

SECTION I I BATS IN FORESTS

The Role of Research in Conserving Bats in Managed Forests

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ABSTRACT

Awareness of bats as an important component of forest ecosystems has only recently begun to receive attention by both research biologists and forest land managers. Data collection has focused primarily on identifying species composition, roost selection, and frequency of use among habitats, with the latter data usually not species specific. Co-ordinated efforts between research and management are now needed to answer questions related to the impacts of intended management programs on bats in forests, particularly the application of silvicultural prescriptions. Conserving populations of bats while achieving other forest management goals needs to be a primary focus. I present examples from Kentucky on how research biologists and forest land managers have co-ordinated efforts to enhance habitat for bats.

INTRODUCTION

Since the seminal work by Thomas (1988) that examined activity levels of bats among forest seral stages of varying age, a number of studies addressing questions on bats in forests have appeared. Research has emphasized identification of bat species (Miller 1990; Crampton 1994; Perkins et al. 1994); location of roosts (Kalcounis 1994; Morrell et al. 1994; Peterson and Perkins 1994; Rainey and Pierson 1994; Sasse and Pekins 1994; Vonhof 1994), and activity levels of bats among habitats (Helmer et al. 1990; Thomas 1991; Navo et al. 1992; Erickson 1993; Holroyd 1993; Stevens et al. 1993; Grindal 1994; Storz 1994; Burford and Lacki 1995), with activity levels used as a measure of habitat use. With a few exceptions (Navo et al. 1992; Storz 1994; Burford and Lacki 1995), most attempts to measure activity levels have not been species specific.

Co-ordinated efforts are now needed between research scientists and forest land management agencies to improve the quality of data collected and apply the information so that maximum benefits in habitat conservation for bats can be achieved. In this paper I review the present state of habitat management for bats in Kentucky, USA, and provide examples

of how combined efforts between research scientists and management personnel of the Daniel Boone National Forest, Kentucky, have enhanced habitat for bats in forests in eastern Kentucky.

METHODS

To determine the extent to which forest lands in Kentucky are being managed to promote the conservation of bats, I surveyed by telephone from June to September 1995, representatives of municipal, state, and federal agencies responsible for the management of public lands in Kentucky. I asked two basic questions of each respondent. First, has any land management action been implemented to enhance habitat suitability for bats? Second, was there any research completed to justify the proposed management action(s) taken? Respondents were permitted to elaborate to the extent that they felt was appropriate, and any additional information they provided was recorded.

I contacted a total of 12 agencies for information, including two municipal (Otter Creek Park, Raven Run Sanctuary), six state (Kentucky Chapter of the Nature Conservancy, Kentucky Department of Fish and Wildlife Resources, Kentucky Department of Parks, Kentucky Department of Transportation, Kentucky Division of Forestry, Kentucky State Nature Preserves Commission), and four federal (National Park Service, Tennessee Valley Authority, U.S. Department of Defense, U.S. Forest Service). With the exception of the Kentucky Chapter of the Nature Conservancy ($n = 2$), I contacted only one representative for information from each municipal and state agency; however, due to differences in management policies among federal land holdings within agencies, I contacted a separate representative of each federal land holding to ensure completeness and accuracy of the data.

I organized management actions as those pertaining directly to roosting habitat or to commuting and foraging habitat, and evaluated them separately. I divided research efforts into two categories, monitoring and original research. Original research projects were then categorized as either field studies, natural experiments, field experiments, or laboratory experiments, following Ratti and Garton (1994, pp. 16–17). I made no attempt to compare management and research actions taken among municipal, state, and federal agencies. Instead, my objective was to make an overall assessment of what was being accomplished statewide for the management and conservation of bats.

RESULTS AND DISCUSSION

Management of Bats
in Kentucky

Kentucky is inhabited by 15 species of insectivorous bats, with the families Vespertilionidae ($n = 14$) and Molossidae ($n = 1$) represented (Barbour and Davis 1974). The sole molossid, *Tadarida brasiliensis*, is known only from one modern record and Pleistocene deposits in Mammoth Cave (Barbour and Davis 1974). Three species, *Myotis sodalis*, *M. grisescens*, and

Corynorhinus townsendii virginianus, are listed as federally endangered (United States Fish and Wildlife Service 1991), and an additional four species, *C. rafinesquii*, *M. austroriparius*, *M. leibii*, and *Nycticeius humeralis*, are listed as threatened or endangered in Kentucky by the state heritage program (Kentucky State Nature Preserves Commission 1994).

Of the agencies surveyed, 66.7% ($n = 8$) actively manage roosting habitat (e.g., caves and mines) for bats (Table 1). A total of 65 roosts receive some form of active management to regulate human intrusion, including gating ($n = 28$), fencing ($n = 2$), or posted signs ($n = 35$), with the latter category referring to roosts not gated or fenced; almost all gated or fenced roosts also have posted signs. The Daniel Boone National Forest (USFS) has closed several roads, and in one case re-routed a road to increase the level of protection at roosts. With the exception ($n = 15$ mine portals) of Big South Fork National River and Recreation Area (NPS), all roosts that have been gated or fenced contain at least one federally endangered bat at some time during the year. Several respondents indicated that plans are underway to gate or fence additional roosts.

Other structures used as roosts are wells and cisterns located on Land Between the Lakes (TVA). These structures are left open depending on consultation with the U.S. Fish and Wildlife Service. Three agencies actively put up bat boxes: Raven Run Sanctuary, Kentucky Department of Fish and Wildlife Resources, and the Daniel Boone National Forest.

TABLE 1 Management for bats and research programs by public land agencies in Kentucky, U.S.A.

Agency ^a	Management roosting habitat	Number cave/mine roosts	Population monitoring	Management foraging habitat	Original research
<i>Municipal</i>					
OCP	yes	1	yes	none	none
RRS	none	—	none	none	none
<i>State</i>					
KCNC	yes	2	yes	yes	yes
KDFWR	yes	1	none	yes	none
KDP	yes	2	yes	none	none
KDT	none	—	yes	yes	none
KDF	none	—	none	yes	none
KSNPC	yes	2	none	yes	none
<i>Federal</i>					
NPS	yes	22	yes	yes	yes
TVA	none	—	none	yes	yes
USDD	yes	1	none	yes	yes
USFS	yes	34	yes	yes	yes

^a Abbreviations for land agencies are Otter Creek Park (OCP), Raven Run Sanctuary (RRS), Kentucky Chapter of the Nature Conservancy (KCNC), Kentucky Department of Fish and Wildlife Resources (KDFWR), Kentucky Department of Parks (KDP), Kentucky Department of Transportation (KDT), Kentucky Division of Forestry (KDF), Kentucky State Nature Preserves Commission (KSNPC), National Park Service (NPS), Tennessee Valley Authority (TVA), U.S. Department of Defense (USDD), and U.S. Forest Service (USFS).

Among those agencies responsible for the management of bat roosts, 62.5% ($n = 5$) monitor population levels (Table 1). In addition, the Kentucky Department of Transportation monitors summer roost trees harbouring maternity colonies of bats in construction-zone rights-of-way, with removal of roost trees taking place outside the maternity season. In a few instances the Department of Transportation altered site selection to avoid loss of roost trees.

Nine agencies (75%) manage their forest lands, at least in part, to provide commuting, foraging, or summer roosting habitat (Table 2). Establishment of no-timber-harvest zones and protection of stream corridors are the most common management practices. The Kentucky Division of Forestry maintains a co-operative relationship with Carter Caves State Resort Park and has established a no-timber-removal policy on the adjacent Tygarts State Forest to protect foraging habitat for the colony of *M. sodalis* that hibernates in a cave in the park. Interestingly, no comparable program for management of foraging habitat is in place for Carter Caves State Resort Park. Cumberland Gap National Historical Park (NPS) has established a moratorium on timber removal, one aim of which is to protect summer roosting habitat of *M. sodalis*. The Daniel Boone National Forest maintains a Cliffline Management Policy to protect roosting and foraging habitat of *C. townsendii virginianus* and *C. rafinesquii*, along with other sensitive animal and plant species. Under this policy, a 92-metre-wide strip of forest, 61 m below cliffs and 31 m above cliffs, is protected within the known range of *C. townsendii virginianus* and within 1.6 km of roosts of *C. rafinesquii*. Further, no timber harvest is permitted within a 0.4-km radius, no-disturbance zone surrounding any known roost of either of these two species. The Daniel Boone National Forest is in the process of developing a summer habitat management policy for *M. sodalis*, with this policy to be based primarily upon the Habitat Suitability Index model for *M. sodalis* developed by 3D/Environmental in cooperation with the Indiana Department of Natural Resources for the U.S. Fish and Wildlife Service (Romme et al. 1995).

TABLE 2 Forest management practices for bats applied by public land agencies in Kentucky, U.S.A.

Agency ^a	No-harvest zones	Midstorey removal	Burning	Streamside management	Snag management	Woodland ponds	Wildlife openings
<i>State</i>							
KDFWR	—	—	—	—	—	—	yes
KCNC	—	—	—	—	—	—	yes
KDT	—	—	—	yes	roosts	—	—
KDF	1 site	—	—	—	—	—	—
KSNPC	yes	—	—	—	—	—	—
<i>Federal</i>							
NPS	1 park	—	—	—	—	—	—
TVA	—	—	—	yes	—	—	—
USDD	—	—	—	yes	—	—	—
USFS	yes	73 ha	364 ha	yes	14/ha	328	120 ha

^a Abbreviations for land agencies are as in Table 1.

Respondents indicated that management of stream corridors is based on the U.S. Fish and Wildlife Service's guidelines for protecting habitat of *M. sodalis* (U.S. Fish and Wildlife Service 1983). Other management practices that have been implemented for bats include midstorey removal, burning, maintaining snags, construction of woodland ponds, and maintaining wildlife openings, with the preponderance of activity taking place in the Daniel Boone National Forest (Table 2). Midstorey removal and burning in stands of timber on the Daniel Boone National Forest has occurred on the southern ranger districts where the federally endangered, red-cockaded woodpecker (*Picoides borealis*) coexists with *C. rafinesquii*, a species that is threatened in Kentucky (Kentucky State Nature Preserves Commission 1994). These practices are designed to reduce predation at nest cavities of *P. borealis* and to enhance foraging habitat for both species.

Research on Bats in
Kentucky Forests

Respondents from five agencies (41.7%), the Kentucky Chapter of the Nature Conservancy, National Park Service, Tennessee Valley Authority, U.S. Department of Defense, and U.S. Forest Service, indicated that original research was supported on some facet of bat ecology, distribution, or association with a management practice. All projects qualified as field studies based on Ratti and Garton's criteria (1994), with the possible exception of an analysis of metal loadings in guano of *M. grisescens* that required laboratory analyses (Lacki 1994). No study was based on a natural experiment or a field experiment.

Mist netting surveys were funded by all five agencies, except the National Park Service where survey efforts focused on inventory of bats using mine portals as hibernacula. The Daniel Boone National Forest was the only land agency to finance more than one project ($n = 4$) and the only agency to examine the suitability of current management practices for bats (Adam et al. 1994; Burford and Lacki 1995; K. Huie-Netting, EKV, unpubl. data; J. Kiser, EKV, unpubl. data). Extensive surveys of cliffs and adjacent habitats were also completed by U.S. Forest Service personnel in each ranger district of the Daniel Boone National Forest.

Coordinated Research
and Management
of Bats

The Daniel Boone National Forest encompasses approximately 271,000 ha and is located in the Cumberland Plateau physiographic region in eastern Kentucky. The terrain is rugged with an extensive series of cliffs present in much of the region. Mixed mesophytic forest is the predominant vegetative cover, and due to past logging practices is composed of stands of timber of varying age.

The U.S. Forest Service began supporting externally funded research on bats in the Daniel Boone National Forest in 1990. Initial efforts focused on foraging habitat requirements of maternity and bachelor colonies of *C. townsendii virginianus*, a federally endangered species that hibernates primarily in a single cave in Kentucky (Lacki et al. 1994). The initial research phase had two objectives. First, to establish the size of foraging areas used by the bats in these colonies and, second, to identify habitats important to foraging bats. The overall goal was to evaluate the appropriateness of the Cliffline Management Policy, described previously, for protecting habitat of *C. townsendii virginianus*. Studies of radio-tagged bats demonstrated considerable movement, with bats observed up to 8.4 km

from roosts, and wide variation in foraging area size tracking periods (Adam et al. 1994). Evaluation of habitat use by radio-tagged bats demonstrated extensive use of cliffs (Adam et al. 1994) reinforcing the need for a Cliffline Management Policy; however, the analysis chosen also showed forest habitat to be important, but did not resolve differences in the condition of forest habitat (e.g., stand age or silvicultural prescription).

A subsequent project examined activity of bats in five habitats using ultrasonic detectors, with all sites selected within the known foraging areas of *C. townsendii virginianus*, and detectors set at the frequency best suited to detect this species. Results showed low activity in stands of timber < 30 years of age, in stands of timber ≥ 30 years of age, and at the bases of cliffs, with high levels of activity on clifftops and in old fields (Burford and Lacki 1995). These results further supported the need for the Cliffline Management Policy and identified openings (e.g., old fields) as foraging habitat of *C. townsendii virginianus*. This research supported an existing management program on the Daniel Boone National Forest of maintaining wildlife openings as habitat for game species, and provided a solid research base to extend the creation of more openings forest-wide as foraging habitat for bats (Table 2). The importance of openings was further substantiated by a simultaneous investigation of food habits of *C. townsendii virginianus* (Shoemaker 1994) that demonstrated consumption by this bat of moths whose larvae feed on agricultural and old field plants, as well as moths whose larvae feed on woody plants.

These research efforts were supplemented with mist netting near the entrance to roosts. Placement of mist nets over road-rut ponds and adjacent to woodland ponds proved to be extremely successful locations for capturing bats, including *C. townsendii virginianus* (J. MacGregor, USFS, unpubl. data). Consequently, a program of constructing woodland ponds and maintaining road-rut ponds was established in the forest to provide drinking sites for bats as well as habitat for amphibians. Considerable progress has been made in the construction of woodland ponds (Table 2), with an expected increase in pond placement such that no pond is more than 0.4 to 0.8 km from an adjacent pond (S. Bonney, KDFWR, pers. comm.). A research project contracted out to Eastern Kentucky University is now examining use of woodland ponds by bats in the forest (K. Huie-Netting, EKV, unpubl. data).

Concern was expressed by management staff of the Daniel Boone National Forest over the need to increase the level of protection at the hibernaculum of *C. townsendii virginianus*. Gating the cave was discussed, but was viewed as potentially harmful as bats occupy the cave year-round. A concurrent phase of monitoring population levels of *C. townsendii virginianus* in the cave over a period of three years (1990–92) showed seasonal fluctuation in population levels, with consistently low numbers of bats inside the cave in August (Lacki et al. 1994). The cave was gated during 11 to 14 August 1993, despite higher numbers present than were recorded previously in mid-August (J. MacGregor, USFS, unpubl. data). Subsequent monitoring efforts in winter months show the population of *C. townsendii virginianus* to remain stable (Figure 1). This cave is also used as a hibernaculum by *M. sodalis*, with this population also remaining unchanged (Figure 1).

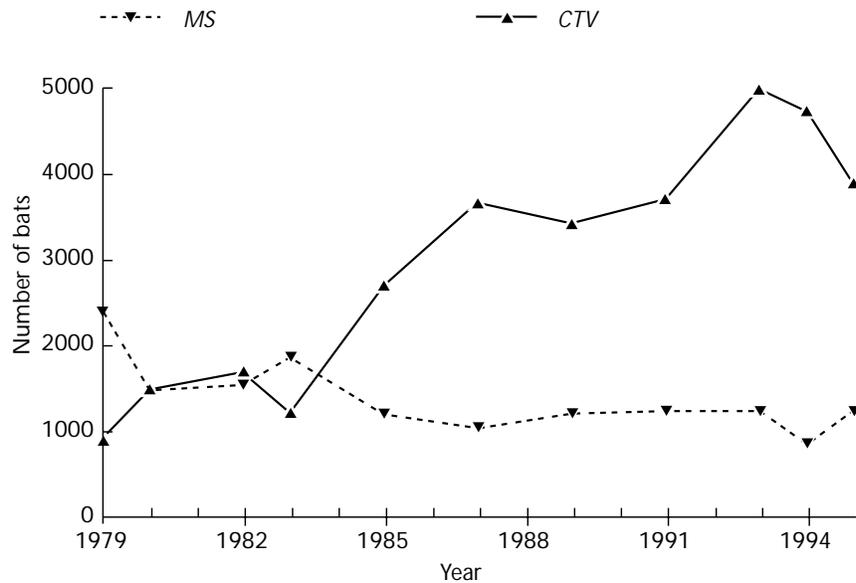


FIGURE 1 Population estimates for hibernating *Corynorhinus townsendii virginianus* and *Myotis sodalis* in a cave in Lee County, Kentucky, USA. The entrance was gated from 11 to 14 August 1993.

Management Implications

These examples demonstrate that research and management can be coordinated to enhance habitat conditions for bats in forests. Research results have been important in the development of management policies on the Daniel Boone National Forest targeting habitat enhancement for bats, including construction of woodland ponds, creation and maintenance of wildlife openings, and protection of cliffs and roosts. Additional research projects are underway to evaluate autumn foraging and roost requirements of *M. sodalis* (J. Kiser, EKU, unpubl. data) and summer foraging requirements of *C. rafinesquii* (T. Hurst, UK, unpubl. data). Communication is the key to this process as research biologists and land managers have different agendas, and may not always agree on the interpretation and meaning of the data. I believe it is extremely important for research biologists to clearly convey the assumptions and limitations behind the research methods chosen, especially in written research proposals, as these have a significant bearing on interpretation and eventual application of data to the management process.

Survey data clearly demonstrate that, although bats receive some attention by most land management agencies in Kentucky, there is a considerable need for improvement (Tables 1 and 2). With the exception of the Daniel Boone National Forest, limited research into the habitat requirements of most bat species on public forest lands in Kentucky has been completed. Further, the relationship between silvicultural prescription and habitat suitability has been largely ignored. There are few data to substantiate the establishment of no-harvest zones as a management option for enhancing habitat for bats, a common silvicultural prescription for bats in Kentucky (Table 2). The one possible exception to this would be stands of timber in the immediate vicinity of caves used as roosts (Adam et al. 1994; J. Kiser, EKU, unpubl. data; T. Hurst, UK, unpubl. data). Clearly, more data are needed to determine habitat use of bats in relation to silvicultural

prescriptions. Due to shifts in the preferred choice of silvicultural prescription over the past several decades, managed forests have undergone extensive change in plant species composition, distribution and frequency of stand age classes, and structural characteristics within stands. Suppression of fire, prescribed burning, clearcutting, shelterwood cutting, selective logging, highgrading, and patch cuts have all been used in Kentucky. Given that historical patterns of habitat use by bats are unknown, neither the present conditions or the observed patterns of use are likely to be representative of what constituted habitat for bats under presettlement conditions. Determining whether managed forests can support populations of bats at higher densities will require experimentation into several available silvicultural options.

Survey results indicated that field studies were the predominant research approach taken for identifying habitat needs of bats in forests in Kentucky. Field studies are limited in their inference because they are based on comparisons between groups that already possess the characteristics of interest (Ratti and Garton 1994). I suggest that field experiments, where treatments (e.g., silvicultural prescriptions) are randomly assigned within the known distribution of roosts and foraging areas of bat species, would strengthen our understanding of habitat requirements of bats in forests. Achievement of successfully designed field experiments will require co-operation between research biologists and land managers. This approach has the advantage of an established baseline, against which long-term monitoring of responses by bats can be compared.

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