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Strong geographic and temporal patterns in conservation status of North American bats

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ABSTRACT

Conservationists are increasingly concerned about North American bats due to the arrival and spread of the White-nose Syndrome (WNS) disease and mortality associated with wind turbine strikes. To place these novel threats in context for a group of mammals that provides important ecosystem services, we performed the first comprehensive conservation status assessment focusing exclusively on the 45 species occurring in North America north of Mexico. Although most North American bats have large range sizes and large populations, as of 2015, 18–31% of the species were at risk (categorized as having vulnerable, imperiled, or critically imperiled NatureServe conservation statuses) and therefore among the most imperiled terrestrial vertebrates on the continent. Species richness is greatest in the Southwest, but at-risk species were more concentrated in the East, and northern faunas had the highest proportion of at-risk species. Most ecological traits considered, including those characterizing body size, roosting habits, migratory behavior, range size, home range size, population density, and tendency to hibernate, were not strongly associated with conservation status. However, nectarivorous bats tended to be more at risk. The conservation status of bats improved from 1985 to 2000 as human disturbances to roosting sites were reduced, but then declined sharply (7%) by 2015 due principally to threats from WNS and wind energy. Although uncertainty about threats from pollution and climate change remain, past experience shows that when threats are clearly identified and management actions taken, populations can recover.

1. Introduction

Bats are one of the most diverse members of the North American mammal fauna, with 45 species occurring in the continental United States and Canada. They are also among the most locally abundant, with colonies numbering into the millions (e.g., Brazilian free-tailed bats, *Tadarida brasiliensis*) and representing some of the largest concentrations of mammals on earth. North American bats also play a role in insect control, providing ecosystem services valued in the millions of dollars annually to farmers and helping to sustain natural habitats (Pierson and Kunz, 1998; Jones et al., 2009a; Boyles et al., 2011; Kunz et al., 2011). Despite the importance of bats in temperate North America, relatively little attention has been focused on characterizing the conservation status of the fauna as a whole.

Concern about the conservation status of North American bats dates back decades. Initially, attention focused on disturbance and destruction of cave-dwelling bats and their habitats (Mohr, 1952, 1953; Humphrey, 1964; Barbour and Davis, 1969). In the 1970s, researchers first quantified the degree of decline for particular colonies of a few cave-dwelling species (Cope and Hendricks, 1970; Humphrey and Cope, 1976; Tuttle, 1979). Today, bats continue to experience threats from cave alteration and disturbance (Gore and Hovis, 1998), habitat loss (Racey and Entwistle, 2003), and forest management practices that are incompatible with tree-roosting species (Carter et al., 2003; Kunz and Lumsden, 2003; Barclay and Kurta, 2007; Carter and Menzel, 2007; Hayes and Loeb, 2007). Bats are also experiencing major novel threats and drastic rapid declines from disease and renewable energy development (O'Shea et al., 2016). White-nose Syndrome (WNS), an introduced and fast-spreading fungal pathogen, has killed several million cave-dwelling bats of multiple species in eastern North America over the past decade (Frick et al., 2010a; Langwig et al., 2012; Reeder and Moore, 2013; Frick et al., 2015; Langwig et al., 2015a, 2015b). During the same period, turbines at rapidly expanding wind energy facilities have killed hundreds of thousands of bats, mostly migratory species

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(Arnett and Baerwald, 2013; Hayes, 2013).

A number of factors may influence the susceptibility of bats to these threats. Long-distance migrants are more vulnerable to mortality from wind turbines and therefore may have less secure populations than non-migratory species. Only species that hibernate and cluster in caves are likely to succumb to WNS and are therefore more likely to have threatened statuses than species that follow other overwintering strategies. Body size has been associated with extinction risk in mammals (Davidson et al., 2009), although not in a global analysis of bats (Jones et al., 2003). North American bats are most diverse in the southwestern US (Hoffmeister, 1986; Frey et al., 2006; Ammerman et al., 2012), where, if all other factors are equal, the highest concentrations of threatened species would be expected to occur. However, WNS has so far been reported largely from colonies in the eastern portion of the continent (Maher et al., 2012; USFWS, 2016). If WNS is causing a significant decline in conservation status, then the eastern species should have a higher proportion of threatened species than elsewhere. Species with smaller range sizes tend to be more threatened with extinction (Böhm et al., 2016), so bats with smaller ranges should be more threatened than those with larger ranges. Finally, the recent nature of threats from disease and wind turbines suggests that the conservation status of North American bats may be declining relative to their status in the late twentieth century.

To explore the relative importance of these factors on bat conservation status, we conducted conservation status assessments of each species that regularly occurs in North America north of Mexico (hereafter referred to North America for simplicity) using a standard methodology. We used historical conservation status assessments spanning the past 30 years to determine how status has changed over time. The results provide a continent-wide snapshot of priorities for action and highlight gaps in our knowledge of bat conservation.

2. Methods

2.1. Geographic/taxonomic scope

We assessed the conservation status of 45 bat species regularly occurring in North America (English and scientific names listed in Table 1). We regarded the western small-footed myotis to include the form *melanorhinus* (following Holloway and Barclay, 2001, Reid, 2006, and Armstrong et al., 2011) and considered the Arizona bat as a distinct species following most authorities (Adams, 2003; Reid, 2006; Harvey et al., 2011; ITIS, 2016).

2.2. Conservation status assessment categories and criteria

We used the NatureServe methodology to determine the conservation status of North American bats (Faber-Langendoen et al., 2012; Master et al., 2012). This method combines information on rarity (e.g., range extent, population size), trends, and threats to produce a global conservation status rank (G rank): G1 = Critically Imperiled; G2 = Imperiled; G3 = Vulnerable; G4 = Apparently Secure; G5 = Secure. Species assigned to the G1–G3 range are referred to as “at risk” and those in the G4–G5 range are here termed “more secure”. In the NatureServe system, at-risk status is independent from designation under the US Endangered Species Act, as amended (ESA), or Canadian Species at Risk Act (SARA), but it is roughly equivalent to the term “Threatened” and “Near Threatened” used for the IUCN Red List, encompassing the Critically Endangered, Endangered, Vulnerable, and Near-Threatened categories (Mace et al., 2008). In addition to overall conservation status, the methodology assigns an impact category (from “negligible” to “very high”) for each threat as well as an overall threat impact score. We assessed these factors rangewide, including the Mexican and Central American portions of the ranges for the species that occur there.

The NatureServe methodology uses generation time (mean age of the breeding cohort) in calculating short-term trend and threat severity (a contributor to threat impact), which is estimated over 10 years or 3 generations, whichever is longer. Generation time for most North American bat species is unknown (Barclay and Harder, 2003), but likely ranges from 2 to several years (Humphrey and Cope, 1976, Frick et al., 2010b, Russell et al., 2011). We therefore estimated the appropriate time frame for short-term trend and threat severity as 10–15 years.

Table 1
Variation in global conservation status ranks of North American bats over 30 years.

Scientific name	English common name	Global conservation status rank		
		1985	2000	2015
Phyllostomidae				
Choeronycteris mexicana	Mexican long-tongued bat	G3G4	G3G4	G3G4
Leptonycteris nivalis	Mexican long-nosed bat	G3	G3	G3
Leptonycteris yerbabuenae	Lesser long-nosed bat	G3	G3	G3
Macrotus californicus	California Leaf-nosed bat	G3G4	G3G4	G3G4
Molossidae				
Eumops floridanus	Florida bonneted bat	G1	G1	G1
Eumops perotis	Greater bonneted bat	G4G5	G4G5	G4G5
Eumops underwoodi	Underwood's bonneted bat	G4	G4	G4
Molossus molossus	Pallas's mastiff bat	G5	G5	G5
Nyctinomops femorosaccus	Pocketed free-tailed bat	G5	G5	G5
Nyctinomops macrotis	Big free-tailed bat	G5	G5	G5
Tadarida brasiliensis	Brazilian free-tailed bat	G5	G5	G5
Mormoopidae				
Mormoops megalophylla	Ghost-faced bat	G5	G5	G5
Vespertilionidae				
Antrozous pallidus	Pallid bat	G4	G4	G4
Corynorhinus rafinesquii	Rafinesque's big-eared bat	G3G4	G3G4	G3G4
Corynorhinus townsendii	Townsend's big-eared bat	G3G4	G3G4	G4
Eptesicus fuscus	Big brown bat	G5	G5	G5
Euderma maculatum	Spotted bat	G4	G4	G4
Idionycteris phyllotis	Allen's big-eared Bat	G4	G4	G4
Lasionycteris noctivagans	Silver-haired Bat	G5	G5	G3G4
Lasiurus blossevillii	Western red bat	G4	G4	G4
Lasiurus borealis	Eastern red bat	G5	G5	G3G4
Lasiurus cinereus	Hoary bat	G5	G5	G3G4
Lasiurus ega	Southern yellow bat	G5	G5	G5
Lasiurus intermedius	Northern yellow bat	G5	G5	G5
Lasiurus seminolus	Seminole bat	G5	G5	G5
Lasiurus xanthinus	Western yellow bat	G4G5	G4G5	G4G5
Myotis auriculus	Southwestern myotis	G5	G5	G5
Myotis austroriparius	Southeastern myotis	G4	G4	G4
Myotis californicus	California myotis	G5	G5	G5
Myotis ciliolabrum	Western small-footed myotis	G5	G5	G5
Myotis evotis	Long-eared myotis	G5	G5	G5
Myotis grisescens	Gray myotis	G2	G3	G4
Myotis keenii	Keen's myotis	G3	G3	G3
Myotis leibii	Eastern small-footed myotis	G4	G4	G4
Myotis lucifugus	Little brown myotis	G5	G5	G3
Myotis occultus	Arizona myotis	G4G5	G4G5	G4G5
Myotis septentrionalis	Northern myotis	G4	G4	G1G2
Myotis sodalis	Indiana myotis	G1G2	G2	G2
Myotis thysanodes	Fringed myotis	G4	G4	G4
Myotis velifer	Cave myotis	G4G5	G4G5	G4G5
Myotis volans	Long-legged myotis	G4G5	G4G5	G4G5
Myotis yumanensis	Yuma myotis	G5	G5	G5
Nycticeius humeralis	Evening bat	G5	G5	G5
Parastrellus hesperus	Canyon bat	G5	G5	G5
Perimyotis subflavus	Tricolored bat	G5	G5	G2G3