BAT POPULATION MONITORING AND CONSERVATION AT THE ROCKY MOUNTAIN ARSENAL NWR 2004

U.S. Department of the Interior
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Rocky Mountain Arsenal National Wildlife Refuge
Commerce City, Colorado

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Project Summary

A study of the bat populations at Rocky Mountain Arsenal NWR (RMA) was conducted from 1997–1998, which provided basic population and contaminant level information. The proposed project in this document would provide follow-up monitoring information on species composition, relative abundance, and contaminant levels for bats at RMA in 2004. Additionally, this proposal includes bat conservation measures involving public education and installation of artificial bat houses. Monitoring of bat population status on RMA will provide an indication of the effectiveness of remediation in reducing contaminant exposure to wildlife and contribute to more effective conservation and management.

Introduction

Bats are a key ecosystem component and healthy bat populations are an indication of proper habitat function (USDA 1999, Fenton 2003). In North America, population declines have been documented for the past several decades for many bat species (Pierson 1998). Declines and loss of species diversity are caused by habitat loss, roost site disturbance, vandalism, and exposure to contaminants (Harvey et al. 1999). Bats are particularly vulnerable due to their often-colonial nature, need for specific microclimate roost conditions, and tendency to utilize man-made structures. Also, relatively slow reproductive rates (1 pup/year) and habitat threats combine to exacerbate population risks.

In 1997 and 1998, O'Shea et al. (1999) conducted a study of the bats at RMA to obtain basic population information and analyze levels of contaminants in big brown bats (*Eptesicus fuscus*;

O'Shea et al. 2001). The presence of 3 species was determined by captures and the probable presence of 2 additional species was determined from acoustic sampling (Table 1, O'Shea et al. 1999). The study goals proposed in this document are to conduct follow-up monitoring of the current bat populations at RMA in 2004. The objectives are to examine species composition, relative abundance, and contaminant levels in big brown bats. These objectives are consistent with the recommendations that resulted from the 1997-1998 study. This information would provide an indication of the effectiveness of remediation efforts. If a long-term monitoring scheme were to be implemented at RMA (i.e. surveys conducted on a 4-5 year cycle), this information would be important in providing a qualitative assessment of population trends. Additional objectives include bat conservation measures involving public education and installation of artificial roosts.

Table 1. Bat species documented at Rocky Mountain Arsenal National Wildlife Refuge, Commerce City, CO, 1997 and 1998.

Common Name	Scientific Name	Documentation Type	Total Captures / % of Total Captures
Big Brown Bat	*Eptesicus fuscus*	Capture, acoustic	151 / 85.8%
Hoary Bat	*Lasiurus cinereus*	Capture	17 / 9.7%
Silver-haired Bat	*Lasionycteris noctivagans*	Capture	8 / 4.5%
Red Bat	*Lasiurus borealis*	Acoustic (probable)	N/A
Myotis species	*Myotis spp.* (possible *Myotis lucifigus*)	Acoustic (probable)	N/A

Project Need and Objectives

Several priority conservation goals that were established by the North American Bat Conservation Partnership are relevant to bat conservation at the RMA and reflect the objectives of this proposed study. Those conservation goals include monitoring relative abundance, determining the effects of environmental contaminants, and implementing education and conservation programs about bats in urban environments, particularly in communities near important bat habitats. The project need and objectives are outlined below.

Species Composition and Relative Abundance

Monitoring bat population status at RMA is important because RMA is a valuable bat foraging area, particularly for breeding colonies of big brown bats (Everette et al. 2001, O'Shea et al. 1999). Replicate monitoring over years is necessary to obtain information to track relative population trends. This study will use capture and acoustic detection techniques to provide data on species composition and relative abundance, contributing to the population baseline information established in 1997-1998. Also, this survey effort would help clarify the status of little brown bats (*Myotis lucifigus*) at RMA, a species that was curiously lacking from the bat community in 1997–1998. Based on acoustic detection in 1997 and rabies submission records for the surrounding area, the little brown bat is suspected to occur at RMA.

Contaminants Status of Big Brown Bats

Contaminants have been shown to contribute to bat population declines (O'Shea et al. 1999). Relatively high in the food web, long-lived, and mobile, bats are vulnerable to contaminants such as DDE (Clark et al. 1995), making them valuable indicators of environmental pollution. Because bats are insectivorous they can be exposed to a variety of organochlorine pesticides. A high metabolic rate demands increased food intake which increases the amount of organochlorines in fat concentrations (Clark and Shore 2001). Therefore, chemicals such as dieldrin and DDE, both of which were manufactured at RMA, can accumulate in bats. Bats have pronounced cycles of fat storage and depletion that supports them during migration, hibernation, and reproduction (O'Shea and Clark 2003). Organochlorines are later released as body fat is utilized. Thus, organochlorines can cause mortality during critical life cycle phases. Also, because organochlorines concentrate in milk, nursing young may receive large amounts of contaminants (Clark and Shore 2001). Sub-lethal effects on bats are poorly studied though there is evidence that organochlorine exposure increases energy metabolism, causes loss of coordination, and intoxication behavior (Clark and Shore 2001, Kunz and Fenton 2003). These effects may influence foraging time, predator susceptibility, time devoted to reproductive demands, and storage of energy for survival during migration and hibernation (Kunz and Fenton 2003, O'Shea and Clark 2003).

In 1997 and 1998, big brown bats were found to use the arsenal for foraging. Big brown bats had elevated levels of dieldrin, DDT, DDE, and mercury and were one of the most contaminated mammal species studied on the RMA. Therefore, dieldrin, DDT, DDE, and mercury will be the primary contaminants of interest for the 2004 study. Valuable information regarding the effectiveness in reducing contaminant exposure to wildlife could be gained by re-examining contaminant levels in big brown bats in 2004. Also, O'Shea et al. (1999) found that little brown bats were largely absent from the community, which is difficult to explain. Though natural history traits of this species (i.e. foraging and roosting preferences) and the habitat character of RMA may explain its absence, organochlorine contamination may have greater impacts on little brown bats than on big brown bats (O'Shea et al. 1999); contaminants may have impacted this species thereby reducing numbers. An increase in numbers of little brown bats using RMA may provide evidence of effective remediation efforts. Also, if sufficient numbers of little brown bats are captured, samples could be collected for contaminant analysis, which would provide a comparison with big brown bats.

Public Education

The decline in bat numbers suggests that much effort is needed to promote bat conservation. Bats are one of the most beneficial yet misunderstood species. Public education efforts help dispel myths and inform people of the benefits of bats to communities. The RMA Visitor Services education program currently includes a bat curriculum. This proposal includes expansion of the bat education program by incorporating current RMA bat population information, an acoustic bat detector demonstration, and a mist netting demonstration.

Habitat Enhancement: Artificial Bat House Installation

Roosting habitat is often limited (Sheffield et al. 1992). Bats are able to manage energy budget requirements more efficiently when resources are in close proximity (USDA 1999). Results from a radio-telemetry study of big brown bats at RMA showed that travel distances from urban roost locations to RMA foraging areas were as far as 12 km (Everette et al. 2001). Providing artificial bat roosts may enhance abundance by creating roosting habitat near important foraging areas. Bats roosting at RMA would conserve energy and avoid increased predation risks associated with a long travel distance to foraging areas. Additionally, if artificial roosts become occupied, they would serve as sites to sample guano for contaminants. Bat houses would also provide an opportunity for public viewing and interpretation.

Bats aid in controlling insect populations and they are the primary predators of many agricultural insect pests and disease-carriers (Long 1996, Tuttle and Taylor 1998). Bats can be an important part of an integrated pest management program. Conserving and enhancing RMA's local bat population is one method to accomplish and maintain long-term insect control. Enhancing habitat for bats at RMA would contribute to protecting the local bat population.

Methods

Species Composition and Relative Abundance

We will use a standardized sampling protocol to assess species composition and relative abundance of bats (Ministry of Environment 1998, Cross 2000). To allow for comparisons of data among years, survey sites and techniques in 2004 will be similar to that used by the 1997-1998 study. Using the previous information as a guide to the most productive survey areas will enable an efficient, logistically more feasible sampling scheme in 2004.

Survey sites will be in the southern portion of the Refuge where lake and riparian habitats provide more foraging opportunities (Sable Quad, sections 1, 2, 5, 6, 7, 8, 11, 12, 31). Bat activity and foraging attempts are most frequent in water and tree edge habitats at RMA (Everette et al. 2001), therefore these areas will be the focus of the monitoring efforts for 2004. In addition, habitats with only trees may also be sampled. Prairie habitats will not be sampled due to the low number of captures and acoustic detection (O'Shea et al. 1999). Due to a likely lack of water in wetlands in 2004, habitats with water only will not be sampled. There are 5-8 potential survey sites that include: Havanna Street Interceptor, Eagle Bottom Pond/First Creek, Lake Mary, Section 31 Pond Complex, Lake Ladora Arm, Lower Derby, section 11 Treebox, and section 6 Bunker Grove (Table 2). Survey sites will be based on recommendations from USGS and finalized this winter.

Due to variation in bat activity, a combined approach of capture and acoustic detection techniques minimizes bias and provides a more complete sample of the bat community (Kuenzi and Morrison 1998, O'Farrell and Gannon 1999, Gannon et al. 2003). We will use both mist nets and acoustic bat detectors at each survey site to determine species composition and relative abundance. To capture bats, mist nets (6-18 m in length) will be placed where bat activity is likely to be highest (i.e. over and along a water source, in a flight corridor). Bats will be

captured from late May to late August in 2004 between sunset and midnight (4 hr sampling period). Sites will be surveyed 1-2 nights/month throughout the survey period. Survey effort will be standardized by 6-m net nights (the total length of nets used divided by 6) and will be similar to 1997 and 1998 effort. Because moonlight may affect bat activity (Hayes 1997) and can adversely affect capture success in open habitats (pers. comm., pers. obs), surveys will be conducted each month during an approximately 1-week period around the time of the new moon (reduced moonlight may render mist nets less visible to bats). Species, age, sex, and reproductive status will be determined, and mass and other body measurements will be recorded. Weather data and site characterization information will also be recorded. A minimum of 2 people will be needed per survey night. Anyone handling bats will be vaccinated for rabies.

An ultrasonic bat detector (AnaBat II, Titley Electronics, Ballina, New South Wales, Australia) will be used for acoustic detection. Acoustic surveys will be conducted concurrently at mist net capture sites. Bat detectors will help detect bats that fly outside the sampling ability of nets (O'Farrell and Gannon 1999). Results from the acoustic surveys will provide a more robust assessment of species composition and will enable comparison of relative differences in bat activity among sites surveyed in 2004. Additional acoustic surveys may also be conducted at sites where bat activity is consistently high. Also, to complement species composition information, acoustic surveys may be conducted in areas where streetlights may be attracting foraging bats (i.e. the visitor center, "fishermen's" restroom). The detectors will be placed 2 m above ground and at a 45° angle. Acoustic surveying will begin 30 min after sunset. Surveys will occur with the detector facing the mist net in a single direction. The unit of activity is defined as a bat pass. A bat pass is a continuous series of ≥1call notes with no pauses greater than 1second between call notes. Bat passes will be sorted into 10-minute intervals and tallied within characteristic frequencies (O'Shea et al. 1999). Bat passes will be identified by species, when possible (O'Farrell and Miller 1999, O'Farrell et al. 1999), or by species groups (Gannon et al. 2003). The bat call library of hand-released bats obtained during the 1997-1998 study will be used to help identify species and bat groups in 2004. Identification will be based on qualitative comparison of call structures with those of hand-released bats from RMA.

Exit surveys or capture surveys may be conducted at select buildings that have potential as night and/or day roost sites for bats. Exit surveys will involve use of a night vision scope to view bats exiting the building. Hand-held tally counters will be used to count bats entering and exiting the building.

The natural history of bats presents challenges to monitoring populations, making robust estimates difficult to obtain (O'Shea et al. 2003). Bat activity patterns vary daily or seasonally in response to factors such as variation in insect abundance, moonlight, water availability, weather, net coverage, and worker experience (Hayes 1997, Cross 2000). These factors introduce potential sources of variation in capture and acoustic results, which confound actual changes in population numbers. The survey methods currently available provide only an index of abundance and require standardization of methodologies to enable comparable data; their limitations must be recognized when interpreting results. Regardless, these methods are tools that will allow us to examine potential trends (O'Shea et al. 2003).

Table 2. Potential bat capture and acoustic survey sites at the Rocky Mountain Arsenal National Wildlife Refuge in 2004. UTM locations are in Zone 13 S, NAD27 Datum.

Site	UTM Northing	UTM Easting	Habitat Type
Havanna Street Interceptor	4405570	0511885	water and tree edge
Eagle Bottom Pond	4406786	0517310	water and tree edge
First Creek	4406886	0517310	water and tree edge
Lake Mary	4407490	0511578	water and tree edge
Section 31 Pond	4409041	0515795	water and tree edge
Lake Ladora "Arm"	4406792	0513048	water and tree edge
Lower Derby	4406962	0513847	water and tree edge
Section 11 "Treebox"	4406064	0513048	tree edge
Section 6 "Bunker Grove"	4407192	0515627	tree edge

Status of Contaminants in Big Brown Bats

Male big brown bats were found to have the highest organochlorine levels in 1997 and 1998 at RMA (O'Shea et al. 2001). We will use mist nets to collect adult and juvenile male big brown bats for contaminant analysis in 2004. We will focus contaminant analysis on dieldrin, DDT, DDE, and mercury because these were found in concentrations indicative of heavier contamination in 1997 and 1998. Brain, carcass, and stomach contents will be evaluated for these contaminants. We will collect approximately 25 male big brown bats for analysis and will euthanize bats using cervical dislocation. We will collect little brown bat samples, given sufficient numbers are captured, to allow for comparisons with big brown bats. Organochlorine content in carcasses varies with fat content (Clark and Shore 2001) therefore we will collect bats during late June-July to avoid times of increased fat deposition (i.e. late summer when bats are accumulating fat for migration and hibernation). Omitting females from the sampling procedure will lessen the impact to the population.

In 1997-1998, big brown bats from Fort Collins, Colorado, 80 km north of RMA, were collected as reference site specimens. There was no known history of excessive contamination for this area. Organochlorine and other contaminant concentrations from guano and carcass reference samples were near or below detection limits and were lower than samples from RMA. For example, dieldrin concentrations in carcasses from RMA exceeded those of bats collected at the Fort Collins reference site by a magnitude of 1-2 orders. The 1997-1998 Fort Collins data and the 1997-1998 RMA data will be used for comparison with 2004 RMA contaminant results.

Samples will be analyzed at the National Wildlife Research Center in Fort Collins, Colorado, or by Army Laboratories. Specimen preparation will be consistent with methods used in the 1997-1998 study (O'Shea et al. 1999) and will follow accepted protocol guidelines of RMA (USFWS 1994). Minimum tissue sample sizes required for analysis of dieldrin, DDT, and DDE are 1.0 g, and 0.25 g for analysis of mercury concentration. Minimum detection limits for carcass and stomach samples are 0.02 :g/g for dieldrin and DDE, and 0.025 :g/g for DDT. Minimum detection limits for brain samples are 0.1 :g/g. Minimum detection limits for mercury are 0.02 :g/g. The percent lipid content will be determined for carcass samples. Concentrations (:g/g wet weight) of organochlorine contaminants and mercury in carcasses, brains, and stomach contents, and % lipids in carcasses, will be analyzed by location and age category using ANOVA.

Public Education and Habitat Enhancement

We will coordinate with FWS Visitor Services in organizing public education programs in June, July, or August that would include mist netting and acoustic bat detector demonstrations. Potential demonstration sites for these programs include Lake Mary and Havanna Ponds. These demonstration programs will be limited to small groups of visitors (approximately 15 people).

Installation of bat houses can be an effective habitat enhancement method. Bat houses would be installed in locations determined by the survey effort to be the most appropriate. The building and installation of houses would be a volunteer or Scout project. Bat houses will be designed and mounted in accordance with recommendations based on tested techniques (Tuttle and Hensley 2001). The appropriate numbers of houses and sites will be determined following 2004 surveys. Scouts may be able to furnish a limited amount of bat house supplies. In the event that artificial roosts become occupied, disturbance should be minimized. If this study finds that contaminant levels in bats remain elevated, installation of bat houses will be re-evaluated.

Equipment and Expenses

Equipment Available at Rocky Mountain Arsenal

Equipment/Service	Number Available
Survey Equipment	
Mist Nets (50 denier)	(1) 6 m net (8) 9 m nets (4) 12 m nets
Net Poles	14 sets
Spotlights	2
Night Vision Binoculars	1
Hand-held Tally Counter	2
Batteries	60 AA, (8) 9-volts
(headlamps, bat detector equip)	
Vehicles	FWS
AnaBat II Bat Detector System	
Bat Detector	2
ZCAIM	2
Delay Switch	1
Universal Timer	1
Temp/Humidity Sensor	1
Detector to Timer Cable	1
Timer to Delay Switch Cable	1
Computer Cable	2
Detector to Tape Recorder Cable	2
Laptop Computer	1
Tape Recorder	1
Bat Processing Equipment	
Scales	(1) 60 g
Calipers	1
Holding Bags	25+
Contaminants Analysis	
Dissecting tools	Available at RMA lab
Chemically clean glassware (2 oz. Jars)	50
Solvent	1 bottle
Public Education	
"Bats of America" Slides	1 set

Needed Equipment/Services

Equipment/Service	Estimated # Needed	Estimated Cost	Estimated Total Cost	Source
Rabies vaccination (Series of 3 shots)	2	$510 per person	$1020	Rocky Mt. Medical Group
Rabies titer check	4	$126	$504	Rocky Mt. Medical Group
Scientific collection permit	1	N/A	N/A	CDOW
Headlamp	2	$35	$70	REI or equivalent
Mist Nets: 6 m	1	$60	$60	Avinet, Inc.
Bat Handling Gloves	3	$15	$45	Sports or hardware store
Waders	2	$70	$140	Outdoor store
Equip. for bat detector stand	1 stand	$50	$50	Hardware store and/or dept. store

Estimated Total Cost = $1889

Cooperators

US Geological Survey personnel from the Fort Collins Science Center (Tom O'Shea, Laura Ellison, and Lance Everette) involved in the 1997-1998 study will provide assistance during the design phase of the study and with using the acoustic bat detector (AnaBat) equipment. Visitor Services staff will coordinate with Noelle Ronan for the public education program and volunteer efforts for bat house construction and installation.

References

Clark, D.R., A. Moreno-Valdez, and M. A. Mora. 1995. Organochlorine residues in bat guano from nine Mexican caves, 1991. Ecotoxicology 4:258-265.

Clark, D. R., and R. F. Shore. 2001. Chiroptera. *In:* Ecotoxicology of Wild Mammals. R. F. Shore and B. A. Rattner (Eds.). John Wiley and Sons, Ltd.

Cross, S. P. 2000. Final Report: towards standardizing a mist-net protocol for surveying and monitoring bats in Pacific Northwest forests. Dept. of Biology, Southern Oregon University, Ashland, Oregon.

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

Fenton, M. B. 2003. Science and the conservation of bats: where to next? Wildlife Society Bulletin 31(1):6-15.

Gannon, W. L., R. E. Sherwin, and S. Haymond. 2003. On the importance of articulating assumptions when conducting acoustic studies of habitat use by bats. Wildlife Society Bulletin 31(1):45-61.

Harvey, M. J., J. S. Altenbach, and T. L. Best. 1999. Bats of the United States. Arkansas Game and Fish Commission. 64 pp.

Hayes, J. P. 1997. Temporal variation in activity of bats and the design of echolocation-monitoring studies. Journal of Mammology 78(2): 514-524.

Kuenzi, A. J. and M. L. Morrison. 1998. Detection of bats by mist-nets and ultrasonic sensors. Wildlife Society Bulletin 26(2):307-311.

Long, R. F. 1996. Bats for Insect Biocontrol in Agriculture. Monitoring the Field of Pest Management. Vol. XVIII, No. 9.

Ministry of Environment, Lands and Parks Resources Inventory Branch for the Terrestrial Ecosystems Task Force Resources Inventory Committee. 1998. Inventory Methods for Bats. Standards for Components of British Columbia's Biodiversity No. 20. Version 2. www.for.gov.bc.ca/ric

O'Farrell, M. J., B. W. Miller, and W. L. Gannon. 1999. Qualitative identification of free-flying bats using the Anabat detector. Journal of Mammology 80(1):11-23.

O'Farrell, M. J. and W. L. Gannon. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. Journal of Mammology 80(1):24-30.

O'Farrell, M. J. and B. W. Miller. 1999. Use of vocal signatures for the inventory of free-flying Neotropical bats. Biotropica 31(2):507-516.

O'Shea, T. J., A. L. Everette, L. A. Stone, J. L. McCance, and L. E. Ellison. 1999. Bats of the Rocky Mountain Arsenal National Wildlife Area: Status and Potential Impacts of Contaminants. Unpubl. Report. Interagency Agreement No. 82020-1491-MC20. U.S. Geological Survey, Midcontinent Ecological Science Center, Fort Collins, CO.

O'Shea, T. J., A. L. Everette, and L. E. Ellison. 2001. Cyclodiene insecticide, DDE, DDT, arsenic, and mercury contamination of big brown bats (*Eptesicus fuscus*) foraging at a Colorado Superfund site. Archives of Environmental Contamination and Toxicology 40:112-120.

O'Shea, T. J., M. A. Bogen, and L. E. Ellison. 2003. Monitoring trends in bat populations of the United States and territories: status of the science and recommendations for the future. Wildlife Society Bulletin 31(1):16-29.

O'Shea, T. J., and D. R. Clark. 2003. An overview of contaminants and bats, with special reference to insecticides and the Indiana bat. *In:* The Indiana Bat: Biology and Management of an Endangered Species. A. Kurta and J. Kennedy (Eds.). Bat Conservation International, Inc., Texas. 265 pp.

Pierson, E. D. 1998. Tall trees, Deep Holes, and Scarred Landscapes: Conservation Biology of North American Bats. *In*: Bat Biology and Conservation. Ed. T. H. Kunz and P. A. Racey. Smithsonian Institution Press, Washington.

Sheffield, S. R., J. H. Shaw, G. A. Heidt, and L. R. McClenaghan. 1992. Guidelines for the protection of bat roosts. Journal of Mammology 73(3):707-710.

Tuttle, M. D. and D. A.R. Taylor. 1998. Bats and Mines. Bat Conservation International, Inc. Resource Publication No. 3.

Tuttle, M. D., and D. L. Hensley. 2001. The Bat House Builder's Handbook. University of Texas Press, Austin, TX.

USDA NRCS Wildlife Habitat Management Institute. 1999. Bats (Order: Chiroptera). Fish and Wildlife Management Leaflet No. 5. www.ms.nrsc.usda.gov/whmi/wildlife.htm

US Fish and Wildlife Service, Rocky Mountain Arsenal National Wildlife Refuge. 1994. Protocols for the Collection and Handling of Fortuitous Specimens. Commerce City, Colorado.