Whitaker et al., 2006) and caves (Whitaker & Rissler, 1992) during the summer period. Northern myotis show a strong preference for foraging in and near forested habitats (Ford et al., 2005). They are common captured in managed forests along the edges (Hogberg et al., 2002), but are also found foraging over ponds and streams (Caceres & Barclay, 2000). Research on the foraging habits of northern myotis also revealed the use of forested hillsides and ridgetops (Caire et al., 1979; Owen et al., 2003).

During the fall, northern myotis migrate to available hibernacula and undergo swarming behavior similar to the little brown myotis (Whitaker & Rissler, 1992). Winter surveys typically under-represent northern myotis, so it is unclear how many individuals hibernate in proximity to the project site. However, northern myotis were historically one of the most commonly captured species during summer population surveys in the region (Hobson, 1993; Caviness & James, 2001; Stihler, 2003; Agosta et al., 2005; Reynolds, 2008). Although Northern myotis populations have been decimated by WNS throughout the northeast, they were one of four species of bats captured during the 2007 summer surveys conducted by the CT DEEP (Kurkar, 2008).

Eastern tricolored bat, *Perimyotis subflavus*

The eastern tricolored bat , until recently known as the eastern pipistrelle (Hoofer et al., 2006) occurs throughout much of the eastern United States, north to southeastern Canada, and south through Honduras (Fujita & Kunz, 1984). During summer months female tricolored bats typically form small maternity colonies (under 10 individuals) in trees, usually using both dead leaf clusters and live foliage (Veilleux et al., 2003). Tricolored bats have also been documented forming larger (approximately 15 individuals) maternity colonies in buildings (Whitaker, 1998). In terms of roost tree preference, tricolored bats prefer deciduous tree species , generally roosting in trees that are taller and wider than the surrounding trees (Perry & Thill, 2007). Radiotracking of individuals suggests that tricolored bats prefer roost trees in both upland forests and riparian woodlands (Veilleux et al., 2003). Tri-colored bats primarily forage in low elevation riparian habitat, although they can be found in pine stands and upland hardwoods (Carter et al., 1999; Ford et al., 2005). Eastern tricolored bats appear to remain relatively close to roost sites while foraging and have relatively small home ranges compared to other species found throughout the region.

During the winter, tri-colored bats hibernate in caves and mines but typically do not form large hibernating congregations like other hibernating species (Fujita & Kunz, 1984). Little is known of the migration behavior of tri-colored bats. Some researchers believe that individuals travel short distances from summering areas to local hibernacula (Unger & Kurta, 1998).

Big brown bat, *Eptesicus fuscus*

The big brown bat occurs throughout most of North America where suitable roosting habitat exists (Kurta & Baker, 1990). During summer, populations of big brown bats in eastern North America typically roost within human related structures (attics, barns, bat houses, bridges: Whitaker & Gummer, 1992; Feldhamer et al., 2003; Whitaker et al., 2006) and form maternity roosts that range in size from several dozen up to 600 bats (Whitaker & Hamilton, 1998). Most maternity colonies are located near water (Mills et al., 1975). Males are mainly solitary during this period, and may roost in the same building as the maternity colony, but not within the colony itself (Whitaker & Hamilton, 1998).

Big brown bats are classified as true habitat generalists, utilizing almost every available habitat within its range (Furlonger et al., 1987; Agosta, 2002). Summer research shows that big brown bats are commonly captured over water (Francl, 2008), along woodland edges, within woodlands, and are frequently the dominant species in rural and urban areas (Kurta & Baker, 1990; Everette et al., 2001; Duchamp et al., 2004; Gehrt & Chelsvig, 2004). Big brown bats are found in both riparian and upland habitats, but were more common at lower elevations (Ford et al., 2005). Big brown bats have extremely small home range sizes compared to other bat species (often as small as 2.5 ha: Duchamp et al, 2004) and generally do not forage more than 1 to 2 km away from their roost(Kurta & Baker, 1990).

During winter, big brown bats hibernate in cave and mines, as well as in buildings (Whitaker & Gummer, 1992; Whitaker & Gummer, 2000; McAlpine et al., 2002). Big brown bats appear to be relatively active during the winter months (Dunbar et al., 2007), but virtually nothing is known about seasonal migration in big brown bats. It is generally assumed that big brown bats do not travel far between summer foraging areas and their hibernacula. However, there is some evidence for big brown bats migrating substantial distances. Like the other common bats, the distribution of big brown bats in Connecticut has not been thoroughly explored, but given their ability to thrive in suburban habitats and the fact that they are much less impacted by White-Nose syndrome than any other hibernating bat species, they are likely to be the most common bat found throughout the state. Big brown bats were one of four species of bats captured during the 2007 summer surveys conducted by the CT DEEP (Kurkar, 2008) and a survey of known maternity colonies throughout the state in 2010 confirmed that the majority of summer resident bats were big brown bats (CT DDEEP, 2011).

Eastern red bat, *Lasiurus borealis*

Eastern red bats are one of the best known migratory tree bats and are a common resident of much of the United States, Central and South America (Shump & Shump, 1982b). In the spring, they migrate into the northern region of their distribution, with some of the oldest records involve red bats migrating off the Atlantic Coast (Miller, 1897; Carter, 1950; Mackiewicz & Backus, 1956; Peterson, 1970). Red bats are known to migrate in the fall along the eastern coast (Miller, 1897) with historic records documenting 'waves of migrant' red bats passing through a region (Constantine, 1966). Although red bats are primarily migratory, there are both fall and winter records of red bats using a variety of short-term roosts, including woodpecker holes (Fassler, 1975) and leaf litter (Saugey et al., 1998; Boyles et al., 2003; Mormann & Robbins, 2007).

During summer months, adult red bats roost alone in the foliage of trees (Shump & Shump, 1982b; Whitaker & Hamilton, 1998). Research on the roost tree preferences of red bats suggest that tree selection is highly variable, although they are almost exclusively deciduous species found within mature forest stands (Ford et al., 2006; Perry et al., 2007; Perry et al., 2008). The research is also consistent in the fact that roost trees are typically taller, larger, and have a higher crown base than random trees (Menzel et al., 2000; Perry et al., 2007). In terms of overall habitat preference, both Menzel et al. (1998) and Hutchinson and Lacki (2000) found that the majority of roost trees used by eastern red bats were located in hardwood forests and in upland areas. In contrast, Medlin and Risch (2008) and Hendricks et al. (2006) found red bats to prefer riparian and bottomland forest habitat. Clearly, red bats are flexible in their roosting habitat requirements and can be considered habitat generalists (Ford et al., 2005; Elmore et al., 2005). Roost trees are typically located in relatively close to permanent water sources (Hutchinson & Lacki, 2000) and red bats prefer forest stands with high canopy density and relatively little slope (Yates & Muzika, 2006).

Research conducted throughout the northeast suggest that red bats are an abundant summer resident species, although recent data from multiple sites suggest that the eastern red bat population has declined substantially since the late 1970's; at some locations by as much as 41% (Winhold et al., 2008). A summer habitat survey conducted by the CT DEEP in 2007 documented red bats at multiple sites (Krukar, 2008), suggesting that this species is one of the more common bats species in the state.

The Hoary Bat, *Lasiurus cinereus*

The hoary bat occurs throughout much of North and South America (Cryan, 2003) although there are very few data that describe seasonal movement of this species. In general, hoary bats appear to migrate throughout their range, wintering in southern latitudes and migrating north each spring to spend the summer months at more northern latitudes. Hoary bats have been documented migrating throughout their range, but little is known about the pattern of these migratory events. Most of the data on the migration of hoary bats comes from bats that collided with structures during the migratory season (Saunders, 1930; Zinn & Baker, 1979) or historic observations of individuals migrating along the Atlantic coast (Miller, 1897). Reynolds (2006) documented a period of high hoary bat activity in the late spring at a wind development site in New York, suggesting a large migratory group of hoary bats was moving across the landscape just prior to dawn. A similar study conducted in Nevada showed that all the hoary bat activity at the Mohave Desert site was concentrated in a very narrow time period, indicative of concentrated migratory movements across the study area (Williams et al., 2006). Overall, it appears hoary bats migrate in groups (Provost & Kirkpatrick, 1952), often in episodic waves across the landscape; in some cases, these movements coincide with migratory birds (Findley & Jones, 1964). Although hoary bats do not generally hibernate, they are known to be capable of prolonged torpor during harsh weather conditions (Genoud, 1993; Cryan & Wolf, 2003; Willig et al., 2006).

Large-scale population surveys suggests that hoary bats are found in a variety of habitats, but they appear to be more commonly found foraging in riparian habitats than upland forests (Hart et al., 1993; Heady & Frick, 1999; Menzel et al., 2005; Ford et al., 2005). Hoary bats are solitary roosting bats with the exception that reproductive females roost with their young (Shump and Shump 1982a). Hoary bats are tree-roosting bats that suspend from foliage in the upper canopy of both deciduous and coniferous trees (Perry & Thill, 2007; Veilleux et al., 2009) but are associated with coniferous forests at higher frequency than other tree-roosting bats (McClure, 1942; Perkins & Cross, 1988). Hoary bats are known to roost in a wide variety of coniferous trees, as well as some deciduous species. Roost trees are typically taller and wider than random trees used for comparison (Perry & Thill, 2007; Miller & Miles, 2008). The foraging habitat of hoary bats is quite diverse; Hart et al. (1993) found hoary bats utilizing forested and aquatic habitats in greater proportions than non-forested and non-aquatic habitats. Veilleux et al. (2009) found hoary bats concentrating their activity in forested habitats (nearly 70%), with less foraging occurring in open fields (17%) or wetlands (15%). Hoary bats are relatively large-winged, open-air foragers that are active at a higher altitude than most other bats found in the eastern United States (Zinn & Baker, 1979; Menzel et al., 2005); they can often be captured foraging and commuting above the canopy (Fenton et al., 1980).

The Silver-Haired Bat, *Lasionycteris noctivagans*

The silver-haired bat occurs throughout much of the majority of southern Canada and the United States (Kunz, 1982), with females migrating to northern latitudes during spring to give birth, while males appear to remain closer to their winter range (Cryan, 2003). Silver-haired bats have historically been seen migrating in groups along the Atlantic Coast (Miller, 1897; Mackiewicz & Backus, 1956) Post-construction mortality surveys at wind development sites suggest that silver-haired bat migratory activity was later than migratory activity of hoary bats and red bats, with most of the silver-haired bat mortality occurring outside the period of peak bat mortality (Fiedler et al., 2007). Although this species does not hibernate to the extent of the cave bats, they have been captured foraging during the winter (Dunbar et al., 2007), they have been tracked to winter roosts in caves (Beer, 1956; Martin & Hawks, 1972; Izor, 1979), houses (Gosling, 1977; Clark, 1993; Sherwood & Kurta, 1999) rock crevices and under exposed roots (Perry et al., 2010), and under leaf litter (Menzel et al., 2000).

The silver-haired bat is a tree-roosting species and during summer months roosts in tree hollows and under exfoliating bark (e.g. Vonhof, 1996; Betts, 1998; Crampton & Barclay, 1998). In terms of landscape level choice, Betts (1998) found silver-haired bats generally roost in mature coniferous forest habitat (Perkins & Cross, 1988; Jung et al., 1999). Arnett (2007) found that silver-haired roosting habitat was highly associated with high snag density and low elevation. Campbell et al. (1996) found roost sites concentrated near riparian areas, particularly on moderately-sloped habitat. Like most tree-roosting bat species, the silver-haired bat roosts are diverse in species, but roost trees are typically taller and wider than random trees used for comparison (Campbell et al., 1996; Vonhof, 1996; Betts, 1998). Barclay (1985) found that the silver-haired bat used similar foraging habitat as hoary bats, with the highest level of activity found in forested habitat, particularly when in proximity to ponds or streams (Schmidly, 2004). Similarly, Duff and Morrell (2007) found low elevation habitat and long riparian flyways to be strong predictors of silver-hair bat activity.

MORTALITY FACTORS RELEVANT TO BAT POPULATIONS

Wildlife from a variety of taxa are being negatively impacted by human development, exotic disease, and climate change at an ever-increasing rate. This may be particularly true for North American bats that are experiencing heavy levels of mortality from two novel sources; wind turbines and White-Nose Syndrome. Although the impact of wind mortality and WNS are generally occurring in different bat species (primarily migratory tree bats for wind development and hibernating bats for WNS), lack of a baseline population in almost all of our bat species generates a large amount of uncertainty as to the population-level impact of these events.

Wind energy has a large impact on migrating bat activity. Project assessments conducted throughout the United States and Canada show that wind turbines can have mortality rates ranging from 0.0 – 63.9 bats per turbine per year (Fiedler et al., 2007). A survey of multiple wind development sites across North America (Erickson et al., 2002; Johnson, 2005) reveal that most of this mortality (approximately 85%) occurs in the three species of migratory tree bats found in Connecticut (eastern red bat, hoary bat, and silver-haired bat). It is currently unclear why these three species of bats are killed at such high rates, although recent studies have suggested that there are operational measures (blade feathering and increased cut-in speeds) that can substantially reduce these mortality events.

White-Nose Syndrome ('WNS') is a cutaneous fungal disease caused by *Geomyces destructans*, a newly isolated psychrophilic fungus that was first identified from a hibernaculum in western New York in 2006 (Blehert et al., 2009). Within two years of this initial discovery, WNS had spread to all known hibernacula within 80 miles of the epicenter, and is currently documented from 25 states and four provinces in Canada (Butchkoski, 2013). *G. destructans* has since been isolated from several countries in Europe, although there does not appear to be any mortality associated with these infections (Puechmaille et al., 2010), suggesting Europe may be the original source of this invasive fungus. Bats infected with WNS have difficulty maintaining homeostasis during hibernation and generally die in early spring as a result of electrolyte imbalance, dehydration, and starvation (Cryan et al., 2010; Turner et al., 2011). WNS has been documented in almost all species of hibernating bats in the eastern United States (Locke, 2008; Reeder & Turner, 2008), and was first documented in bat hibernating in Connecticut in 2008 (Dickson, 2009). Recent hibernacula surveys in Connecticut have confirmed the devastating impact of this disease on the state's bat population (Kocer, 2009; CT DEEP, 2012). Currently, WNS is estimated to have killed over three million bats and generally results in population declines in excess of 90% for bats within the genus *Myotis*.

POTENTIAL IMPACTS OF PROJECT DEVELOPMENT FOR BATS

Development of the current project site could impact bats either directly (i.e. mortality) or indirectly (i.e. interference or nuisance effects), and therefore either kill individuals or impair their ability to forage, reproduce, or survive. The primary risk factors for direct impact are 1) mortality resulting from the construction or operation of the facility, 2) mortality resulting from traffic collisions caused by increased road surface and traffic volume, and 3) increased predation risk to bats caused by the introduction of novel predators to the landscape. The primary risk factors for indirect impacts are 4) loss of roosting and foraging habitat due to construction of the facility and 5) impaired movement across the landscape due to a 'barrier effect'.

It is unlikely that the operation of a solar array facility would present any direct impact to bats, as bats seldom collide with stationary objects (Young et al., 2003; Arcadis US, 2011) and such a facility would not have any of the risk factors (e.g. rotating turbine blades and barotrauma) that are known to cause mortality at wind energy facilities (Baerwald et al., 2008; Cryan & Barclay, 2009). Although there is increasing research on the impact of road collisions on bats (Kiefer et al., 1995; Bartonicka et al., 2008; Lesinski et al., 2011), it is also unlikely that the type of roads that would be constructed at the project site, and the traffic volume that they would create, would present any significant collision risk to bats as they commuted across the project site. Similarly, all the available data suggest that predation is not a significant source of mortality for bat populations in the northeast due to the fact that predators are opportunistic and have only a localized impact on bats. Therefore, the only reasonable risk of a direct impact on bats would be due to mortality that occurs during construction of the facility. Bats could be directly impacted by construction activities at the project site if their roosts (trees, caves, mines, or rock debris) are destroyed while they are roosting in them. For the proposed site, the only relevant roosting structures would be trees or man-made roosts (e.g. barns, sheds, or abandoned buildings) used by bats during the summer months. Direct impact to bats as a result of tree removal can be controlled by avoiding the removal of potential roost trees or by timing the removal of such trees to periods of time when the bats would not be occupying those roosts. Similarly, the removal or demolition of man-made structures at the project site should be avoided, or the timing of these activities should be limited to time periods when the bats would not be occupying those roosts. To minimize the impact of construction activities on bats at the project site, deforestation and destruction of commensal roosts should occur during the winter and early spring months.

For indirect effects, habitat alteration and fragmentation can lead to changes in the landscape that negatively impact the ability of bats to forage, commute, or roost at the project site (Grindal and Brigham, 1988). Habitat fragmentation is often associated with the energy development projects but these concerns may not be very applicable to the present proposal, as much of the project site has already been deforested and is currently dominated by open habitat (agriculture and early successional fields). Furthermore, roads and other linear elements that are often associated with development can actually improve the habitat quality for foraging and commuting bats (Walsh and Harris, 1996; Wolcott and Vulinec, 2012). Given the low density of potential roost trees on the project site and the large tracts of forested habitat surrounding the project site, it is unlikely that habitat modifications on the project site will present a significantly impact the roosting or commuting resources available to bats. Similarly, the fact that the proposed project will not impact any surface water bodies and minimally impact wetlands at the site should indicate that the project will not negatively impact the foraging resources available to bats.

It is possible that the presence of a large number of ground-mounted photovoltaic panels will represent a physical barrier to commuting bats across the project site. However, it seems likely that most of these bats would simply fly above the panels much as they fly above the canopy of a densely-forested habitat. If bats did avoid the project site because of these panels, there is no evidence that suggests that there are any resources on the project site that are not readily available in the surrounding area.

LITERATURE CITED

Agosta, S.J. 2002. Habitat use, diet and roost selection by the big brown bat (*Eptesicus fuscus*) in North America: a case for conserving an abundant species. Mammal Review, 32:179-198.

Arcadis U.S., Inc. 2011. Year one post-construction avian and bat mortality study, Elkhorn Ridge Wind, LLC. Report submitted to Edison Mission Energy, January 2011.

Arnett, E.B., 2007. Presence, relative abundance, and resource selection of bats in managed forest landscapes in western Oregon. Ph.D. Dissertation Oregon State University; Corvallis, OR.

Baerwald, E., G. D'Amours, B.J. Klug, and R.M.R. Barclay, 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. Current Biology, 18: R695-R696.

Barclay, R.M.R. and K. Cash. 1985. A non-commensal maternity roost of the little brown bat (*Myotis lucifugus*). Journal of Mammalogy, 66: 782-783.

Bartonicka, T., J. Gaisler, and Z. Rehak, 2008. Vliv silničniho provozu na netopýry a návrh ochrany (Road traffic effects on bats and conservation proposals). Ziva, 4: 181-183.

Beer, J.R., 1956. A record of a silver-haired bat in a cave. Journal of Mammalogy, 37:282.

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

Betts, B.J. 1998. Roosts used by maternity colonies of silver-haired bats in northeastern Oregon. Journal of Mammalogy, 79: 643-650.

Blehert, D.S., A.C. Hicks, M. Behr, C. U. Meteyer, B.M. Berlowski-Zier, E.L. Buckles, J.T.H. Coleman, S.R. Darling, A. Gargas, R. Niver, J.C. Okoniewski, R.J. Rudd, and W.B. Stone. 2009. Bat White-Nose Syndrome: an emerging fungal pathogen? Science 323: 227-228

Boyles, J. G., J. C. Timpone, and L. W. Robbins. 2003. Late-winter observations of red bats, *Lasiurus borealis*, and evening bats, *Nycticeius humeralis*, in Missouri. Bat Research News 44:59-61.

Butchkoski, C. & J.D. Hassinger, 2002. Ecology of a maternity colony roosting in a building Pp. 130-142 *In*: A. Kurta and J. Kennedy (eds.) The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International: Austin, Texas, USA.

Butchkoski, C. 2013. White Nose Syndrome (WNS) Occurrence by County/District. Map released 26 April, 2013, Pennsylvania Game Commission.

Caceres, M.C. and R.M.R. Barclay. 2000. *Myotis septentrionalis*. Mammalian Species, 634: 1-4.

Caire, W., R.K. Laval, M. Laval, and R.L. Clawson, 1979. Notes on the ecology of *Myotis keenii* (Chiroptera: Vespertilionidae) in eastern Missouri. American Midland Naturalist, 102: 404-407.

Campbell, L.A., J.G. Hallett, and M.A. O'Connell. 1996. Conservation of bats in managed forests: Use of roosts by *Lasionycteris noctivagans*. Journal of Mammalogy, 77: 976-984.

Carroll, S.K., T.C. Carter, and G.A. Feldhamer, 2002. Placement of nets for bats: effects on perceived fauna. Southeastern Naturalist 1: 193-198.

Carter, T. D. 1950. On the migration of the red bat, *Lasiurus borealis borealis*. Journal of Mammalogy 31:349-350.

Carter, T.C., M.A. Menzel, B.R. Chapman, and K.V. Miller. 1999. Summer foraging and roosting behavior of an eastern pipistrelle, *Pipistrellus subflavus*. Bat Research News, 40: 5-6.

Carter, T.C., G. Feldhamer, and J. Kath, 2001. Notes on summer roosting of Indiana bats. Bat Research News 42:197-198.

Carter, T., S.K. Carroll, J.E. Hofmann, J.E. Gardner, and G.A. Feldhamer. 2002. Landscape analysis of roosting habitat in Illinois Pp. 160-164 *In*: A. Kurta and J. Kennedy (eds.) The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International: Austin, Texas, USA.

Caviness, M.L. and D.A. James, 2001. Results of a bat survey in the Western Ozark National Forest. *Journal of the Arkansas Academy of Science*, 55: 168-171.

Clark, M. K. 1993. A communal winter roost of silver-haired bats, *Lasionycteris noctivagans* (Chiroptera ; Vesperitilionidae). Brimleyana: 137-139.

Clawson, R.L., 2002. Trends in population size and current status Pp. 2-8 *In*: A. Kurta and J. Kennedy (eds.) The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International: Austin, Texas.

Constantine, D. G. 1966. Ecological observations on lasiurine bats in Iowa. Journal of Mammalogy 47:34-41.

Crampton, L.H. and R.M.R. Barclay. 1998. Selection of roosting and foraging habitat by bats in different-aged aspen mixedwood stands. Conservation Biology, 12: 1347-1358.

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

Cryan, P. M. and B. O. Wolf. 2003. Sex differences in the thermoregulation and evaporative water loss of a heterothermic bat, *Lasiurus cinereus*, during its spring migration. Journal of Experimental Biology 206:3381-3390.

Cryan, P. and R.M.R. Barclay. 2009. Causes of bat fatalities at wind turbines: hypotheses and predictions. Journal of Mammalogy 90: 1330-1340.

Cryan, P., C. Meteyer, J.G. Boyles, and D. Blehert. 2010. Wing pathology of white-nose syndrome in bats suggests life-threatening disruption of physiology. BMC Biology, 8: 135.

CT DEEP [Connecticut Department of Energy and Environmental Protection], 2011. The race to save bats continues. Connecticut Wildlife, 31 (1): 11.

CT DEEP [Connecticut Department of Energy and Environmental Protection], 2012. A County Report of Connecticut's Endangered, Threatened and Special Concern Species for New London County, released November 30, 2012.

Dickson, J. 2009. Bad news for bat conservation. Connecticut Wildlife, 28 (3): 4.

Duchamp, J. D.W. Sparks, and J.O Whitaker. 2004. Foraging-habitat selection by bats at an urban-rural interface: comparison between a successful and a less successful species. Canadian Journal of Zoology, 82: 1157-1164.

Duff, A.A. and T.E. Morrell. 2007. Predictive occurrence models for bat species in California. Journal of Wildlife Management, 71: 693-700.

Dunbar, M., J.O. Whitaker, and L.W. Robbins. 2007. Winter feeding by bats in Missouri. Acta Chiropterologica, 9: 305-322.

Elmore, L.W., D.A. Miller, and F.J. Vilella. 2005. Foraging area size and habitat use by red bats (*Lasiurus borealis*) in an intensively managed pine landscape in Mississippi. American Midland Naturalist, 153:405-17.

EPS [Environmental Planning Services], 2012. Natural Resource Inventory and Impact Assessment, Solar Array Farm, Walnut Hill and Grassy Hill Road, East Lyme Connecticut. Report prepared for Greenskies Renewable Energy, Dec. 2012.

Erickson, W., G.D. Johnson, D. Young, M.D. Strickland, R. Good, M. Bourassa, K. Bay, and K. Sernka. 2002. Synthesis and comparison of baseline avian and bat use, raptor nesting and mortality information from proposed and existing wind development: Report for Bonneville Power Administration, Dec. 2002, 124 pp.

Everette, L., T.J. O'Shea, L. Ellison, L. Stone, and J.L. McCance. 2001. Bat use of a high-plains urban wildlife refuge. Wildlife Society Bulletin, 29: 967-973.

Fassler, D. J. 1975. Red bat hibernating in woodpecker hole. The American Midland Naturalist 93:254.

Feldhamer, G.A., T.C. Carter, A.T. Morzillo, and E.H. Nicholson. 2003. Use of bridges as day roosts by bats in Southern Illinois. Transactions of the Illinois State Academy of Science, 96: 107-112.

Fenton, M.B. and G.P. Bell. 1979. Echolocation and feeding behaviour in four species of *Myotis* (Chiroptera). Canadian Journal of Zoology, 57: 1271-1277.

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

Fenton, M.B., C.G. van Zyll de Jong, G.P. Bell, D.G. Campbell, and M. LaPlante. 1980. Distribution, parturition dates, and feeding of bats in South-Central British Columbia. Canadian Field Naturalist, 94: 416-420.

Fenton, M.B. and C.M. Downes. 1981. A study of summer populations of the endangered Indiana bat, *Myotis sodalis*, near Watertown, New York. NYDEC Project E-1-5.

Fenton, M.B. and D.W. Thomas. 1985. Migration and dispersal of bats (Chiroptera) Pp. 409-424 In: (M.A. Rankin, ed.) Contributions to Marine Science Special Supplement. 27.

Fiedler, J., T.H. Henry, R.D. Tankersley, and C.P. Nicholson, 2007. Results of bat and bird mortality monitoring at the expanded Buffalo Mountain Windfarm, 2005. Report prepared for the Tennessee Valley Authority, June 28, 2007. 38 pp.

Findley, J.S. and C. Jones. 1964. Seasonal distribution of the hoary bat. Journal of Mammalogy, 45: 461-470.

Ford, W.M., J. Menzel, M. Menzel, and J.W. Edwards. 2002. Summer roost-tree selection by a male Indiana bat on the Fernow Experimental Forest. U.S. Department of Agriculture Report GTR NE-378, 7 pp.

Ford, W.M. M. Menzel, J.L. Rodrigue, J. Menzel, and J.B. Johnson, 2005. Relating bat species presence to simple habitat measures in a central Appalachian forest. Biological Conservation, 126: 528-539.

Ford, W.M., S.G. Owen, J.W. Edwards, and J.L. Rodrigue. 2006. *Robinia pseudoacacia* (Black Locust) as day-roosts of male *Myotis septentrionalis* (Northern bats) on the Fernow Experimental Forest, West Virginia. Northeastern Naturalist, 13: 15-24.

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.

Francl, K.E. 2005. Bat activity in woodland vernal pools -- report prepared for the USDA Forest Service, Ottawa National Forest, April 2005. 26 pp.

Francl, K.E. 2008. Summer bat activity at woodland seasonal pools in the northern Great Lakes region. Wetlands, 28: 117-124.

Frick, W., J. Pollock, A. Hicks, K. Langwig, D.S. Reynolds, G. Turner, C. Butchkoski, and T.H. Kunz. 2010. An emerging disease causes regional population collapse of a common North American bat species. Science 329: 679-682.

Fujita, M.S. and T.H. Kunz. 1984. *Pipistrellus subflavus*. Mammalian Species, 228: 1-6.

Furlonger, C.L., H.J. Dewar, and M.B. Fenton. 1987. Habitat use by foraging insectivorous bats. Canadian Journal of Zoology, 65: 284-288.

Gannon, W.L. and R.E. Sherwin, 2001. Bat survey work conducted at West Point Military Academy, New York 1999-2000. West Point, New York, USA., 38 pp.

Gehrt, S.D. and J.E. Chelsvig, 2003. Bat activity in an urban landscape: patterns at the landscape and microhabitat scale. Ecological Applications, 13:939-950.

Genoud, M. 1993. Temperature regulation in subtropical tree bats. Comparative Biochemistry and Physiology 104A:321-331.

Gosling, N. M. 1977. Winter record of silver-haired bat, *Lasionycteris noctivagans* (Le-Conte), in Michigan. Journal of Mammalogy 58:657-657.

Griffin, D. 1940. Migrations of New England bats. Bulletin of the Museum of Comparative Zoology. 86 :217-246.

Griffin, D., 1970. Migrations and homing of bats: *In* W.A. Wimsatt (ed) Biology of Bats Academic Press, NY.

Grindal, S.D. and R. M. Brigham, 1988. Short-term effects of small-scale habitat disturbance on activity by insectivorous bats. *Journal of Wildlife Management*, 62: 996-1003.

Hart, J.A., G.L. Kirkland, and S.C. Grossman, 1993. Relative abundance and habitat use by tree bats, *Lasiurus* spp., in southcentral Pennsylvania. Canadian Field Naturalist, 107: 208-212.

Heady, P.A. and W.F. Frick. 1999. Bat inventory of Muir Woods National Monument -- Final Report. Submitted to the National Park Service.

Hendricks, P.C., B. Maxell, S. Lenard, C. Currier, and J. Johnson. 2006. Riparian bat surveys in eastern Montana. A report to the USDI Bureau of Land Management, Montana State Office. Montana Natural Heritage Program, Helena, MT 13pp.

Henry, M, D.W. Thomas, R. Vaudry, and M. Carrier. 2002. Foraging distances and home range of pregnant and lactating little brown bats (*Myotis lucifugus*). Journal of Mammalogy, 83: 767-774.

Hicks, A., 2003. Indiana bat (*Myotis sodalis*) protection and management in New York State: Fiscal Year April 01,2002 - April 01, 2003 Annual Report (Project W-166-E), 21 pp.

Hobson, C. 1993. Status, distribution, and summer ecology of bats in western Virginia: A survey for the endangered Indiana bat, Myotis sodalis. Submitted to VADGIF, Richmond, VA February.

Hogberg, L., K. Patriquin, and R.M.R. Barclay, 2002. Use by bats of patches of residual trees in logged areas of the boreal forest. *American Midland Naturalist* 148: 282-288.

Humphrey, S.R. 1971. Population ecology of the little brown bat, *Myotis lucifugus* in Indiana and North-Central Kentucky. Ph.D. Thesis, Oklahoma State University; Stillwater, Oklahoma, 138 pp.

Hutchinson, J.T. and M.J. Lacki. 2000. Selection of day roosts by red bats in mixed mesophytic forests. Journal of Wildlife Management, 64: 87-94.

Izor, R. J. 1979. Winter range of the silver-haired bat. Journal of Mammalogy 60:641-643.

Jaycox, J., 2003. Indiana bat (*Myotis sodalis*) survey at West Point military reservation. Report for the United States Military Academy Natural Resources Branch, 122 pp.

Johnson, G.D. 2005. A review of bat mortality at wind-energy developments in the United States. Bat Research News 46:45-49.

Jung, T.S., I.D. Thompson, R. Titman, and A.P. Applejohn, 1999. Habitat selection by forest bats in relation to mixed-wood stand types and structure in central Ontario. Journal of Wildlife Management, 63: 1306-1319.

Kiefer, A., H. Merz, W. Rackow, H. Roer, and D. Schlegel. 1995. Bats as traffic casualties in Germany. *Myotis*, 32: 215-220.

Kocer, C., 2009. White-Nose Syndrome devastates CT's hibernating bats. Connecticut Wildlife, 29 (2): 7.

Kunz, T.H. 1982. *Lasionycteris noctivagans.* Mammalian Species. 172: 1-5.

Krukar, G. 2008. Seeking the Endangered Indiana bat. Connecticut Wildlife, 28 (6): 12-13.

Kurta, A. and R.H. Baker, 1990. *Eptesicus fuscus*. Mammalian Species, 356: 1-10.

Kurta, A., D. King, J.A. Teramino, J.M. Stribley, and K. Williams, 1993. Summer roosts of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. American Midland Naturalist 129: 132-138.

Kurta, A. and H. Rice, 2002. Ecology and management of the Indiana bat in Michigan. Michigan Academician, 34:175-190.

LaGory, K.E., D.S. Reynolds, and J.A. Kuiper. 2002. A survey of the bats of New Boston Air Force Station, New Hampshire. Unpublished Report to the U.S. Department of the Air Force. 32 pp.

Larson, M.A., W.D. Dijak, F.R. Thompson, and J.J. Millspaugh. 2003. Landscape-level habitat suitability models for twelve wildlife species in southern Missouri. General Technical Report NC-233. St. Paul, MN: U.S. Dept. of Agriculture, Forest Service, North Central Research Station, 51pp.

Lesinski, G. 2007. Bat road casualties and factors determining their number. Mammalia, 2007: 138-142.

Mackey, R.L. and R.M.R. Barclay. 1989. The influence of physical clutter and noise on the activity of bats over water. Canadian Journal of Zoology, 67: 1167-1170.

Mackiewicz, J. and R.H. Backus. 1956. Oceanic records of *Lasionycteris noctivagans* and *Lasiurus borealis*. Journal of Mammalogy, 37: 442-443.

Martin, R.L. and B.G. Hawks. 1972. Hibernating bats of the Black Hills of South Dakota. Bulletin of the New Jersey Academy of Science. 17:24:30.

McAlpine, D.F., F. Muldoon, G.J. Forbes, A.I. Wandeler, S. Makepeace, H.G. Broders, and J.P. Goltz. 2002. Over-wintering and reproduction by the Big Brown Bat, *Eptesicus fuscus*, in New Brunswick. Canadian Field Naturalist, 116: 645-647.

McClure, J. E. 1942.Summer activities of bats (Genus *Lasiurus*) in Iowa. Journal of Mammalogy, 23: 430-434.

Medlin, R.E. and T.S. Risch. 2008. Habitat associations of bottomland bats, with focus on Rafinesque's big-eared bat and southeastern myotis. American Midland Naturalist, 160: 400-412.

Menzel, M.A., T.C. Carter, B.R. Chapman, and J. Laerm. 1998. Quantitative comparison of tree roosts used by red bats (*Lasiurus borealis*) and seminole bats (*L. seminolus*). Canadian Journal of Zoology, 76: 630-634.

Menzel, J. M., M. A. Menzel, G. F. McCracken, and B. R. Chapman. 2000. Notes on bat activity above the forest canopy in the eastern United States. Georgia Journal of Science 58:212-216.

Menzel, M.A., J.M. Menzel, T.C. Carter, W.M. Ford, J.W. Edwards. 2001. Review of the forest habitat relationships of the Indiana bat (*Myotis sodalis*). General Techical Report NE-284. U.S. Department of Agriculture, Newtown Square, Pennsylvania.

Menzel, M.A., S.F. Owen, W.M. Ford, J.W. Edwards, P.B. Wood, B.R. Chapman and K.V. Miller. 2002. Roost tree selection by northern long-eared bats (*Myotis septentionalis*) maternity colonies in an industrial forest of the central Appalachian mountains. Forest Ecology and Management, 155:107-114.

Menzel, J.M., M.A. Menzel, J.C. Kilgo, W.M. Ford, J.W. Edwards, and G.F. McCracken. 2005. Effect of habitat and foraging height on bat activity in the coastal plain of South Carolina. Journal of Wildlife Management, 69: 235-245.

Merguerian, C. and J.E. Sanders, 2010. Trips on the Rocks, Guide 22: New Haven-East Haven-Branford Area, Connecticut. Duke Geological Laboratory, Field Notes released 2010. <//people.hofstra.edu/charles_merguerian/Publications/PubsPdf/OTR22_NewHaven_sm.pdf> accessed 11 May, 2013.

Miller, G. S., JR. 1897. Migration of bats on Cape Cod, Massachusetts. Science 5:541-543.

Miller, D.A. and A.C. Miles. 2008. Roosting by a lactating hoary bat (*Lasiurus cinereus*) in an intensively managed loblolly pine (*Pinus taeda*) landscape in Mississippi. Bat Research News, 49: 35-36.

Mills, R.S., G.W. Barrett, and M.P. Farrell. 1975. Population dynamics of the big brown bat (*Eptesicus fuscus*) in southwestern Ohio. Journal of Mammalogy, 56: 591-604.

Mormann, B.R. and L.W. Robbins. 2007. Winter roosting ecology of eastern red bats in southwest Missouri. Journal of Wildlife Management, 71: 213-217.

Owen, S.F., M.A. Menzel, W.M. Ford, J.W. Edwards, B.R. Chapman, K.V. Miller, and P.B. Wood, 2002. Roost tree selection by maternal colonies of northern long-eared Myotis in an intensively managed forest. US Dept Agriculture Report GTR NE-292.

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

Perkins, J.M. and S.P. Cross. 1988. Differential use of some coniferous forest habitats by hoary and silver-haired bats in Oregon. The Murrelet, 69: 21-24.

Perry, R.W. and R.E. Thill. 2007. Roost selection by male and female northern long-eared bats in a pine-dominated landscape. Forest Ecology and Management, 247: 220-226.

Perry, R.W., R.E. Thill, and S.A. Carter. 2007. Sex-specific roost selection by adult red bats in a diverse forested landscape. Forest Ecology and Management, 253: 48-55.

Perry, R.W., R.E. Thill, and D.M. Leslie. 2008. Scale-dependent effects of landscape structure and composition on diurnal roost selection by forest bats. Journal of Wildlife Management, 72: 913-925.

Perry, R.W., D. Saugey, and B. Crump. 2010. Winter roosting ecology of silver-haired bats in an Arkansas forest. Southeastern Naturalist, 9: 563-572.

Peterson, R. 1970. Another red bat, *Lasiurus borealis*, taken aboard ship off the coast of Nova Scotia. Canadian Field Naturalist, 1970: 401.

Puechmaille, S., G. Wibbelt, V. Korn, H. Fuller, F. Forget, K. Muhldorfer, A. Kurth, W. Bogdanowicz, C. Borel, T. Bosch, T. Cherezy, M. Drebet, T. Gorfol, A. Haarsma, F. Herhaus, G. Hallart, M. Hammer, C. Jungmann, Y. Le Bris, L. Lutsar, M. Masing, B. Mulkens, K. Passior, M. Starrach, A. Woktaszewski, U. Zophel, and E. Teeling. 2011. Pan-European distribution of White-Nose Syndrome fungus (*Geomyces destructans*) not associated with mass mortality e19167. PloS One, 6: 1-11.

Provost, E.E. and C.M. Kirkpatrick. 1952. Observations on the hoary bat in Indiana and Illinois. Journal of Mammalogy, 33: 110-113.

Reynolds, D.S., 2006. Monitoring the potential impact of a wind development site on bats in the Northeast. Journal of Wildlife Management, 70: 1219-1227.

Reynolds, D.S., 2008. Data summary for bat activity monitoring survey at Chestnut Flats Wind Project – report prepared for Gamesa Energy USA, LLC – Feb 2008, 19 pp.

Saugey, D. A., R. L. Vaughn, B. G. Crump, and G. A. Heidt. 1998. Notes on the natural history of *Lasiurus borealis* in Arkansas. Journal of the Arkansas Academy of Science 52:92-98.

Saunders, W.E., 1930. Bats in migration. Journal of Mammalogy, 11: 225.

Scherer, A., 1999. A survey for the federally listed endangered Indiana bat (*Myotis sodalis*), Picatinny Arsenal, Morris County, New Jersey. Draft Report. U.S. Dept of the Interior, Fish and Wildlife Service, NJ Field Office.

Sherwood, D.H. and A. Kurta. 1999. Winter record of a silver-haired bat (Lasionycteris noctivagans) from Wayne County. Michigan Birds and Natural History, 6: 153-155.

Schmidly, D.J. 2004. Mammals of Texas. 6th Edition. University of Texas Press. Austin, TX. 501 pp.

Shump, K.A. and A.U. Shump, 1982a. *Lasiurus cinereus*. Mammalian Species, 185: 1-5.

Shump, K.A., Jr. and A.U. Shump. 1982b. *Lasiurus borealis*. Mammalian Species, 183: 1-6.

Stihler, C.W. 2003. Shedding light on West Virginia's cave-dwelling bats. West Virginia Wildlife, 2003: 10-13.

Thogmartin, W., R.A. King, P. McKann, J. Szymanski, and L. Pruitt. 2012. Population-level impact of white-nose syndrome on the endangered Indiana bat. Journal of Mammalogy, 93: 1086-1098.

Thomas, D.W., 1993. Status of the eastern small-footed bat (*Myotis leibii*) in Vermont. Final Report for the Vermont Fish and Wildlife Service VTHER 92-01-21. 22 pp.

Thomson, C.E., 1982. *Myotis sodalis*. *Mammalian Species* **163**:1-5.

Trombulak, S., P.E. Higuera, and M. Desmeules, 2001. Population trends of wintering bats in Vermont. Northeastern Naturalist 8:51-62.

Turner, G., D. Reeder, and J. Coleman. 2011. A five-year assessment of mortality and geographic spread of white-nose syndrome in North American bats and a look to the future. Bat Research News, 52: 13-27.

UCONN MAGIC [University of Connecticut Libraries Map and Geographic Information Center], 2013. Connecticut USGS Topographic Map Collection, 1:24K Quadragle Map Layers. <<http://magic.lib.uconn.edu/topographic_maps.html>> accessed 11 May, 2013.

Unger, C. and A. Kurta. 1998. Status of the eastern pipistrelle (Mammalia: Chiroptera) in Michigan. Michigan Academician, 30: 423-437.

[USFWS] U.S. Fish and Wildlife Service. 1999. Agency draft Indiana bat (*Myotis sodalis*) revised recovery plan. Fort Snelling, Minnesota.

Veilleux, J.P., J.O. Whitaker, Jr., and S.L. Veilleux. 2003. Tree-roosting ecology of reproductive female eastern pipistrelles, *Pipistrellus* [*Perimyotis*] *subflavus*, in Indiana. Journal of Mammalogy, 84: 1068-1075.

Veilleux, J.P., P.R. Moosman, Jr., D.S. Reynolds, K.E. LaGory, and L.J. Walston, Jr. 2009. Observations of summer roosting and foraging behavior of a hoary bat (*Lasiurus cinereus*) in southern New Hampshire. Northeastern Naturalist. 16: 148-152.

Von Frenckell, B. and R.M.R. Barclay. 1987. Bat activity over calm and turbulent water. Canadian Journal of Zoology, 65: 219-222.

Vonhof, M. J. 1996. Roost site preferences of big brown bats (*Eptesicus fuscus*) and silver-haired bats (*Lasionycteris noctivagans*) in the Pend d'Oreille Valley in Southern British Columbia. Pp. 62-80 *In*: Bats and Forests Symposium (R. M. R. Barclay & R. M. Brigham, eds.), Victoria, British Columbia, Canada. Research Branch, British Columbia Ministry of Forests, Victoria, B.C.

Walsh, A.L. and S. Harris. 1996. Foraging habitat preferences of vespertilionid bats in Britain. Journal of Applied Ecology, 33: 508-518.

Whitaker, J.O. and S.L. Gummer, 1992. Hibernation of the big brown bat, *Eptesicus fuscus*, in buildings. Journal of Mammalogy 73: 312-316.

Whitaker, J.O. and L. Rissler. 1992. Seasonal activity of bats at Copperhead Cave. Proceedings of the Indiana Academy of Sciences, 101: 127-134.

Whitaker, J.O., Jr. 1998. Life history and roost switching in six summer colonies of eastern pipistrelles in buildings. Journal of Mammalogy, 79: 651-659.

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

Whitaker, J.O., Jr. & S.L. Gummer, 2000. Population structure and dynamics of big brown bats (*Eptesicus fuscus*) hibernating in buildings in Indiana. American Midland Naturalist, 143: 389-396.

Whitaker, J.O., D.W. Sparks, and V. Brack. 2006. Use of artificial roost structures by bats at the Indianapolis International Airport. Environmental Management, 38: 28-36.

Williams, J.A., M.J. O'Farrell, and B.R. Riddle. 2006. Habitat use by bats in a riparian corridor of the Mojave Desert in southern Nevada. Journal of Mammalogy, 87: 1145-1153.

Willig, C.K.R., R.M. Brigham, and F. Geiser. 2006. Deep, prolonged torpor by pregnant, free-ranging bats. Naturwissenschaften, 93: 80-83.

Winhold, L., A. Kurta, and R. Foster. 2008. Long-term change in an assemblage of North American bats: are eastern red bats declining? Acta Chiropterologica, 10: 359-366.

Wolcott, K. and K. Vulinec. 2012. Bat activity at woodland/farmland interfaces in central Delaware. Northeastern Naturalist, 19: 87-98.

Yates, M.D. and R.M. Muzika. 2006. Effect of forest structure and fragmentation on site occupancy of bat species in Missouri Ozark forest. Journal of Wildlife Management, 70: 1238-1248.

Young, D.P., W.P. Erickson, R.E. Good, M.D. Strickland, and G.D. Johnson, 2003. Avian and bat mortality associated with the initial phase of the Foote Creek Rim windpower project, Carbon County, Wyoming prepared for Pacificorp, Inc., SeaWest Windpower, Inc, and BLM January 2003.

Zinn, T.L. and W.W. Baker, 1979. Seasonal migration of the hoary bat, *Lasiurus cinereus*, through Florida. Journal of Mammalogy, 60: 634-635.