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Long-term change in an assemblage of North American bats: are eastern red bats declining?

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We examined changes in the assemblage of bats in southern Lower Michigan, USA, using results of paired netting surveys conducted with similar techniques but separated by 12–26 years. Species diversity declined by 18–35% and evenness decreased by 0–35% throughout the region and in two specific areas. Changes in diversity and evenness were attributed primarily to decreases of 44% or more in relative abundance of the foliage-roosting eastern red bat (*Lasiurus borealis*). Number of *L. borealis* captured per net-night decreased 52–85%. The decline in relative abundance of *L. borealis* suggested by mist netting was supported by a 10-fold decrease over 38 years in the proportion of *L. borealis* that were tested for rabies by the state health laboratory. The apparent decline in *L. borealis* is especially alarming in light of the recent upsurge in use of wind power and the large number of *L. borealis* that are killed at such developments. We recommend that other previously completed surveys in eastern North America be duplicated, as one way of helping to confirm or refute the trend that we have identified.

Key words: assemblage, bat, diversity, evenness, *Lasiurus borealis*, long-term change, Michigan

INTRODUCTION

Effective management of assemblages, species, and populations of animals requires information concerning the number of individuals present or, at least, knowledge of whether numbers are increasing or decreasing. Unfortunately, small size, nocturnal behavior, and cryptic roost sites make it impossible to obtain estimates of total population size for most North American bats (Kunz, 2003), except a few highly gregarious species, such as the Indiana bat, *Myotis sodalis* (Clawson, 2002). Even knowledge of simple trends in population size is limited and primarily comes from counts made at isolated roosts of a few colonial species (Ellison *et al*., 2003). However, it also is possible to obtain information on long-term changes in relative abundance of species and to infer whether a particular population is increasing or decreasing by replicating surveys of an entire assemblage in different years (e.g., Whitaker *et al*., 2002). It is essential, though, that the species in question have known detection probabilities or that studies completed at different times have comparable methodology for comparisons to be meaningful (Conroy and Nichols, 1996; Winhold and Kurta, 2008).

Although acoustic surveys of bat assemblages are becoming increasingly common, most summer surveys in North America during the latter half of the 20th century involved mist-netting (Kunz and Kurta, 1988). Mist-netting studies, however, typically have not been replicated over time by the original workers, possibly because of the labor-intensive nature of the technique. Furthermore, published accounts of netting surveys seldom provide sufficient methodological information to insure comparability of techniques during repeat surveys by new workers (Winhold and Kurta, 2008). Hence long-term information on entire bat assemblages from North America is rare.

In southern Lower Michigan, USA, the regional bat assemblage potentially consists of seven vespertilionid insectivores, with two additional species known from single sites that recently were discovered near the southern border (Kurta, 1995, 2008; Kurta *et al*., 2005, 2007). We have been studying bats in this region since 1978, which allows us to examine long-term changes in the assemblage using data gathered with similar techniques. We were particularly interested in detecting possible changes in relative abundance of two resident species: the eastern red bat (*Lasiurus borealis*) and hoary bat (*Lasiurus cinereus*). Bats in the genus *Lasiurus* are unusual among North American species in that they are solitary, roost in foliage, and often perform seasonal migrations exceeding 1,000 km (Cryan and Veilleux, 2007). Although these little-studied species are geographically widespread, anecdotal information suggests a decline in abundance over the last century (Carter *et al*., 2003*a*).

Herein, we compare species diversity, evenness, and relative abundance, within three paired sets of mist-netting surveys that occurred 12–26 years apart. For an additional comparison, we examine changes in relative abundance using bats submitted over 38 years to the state health laboratory for testing for rabies.

Materials and Methods

Southern Lower Michigan (ca. 41.7– 43.0°N, 83.0–86.5°W) is composed of glacial moraines and lake plains, with an abundance of small streams, lakes, and ponds (Albert *et al*., 1986). Maximum elevation is about 250 m. Although the area mostly was covered by deciduous forest when Europeans arrived, remaining woodlands are highly fragmented, and agriculture is now the dominant land use.

All netting sites originally were established during searches for the Indiana bat, *Myotis sodalis*, an endangered species (Hutson *et al*., 2001), although subsequent netting at some sites occurred as part of other projects. The Indiana bat roosts and forages predominantly in broadleaf woodlands (Kurta and Kennedy, 2002), and consequently, we placed all netting sites in areas of mature deciduous woods. Potential netting sites first were located using maps or aerial photographs, and final site selection depended upon permission of landowners, presence of a suitable flight corridor, and ease of access. In all surveys, nets were placed perpendicular to the available flight corridor, extending as much as possible into the woods on each side of the corridor and from the ground or water into the overhanging tree canopy.

During all surveys, we checked nets at intervals of 15 minutes or less. Bats typically were banded (Lambournes, Ltd., Leominster, Middlesex, United Kingdom) or punch-marked (Bonaccorso and Smythe, 1972) before release, and repeat captures of marked animals were not used in any analysis. Netting began at sunset and continued for 4 or 5 h after sunset, depending on survey, rather than ending at a specific time, such as midnight or 01:00 h (Winhold and Kurta, 2008). We consistently ceased netting when air temperature fell below 10°C or if prolonged rain occurred; data from cold- or rain-shortened nights were not included in any analysis.

Regional Netting Surveys

In 1978–1979, a regional survey of bats was performed by mist-netting in rural areas throughout southern Lower Michigan (Kurta, 1980). Bats were caught in nets placed across streams at 31 sites. Individual nets were made from 50-denier, braided nylon and joined to form larger nets that were 9–13-m wide and 4.3–9-m high. Multiple, short nets occasionally were placed in 1978, whereas in 1979, one tall netting system usually was employed. Netting occurred for one night at each site from sunset until 4 h after sunset. For the present report, we only used data from Kurta (1980) that were collected from 12 May through 18 August.

In 2004–2006, a second regional survey occurred in the same part of Michigan (Winhold, 2007). Most nets also were made from 50-denier, braided nylon and 9–13-m wide. Two tall nets, 6–9-m high, were placed at least 100 m apart at each site, following the netting protocol suggested by the U.S. Fish and Wildlife Service (1999) for *M. sodalis*. Although Winhold (2007) netted for 5 h after sunset and in a variety of landscapes, we only used data from her study that were obtained during the first 4 h after sunset, using nets placed over rivers, for comparison with 1978–1979. Netting occurred at 45 riparian sites between 15 May and 15 August, usually on two consecutive nights at each site. Although netting for a second night at the same site leads to a reduced number of captures, it does not affect relative abundance, diversity, or evenness (Winhold and Kurta, 2008); consequently, captures from both nights were included.

Netting Surveys along the Thornapple River

Near the village of Vermontville (42.63°N, 85.02°W), the Thornapple River is about 13-m wide, with typical depths of 1–3 m. Adjacent land cover is dominated by row crops and pastures. Most forested areas are small and isolated, although a strip of continuous woods of variable width borders the river.

On 23 nights during 1978–1979, bats were netted at five sites along a 5-km section of this river, partly in conjunction with a study of spatial use by foraging big brown bats (*Eptesicus fuscus*) and little brown bats (*Myotis lucifugus* — Kurta, 1980, 1982). Netting systems were 9-m high and 13-m wide, just spanning the river, and nets were made from 50-denier, braided threads. Netting lasted for 4 h after sunset. Only data that were obtained between 10 May and 18 August of each year were used in the current report.

Between 11 May and 17 August 1993 and 1994, bats also were netted at five sites over this section of the Thornapple River while studying the ecology and behavior of northern bats (*Myotis septentrionalis*) and *M. sodalis* (Kurta *et al*., 1996; Foster 1997; Foster and Kurta, 1999). Netting systems were similar in size to those used in 1978–1979, although nets in the later studies were made from 30-denier braided threads or monofilament nylon. Duration of netting was variable, so we only used data from 21 nights on which netting occurred for about 4 h after sunset when making comparisons with 1978–1979.

Netting Surveys at the Fort Custer Military Training Center

The Fort Custer Military Training Center is a 3,066-ha facility of the Michigan National Guard located on the western edge of the city of Battle Creek (42.32°N, 85.18°W). The installation was established on open farmland in 1917 and expanded in 1940, but today, it is mostly covered by oak-hickory (*Quercus*-*Carya*) forests of varying age with a few open fields.

Ponds and other wetlands are common, although the largest stream is only 2–3 m in width and mainly flows through an open marsh. A network of gravel roads traverses the property, but they are not open to the public.

Bats at Fort Custer were surveyed from 15 July to 3 August 1993 and again from 5 to 19 July 2005. From the 1993 study, we selected data obtained with nets placed across roads through the forest at 19 sites. Typical netting systems were 9-m high and 9- or 13-m wide. A single net was placed at each site and monitored from sunset to 5 h after sunset on two nights, for a total of 38 net-nights. Netting sites were generally 100–1,000 m apart.

In 2005, we followed the netting protocol suggested by the U.S. Fish and Wildlife Service (1999) for *M. sodalis*. Consequently, two nets were placed at 10 sites, and each net was monitored for 5 h after sunset, on two nights, for a total of 40 net-nights. Nets were placed over roads through the forest, and nets at individual sites usually were spaced 100–300 m apart. Like the earlier survey, most nets were 9-m high and 9- or 13-m wide. Both studies primarily used nets made from monofilament or 30-denier braided nylon.

Bats Submitted for Rabies Testing

In addition to captures from mist-netting, bats that are submitted by citizens to public health departments to be tested for the rabies virus provide a statewide sample that can be analyzed for changes in relative abundance (e.g., Whitaker *et al*., 2002). In Michigan, most bats that are tested for rabies are sent to laboratories of the Michigan Department of Community Health. We reviewed published data covering bats that were submitted from 1968 to 1978 (Kurta, 1979), as well as unpublished data of one of us (AK) for 1979–1982. Identification to species was not performed consistently after 1982, but we were able to obtain published data from Feller *et al*. (1997) for 1993 and unpublished data from the Michigan Department of Community Health for 1997–2005 (P. Clark, in litt.). Identifications of bats between 1968 and 1982 were made by mammalogists at the Michigan State University Museum, whereas later identifications were made by personnel of the Michigan Department of Community Health.

Statistics

To search for temporal change in the assemblage of bats, we compared species diversity, evenness, and relative abundance between our matched sets of netting data. For a measure of diversity, we calculated Simpson's Index, which is equal to: $1 - [\sum n_i (n_i - 1)] / N (N - 1)$, where n_i is the number of individuals from each species and N equals the grand total of captured bats (Brower and Zar, 1984). We statistically compared values of diversity using a t-test with infinite degrees of freedom (Brower and Zar, 1984). Evenness was calculated as the ratio of observed diversity and maximum possible diversity for an assemblage with that number of individuals and species (Brower and Zar, 1984). Maximum diversity was calculated as: $[(s - 1) / s] \times [N / (N - 1)]$, where s represents number of different species in the sample and N equals the grand total of captured individuals. Values for evenness were compared by inspection only, because we were unable to find an appropriate statistical test. Each species was included in calculations of diversity and evenness, regardless of number of captures, and no species was deleted or combined with others. Finally, we used chi-squared tests to determine whether differences in relative abundance existed among species and between sets of data, and we then performed appropriate post-hoc tests to determine specifically which groups differed (MacDonald and Gardner, 2000; Gardner, 2001).

Calculations were performed using a standard spreadsheet (Excel, Microsoft Corporation, Redmond, Washington, USA). Alpha was set at 0.05 for statistical tests, except when post-hoc comparisons required Bonferroni adjustments. All means are presented with the associated standard error.

RESULTS

Regional Netting Survey

In 1978–1979, 139 bats were captured at 31 sites, whereas in 2004–2006, 430 bats were netted at 45 sites (Table 1). Diversity declined ($t_\infty = 4.00$; $P < 0.001$) 30% between studies, from 0.44 in 1978–1979 to only 0.31 in 2004–2006. Similarly, evenness declined by 35%, with a value of 0.55 in 1978–1979 and 0.36 in 2004–2006.

In each study, *E. fuscus* and *L. borealis* were most abundant, and no other species represented more than about 5% of total captures (Table 1).

TABLE 1. Number of bats captured (% of total captures in parentheses), sites, and net-nights for three pairs of netting surveys in southern Lower Michigan, USA

Comparison	Regional		Thornapple River		Fort Custer	
	1978–1979	2004–2006	1978–1979	2004–2006	1993	2005
Eptesicus fuscus	100 (71.9)	354 (82.3)	124 (55.6)	144 (66.4)	112 (53.8)	92 (78.0)
Lasiurus borealis	26 (18.7)	45 (10.5)	21 (9.4)	3 (1.4)	93 (44.7)	26 (22.0)
L. cinereus	4 (2.9)	3 (0.7)	4 (1.8)	2 (0.9)	2 (1.0)	–
Lasionycteris noctivagans	–	–	4 (1.8)	–	–	–
Myotis lucifugus	6 (4.3)	22 (5.1)	56 (25.1)	45 (20.7)	1 (0.5)	–
M. septentrionalis	–	1 (0.2)	4 (1.8)	10 (4.6)	–	–
M. sodalis	3 (2.2)	4 (0.9)	10 (4.5)	13 (6.0)	–	–
Nycticeius humeralis	–	1 (0.2)	–	–	–	–
Total captures	139	430	223	217	208	118
Number of sites	31	45	23	21	19	10
Number of net-nights	52	131	23	21	38	40

Consequently, we were forced to eliminate two uncommon and morphologically dissimilar species from statistical analyses of relative abundance to avoid low expected values. These species were the hoary bat and evening bat (*Nycticeius humeralis*), which represented 1.2 and 0.2%, respectively, of all animals captured. In addition, we combined three morphologically similar species of *Myotis* — *M. lucifugus, M. septentrionalis* and *M. sodalis* — into one category for analyses of relative abundance. Although combining all *Myotis* into a single group may obscure differences within the genus, such consolidation was necessary to avoid small expected values. Hence, the test of relative abundance used a 3-by-2 contingency table, with *E. fuscus*, *L. borealis*, and *Myotis* as the three categories.

Relative abundance differed between periods ($\chi^2_2 = 7.17$, $P < 0.05$). The partial χ^2 for *L. borealis* was the largest contributor (85%) to overall χ^2 (Table 2), which suggested that a decline in *L. borealis* was most responsible for the overall difference. A post-hoc test on a collapsed 2-by-2 contingency table comparing abundance of *L. borealis* to that of all other species was significant ($\chi^2_1 = 7.01$, $P < 0.01$; $\alpha = 0.017$ after a Bonferroni adjustment), whereas similar tests comparing *E. fuscus* ($\chi^2_1 = 5.41$, $P > 0.017$) or *Myotis* ($\chi^2_1 = 0.02$, $P > 0.017$) to all others were not significant.

Netting Surveys along the Thornapple River

In 1978–1979, 223 bats were captured on 23 nights in nets placed across the Thornapple River (Table 1). The most common species was *E. fuscus*, followed by *M. lucifugus* and *L. borealis*. In 1993–1994, 217 bats were caught on 21 nights, and most bats were *E. fuscus* and *M. lucifugus*, followed by *M. sodalis*.

Species diversity declined by 18% ($t_\infty = 2.89$, $P < 0.01$), with values of 0.62 in the earlier study and 0.51 in the later one. Evenness declined by 12% from 0.72 in 1978–1979 to 0.61 in 1993–1994. For analysis of relative abundance, we deleted hoary bats and silver-haired bats (*Lasionycteris noctivagans*) because of their small contribution to total captures (1.4 and 0.2%, respectively) and again analyzed relative abundance of *E. fuscus*, *L. borealis*, and *Myotis*. There was a significant difference in relative abundance between surveys ($\chi^2_2 = 15.02$, $P < 0.001$). The partial χ^2 for *L. borealis* represented 90% of total χ^2, suggesting that most observed change was due to a decrease in *L. borealis* (Table 2). A post-hoc test comparing abundance of *L. borealis* to that of all other species between periods was significant ($\chi^2_1 = 11.38$, $P < 0.001$, $\alpha = 0.017$), whereas similar tests comparing *E. fuscus* ($\chi^2_1 = 0.36$, $P > 0.017$) or *Myotis* ($\chi^2_1 = 1.18$, $P > 0.017$) to all others were not significant.

Use of identical protocols allowed comparisons of nightly rates of capture. Number of *L. borealis* caught per night significantly declined (unequal variances, $t_{29} = 3.62$, $P = 0.001$) from 0.91 ± 0.2 bats/ night in 1978–1979, to only 0.14 ± 0.08 bats/ night in 1993–1994. Number of *E. fuscus*, however, did not differ ($t_{42} = 1.03$, $P > 0.05$), with 6.9 ± 1.1 captures/night in 1978–1979 and 5.4 ± 0.9 bats/night in 1993–1994.

Netting Surveys at the Fort Custer Military Training Center

In 1993, 208 bats were captured in 38 net-nights at Fort Custer, and 205 of the animals were either *E. fuscus* or *L. borealis* (Table 1). Twelve years later in 2005, 118 bats were caught in 40 net-nights, and all bats were either *E. fuscus* or *L. borealis*. Species diversity declined by 41% ($t_\infty = 3.95$, $P < 0.001$) over the intervening 12 years from 0.51 in 1993 to 0.34 in 2005, while evenness remained the same at 0.68.

Comparison of relative abundance between studies was performed on only two categories —

TABLE 2. Chi-squared comparison of each pair of surveys. Chi-squared values listed for individual species or groups represent their additive contribution to total chi-square and are not separate tests. For rabies testing, all species except *L. borealis* are combined in the category of '*E. fuscus*'

Species	Regional			Thornapple River			Fort Custer			Rabies testing		
	1978–1979	2004–2005	χ^2	1978–1979	1993–1994	χ^2	1993	2005	χ^2	1965–1982	1993–2005	χ^2
E. fuscus	100	354	1.03	124	96	1.49	112	92	6.46	1,379	7,119	0.34
L. borealis	26	45	6.13	21	2	13.50	93	26	11.07	27	16	67.11
Myotis spp.	9	27	0.02	70	60	0.03	–	–	–	–	–	–
Total	135	426	7.17^{*}	215	158	15.02^{***}	205	118	17.52^{***}	1,406	7,135	67.45^{***}

* — $P < 0.05$, *** — $P < 0.001$

E. fuscus and *L. borealis* — because of low expected values for other groups. Proportions of species captured in the two surveys were statistically different (χ^2_1= 17.52, P < 0.001), suggesting a decline of *L. borealis* relative to *E. fuscus*; the partial χ^2 for *L. borealis* accounted for 63% of total χ^2 (Table 2). Number of *E. fuscus* captured per net-night did not differ (unequal variances, t_{54} = 0.83, P > 0.05) between 1993 (2.9 ± 0.7 bats/night) and 2005 (2.3 ± 1.1 bats/night). *L. borealis*, in contrast, showed a significant decline, from 2.4 ± 0.5 bats/net-night in 1993 to only 0.7 ± 0.4 bats/net-night in 2005 (unequal variances, t_{49} = 3.53, P = 0.001).

Bats Submitted for Rabies Testing

As in netting, several species, such as hoary bats or evening bats, were extremely uncommon in the samples (Table 2). Furthermore, technicians at the Michigan Department of Community Health, who made identifications in 1993 and 1999–2005, had difficulty distinguishing the various drab-colored *Myotis* from *E. fuscus*. Consequently, we did not calculate diversity or evenness and restricted the analysis of relative abundance to a simple comparison of brightly colored, easily identified *L. borealis* to all other species combined. From 1965–1982, *L. borealis* represented 2.0% of all bats tested but comprised only 0.2% of all bats tested from 1993–2005. These proportions were significantly different (χ^2_1 = 67.63, P < 0.001), indicating a decrease in relative abundance of *L. borealis* over this 38-year span (Table 2).

Discussion

Data from mist-netting captures and rabies submissions are only indices to abundance and can not be used to determine number of animals in a population (O'Shea and Bogan, 2003; Weller, 2007). To do so requires information on the proportion of a population that actually is netted (detection probability), and gathering that information requires the capture and recapture of marked individuals. Use of capture-recapture techniques during summer, however, is not feasible with bats in general and especially with over-dispersed foliage-roosting species. Nevertheless, mist-netting surveys performed with comparable techniques are potentially valuable because they can function as "early warning systems . . . [that] enable identification of probable changes in the distribution of species through time and . . . provide evidence of potential dramatic changes in abundance of species" (Carter *et al.*, 2003*b*: 251).

Early netting studies of bats in southern Lower Michigan demonstrated that the assemblage was dominated by *E. fuscus*, a colonial species that roosts in buildings, and the solitary foliage- roosting *L. borealis* (Table 1). Although that general pattern remains true, paired data from Fort Custer, the Thornapple River, and regional surveys of southern Lower Michigan suggest that the bat assemblage has changed over the past few decades, with declines in species diversity and steady or decreasing evenness. These changes are mostly attributable to a 44% or greater decline in the proportion of *L. borealis* in each paired survey (Table 1). *Lasiurus borealis* contributes the highest chi-squared values to each analysis, suggesting that the overall change is primarily due to a decrease in *L. borealis* and not necessarily an increase in other species (Steel and Torrie, 1980; Gardner, 2001). A post-hoc comparison (Macdonald and Gardner, 2000) of the proportion of *L. borealis* compared to all others also indicates a significant change in the proportion of *L. borealis* in the regional survey and along the Thornapple River. In addition, comparisons of nightly netting success at Fort Custer and along the Thornapple River, the two studies with essentially identical sampling methods, indicate no significant change in number of *E. fuscus*/net-night but a 52–85% decrease in number of *L. borealis*/net-night. Although there are slight differences in the netting techniques between paired surveys, we do not feel that these methodological differences can account totally for the large changes in relative abundance of *L. borealis* in each paired survey (Table 1).

The apparent decline in *L. borealis* also was evident among animals tested for rabies in Michigan (Table 2), and a similar trend has been documented in more southern states, where this migratory species is found throughout the year. In Indiana, the proportion of *L. borealis* among bats that were submitted decreased significantly from 23% in the 1960s to 19% in the 1990s (Whitaker *et al.*, 2002), whereas in Arkansas the absolute number of *L. borealis* submitted declined significantly from ca. 65 animals/year in the early 1980s to only 25–30 bats/year in the late 1990s (Carter *et al.*, 2003*a*). Carter *et al.* (2003*a*) noted that the decrease in Arkansas occurred despite an increased awareness of bats and rabies among citizens and an increased human population, two factors that should have increased submissions of these colorful bats.

Thus, there are now six sets of data (three from mist-netting and three from rabies submissions) that indicate a significant decrease in number of *L. borealis* in the eastern United States during the last 40 years, and anecdotal evidence suggests that this decline may have been occurring for the past century. A number of older reports claim that red bats commonly migrated in large groups even during daylight (Howell, 1908; Allen, 1939). Mearns (1898: 344), for example, describes seeing (and shooting at) "great flights" of red bats migrating through New York "during the whole day," apparently on multiple occasions in different years. However, we are not aware of any mass migrations being reported in the last 30 years, and moderate concentrations (hundreds) of *L. borealis* only have been noted in southern states that likely are the endpoint of autumn migration rather than a migratory pathway (e.g., LaVal and LaVal, 1979; Saugey *et al.*, 1989). Similarly, all published observations of diurnal migration appear to be more than 35-years old (e.g., Mumford and Whitaker, 1982).

If this decline in *L. borealis* is real, there are several possible causes, including reduction and/or fragmentation of forested habitat (Carter *et al.*, 2003*a*) and the effects of pesticides and other environmental pollutants (Clark and Shore, 2001). *Lasiurus borealis* also appears more susceptible than other species, especially during migration, to collisions with various human-made objects, such as tall buildings (Terres, 1956; Timm, 1989), airplanes (Martin *et al.*, 2005), and automobiles (Starrett and Rolle, 1962; Long, 1978; Farmer, 1999), and all these objects are more abundant than they were 100 years ago. Furthermore, *L. borealis* often hibernates in leaf litter, which exposes it to controlled (prescribed) fire, a tool that foresters have used increasingly over the last three decades in winter (Saugey *et al.*, 1989; Moorman *et al.*, 1999; Mormann and Robbins, 2007). Although the factors that are contributing to the apparent decline of *L. borealis* are unknown, the decrease actually may be the cumulative result of all these human-related factors impacting *L. borealis* during summer, winter, and migration over the last century (Cryan and Veilleux, 2007). The apparent long-term reduction in the population of *L. borealis* is especially alarming in light of the recent upsurge in use of wind power and the large number of *L. borealis* that are being killed at such developments (Kunz *et al.*, 2007; Arnett *et al.*, 2008).

Although analyses that rely on data from mist netting or rabies submissions lack the statistical rigor of mark-recapture techniques, there currently are few other ways of investigating changes that may have taken place over the last 30–60 years. Other previous surveys in the East have involved extensive or intensive mist-netting of bats (e.g., Kunz, 1973; Lacki and Bookhout, 1983) or examined animals submitted for rabies testing (e.g., Biggler *et al.*, 1975). We suggest that such surveys be replicated, preferably by the original investigators to insure comparability of techniques, as a way of confirming or refuting the potential decline in *L. borealis* that we have identified. Meanwhile, further study of the ecology, behavior, and physiology of *L. borealis* is warranted before its population decreases to the point that this seemingly common animal must be placed on a list of endangered species.

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