Received: 14 March 2024 | Accepted: 11 September 2024

DOI: 10.1002/2688-8319.12392

Ecological Solutions and Evidence | BRITISH ECOLOGICAL SOCIETY

REVIEW

Maximizing benefits to bat populations through management of power line corridors

C. J. Campbell[1] | Tina L. Cheng[1] | Karin L. Akre[1] | Amanda M. Adams[1] | Donald I. Solick[2] | Ashley Bennett[2] | Christian Newman[2] | Winifred F. Frick[1,3]

[1]Bat Conservation International, Austin, Texas, USA

[2]Electric Power Research Institute, Palo Alto, California, USA

[3]University of California Santa Cruz, Santa Cruz, California, USA

Correspondence
C. J. Campbell
Email: ccampbell@batcon.org

Handling Editor: Carolyn Kurle

Abstract

1. Power line corridors are ubiquitous worldwide and are commonly used by bats as habitat. Targeted management of these corridor habitats has the potential to aid bat populations, which is critically important given the multifaceted threats facing bat species, including the emerging infectious disease white-nose syndrome (WNS) in North America.
2. Here, we review known and potential impacts of management of existing power line corridors on three bat behaviours: foraging, roosting and commuting. We also identify bats in the United States that would benefit from changes to management of power line corridors for improvements to roosting and foraging habitats, particularly species of conservation concern that roost and forage along forest edges.
3. Key recommendations are to avoid disturbance to roosting bats when maintaining vegetation along power line corridors, apply integrated vegetation management to maximize native plant diversity to improve prey options for bats and apply targeted interventions (e.g. artificial roost creation, creation of ponds) in a well-justified ecological context.
4. *Practical implication*. We highlight high-priority research topics to fill knowledge gaps, including testing whether vegetation management treatments targeting plant and insect communities increase bat fitness and cause positive population-level responses in focal bat species. We conclude that building evidence on how bats are affected by power line corridor management is a conservation need.

KEYWORDS
Chiroptera, electric power transmission, integrated vegetation management, renewable energy, right of way, transmission lines

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.
© 2024 The Author(s). *Ecological Solutions and Evidence* published by John Wiley & Sons Ltd on behalf of British Ecological Society.

1 | INTRODUCTION

Bats are among the most threatened and least-understood groups of mammals worldwide (Frick et al., 2020). In North America, bats are threatened by multiple stressors, including climate change, habitat loss and degradation, wind energy development and the infectious disease white-nose syndrome (WNS; Cheng et al., 2021; Frick et al., 2020; O'Shea et al., 2016). WNS is the single dominating threat to a number of hibernating bat species in North America (Cheng et al., 2021), and it remains unclear if diminished remnant populations will stabilize and recover. Although disease-induced mortality from WNS primarily occurs during winter hibernation, targeted conservation interventions at other times of the year are promising avenues to increase individual fitness that can aid population resilience and recovery (e.g. feeding stations to improve WNS survivorship as in Frick et al., 2023). Additionally, such interventions could help mitigate other pressures that might adversely affect bat populations already weakened by WNS, such as habitat loss and disturbances during the maternity season. Thus, there is considerable interest in scalable solutions to facilitate recovery and resilience of bat populations, especially those affected by WNS.

Utility power transmission lines are ubiquitous throughout natural and developed areas around the world. For example, as of 2018, there were roughly 700,000 miles of high-voltage electric transmission lines across the United States (U.S. Energy Information Administration, 2018). With growing energy demand and conversion to renewable energy, the number of new within-region lines required to meet high-load/high-clear energy scenarios is likely almost 1.5 times that of existing lines in 2020 (United States Department of Energy, 2023, p. 144). The spaces cleared of tall vegetation for utility transmission lines (i.e. power line corridors) can be used by bats for roosting, commuting and foraging habitats (Figure 1; e.g. Brack Jr. et al., 2022; Johnson & Strickland, 2004; Saugey et al., 1989; Tella et al., 2020). Given their ubiquity on the landscape and interest from electric power companies in mitigating impacts to protected species, there is great potential in managing power line corridors to maximize potential benefits to bat populations.

Power line corridor management has the potential to support healthy populations of species or communities of conservation interest, an interest compatible with their fundamental purpose of transmitting electric energy. Here, we review the known and possible interactions between bats, power line corridors and power line corridor management actions through narrative review. The aim of this review was to provide guidance and perspective in identifying potential interventions helpful for managing bat populations as well as to identify key knowledge gaps. Although we chose to centre our aims on temperate North American species, particularly those impacted by WNS, we synthesize information on power line management and bat ecology worldwide. Finally, we summarize key recommendations for both current management and areas of future research.

2 | MANAGEMENT AND STRUCTURE OF EXISTING POWER LINE CORRIDORS

Power line corridors are strips of land that have been cleared of trees and other vegetation to prevent damage to electric lines and disruption of electric service. In North America, utility companies adhere to North American Electric Reliability Corporation (NERC) standards (FAC-003-5) which mandate the establishment of minimum vegetation clearance distances surrounding high voltage transmission lines using vegetation management practices (the 'wire' and 'border' zones; Figure 1). The required minimum vegetation clearance distance required by NERC will vary depending on line voltage, the type of current carried (e.g. alternating or direct current), ambient temperature, load and elevation (North American Electric Reliability Corporation, 2020). Lower voltage power lines (below 100 kV) have less required clearance distances and fall under state and local regulatory oversight. To ensure vegetation clearance distances are not

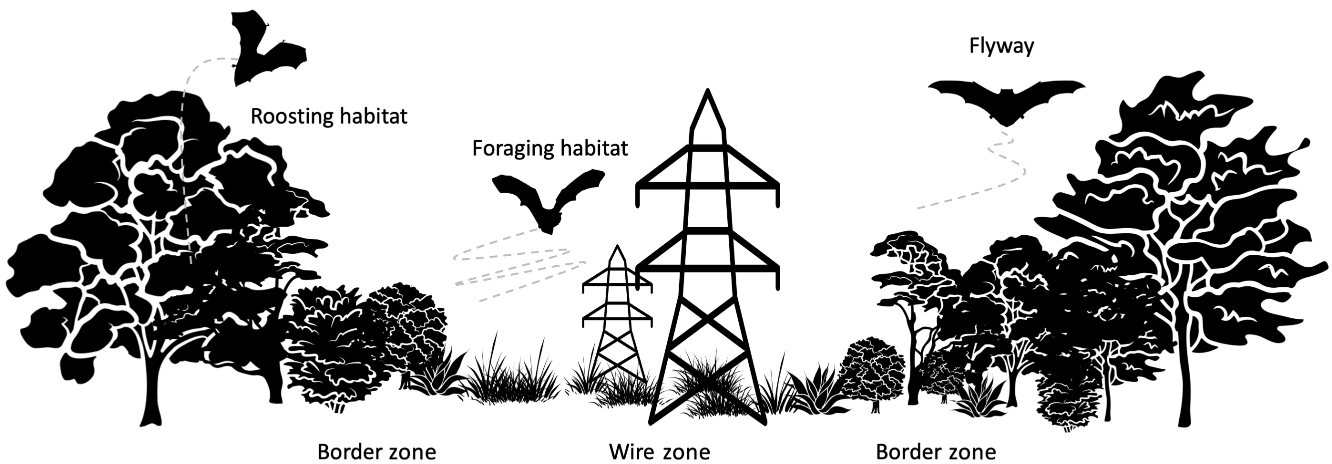

FIGURE 1 A conceptual illustration of a power line corridor and common behavioural uses by North American bats. Maintenance of power line corridors generally includes a low-growing area immediately beneath and adjacent to power lines (the 'wire zone') and a 'border zone' free of tall vegetation and debris.

26888319, 2024, 4, Downloaded from https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12392, Wiley Online Library on [30/10/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

RIGHTSLINK

violated, utilities systematically inspect lines and periodically address immediate vegetation threats (e.g. trees at risk of falling on power lines), as well as implement long-term system-wide vegetation management plans.

Vegetation management across the entire line system typically occurs across a 3- to 5-year cycle, depending on the utility company, with vegetation management targeting a section of the system each year. Standard techniques for maintaining power line corridor vegetation height include general or targeted mowing, cutting, hand removal or herbicide application to maintain compatible low-growing vegetation. Many companies use integrated vegetation management (IVM) practices which predominantly use a combination of targeted chemical and mechanical methods to control tall-growing trees and shrubs while favouring a competitive herbaceous layer that naturally inhibits re-establishment of incompatible vegetation (Miller, 2021; Tree Care Industry Association, Inc, 2012). IVM can provide significant cost savings over the long term compared to more traditional cycle-based programmes that are not responsive to changes in vegetation in power line corridors (Turk, 2015; Yahner & Hutnik, 2004). Furthermore, IVM approaches can include promoting native plant communities by planting native seed mixes, and controlling invasive species that likely benefit insects and other wildlife.

2.1 | Habitat types maintained by power line corridors

The plant communities within power line corridors often represent a subset of the native and non-native regional plant diversity. A key aspect of these plant communities is that their structural compositions are managed to maintain limited vegetation height within the corridor. Three common and overlapping categories of habitat are commonly maintained at power line corridors: early successional habitat, low-vegetation habitats and edge habitats.

Corridors transecting forested environments are often associated with early successional habitat, where tall-growing trees are periodically removed or trimmed, and vegetation management regimens are implemented to favour the growth of stable low-growing plant communities comprising grasses, forbs and shrubs (Nowak & Ballard, 2005). In natural forested ecosystems, early successional habitats represent an initial stage in the regeneration of forests following a perturbation (e.g. fire, flood and storm) and prior to eventual reforestation. The maintenance of power line corridors introduces periodic, artificial perturbation that commonly maintains early-successional plant communities (Niering & Goodwin, 1974). Thus, the sustained vegetation management of power line corridors presents an opportunity to protect and conserve species that depend on early successional habitat (Oki et al., 2021).

Power line corridors can also support prairie, grassland, scrub and other low-vegetation habitats that are not early successional (Askins, 2001; Garfinkel et al., 2022; Lampinen et al., 2015). Supporting these habitats can offer important opportunities for conservation as grasslands, in particular, have experienced significant declines. For example, <44% of the Great Plains' historical grassland and shrubland remains (Augustine et al., 2021), and only 5% of North America's tallgrass prairies remain intact (Rice et al., 2018). When managed to support grasslands, power line corridors can provide refugia for grassland and scrub plants, including threatened species (Sheridan et al., 1997). Supporting diverse plant communities can, in turn, support higher trophic-level species that rely on grasslands for food resources. For example, declining grassland bird species (Askins et al., 2012) can be supported in low-vegetation habitats occurring along power line corridors (Confer & Pascoe, 2003; Hunter et al., 2022; King & Byers, 2002), as can rare savanna (Forrester et al., 2005), grassland butterflies (Berg et al., 2011, 2013), scrub-dwelling birds (King et al., 2009) and threatened bees (Russell et al., 2005).

When power line corridors intersect habitat distinct from the low-vegetation type maintained within them, edge habitat is inevitably created. In forested landscapes, power line corridors create edges associated with increased visibility, light and open space for animal movement (Murcia, 1995). Forested edges influence the abundance, distribution and behaviour of organisms (Eldegard et al., 2015; Kroodsma, 1982). Although edge habitat is commonly associated with the negative impacts of habitat fragmentation (e.g. Fletcher Jr., 2005; Murcia, 1995; Ries et al., 2004), some species are less sensitive to the effects of habitat edges (Ries & Sisk, 2010) and may be associated with edges, including those along power line corridors (e.g. Kroodsma, 1982).

3 | IMPROVING FORAGING FOR BAT POPULATIONS

3.1 | Insectivorous bats may use power line corridors as foraging habitat

Early successional, low-vegetation and edge habitats can provide important foraging opportunities for bats, as demonstrated by studies documenting differences in foraging or general activity in various habitat types. Bats that are adapted to forage in open habitats are expected to benefit the most from early successional habitat (Loeb & O'Keefe, 2011), although clutter-adapted bats may also benefit as they can forage in both cluttered and open environments (Brooks, 2017). Bats' use of early successional habitats for foraging varies depending on habitat characteristics, such as patch size and vegetation type (Loeb & O'Keefe, 2011). Landscape-scale features, such as nearby land cover, can influence bat habitat use (Starbuck et al., 2015). Many bats prefer forested and water edges to open prairie and forest interiors (Everette et al., 2001; Hein et al., 2009; Slough et al., 2023). Forest gaps and patches of disturbed habitat, which likely attract bat species that prefer both open and edge habitats, are associated with heightened bat activity across several bat species and foraging guilds (Dodd et al., 2012; Erasmy et al., 2021;

26888319, 2024, 4, Downloaded from https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12392, Wiley Online Library on [30/10/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License
RIGHTSLINK

Loeb & O'Keefe, 2011). Habitat heterogeneity, a measure of the complexity of spatially integrated habitat types (e.g. forested cover, forest edge, riparian corridors and wetlands and other water bodies), is likely another important factor in whether a given area can help to support the full annual cycle of bats' needs (Cable et al., 2021; Dodd et al., 2008; Johnson & Lacki, 2013).

Multiple factors may contribute to why many bat species prefer to forage in low vegetation, early successional or edge habitats. These habitats are associated with less clutter than interior forested habitat, which may facilitate higher rates of foraging efficiency (Grindal & Brigham, 1999; Loeb & O'Keefe, 2011). As linear features, forested edges can be used as travel corridors (see Section 4), which may drive higher incidental foraging activity during commutes along and within power line corridors (Grindal & Brigham, 1999; Morris et al., 2010). Another factor that may drive bat preferences for forest edges is heightened insect abundance (Deans et al., 2005; Dodd et al., 2008; Grindal & Brigham, 1999; Johnson & Lacki, 2013; Morris et al., 2010), although early successional habitats have variable relationships relative to mature forests in terms of both insect abundance (Loeb & O'Keefe, 2011) and insect diversity (Burford et al., 1999).

In general, while potentially beneficial features attract some organisms to edges and successional habitats for foraging, others may avoid edges and open areas (Ries & Sisk, 2010). For example, the small-bodied, high-frequency echolocating *Myotis* species tend to be more active within larger, intact forests than open areas or edges (Beilke et al., 2021; Morris et al., 2010; Owen et al., 2004; Patriquin & Barclay, 2003). However, the context of open areas within the broader landscape matrix is likely crucial (Loeb & O'Keefe, 2011), as some *Myotis* species may prefer small natural gaps or forage in low- to medium-density vegetation (Beilke et al., 2021; Loeb & O'Keefe, 2006).

3.2 | Management for insect prey may enhance bat foraging habitat

Existing corridor management may provide foraging habitat for some bats, and targeted management could potentially increase desirable insect prey. Power line corridors located in agricultural areas can serve as refuges for insect pollinators by providing access to greater plant diversity than crop monocultures (Nicholls & Altieri, 2013). Increasing the diversity of native plants in power line corridors while minimizing the spread of invasive plants could increase insect diversity and abundance (Swab et al., 2017). For example, power line corridors maintained as restored prairie or as brush on a 5-year maintenance cycle exhibit increased insect diversity relative to mown turf grass (Garfinkel et al., 2022). Many IVM strategies focus on increasing abundance or diversity of diurnal insect pollinators; enacting strategies such as adjusting the timing and frequency of herbicide spray or vegetation removal (Acklen & Goodrich-Mahoney, 2017), reducing herbicide levels (Russo et al., 2021), and preserving flowers favoured by insect pollinators by avoiding mowing (Hopwood et al., 2015) or herbicide spray during peak flowering times (Kovács-Hostyánszki et al., 2017) can positively impact pollinator diversity and abundance, which likely increases overall insect diversity and abundance. As bats may be particularly vulnerable to the bioaccumulation of pesticides (Cable et al., 2022; Jones et al., 2009), including chemicals used in broad-spectrum herbicides (Hooper et al., 2022; Kuzukiran et al., 2021; Martín et al., 2023; Schanzer et al., 2022), strategies that reduce overall pesticide use in bat habitat may also improve bat fitness (Frick et al., 2007). Early work suggests that experimentally increasing the local abundance of insect prey increases bat foraging activity by a WNS-affected species (Frick et al., 2023). Less is known about the optimal methods for promoting healthy insect prey populations and how they translate into demographic effects in bat populations (Box 1.2).

4 | MANAGEMENT OF CORRIDORS FOR ROOSTING HABITAT

4.1 | Bats roost within and near power line corridors

Bats that roost in tree cavities and bark, foliage (either on tree branches or fallen on the ground) or in caves might be impacted by nearby management activities of power line corridors. Roosts provide critical habitat that supports the energetic and biological needs of bats according to their sex, age and reproductive condition, and individual roosting needs vary with seasonal change and across ecoregions (Kunz, 2003). As most temperate bat species shift habitats between the warm and cool seasons, roosts are commonly characterized as 'summer' or 'winter' roosts. Within seasons, bats may use multiple roosts and may switch between roosts regularly. Roost type and behaviour vary by species. A species may roost solitarily, communally or use both strategies. Roosts are often used for sleep and hibernation, but they are also important for raising young, mating and social activity. Bats are particularly vulnerable to roost disturbances while raising their young (Kunz, 2003; The Protection of Bat Roost Guidelines Subcommittee et al., 1992).

Several species of bats are likely to roost along or near power line corridors when corridors pass through forests. Maternity colonies, in particular, often select roosts with high solar exposure, which likely minimizes energy expenditure (Lausen & Barclay, 2006; Willis et al., 2006). Associations between roost selection and locations along forested edges are documented for the following species: *M. evotis* (Rancourt et al., 2005), *M. sodalis* (Callahan et al., 1997; Carter & Feldhamer, 2005) and *Myotis* spp. (Grindal & Brigham, 1999). Several species are known to roost in early successional habitat, including *M. septentrionalis* (Menzel et al., 2001, 2002) and *Lasiurus* spp. (Leput, 2004; Mager & Nelson, 2001; O'Keefe et al., 2009; Perry et al., 2008), as well as in forest gaps (*Lasionycteris noctivagans*, Campbell et al., 1996; *Perimyotis subflavus*, Perry et al., 2008). Although not present in the wire zone, roost trees may be located along the edges of power line corridor border zones (Figure 1).

26888319, 2024, 4, Downloaded from https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12392, Wiley Online Library on [30/10/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

RIGHTSLINK Copyright Clearance Center

BOX 1 Highlighted research areas that would improve capacity and implementation of power line corridor management to support bat populations

1.1 Describe power line corridor use by bat community assemblages. Many North American bat species appear to use power line corridors as foraging, roosting and commuting habitats (Table 1), but overall data on this type of habitat use are sparse (Table 1). Improved understanding of species-, season- and region-specific use of power line corridors is essential to inform local and general management of corridors. Identifying species that avoid power line corridors, possibly by comparing community assemblages on and off corridors, would also inform understanding how species might respond to current and future power line installation.

1.2 Identify management practices that improve foraging success or efficiency. Most North American bats are insectivorous, and their populations likely depend on the abundance and diversity of suitable insect prey. Insect diversity and abundance are strongly related to the plant communities that shape habitat structure, the availability of host plants for larval insects and the availability of nectar and pollen resources for pollinators (Borer et al., 2012; Ebeling et al., 2018; Scherber et al., 2010). Research on bat dietary compositions is a growing area (e.g. Bernard et al., 2021; Clare et al., 2009; Clare, Symondson, Broders, et al., 2014; Clare, Symondson, & Fenton, 2014; Ingala et al., 2021). However, little is known about the direct relationships between plant communities, insect communities and bat populations. Priority areas of research include measuring how and if targeted conversion to and support of native plant assemblages (e.g. through seeding or IVM) impacts nocturnal insect abundance and bat foraging activity. Ideally, studies should control for effects of vegetation structure and plant diversity since insects may select for more open versus more sheltered areas based on functional traits like body size (Loeb & O'Keefe, 2011). Detection probability for both bats and insects likely vary with functional traits and vegetation structure (Iknayan et al., 2014).

1.3 Establish best practices for generating and maintaining bat roosts. Although much work has been done to study specific techniques for designing and siting artificial roosts and generating snags (see Section 4.2.2), the long-term effects they have on local and regional bat populations remain unclear. Future research should investigate the efficacy of created roosts and examine when and where roost generation is most beneficial. In addition, future research should focus on improving strategies for power line corridor maintenance crews to identify and retain current and potential roost trees and local, site-specific understanding of mitigation best practices that focus on species-, ecosystem- and region-specific contexts. For example, potentially hazardous trees that would otherwise be removed might be 'tree-topped' and converted into artificial snags. We also note that colonization of roost trees and artificial roosts is not an optimal indicator of 'conservation success' (Crawford & O'Keefe, 2023). Instead, we encourage future work into the demographic consequences of roost augmentation and supplementation. For example, does artificial roost installation support survival and reproductive success over time and in different regions? The use of passive acoustic monitoring and passive integrated transponder tags has the potential to support this line of inquiry (O'Shea et al., 2004; van Harten et al., 2019).

1.4 Expand research on encouraging bat movement through human-modified habitats. The majority of bat species of current conservation concern in the United States are likely willing to use forest edge habitat and are thus unlikely to be restricted by power line corridors (Table 1). Power line corridors may help some species move through human-modified landscapes. Targeted tracking studies could confirm this and provide insight into whether bats use power line corridors to increase foraging and commuting efficiency. In contrast, bats with limited dispersal capacities (e.g. *Myotis leibii*; Table 1) or clutter-adapted species that may be reluctant to cross open areas (e.g. *M. septentrionalis*; Table 1) might have less connectivity across habitat patches bisected by power line corridors. Targeted research can evaluate the efficacy of methods that may restore genetic connectivity when intervention is necessary (e.g. Berthinussen & Altringham, 2012; Claireau et al., 2019; see also Soanes et al., 2024).

1.5 Explore the use of constructed ponds to improve habitat. Construction of artificial ponds within power line corridors has been demonstrated to increase bat activity in a water-limited area (Brack Jr. et al., 2022). Improved access to water bodies may benefit bats, but little is known about the long-term effectiveness of artificial water bodies. As many bats are sensitive to water quality (Kalcounis-Rueppell et al., 2007; Li & Kalcounis-Rueppell, 2018), design or management limitations that result in polluted or eutrophic water bodies may counter ecological benefits. Future research should include monitoring bat activity and fitness relative to use of artificial water bodies and how their features change over time. These studies could also assess if constructing water bodies would be a scalable solution for utilities, given the regulatory, cost and operating constraints of power line corridors.

26888319, 2024, 4, Downloaded from https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12392, Wiley Online Library on [30/10/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

RIGHTSLINK

TABLE 1 Selected bat species occurring in the United States and Canada, based on their conservation status and/or likelihood of roosting or foraging in proximity to corridors, that may benefit from vegetation management within power line corridors. We included species that have federal listing protection and a selection of species that seemed likely to utilize power line corridors, based on the research conducted as part of this review.

Species	Conservation status and considerations	Tree roosting?[a,b]	Foraging space[a,b]	Reported activity in power line corridors
Corynorhinus rafinesquii Rafinesque's big-eared bat	SGCN: 17 states[c]	Yes: year-round	Edge	
C. townsendii	SGCN: 13 states[c] ESA: Endangered (*virginianus* and *ingens* subspecies)[d]	No	Edge	
Eptesicus fuscus Big brown bat	SGCN: 21 states[c]	Yes: summer	Edge	Roosts in artificial roost in corridor (Brack Jr. et al., 2022)
Euderma maculatum Spotted bat	SGCN: 9 states[c] COSEWIC and SARA: special concern[e]	No	Open	
Idionycteris phyllotis Allen's big-eared bat	SGCN: 4 states[c]	Yes: summer	Edge	
Lasiurus borealis Eastern red bat	SGCN: 18 states[c] COSEWIC: endangered[e]	Yes: year-round	Edge	Forages within corridors (Saugey et al., 1989)
Myotis austroriparius Southeastern myotis	SGCN: 17 states[c]	Yes: summer	Edge	
M. evotis Long-eared bat	SGCN: 5 states[c]	Yes: year-round	Narrow	
M. grisescens Grey bat	SGCN: 14 states[c] ESA: endangered[d]	No	Edge	
M. leibii Eastern small-footed bat	SGCN: 25 states[c]	No	Narrow	
M. lucifugus Little brown bat	SGCN: 37 states[c] ESA: under review[d] COSEWIC & SARA: endangered[e] IUCN: endangered[f] WNS-caused 96% decline[g]	Yes: summer	Edge	Found within power line corridors (Brack Jr. et al., 2022)
M. septentrionalis Northern long-eared bat	SGCN: 36 states[c] ESA: endangered[d] COSEWIC & SARA: endangered[e] IUCN: near-threatened[f] WNS-caused >99% decline[g]	Yes: summer	Narrow	Roosts adjacent to corridors (Burrell & Bergeson, 2022; Swingen et al., 2018); found within power line corridors (Brack Jr. et al., 2022)
M. sodalis Indiana bat	SGCN: 23 states[c] ESA: endangered[d] IUCN: near-threatened[f] WNS-caused 30% decline[g]	Yes: summer	Edge	Roosts along corridors (Brack, 2006); uses corridors for commuting (Johnson & Strickland, 2004)
Perimyotis subflavus Tricolored bat	SGCN: 30 states[c] ESA: proposed endangered[d] COSEWIC & SARA: endangered[e] IUCN: vulnerable[f] WNS-caused 93% decline[g]	Yes: summer	Edge	Found within power line corridors (Brack Jr. et al., 2022)

[a]Loeb and O'Keefe (2011).

[b]Barbour and Davis (1969).

[c]Species of Greatest Conservation Need (SGCN), https://www1.usgs.gov/csas/swap/national_list.html, accessed 2 July 2024.

[d]U.S. Fish and Wildlife Service Environmental Conservation Online System. https://ecos.fws.gov/ecp/species/9051, accessed 2 July 2024.

[e]Committee of the Status of Endangered Wildlife in Canada (COSEWIC) and Species at Risk Act (SARA), https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html.

[f]International Union for Conservation of Nature (IUCN), https://www.iucnredlist.org/, accessed 2 July 2024.

[g]Cheng et al. (2021).

26888319, 2024, 4, Downloaded from https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12392, Wiley Online Library on [30/10/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

RIGHTSLINK Copyright Clearance Center

4.2 | Management considerations related to bat roosts

The protection of bat roosts is a major focus of bat conservation (Frick et al., 2020; Medellin et al., 2017; Meierhofer et al., 2023; The Protection of Bat Roost Guidelines Subcommittee et al., 1992). A number of published reports and reviews are available with recommendations on best practices to promote forested habitat for bats (e.g. Hayes & Loeb, 2007; Lacki et al., 2007), and these resources should be referred to when developing strategies to enhance roosting habitat. Here, we summarize general considerations to limit negative effects of vegetation management on roost habitats for temperate insectivorous bats based on our understanding of their roosting ecology. Broadly, corridor management poses potential risks to known or possible bat roosts, a topic that has not been well studied or documented. Type and magnitude of impacts to individual bat roosts are dependent on the temporal and spatial overlap of active bat roosts with the periodic, site-specific management actions that would disturb roosting bats. We focus on responding to general trends for temperate insectivorous bats, and we encourage managers to develop plans specific to their region and species of interest, and to address site-specific threats to roosting habitat, which may vary over time and space.

4.2.1 | Minimize disturbance to summer maternity colonies

The protection of maternity colonies is a key component in conserving bat populations, and is a major focus of protection in recovery plans for US endangered bat species (Bagley, 1984; Brady et al., 1982). Loss and degradation of summer forested habitat is thought to be one of the main contributing factors leading to the historic declines of *M. sodalis* in the 1960–1970s (Gardner et al., 1990; Garner & Gardner, 1992; U.S. Fish and Wildlife Service, 1983; Whitaker Jr. et al., 2002). Most temperate insectivorous bat species produce only a single pup per female annually, which sets life-history constraints and limits maximum growth rates (Barclay et al., 2003; Racey & Entwistle, 2000). Thus, the destruction of maternity tree roosts is problematic because often it involves, at a minimum, the loss of reproductive effort for an entire colony for the year. Loss of suitable roosts, even when roosts are not currently in use, can also degrade the quality of a network of potential future roosts among groups of breeding females (Bondo et al., 2019; Perry, 2011), increasing the distance travelled between roosts (Silvis et al., 2014) and disrupting the social network of a colony (Silvis et al., 2015).

The timing of vegetation management could reduce direct impacts on reproductive females and their young. Specifically, managers should avoid tree removal of active maternity roost trees. Maternity season varies with species and geographic location, but May to August broadly defines the season for insectivorous bat species in temperate North America (U.S. Fish and Wildlife Service, 2023). Bats are most vulnerable to disturbance of maternity roost trees in summer after pups are born but before they can fly, generally in June and July (U.S. Fish and Wildlife Service, 2023), although precise timing varies by species and location. Tree-clearing activities that directly impact maternity trees likely pose the greatest direct risk to maternity colonies. However, indirect impacts—which in power line corridors might include noise and chemical exposure from mowing, cutting or spraying of nearby vegetation—can also disrupt existing maternity colonies, which in severe cases could prompt abandonment of roosts (López-Roig & Serra-Cobo, 2014; Sano, 2016).

4.2.2 | Artificial and augmented roosts can be installed in power line corridors

Bats select roost trees based on several characteristics and often select larger trees as roosts, including living or dead trees with exfoliating bark, hollow limbs and crevices (Kunz, 2003). A number of species also favour snags, and the creation of snags (an 'augmented roost' generated from an existing tree) is a growing area of research (Box 1.3). Snags can be created through a variety of methods (Schroder & Ward, 2022) and have the benefit of mimicking the thermal properties of naturally occurring roosts in caves and tree cavities, making them potentially more attractive than artificial roosts such as bat boxes (Crawford & O'Keefe, 2023). One study from Australia reported a 50% occupancy rate by bats in cavities created by chainsaws (Rueegger, 2017). Because snags have a shorter lifespan than artificial roosts, they tend to require more maintenance (e.g. generation every few years) than artificial roosts (Schroder & Ward, 2022). Managers could potentially support tree-roosting bats by avoiding complete removal of desirable living trees and creating snags in dead trees when these are a limiting resource.

Artificial roosts, particularly the installation of bat boxes, are a popular means of providing roosting habitat to several bat species, including along and within power line corridors (e.g. Brack Jr. et al., 2022). Installation of artificial roosts is generally conducted as a surrogate for tree roosts (Rueegger, 2016). Provision of artificial roosts is a common low-cost strategy used in bat management in response to exclusion, disturbance or destruction of an existing roost (Holroyd et al., 2023). Because the quality of a roost site has direct influences on the survival and fitness of individual bats (Rueegger, 2016), the design (Crawford et al., 2022; Fontaine et al., 2021; Tillman et al., 2021), siting (Crawford et al., 2022; Mering & Chambers, 2014; Pschonny et al., 2022) and maintenance (Holroyd et al., 2023; Rueegger, 2016) of artificial roosts must be maximized to avoid attracting bats to unsuitable roosts (an *ecological trap*; see Battin, 2004; Holroyd et al., 2023). Bat boxes have been associated with potential disadvantages, including higher internal temperatures that are harmful to bats (Crawford & O'Keefe, 2021), and the potential for increased predation and higher parasite loads than ephemeral roosts in trees (Crawford & O'Keefe, 2023). In general,

26888319, 2024, 4, Downloaded from https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12392, Wiley Online Library on [30/10/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License
RIGHTSLINK Copyright Clearance Center

artificial roosts continue to be widely deployed with mixed success of colonization by bats (Brittingham & Williams, 2000; Hoeh et al., 2018). Additionally, artificial roosts commonly colonized by bat species that are not the target of conservation efforts. In such cases, artificial roosts might increase competition towards conservation target species (Griffiths et al., 2017; Mering & Chambers, 2014; Rueegger, 2017). The benefits of artificial roosts would be maximized by careful siting, design and deployment in locations where suitable tree roosts have been or must be removed (Box 1.3; Holroyd et al., 2023), including in power line corridors.

4.2.3 | Reduce disturbance to winter populations

Winter is a sensitive time for bats, particularly for hibernating species that use torpor to reduce energy expenditure, because disturbances can result in loss of critical fat reserves (Boyles, 2017; Speakman et al., 1991). While many hibernating bats use subterranean features during the winter, a number of species use trees (Kunz, 2003) and even leaf litter (e.g. Moorman, 1999) in the winter. There are some concerns that bats may not be able to arouse from a torpid state in time to escape disturbances in the winter months (Flinn et al., 2021), meaning management activities during this interval could have negative impacts. Timing winter vegetation management to relatively warm days and warmer times of day would decrease energetic expenditure required for bats to escape disturbance (Flinn et al., 2021; Layne et al., 2021).

5 | MANAGEMENT OF CORRIDORS FOR BAT MOVEMENT

5.1 | Bats use power line corridors as commuting flyways

Bats are sophisticated navigators that will undertake long-distance directed flights between destinations (Harten et al., 2020; Toledo et al., 2020), often using consistent routes known as 'flyways' (Bateman & Vaughan, 1974; Boere & Stroud, 2006; Schaub & Schnitzler, 2007). Forest edges and linear features are likely used as navigational cues by many species (Schaub & Schnitzler, 2007), aiding in the establishment of familiar flight paths and reducing overall commuting time (Bateman & Vaughan, 1974). Flyways are generally associated with higher bat activity levels when compared to open areas (Boughey et al., 2011; Finch et al., 2020; Harms et al., 2020), and bats generally travel closer to treelines when commuting than when foraging (Downs & Racey, 2006; Kalcounis-Rueppell et al., 2013). Linear landscape features serve as flyways for bats because edges provide navigational assistance, likely by maintaining acoustic contact (Verboom & Spoelstra, 1999), and energetically efficient routes sheltered from wind and free of obstructions (Verboom & Huitema, 1997, 2010; Verboom & Spoelstra, 1999). Some bat species strongly prefer routes tracking tall treelines, while others are less selective and follow tree and shrub lines regardless of vegetation height (Boughey et al., 2011; Downs & Racey, 2006; Finch et al., 2020). Power line corridors may act as flyways for many species, but may also present barriers to bats reluctant to cross open areas, for example, the small *M. leibii* or clutter-adapted *M. septentrionalis* (Box 1).

5.2 | Management considerations for bat commuting along power line corridors

Outside of siting considerations during installation, management of power line corridors for bat commuting will broadly be dependent on the context of known bat communities, commuting habits and surrounding environmental conditions. When possible, maintaining consistent treelines along corridors when they pass through forested habitat could maximize the navigational benefits to bats already using them as flyways. Other interventions that may benefit the movements of dispersal-limited species remain in the exploratory research phase (Box 1.5).

6 | CONCLUSIONS

There is a continued need for solutions to facilitate recovery and resilience in bat populations, particularly those affected by WNS. Power line corridors remain a pervasive and growing form of human-managed habitat in much of the world that is critical for energy infrastructure. Ecological management of power line corridors has potential to help support bat populations by promoting foraging and commuting habitat and by protecting roosts. Bat prey availability and foraging efficiency may be supported within actively maintained corridors that are periodically disturbed and result in permanent edge, open and early successional habitats. Promotion of desirable foraging habitat near roosts could increase foraging efficiency and lead to increased survival from WNS and increased reproductive success. In addition, active management of trees and instalment of artificial roosts along corridors could support at-risk bat populations.

These corridors represent hundreds of thousands of miles of managed land that could be leveraged and managed in a way to make meaningful positive impacts to bats in need of conservation assistance. To fully capitalize on the potential of power line corridors as conservation spaces, it is necessary to build a body of evidence on their conservation value and the effectiveness of management practices for bat populations. These results would serve as a critical resource in developing vegetation management strategies that might improve conditions for bat populations while meeting energy generation and transmission goals.

AUTHOR CONTRIBUTIONS

Winifred F. Frick, Christian Newman, Tina L. Cheng, Donald I. Solick, Ashley Bennett and C. J. Campbell conceived the study; Christian Newman coordinated funding to support the study; C. J. Campbell, Tina L. Cheng and Karin L. Akre designed and conducted the review;

26888319, 2024, 4, Downloaded from https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12392, Wiley Online Library on [30/10/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

RIGHTSLINK

Amanda M. Adams and Tina L. Cheng led the data synthesis within Table 1; C. J. Campbell, Tina L. Cheng and Karin L. Akre led the writing of the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

ACKNOWLEDGEMENTS

We thank Lewis Payne and two anonymous reviewers for providing helpful feedback on the manuscript.

FUNDING INFORMATION

Funding was provided by the Electric Power Research Institute (grant number 10016535) and the National Fish and Wildlife Federation (grant number 0406.21.072572).

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

No data were collected as part of this study.

ORCID

C. J. Campbell https://orcid.org/0000-0002-8199-7775
Winifred F. Frick https://orcid.org/0000-0002-9469-1839

REFERENCES

Acklen, J., & Goodrich-Mahoney, J. (2017). *Vegetation best management practices to protect birds and bats along electric transmission rights-of-way* [technical report]. Electric Power Research Institute. www.epri.com

Askins, R. A. (2001). Sustaining biological diversity in early successional communities: The challenge of managing unpopular habitats. *Wildlife Society Bulletin*, *29*(2), 407–412.

Askins, R. A., Folsom-O'Keefe, C. M., & Hardy, M. C. (2012). Effects of vegetation, corridor width and regional land use on early successional birds on powerline corridors. *PLoS One*, *7*(2), e31520. https://doi.org/10.1371/journal.pone.0031520

Augustine, D., Davidson, A., Dickinson, K., & Van Pelt, B. (2021). Thinking like a grassland: Challenges and opportunities for biodiversity conservation in the great plains of North America. *Rangeland Ecology & Management*, *78*, 281–295. https://doi.org/10.1016/j.rama.2019.09.001

Bagley, F. M. (1984). *A recovery plan for the Ozark big-eared bat and the Virginia big-eared bat*. U.S. Fish and Wildlife Service.

Barbour, R. W., & Davis, W. H. (1969). *Bats of America*. The University Press of Kentucky.

Barclay, R. M., Harder, L. D., Kunz, T. H., & Fenton, M. B. (2003). Life histories of bats: Life in the slow lane. In I. T. H. Kunz & M. B. Fenton (Eds.), *Bat ecology* (Vol. *209*, pp. 206–256). University of Chicago Press Chicago.

Bateman, G. C., & Vaughan, T. A. (1974). Nightly activities of mormoopid bats. *Journal of Mammalogy*, *55*(1), 45–65. https://doi.org/10.2307/1379256

Battin, J. (2004). When good animals love bad habitats: Ecological traps and the conservation of animal populations. *Conservation Biology*, *18*(6), 1482–1491. https://doi.org/10.1111/j.1523-1739.2004.00417.x

Beilke, E. A., Blakey, R. V., & O'Keefe, J. M. (2021). Bats partition activity in space and time in a large, heterogeneous landscape. *Ecology and Evolution*, *11*, 6513–6526. https://doi.org/10.1002/ece3.7504

Berg, Å., Ahrné, K., Öckinger, E., Svensson, R., & Söderström, B. (2011). Butterfly distribution and abundance is affected by variation in the Swedish forest-farmland landscape. *Biological Conservation*, *144*(12), 2819–2831. https://doi.org/10.1016/j.biocon.2011.07.035

Berg, Å., Ahrné, K., Öckinger, E., Svensson, R., & Wissman, J. (2013). Butterflies in semi-natural pastures and power-line corridors—Effects of flower richness, management, and structural vegetation characteristics. *Insect Conservation and Diversity*, *6*(6), 639–657. https://doi.org/10.1111/icad.12019

Bernard, R. F., Willcox, E. V., Jackson, R. T., Brown, V. A., & McCracken, G. F. (2021). Feasting, not fasting: Winter diets of cave hibernating bats in the United States. *Frontiers in Zoology*, *18*, 1–13.

Berthinussen, A., & Altringham, J. (2012). Do bat gantries and underpasses help bats cross roads safely? *PLoS One*, *7*(6), e38775. https://doi.org/10.1371/journal.pone.0038775

Boere, G. C., & Stroud, D. A. (2006). The flyway concept: What it is and what it isn't. In D. B. A. Thompson & L. G. Underhill (Eds.), *Waterbirds around the world* (pp. 40–47). The Stationery Office Edinburgh.

Bondo, K. J., Willis, C. K. R., Metheny, J. D., Kilgour, R. J., Gillam, E. H., Kalcounis-Rueppell, M. C., & Brigham, R. M. (2019). Bats relocate maternity colony after the natural loss of roost trees. *The Journal of Wildlife Management*, *83*(8), 1753–1761. https://doi.org/10.1002/jwmg.21751

Borer, E. T., Seabloom, E. W., & Tilman, D. (2012). Plant diversity controls arthropod biomass and temporal stability. *Ecology Letters*, *15*(12), 1457–1464. https://doi.org/10.1111/ele.12006

Boughey, K. L., Lake, I. R., Haysom, K. A., & Dolman, P. M. (2011). Improving the biodiversity benefits of hedgerows: How physical characteristics and the proximity of foraging habitat affect the use of linear features by bats. *Biological Conservation*, *144*(6), 1790–1798. https://doi.org/10.1016/j.biocon.2011.02.017

Boyles, J. G. (2017). Benefits of knowing the costs of disturbance to hibernating bats. *Wildlife Society Bulletin*, *41*(2), 388–392. https://doi.org/10.1002/wsb.755

Brack, V., Jr., Sparks, D. W., & Kennedy, S., Jr. (2022). *Case study: Upland ponds provide on-site mitigation for bat habitat along American electric Power's 765-kV powerline ROW in the Appalachian Mountains, USA*. IntechOpen. https://doi.org/10.5772/intechopen.109061

Brack, V. (2006). Autumn activity of *Myotis sodalis* (Indiana bat) in Bland County, Virginia. *Northeastern Naturalist*, *13*(3), 421–434. https://doi.org/10.1656/1092-6194(2006)13[421:AAOMSI]2.0.CO;2

Brady, J., Kunz, T., Merlin, T., & Wilson, D. (1982). *Gray bat recovery plan*. U.S. Fish and Wildlife Service.

Brittingham, M. C., & Williams, L. M. (2000). Bat boxes as alternative roosts for displaced bat maternity colonies. *Wildlife Society Bulletin*, *28*(1), 197–207. https://www.jstor.org/stable/4617303

Brooks, J. D., Loeb, S. C., & Gerard, P. D. (2017). Effect of forest opening characteristics, prey abundance, and environmental factors on bat activity in the Southern Appalachians. *Forest Ecology and Management*, *400*, 19–27.

Burford, L. S., Lacki, M. J., & Covell, C. V., Jr. (1999). Occurrence of moths among habitats in a mixed mesophytic forest: Implications for management of forest bats. *Forest Science*, *45*(3), 323–332. https://doi.org/10.1093/forestscience/45.3.323

Burrell, G. E., & Bergeson, S. M. (2022). Roosting behavior of northern long-eared bats (*Myotis septentrionalis*) in an urban-adjacent forest fragment. *Forests*, *13*(12), 1972. https://doi.org/10.3390/f13121972

Cable, A. B., O'Keefe, J. M., Deppe, J. L., Hohoff, T. C., Taylor, S. J., & Davis, M. A. (2021). Habitat suitability and connectivity modeling reveal priority areas for Indiana bat (*Myotis sodalis*) conservation in a complex habitat mosaic. *Landscape Ecology*, *36*(1), 119–137. https://doi.org/10.1007/s10980-020-01125-2

26888319, 2024, 4, Downloaded from https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12392, Wiley Online Library on [30/10/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Cable, A. B., Willcox, E. V., & Leppanen, C. (2022). Contaminant exposure as an additional stressor to bats affected by white-nose syndrome: Current evidence and knowledge gaps. *Ecotoxicology*, *31*(1), 12–23.

Callahan, E. V., Drobney, R. D., & Clawson, R. L. (1997). Selection of summer roosting sites by Indiana bats (*Myotis sodalis*) in Missouri. *Journal of Mammalogy*, *78*(3), 818–825. https://doi.org/10.2307/1382939

Campbell, L. A., Hallett, J. G., & O'Connell, M. A. (1996). Conservation of bats in managed forests: Use of roosts by *Lasionycteris noctivagans*. *Journal of Mammalogy*, *77*(4), 976–984. https://doi.org/10.2307/1382778

Carter, T. C., & Feldhamer, G. A. (2005). Roost tree use by maternity colonies of Indiana bats and northern long-eared bats in southern Illinois. *Forest Ecology and Management*, *219*(2), 259–268. https://doi.org/10.1016/j.foreco.2005.08.049

Cheng, T. L., Reichard, J. D., Coleman, J. T. H., Weller, T. J., Thogmartin, W. E., Reichert, B. E., Bennett, A. B., Broders, H. G., Campbell, J., Etchison, K., Feller, D. J., Geboy, R., Hemberger, T., Herzog, C., Hicks, A. C., Houghton, S., Humber, J., Kath, J. A., King, R. A., … Frick, W. F. (2021). The scope and severity of white-nose syndrome on hibernating bats in North America. *Conservation Biology*, *35*, 1586–1597. https://doi.org/10.1111/cobi.13739

Claireau, F., Bas, Y., Julien, J.-F., Machon, N., Allegrini, B., Puechmaille, S. J., & Kerbiriou, C. (2019). Bat overpasses as an alternative solution to restore habitat connectivity in the context of road requalification. *Ecological Engineering*, *131*, 34–38. https://doi.org/10.1016/j.ecoleng.2019.02.011

Clare, E. L., Fraser, E. E., Braid, H. E., Fenton, M. B., & Hebert, P. D. N. (2009). Species on the menu of a generalist predator, the eastern red bat (*Lasiurus borealis*): Using a molecular approach to detect arthropod prey. *Molecular Ecology*, *18*(11), 2532–2542. https://doi.org/10.1111/j.1365-294X.2009.04184.x

Clare, E. L., Symondson, W. O. C., Broders, H., Fabianek, F., Fraser, E. E., Mackenzie, A., Boughen, A., Hamilton, R., Willis, C. K. R., Martinez-Nuñez, F., Menzies, A. K., Norquay, K. J. O., Brigham, M., Poissant, J., Rintoul, J., Barclay, R. M. R., & Reimer, J. P. (2014). The diet of *Myotis lucifugus* across Canada: Assessing foraging quality and diet variability. *Molecular Ecology*, *23*(15), 3618–3632. https://doi.org/10.1111/mec.12542

Clare, E. L., Symondson, W. O. C., & Fenton, M. B. (2014). An inordinate fondness for beetles? Variation in seasonal dietary preferences of night-roosting big brown bats (*Eptesicus fuscus*). *Molecular Ecology*, *23*(15), 3633–3647. https://doi.org/10.1111/mec.12519

Confer, J. L., & Pascoe, S. M. (2003). Avian communities on utility rights-of-ways and other managed shrublands in the northeastern United States. *Forest Ecology and Management*, *185*(1), 193–205. https://doi.org/10.1016/S0378-1127(03)00255-X

Crawford, R. D., Dodd, L. E., Tillman, F. E., & O'Keefe, J. M. (2022). Evaluating bat boxes: Design and placement alter bioenergetic costs and overheating risk. *Conservation Physiology*, *10*(1), coac027. https://doi.org/10.1093/conphys/coac027

Crawford, R. D., & O'Keefe, J. M. (2021). Avoiding a conservation pitfall: Considering the risks of unsuitably hot bat boxes. *Conservation Science and Practice*, *3*(6), e412. https://doi.org/10.1111/csp2.412

Crawford, R. D., & O'Keefe, J. M. (2023). Improving the science and practice of using artificial roosts for bats. *Conservation Biology*, *38*, e14170. https://doi.org/10.1111/cobi.14170

Deans, A. M., Malcolm, J. R., Smith, S. M., & Bellocq, M. I. (2005). Edge effects and the responses of aerial insect assemblages to structural-retention harvesting in Canadian boreal peatland forests. *Forest Ecology and Management*, *204*(2), 249–266. https://doi.org/10.1016/j.foreco.2004.09.015

Dodd, L. E., Lacki, M. J., Britzke, E. R., Buehler, D. A., Keyser, P. D., Larkin, J. L., Rodewald, A. D., Wigley, T. B., Wood, P. B., & Rieske, L. K. (2012). Forest structure affects trophic linkages: How silvicultural disturbance impacts bats and their insect prey. *Forest Ecology and Management*, *267*, 262–270. https://doi.org/10.1016/j.foreco.2011.12.016

Dodd, L. E., Lacki, M. J., & Rieske, L. K. (2008). Variation in moth occurrence and implications for foraging habitat of Ozark big-eared bats. *Forest Ecology and Management*, *255*(11), 3866–3872. https://doi.org/10.1016/j.foreco.2008.03.034

Downs, N. C., & Racey, P. A. (2006). The use by bats of habitat features in mixed farmland in Scotland. *Acta Chiropterologica*, *8*(1), 169–185.

Ebeling, A., Hines, J., Hertzog, L. R., Lange, M., Meyer, S. T., Simons, N. K., & Weisser, W. W. (2018). Plant diversity effects on arthropods and arthropod-dependent ecosystem functions in a biodiversity experiment. *Basic and Applied Ecology*, *26*, 50–63. https://doi.org/10.1016/j.baae.2017.09.014

Eldegard, K., Totland, Ø., & Moe, S. R. (2015). Edge effects on plant communities along power line clearings. *Journal of Applied Ecology*, *52*(4), 871–880. https://doi.org/10.1111/1365-2664.12460

Erasmy, M., Leuschner, C., Balkenhol, N., & Dietz, M. (2021). Shed light in the dark—How do natural canopy gaps influence temperate bat diversity and activity? *Forest Ecology and Management*, *497*, 119509. https://doi.org/10.1016/j.foreco.2021.119509

Everette, A. L., O'Shea, T. J., Ellison, L. E., Stone, L. A., & McCance, J. L. (2001). Bat use of a high-plains urban wildlife refuge. *Wildlife Society Bulletin*, *29*(3), 967–973.

Finch, D., Schofield, H., & Mathews, F. (2020). Habitat associations of bats in an agricultural landscape: Linear features versus open habitats. *Animals*, *10*(10), 1856. https://doi.org/10.3390/ani10101856

Fletcher, R. J., Jr. (2005). Multiple edge effects and their implications in fragmented landscapes. *Journal of Animal Ecology*, *74*(2), 342–352. https://doi.org/10.1111/j.1365-2656.2005.00930.x

Flinn, J. R., Perry, R. W., & Robbins, L. W. (2021). Winter roosting by eastern red bats in Ozark Mountain Forests of Missouri. *Forests*, *12*(12), 1769. https://doi.org/10.3390/f12121769

Fontaine, A., Simard, A., Dubois, B., Dutel, J., & Elliott, K. H. (2021). Using mounting, orientation, and design to improve bat box thermodynamics in a northern temperate environment. *Scientific Reports*, *11*(1), 7728. https://doi.org/10.1038/s41598-021-87327-3

Forrester, J. A., Leopold, D. J., & Hafner, S. D. (2005). Maintaining critical habitat in a heavily managed landscape: Effects of power line corridor management on Karner blue butterfly (*Lycaeides melissa samuelis*) habitat. *Restoration Ecology*, *13*(3), 488–498. https://doi.org/10.1111/j.1526-100X.2005.00061.x

Frick, W. F., Dzal, Y. A., Jonasson, K. A., Whitby, M. D., Adams, A. M., Long, C., Depue, J. E., Newman, C. M., Willis, C. K. R., & Cheng, T. L. (2023). Bats increased foraging activity at experimental prey patches near hibernacula. *Ecological Solutions and Evidence*, *4*(1), e12217. https://doi.org/10.1002/2688-8319.12217

Frick, W. F., Kingston, T., & Flanders, J. (2020). A review of the major threats and challenges to global bat conservation. *Annals of the New York Academy of Sciences*, *0*, 5–25. https://doi.org/10.1111/nyas.14045

Frick, W. F., Rainey, W. E., & Pierson, E. D. (2007). Potential effects of environmental contamination on yuma myotis demography and population growth. *Ecological Applications*, *17*(4), 1213–1222. https://doi.org/10.1890/06-1021

Gardner, J. E., Garner, J. D., & Hofmann, J. E. (1990). *Ecological aspects of summer roost selection and roosting behavior of Myotis sodalis (Indiana bat) in Illinois*. Illinois Natural History Survey and Illinois Department of Conservation.

Garfinkel, M., Hosler, S., Whelan, C., & Minor, E. (2022). Powerline corridors can add ecological value to suburban landscapes when not maintained as lawn. *Sustainability*, *14*(12), 7113. https://doi.org/10.3390/su14127113

26888319, 2024, 4, Downloaded from https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12392, Wiley Online Library on [30/10/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Garner, J. D., & Gardner, J. E. (1992). *Determination of summer distribution and habitat utilization of the Indiana bat (Myotis sodalis) in Illinois*. Division of Natural Heritage, Illinois Department of Conservation. https://www.ideals.illinois.edu/items/10339/bitstreams/37837/object

Griffiths, S. R., Bender, R., Godinho, L. N., Lentini, P. E., Lumsden, L. F., & Robert, K. A. (2017). Bat boxes are not a silver bullet conservation tool. *Mammal Review*, *47*(4), 261–265.

Grindal, S. D., & Brigham, R. M. (1999). Impacts of forest harvesting on habitat use by foraging insectivorous bats at different spatial scales. *Écoscience*, *6*(1), 25–34. https://doi.org/10.1080/11956860.1999.11952206

Harms, K., Omondi, E., & Mukherjee, A. (2020). Investigating bat activity in various agricultural landscapes in Northeastern United States. *Sustainability*, *12*(5), 1959. https://doi.org/10.3390/su12051959

Harten, L., Katz, A., Goldshtein, A., Handel, M., & Yovel, Y. (2020). The ontogeny of a mammalian cognitive map in the real world. *Science*, *369*(6500), 194–197. https://doi.org/10.1126/science.aay3354

Hayes, J. P., & Loeb, S. C. (2007). The influences of forest management on bats in North America. In M. J. Lacki, J. P. Hayes, & A. Kurta (Eds.), *Bats in forests: Conservation and management* (pp. 207–235). Johns Hopkins University Press.

Hein, C. D., Castleberry, S. B., & Miller, K. V. (2009). Site-occupancy of bats in relation to forested corridors. *Forest Ecology and Management*, *257*(4), 1200–1207. https://doi.org/10.1016/j.foreco.2008.09.054

Hoeh, J. P. S., Bakken, G. S., Mitchell, W. A., & O'Keefe, J. M. (2018). In artificial roost comparison, bats show preference for rocket box style. *PLoS One*, *13*(10), e0205701. https://doi.org/10.1371/journal.pone.0205701

Holroyd, S., Lausen, C., Dulc, S., De Freitas, E., Crawford, R., O'Keefe, J. O. I. U.-C., Boothe, C., & Segeres, J. (2023). *Best management practices for the use of bat houses in the US and Canada*. https://doi.org/10.7944/P99K4BF5

Hooper, S. E., Amelon, S. K., & Lin, C.-H. (2022). Development of an LC-MS/MS method for non-invasive biomonitoring of neonicotinoid and systemic herbicide pesticide residues in bat hair. *Toxics*, *10*(2), Article 2. https://doi.org/10.3390/toxics10020073

Hopwood, J., Black, S. H., Lee-Mäder, E., Charlap, A., Preston, R., Mozumder, K., & Fleury, S. (2015). *Pollinator habitat enhancement and best management practices in highway rights-of-way*. The Xerces Society for Invertebrate Conservation in collaboration with ICF International. https://xerces.org/sites/default/files/2018-05/15-055_01_pollinators_BMPs_in_highway_ROW.pdf

Hunter, E. A., Dwire, A., & Schneider, T. M. (2022). *Demography and site fidelity of a grassland bird, the Henslow's Sparrow, in powerline right-of-way habitat*. https://doi.org/10.5751/JFO-00077-930109

Iknayan, K. J., Tingley, M. W., Furnas, B. J., & Beissinger, S. R. (2014). Detecting diversity: Emerging methods to estimate species diversity. *Trends in Ecology & Evolution*, *29*(2), 97–106. https://doi.org/10.1016/j.tree.2013.10.012

Ingala, M. R., Simmons, N. B., Wultsch, C., Krampis, K., Provost, K. L., & Perkins, S. L. (2021). Molecular diet analysis of neotropical bats based on fecal DNA metabarcoding. *Ecology and Evolution*, *11*(12), 7474–7491.

Johnson, G., & Strickland, D. (2004). *An assessment of potential collision mortality of migrating Indiana bats (Myotis sodalis) and Virginia big-eared bats (Corynorhinus townsendii virginianus) traversing between caves*. Western Ecosystem Technologies, Inc.

Johnson, J. S., & Lacki, M. J. (2013). Habitat associations of Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) and their lepidopteran prey in bottomland hardwood forests. *Canadian Journal of Zoology*, *91*(2), 94–101. https://doi.org/10.1139/cjz-2012-0248

Jones, G., Jacobs, D. S., Kunz, T. H., Wilig, M. R., & Racey, P. A. (2009). Carpe noctem: The importance of bats as bioindicators. *Endangered Species Research*, *8*(1–2), 93–115. https://doi.org/10.3354/esr00182

Kalcounis-Rueppell, M. C., Briones, K. M., Homyack, J. A., Petric, R., Marshall, M. M., & Miller, D. A. (2013). Hard forest edges act as conduits, not filters, for bats. *Wildlife Society Bulletin*, *37*(3), 571–576. https://doi.org/10.1002/wsb.289

Kalcounis-Rueppell, M. C., Payne, V. H., Huff, S. R., & Boyko, A. L. (2007). Effects of wastewater treatment plant effluent on bat foraging ecology in an urban stream system. *Biological Conservation*, *138*(1), 120–130. https://doi.org/10.1016/j.biocon.2007.04.009

King, D. I., & Byers, B. E. (2002). An evaluation of powerline rights-of-way as habitat for early-successional shrubland birds. *Wildlife Society Bulletin*, *30*(3), 868–874.

King, D. I., Chandler, R. B., Collins, J. M., Petersen, W. R., & Lautzenheiser, T. E. (2009). Effects of width, edge and habitat on the abundance and nesting success of scrub–shrub birds in powerline corridors. *Biological Conservation*, *142*(11), 2672–2680. https://doi.org/10.1016/j.biocon.2009.06.016

Kovács-Hostyánszki, A., Espíndola, A., Vanbergen, A. J., Settele, J., Kremen, C., & Dicks, L. V. (2017). Ecological intensification to mitigate impacts of conventional intensive land use on pollinators and pollination. *Ecology Letters*, *20*(5), 673–689. https://doi.org/10.1111/ele.12762

Kroodsma, R. L. (1982). Edge effect on breeding forest birds along a power-line corridor. *Journal of Applied Ecology*, *19*(2), 361–370. https://doi.org/10.2307/2403473

Kunz, T. H. (2003). Roosting ecology of bats. In T. H. Kunz & B. M. Fenton (Eds.), *Ecology of bats* (pp. 1–55). Springer. https://doi.org/10.1007/978-1-4613-3421-7_1

Kuzukiran, O., Simsek, I., Yorulmaz, T., Yurdakok-Dikmen, B., Ozkan, O., & Filazi, A. (2021). Multiresidues of environmental contaminants in bats from Turkey. *Chemosphere*, *282*, 131022. https://doi.org/10.1016/j.chemosphere.2021.131022

Lacki, M. J., Hayes, J. P., & Kurta, A. (2007). *Bats in forests: Conservation and management*. JHU Press.

Lampinen, J., Ruokolainen, K., & Huhta, A.-P. (2015). Urban power line corridors as novel habitats for grassland and alien plant species in South-Western Finland. *PLoS One*, *10*(11), e0142236. https://doi.org/10.1371/journal.pone.0142236

Lausen, C. L., & Barclay, R. M. R. (2006). Winter bat activity in the Canadian prairies. *Canadian Journal of Zoology*, *84*(8), 1079–1086. https://doi.org/10.1139/z06-093

Layne, J. T., Green, D., Scesny, A., & Robbins, L. W. (2021). Eastern red bat responses to fire during winter torpor. *Forests*, *12*(10), 1347. https://doi.org/10.3390/f12101347

Leput, D. (2004). *Eastern red bat (Lasiurus borealis) and eastern pipistrelle (Pipistrellus subflavus) maternal roost selection: Implications for forest management*. Master's thesis. Clemson University. https://tigerprints.clemson.edu/arv_theses/5446

Li, H., & Kalcounis-Rueppell, M. (2018). Separating the effects of water quality and urbanization on temperate insectivorous bats at the landscape scale. *Ecology and Evolution*, *8*(1), 667–678. https://doi.org/10.1002/ece3.3693

Loeb, S. C., & O'Keefe, J. M. (2006). Habitat use by forest bats in South Carolina in relation to local, stand, and landscape characteristics. *The Journal of Wildlife Management*, *70*(5), 1210–1218. https://doi.org/10.2193/0022-541X(2006)70[1210:HUBFBI]2.0.CO;2

Loeb, S. C., & O'Keefe, J. M. (2011). Bats and gaps: The role of early successional patches in the roosting and foraging ecology of bats. In C. Greenberg, B. Collins, & F. Thompson, III (Eds.), *Sustaining young forest communities: Ecology and management of early successional habitats in the central hardwood region, USA* (pp. 167–189). Springer. https://doi.org/10.1007/978-94-007-1620-9_10

26888319, 2024, 4, Downloaded from https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12392, Wiley Online Library on [30/10/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

López-Roig, M., & Serra-Cobo, J. (2014). Impact of human disturbance, density, and environmental conditions on the survival probabilities of pipistrelle bat (*Pipistrellus pipistrellus*). *Population Ecology*, *56*(3), 471–480. https://doi.org/10.1007/s10144-014-0437-2

Mager, K. J., & Nelson, T. A. (2001). Roost-site selection by eastern red bats (*Lasiurus borealis*). *The American Midland Naturalist*, *145*(1), 120–126. https://doi.org/10.1674/0003-0031(2001)145[0120:RSSBER]2.0.CO;2

Martín, J., Gonkowski, S., Kortas, A., Sobiech, P., Rytel, L., Santos, J. L., Aparicio, I., & Alonso, E. (2023). Multiclass method to determine emerging pollutants in bats using a non-invasive approach based on guano matrix. *Microchemical Journal*, *188*, 108486. https://doi.org/10.1016/j.microc.2023.108486

Medellin, R. A., Wiederholt, R., & Lopez-Hoffman, L. (2017). Conservation relevance of bat caves for biodiversity and ecosystem services. *Biological Conservation*, *211*, 45–50. https://doi.org/10.1016/j.biocon.2017.01.012

Meierhofer, M. B., Johnson, J. S., Perez-Jimenez, J., Ito, F., Webela, P. W., Wiantoro, S., Bernard, E., Tanalgo, K. C., Hughes, A., Cardoso, P., Lilley, T., & Mammola, S. (2023). Effective conservation of subterranean-roosting bats. *Conservation Biology*, *38*(1), e14157. https://doi.org/10.1111/cobi.14157

Menzel, M. A., Menzel, J. M., Carter, T. C., Ford, W. M., & Edwards, J. W. (2001). *Review of the forest habitat relationships of the Indiana bat (Myotis sodalis)*. U.S. Department of Agriculture, Forest Service, Northeastern Research Station.

Menzel, M. A., Owen, S. F., Ford, W. M., Edwards, J. W., Wood, P. B., Chapman, B. R., & Miller, K. V. (2002). Roost tree selection by northern long-eared bat (*Myotis septentrionalis*) maternity colonies in an industrial forest of the central Appalachian mountains. *Forest Ecology and Management*, *155*(1), 107–114. https://doi.org/10.1016/S0378-1127(01)00551-5

Mering, E. D., & Chambers, C. L. (2014). Thinking outside the box: A review of artificial roosts for bats. *Wildlife Society Bulletin*, *38*(4), 741–751. https://doi.org/10.1002/wsb.461

Miller, R. H. (2021). *Best management practices: Integrated vegetation management for utility rights-of-way*. International Society of Arboriculture.

Moorman, C. E. (1999). Bats roosting in deciduous leaf litter. *Bat Research News*, *40*, 74–75.

Morris, A. D., Miller, D. A., & Kalcounis-Rueppell, M. C. (2010). Use of forest edges by bats in a managed pine forest landscape. *The Journal of Wildlife Management*, *74*(1), 26–34. https://doi.org/10.2193/2008-471

Murcia, C. (1995). Edge effects in fragmented forests: Implications for conservation. *Trends in Ecology & Evolution*, *10*(2), 58–62. https://doi.org/10.1016/S0169-5347(00)88977-6

Nicholls, C. I., & Altieri, M. A. (2013). Plant biodiversity enhances bees and other insect pollinators in agroecosystems. A review. *Agronomy for Sustainable Development*, *33*(2), 257–274. https://doi.org/10.1007/s13593-012-0092-y

Niering, W. A., & Goodwin, R. H. (1974). Creation of relatively stable shrublands with herbicides: Arresting "succession" on rights-of-way and pastureland. *Ecology*, *55*(4), 784–795. https://doi.org/10.2307/1934414

North American Electric Reliability Corporation. (2020). *Transmission Vegetation Management (FAC-003-5)*. https://www.nerc.com/pa/Stand/Project%20201509%20Establish%20and%20Communicate%20System%20Op/2015-09_FAC-003-5%20-%20clean.pdf

Nowak, C. A., & Ballard, B. D. (2005). A framework for applying integrated vegetation management on rights-of-way. *Arboriculture & Urban Forestry*, *31*(1), 28–37.

O'Keefe, J. M., Loeb, S. C., Lanham, J. D., & Hill, H. S. (2009). Macrohabitat factors affect day roost selection by eastern red bats and pipistrelles in the southern Appalachian Mountains, USA. *Forest Ecology and Management*, *257*(8), 1757–1763. https://doi.org/10.1016/j.foreco.2009.01.037

Oki, K., Soga, M., Amano, T., & Koike, S. (2021). Power line corridors in conifer plantations as important habitats for butterflies. *Journal of Insect Conservation*, *25*(5), 829–840. https://doi.org/10.1007/s10841-021-00343-6

O'Shea, T. J., Cryan, P. M., Hayman, D. T. S., Plowright, R. K., & Streicker, D. G. (2016). Multiple mortality events in bats: A global review. *Mammal Review*, *2016*, 175–190. https://doi.org/10.1111/mam.12064

O'Shea, T. J., Ellison, L. E., & Stanley, T. R. (2004). Survival estimation in bats: Historical overview, critical appraisal, and suggestions for new approaches. In W. Thompson (Ed.), *Sampling rare or elusive species: Concepts, designs, and techniques for estimating population parameters* (pp. 297–336). Island Press.

Owen, S. F., Menzel, M. A., Edwards, J. W., Ford, W. M., Menzel, J. M., Chapman, B. R., Wood, P. B., & Miller, K. V. (2004). Bat activity in harvested and intact forest stands in the Allegheny mountains. *Northern Journal of Applied Forestry*, *21*(3), 154–159. https://doi.org/10.1093/njaf/21.3.154

Patriquin, K. J., & Barclay, R. M. R. (2003). Foraging by bats in cleared, thinned and unharvested boreal forest. *Journal of Applied Ecology*, *40*(4), 646–657. https://doi.org/10.1046/j.1365-2664.2003.00831.x

Perry, R. W. (2011). Fidelity of bats to forest sites revealed from mist-netting recaptures. *Journal of Fish and Wildlife Management*, *2*(1), 112–116. https://doi.org/10.3996/082010-JFWM-030

Perry, R. W., Thill, R. E., & Leslie, D. M., Jr. (2008). Scale-dependent effects of landscape structure and composition on diurnal roost selection by Forest bats. *The Journal of Wildlife Management*, *72*(4), 913–925. https://doi.org/10.2193/2006-435

Pschonny, S., Leidinger, J., Leitl, R., & Weisser, W. W. (2022). What makes a good bat box? How box occupancy depends on box characteristics and landscape-level variables. *Ecological Solutions and Evidence*, *3*(1), e12136. https://doi.org/10.1002/2688-8319.12136

Racey, P. A., & Entwistle, A. C. (2000). Life-history and reproductive strategies of bats. In E. G. Crichton & P. H. Krutzsch (Eds.), *Reproductive biology of bats* (pp. 363–414). Academic Press. https://doi.org/10.1016/B978-012195670-7/50010-2

Rancourt, S. J., Rule, M. I., & O'Connell, M. A. (2005). Maternity roost site selection of long-eared myotis, *Myotis evotis*. *Journal of Mammalogy*, *86*(1), 77–84. https://doi.org/10.1644/1545-1542(2005)086<0077:MRSSOL>2.0.CO;2

Rice, J., Seixas, C. S., Zaccagnini, M. E., Bedoya-Gaitán, M., Valderrama, N., Anderson, C. B., Arroyo, M. T. K., Bustamante, M., Cavender-Bares, J., Diaz-de-Leon, A., Fennessy, S., García Márquez, J. R., Garcia, K., Helmer, E. H., Herrera, B., Klatt, B., Rodríguez Osuna, V., Scarano, F. R., … Farinaci, J. S. (Eds.). (2018). *IPBES (2018): Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for the Americas of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. IPBES.

Ries, L., Fletcher, R. J., Battin, J., & Sisk, T. D. (2004). Ecological responses to habitat edges: Mechanisms, models, and variability explained. *Annual Review of Ecology, Evolution, and Systematics*, *35*(1), 491–522. https://doi.org/10.1146/annurev.ecolsys.35.112202.130148

Ries, L., & Sisk, T. D. (2010). What is an edge species? The implications of sensitivity to habitat edges. *Oikos*, *119*(10), 1636–1642. https://doi.org/10.1111/j.1600-0706.2010.18414.x

Rueegger, N. (2016). Bat boxes—A review of their use and application, past, present and future. *Acta Chiropterologica*, *18*(1), 279–299. https://doi.org/10.3161/15081109ACC2016.18.1.017

Rueegger, N. (2017). Artificial tree hollow creation for cavity-using wildlife—Trialling an alternative method to that of nest boxes. *Forest*

26888319, 2024, 4, Downloaded from https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12392, Wiley Online Library on [30/10/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

RIGHTSLINK

Ecology and Management, *405*, 404–412. https://doi.org/10.1016/j.foreco.2017.09.062

Russell, K. N., Ikerd, H., & Droege, S. (2005). The potential conservation value of unmowed powerline strips for native bees. *Biological Conservation*, *124*(1), 133–148. https://doi.org/10.1016/j.biocon.2005.01.022

Russo, L., Stout, H., Roberts, D., Ross, B. D., & Mahan, C. G. (2021). Powerline right-of-way management and flower-visiting insects: How vegetation management can promote pollinator diversity. *PLoS One*, *16*(1), e0245146. https://doi.org/10.1371/journal.pone.0245146

Sano, A. (2016). Fission and reorganization of maternity colonies by human disturbance in the greater horseshoe bat, *Rhinolophus ferrumequinum*. *Mammal Study*, *41*(4), 239–243. https://doi.org/10.3106/041.041.0409

Saugey, D., Heath, D., & Heidt, G. (1989). Bats of the Ouachita Mountains. *Journal of the Arkansas Academy of Science*, *43*(1), 71–77.

Schanzer, S., Koch, M., Kiefer, A., Jentke, T., Veith, M., Bracher, F., Bracher, J., & Müller, C. (2022). Analysis of pesticide and persistent organic pollutant residues in German bats. *Chemosphere*, *305*, 135342. https://doi.org/10.1016/j.chemosphere.2022.135342

Schaub, A., & Schnitzler, H.-U. (2007). Flight and echolocation behaviour of three vespertilionid bat species while commuting on flyways. *Journal of Comparative Physiology A*, *193*(12), 1185–1194. https://doi.org/10.1007/s00359-007-0269-z

Scherber, C., Eisenhauer, N., Weisser, W. W., Schmid, B., Voigt, W., Fischer, M., Schulze, E.-D., Roscher, C., Weigelt, A., Allan, E., Beßler, H., Bonkowski, M., Buchmann, N., Buscot, F., Clement, L. W., Ebeling, A., Engels, C., Halle, S., Kertscher, I., … Tscharntke, T. (2010). Bottom-up effects of plant diversity on multitrophic interactions in a biodiversity experiment. *Nature*, *468*(7323), 553–556. https://doi.org/10.1038/nature09492

Schroder, E. S., & Ward, R. L. (2022). Tree girdling for potential bat roost creation in Northwestern West Virginia. *Forests*, *13*(2), 274. https://doi.org/10.3390/f13020274

Sheridan, P. M., Orzell, S. L., & Bridges, E. L. (1997). Powerline easements as refugia for state rare seepage and pineland plant taxa. *Aster*, *5*, S3.

Silvis, A., Ford, W. M., & Britzke, E. R. (2015). Effects of hierarchical roost removal on northern long-eared bat (*Myotis septentrionalis*) maternity colonies. *PLoS One*, *10*(1), e0116356. https://doi.org/10.1371/journal.pone.0116356

Silvis, A., Ford, W. M., Britzke, E. R., & Johnson, J. B. (2014). Association, roost use and simulated disruption of *Myotis septentrionalis* maternity colonies. *Behavioural Processes*, *103*, 283–290. https://doi.org/10.1016/j.beproc.2014.01.016

Slough, B. G., Reid, D. G., Schultz, D. S., & Leung, M. C.-Y. (2023). Little brown bat activity patterns and conservation implications in agricultural landscapes in boreal Yukon, Canada. *Ecosphere*, *14*(3), e4446. https://doi.org/10.1002/ecs2.4446

Soanes, K., Rytwinski, T., Fahrig, L., Huijser, M. P., Jaeger, J. A. G., Teixeira, F. Z., van der Ree, R., & van der Grift, E. A. (2024). Do wildlife crossing structures mitigate the barrier effect of roads on animal movement? A global assessment. *Journal of Applied Ecology*, *61*, 417–430. https://doi.org/10.1111/1365-2664.14582

Speakman, J. R., Webb, P. I., & Racey, P. A. (1991). Effects of disturbance on the energy expenditure of hibernating bats. *Journal of Applied Ecology*, *28*(3), 1087–1104. https://doi.org/10.2307/2404227

Starbuck, C. A., Amelon, S. K., & Thompson, F. R., III. (2015). Relationships between bat occupancy and habitat and landscape structure along a savanna, woodland, forest gradient in the Missouri Ozarks. *Wildlife Society Bulletin*, *39*(1), 20–30. https://doi.org/10.1002/wsb.512

Swab, R. M., Lorenz, N., Byrd, S., & Dick, R. (2017). Native vegetation in reclamation: Improving habitat and ecosystem function through using prairie species in mine land reclamation. *Ecological Engineering*, *108*, 525–536. https://doi.org/10.1016/j.ecoleng.2017.05.012

Swingen, M., Moen, R., Walker, M., Baker, R., Nordquist, G., Catton, T., Kirschbaum, K., Dirks, B., & Dietz, N. (2018). *Northern long-eared bat roost tree characteristics 2015–2017*. https://conservancy.umn.edu/handle/11299/204334

Tella, J. L., Hernández-Brito, D., Blanco, G., & Hiraldo, F. (2020). Urban sprawl, food subsidies and power lines: An ecological trap for large frugivorous bats in Sri Lanka? *Diversity*, *12*(3), 94. https://doi.org/10.3390/d12030094

The Protection of Bat Roost Guidelines Subcommittee, Sheffield, S. R., Shaw, J. H., Heidt, G. A., & McClenaghan, L. R. (1992). Guidelines for the protection of bat roosts. *Journal of Mammalogy*, *73*(3), 707–710. https://doi.org/10.2307/1382051

Tillman, F. E., Bakken, G. S., & O'Keefe, J. M. (2021). Design modifications affect bat box temperatures and suitability as maternity habitat. *Ecological Solutions and Evidence*, *2*(4), e12112. https://doi.org/10.1002/2688-8319.12112

Toledo, S., Shohami, D., Schiffner, I., Lourie, E., Orchan, Y., Bartan, Y., & Nathan, R. (2020). Cognitive map–based navigation in wild bats revealed by a new high-throughput tracking system. *Science*, *369*(6500), 188–193. https://doi.org/10.1126/science.aax6904

Tree Care Industry Association, Inc. (2012). *Tree, shrub, and other woody plant management standard practices: Integrated vegetation management A. Utility rights-of-way (A300 (Part 7)-2012; American National Standard for Tree Care Operations)*. https://west-chester.com/DocumentCenter/View/10144/A300-7

Turk, J. R. (2015). Assessing the costs and benefits of native plant species for electric transmission line right-of-way revegetation within the Tennessee Valley Authority power service area. Master's thesis, University of Tennessee at Chattanooga. https://scholar.utc.edu/theses/162

U.S. Energy Information Administration. (2018). *Assessing HVDC transmission for impacts of non-dispatchable generation*. U.S. Department of Energy. https://www.eia.gov/analysis/studies/electricity/hvdctransmission/pdf/transmission.pdf

U.S. Fish and Wildlife Service. (2023). *Range-wide Indiana bat & northern long-eared bat survey guidelines*. U.S. Fish and Wildlife Service. https://www.fws.gov/sites/default/files/documents/USFWS_Range-wide_IBat_%26_NLEB_Survey_Guidelines_2023.05.10_0.pdf

U.S. Fish and Wildlife Service (USFWS). (1983). *Recovery plan for the Indiana bat*. U.S. Fish and Wildlife Service.

United States Department of Energy. (2023). *National transmission needs study*. https://www.energy.gov/sites/default/files/2023-12/National%20Transmission%20Needs%20Study%20-%20Final_2023.12.1.pdf

van Harten, E., Reardon, T., Lumsden, L. F., Meyers, N., Prowse, T. A. A., Weyland, J., & Lawrence, R. (2019). High detectability with low impact: Optimizing large PIT tracking systems for cave-dwelling bats. *Ecology and Evolution*, *9*(19), 10916–10928. https://doi.org/10.1002/ece3.5482

Verboom, B., & Huitema, H. (1997). The importance of linear landscape elements for the pipistrelle *Pipistrellus pipistrellus* and the serotine bat *Eptesicus serotinus*. *Landscape Ecology*, *12*(2), 117–125. https://doi.org/10.1007/BF02698211

Verboom, B., & Huitema, H. H. (2010). The influence of treeline structure and wind protection on commuting and foraging common pipistrelles (*Pipistrellus pipistrellus*). *Lutra*, *53*(2), 63–80.

Verboom, B., & Spoelstra, K. (1999). Effects of food abundance and wind on the use of tree lines by an insectivorous bat, *Pipistrellus pipistrellus*. *Canadian Journal of Zoology*, *77*(9), 1393–1401. https://doi.org/10.1139/cjz-77-9-1393

26888319, 2024, 4, Downloaded from https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12392, Wiley Online Library on [30/10/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Whitaker, J. O., Jr., Brack, V., Jr., & Cope, J. B. (2002). Are bats in Indiana declining? *Proceedings of the Indiana Academy of Sciences*, *111*(1), 95–106. https://journals.iupui.edu/index.php/ias/article/download/7246/7270

Willis, C. K. R., Brigham, R. M., & Geiser, F. (2006). Deep, prolonged torpor by pregnant, free-ranging bats. *Naturwissenschaften*, *93*(2), 80–83. https://doi.org/10.1007/s00114-005-0063-0

Yahner, R. H., & Hutnik, R. J. (2004). Integrated vegetation management on an electric transmission right-of-way in Pennsylvania, U.S. *Journal of Arboriculture*, *30*(5), 295–300.

How to cite this article: Campbell, C. J., Cheng, T. L., Akre, K. L., Adams, A. M., Solick, D. I., Bennett, A., Newman, C., & Frick, W. F. (2024). Maximizing benefits to bat populations through management of power line corridors. *Ecological Solutions and Evidence*, *5*, e12392. https://doi.org/10.1002/2688-8319.12392

26888319, 2024, 4, Downloaded from https://besjournals.onlinelibrary.wiley.com/doi/10.1002/2688-8319.12392, Wiley Online Library on [30/10/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License