THE SOUTHWESTERN NATURALIST 44(4):501–506 DECEMBER 1999

BATS CAPTURED IN TWO PONDEROSA PINE HABITATS IN NORTH-CENTRAL ARIZONA

THOMAS E. MORRELL, MICHAEL J. RABE, JAMES C. DEVOS, JR., HEATHER GREEN, AND C. RICHARD MILLER

Department of Biology, Ball State University, Muncie, IN 47306
Present address of MR, JCdV: Research Branch, Arizona Game and Fish Department, 2221 W. Greenway Road, Phoenix, AZ, 85023
Present address of HG: Coconino National Forest, Morman Lake Ranger District, 4825 S. Lake Mary Road, Flagstaff, AZ 86001
Present address of CRM: Region 2 Office, Arizona Game and Fish Department, 3500 S. Lake Mary Road Flagstaff, AZ, 86001

ABSTRACT—We used mist nets to capture bats in two ponderosa pine (*Pinus ponderosa*) habitats in the Coconino National Forest, Arizona during June and July, 1993 to 1995. We captured 1,123 bats representing 12 species in ponderosa pine forest habitat and 561 bats representing 15 species in ponderosa pine-oak forest habitat. Four species comprised 76% of all captures: *Myotis volans* (23.7%), *Eptesicus fuscus* (23.1%), *M. evotis* (16.0%), and *M. occultus* (13.4%). Based on netting effort alone we captured more *E. fuscus, Lasiurus cinereus,* and *M. evotis* and fewer *Antrozous pallidus, Lasionycteris noctivagans,* and *M. auriculus* in the ponderosa pine habitat than in the pine-oak habitat. Pregnant and lactating bats from nine species accounted for 60% of all female captures. Because some of these species roost in pine forest, intensive forest management practices in ponderosa pine habitats during summer months may negatively influence their reproductive success.

RESUMEN—Usamos redes de malla para capturar murciélagos en dos hábitats de pino ponderosa (*Pinus ponderosa*) en el Coconino National Forest, Arizona, durante junio y julio, 1993 y 1995. Capturamos 1,123 murciélagos que representan 12 especies en hábitat de pino ponderosa y 561 murciélagos que representan 15 especies en hábitat de pino ponderosa-roble. Cuatro especies comprendieron el 76% de todas las capturas: *Myotis volans* (23.7%), *Eptesicus fuscus* (23.1%), *M. evotis* (16.0%), y *M. occultus* (13.4%). En base a sólo los esfuerzos de captura obtuvimos más *E. fuscus, Lasiurus cinereus, M. evotis,* y menos *Antrozous pallidus, Lasionycteris noctivagans* y *M. auriculus* en el hábitat de pino ponderosa que en hábitat de pino-roble. Murciélagos preñadas y lactando de nueve especies comprendieron el 60% de las hembras capturadas. Prácticas intensivas de manejo de bosques en hábitat de pino ponderosa durante los meses de verano cuando los murciélagos están reproductivamente activos pueden influenciar negativamente su éxito reproductivo.

Forest age, structure, and management can influence the abundance, diversity, and distribution of species of bats (Thomas, 1988; Erickson and West, 1996; Grindal, 1996; Krusic et al., 1996). Because ponderosa pine (*Pinus ponderosa*) habitat in the Coconino National Forest, Arizona is managed, in part, for timber production and cattle grazing (United States Department of Agriculture Forest Service, 1987), abundance and distribution of some species of bats may be affected by land use practices. However, resource managers currently are unable to predict if proposed land uses will affect bats because of the lack of information regarding occurrence of bats in ponderosa pine forests. Thus, data on distribution and abundance are needed to enable resource managers to make informed decisions regarding forest land uses and possible impacts on bats.

Hoffmeister (1986) provided distributions in Arizona based on specimens, historical accounts, and spot surveys. Jones (1965, 1966) and Jones and Suttkus (1972) reported abundances and distributions of bats captured in mist nets in some Arizona and New Mexico forests. However, there is little detailed information on current distributions and relative abun-

dances of species of bats occupying forests in the southwestern United States.

MATERIALS AND METHODS—As a part of a larger telemetry investigation aimed at locating roost sites of reproductively active females, bats were captured with mist nets at 31 locations (Appendix 1) in two study areas in the Coconino National Forest, Arizona. Sixteen sites were located in ponderosa pine forest habitat approximately 14 km NW Flagstaff, Arizona (hereafter referred to as the north area). Elevations in this area ranged from 2,262 to 2,621 m. Conspicuous trees and shrubs in the north area included ponderosa pine, quaking aspen (*Populus tremuloides*), Utah service-berry (*Amalanchier utahensis*), buckbrush (*Ceanothus fendleri*), rose (*Rosa arizonica*), and wax current (*Ribes cereum*). Netting effort in the north area consisted of 11,509 linear net hours during 16 June to 7 July 1993, 13 June to 9 July 1994, and 19 June to 26 July 1995. Netting effort was determined by summing linear m of net set each hour (e.g., three 18-m nets set for 3 h provided 162 linear net hours of effort).

Fifteen capture locations were located in ponderosa pine-oak forest habitat approximately 30 km S Flagstaff (hereafter referred to as the south area). Elevations of capture locations in this study area ranged from 2,018 to 2,276 m. Conspicuous trees and shrubs in the south area included ponderosa pine, Gambel oak (*Quercus gambelli*), juniper (*Juniperus osteosperma, J. deppeana*) buckbrush, creeping mahonia (*Berberis repens*) and locust (*Robinia neomexicana*). Netting effort in the south area consisted of 16,755 linear net hours during 20 June to 12 July 1994 and 19 June to 24 July 1995. Although we netted 3 years on the north area and only 2 years on the south area, 31% less trapping effort took place on the north area.

Mist nets 2.1 m high and of varying lengths (5.5 to 18.3 m) were set over water impoundments and springs. In most instances we set multiple nets (two to four) at a location. The majority (99%) of netting took place between dusk and midnight. Captured bats were identified (Hoffmeister, 1986), weighed to nearest 0.2 g, sex was determined, and the reproductive status of females noted. Pregnancy was determined by palpation, and lactation was determined by visual observation and presentation of milk. Most species were easily identifiable, but we closely examined three characteristics to distinguish *M. californicus* from *M. ciliolabrum*. Bats were identified as *M. californicus* if they had an abrupt rise from rostrum to braincase, a thumb length <4 mm, and a distinct black facial mask, whereas bats were identified as *M. ciliolabrum* if they had a gradual rise from rostrum to braincase, a thumb length ≥ 4 mm, and no distinct facial mask.

RESULTS—We captured 1,684 bats at 31 locations during 59 nights with 28,264 linear net hours of netting effort. A total of 1,123 bats representing 12 species were captured on the north area, and 561 bats of 15 species were captured on the south area (Table 1).

Four species comprised 76.2% of all captures (Table 1): *M. volans* (23.7%), *E. fuscus* (23.1%), *M. evotis* (16.0%), and *M. occultus* (13.4%). Ten species each accounted for $\leq 4\%$ of all captured bats. Four species were captured ≤ 8 times (0.4%) each (Table 1). *Eptesicus fuscus* was the most widely distributed bat and was captured at all but two sites. *Myotis occultus* was captured at 82% of the sites, and *M. volans* and *M. evotis* were both captured at 77% of the sites, respectively. *Corynorhinus townsendii, Tadarida brasiliensis, M. yumanensis,* and *Antrozous pallidus* were less widely distributed and were only trapped in the south area at ≤ 6 locations. *Myotis californicus* occurred in both study areas but was netted only at five (14%) sites (Table 1).

Frequency of captures of nine species differed between the north and south areas. *Eptesicus fuscus, Lasiurus cinereus, M. evotis,* and *M. occultus* were captured more than expected in the north area based on netting effort alone (Table 1). In contrast, *A. pallidus, Lasionycteris noctivagans,* and *M. auriculus* were captured more frequently in the xeric pine-oak community of the south area than expected (Table 1).

Capture success between sexes varied among some species (Table 1). Notably, we did not capture any female *L. cinereus* or *L. noctivagans,* and we captured only 1 male *Idionycteris phyllotis* out of 26 total (Table 1).

We captured pregnant and lactating bats from nine species (Table 2). In the ponderosa pine habitat, *E. fuscus* and *I. phyllotis* were the only species in which a majority of females captured were pregnant and lactating, respectively. Similarly, in pine-oak habitat *M. ciliolabrum* was the only species in which a majority of females captured were pregnant, and a majority of female *A. pallidus, M. thysanodes,* and *M. volans* were lactating (Table 2). No bats were observed carrying young.

DISCUSSION—Jones (1965, 1966) and Jones and Suttkus (1972) surveyed bats from 1957 to 1968 in similar habitats in east-central Arizona and west-central New Mexico and reported relative abundances that were similar to ours with

TABLE 1—Species (listed alphabetically), number of male and female bats captured, number captured per net hour, percent of total captures, number of sites species were caught at, and chi-square statistic comparing the number of bats captured in two ponderosa pine habitats on the Coconino National Forest, Arizona during June and July, 1993 to 1995. Eleven bats escaped before sex was determined.

	Ponderosa pine			Ponderosa pine-oak						
Species	Males	Females	Number captured/ linear m net/h ×1000	Males	Females	Number captured/ linear m net/h ×1000	Percent of total captures	Number of sites species were caught at (n = 31)	Chi-square goodness of fit χ^2	P
Antrozous pallidus	0	0	0	4	37	2.4	2.4	6	28.2	<0.0001
Corynorhinus townsendii	0	0	0	0	2	0.1	0.1	1	1.3	0.2401
Eptesicus fuscus	80	164	21.2	50	96	8.7	23.1	29	77.2	<0.0001
Idionycteris phyllotis	0	12	1.0	1	13	0.8	1.5	10	0.3	0.5776
Lasionycteris noctivagans	10	0	0.8	60	0	3.5	4.1	17	20.2	<0.0001
Lasiurus cinereus	28	0	2.4	15	0	0.9	2.6	15	10.6	0.0011
Myotis auriculus	1	2	0.2	25	28	3.1	3.3	11	29.0	<0.0001
M. californicus	2	0	0.1	5	1	0.3	0.5	5	0.8	0.3681
M. ciliolabrum	8	0	0.7	5	4	0.5	1.0	10	0.3	0.5876
M. evotis	119	93	18.4	34	23	3.4	16.0	24	161.7	<0.0001
M. occultus	77	38	9.9	58	51	6.5	13.4	27	10.4	0.0012
M. thysanodes	49	52	8.7	8	13	1.2	7.3	18	89.6	<0.0001
M. volans	202	182	33.3	9	7	0.9	23.7	24	506.8	<0.0001
M. yumanensis	0	0	0	0	3	0.1	0.1	2	2.0	0.1522
Tadarida brasiliensis	0	0	0	4	0	0.2	0.2	3	2.7	0.0978
Total	576	543		286	268					

TABLE 2—Number (percent captured females within a species) and time frames of observed pregnant and lactating bats in two ponderosa pine habitats on the Coconino National Forest, Arizona during June and July, 1993 to 1995. A dash indicates that no reproductively active females were captured.

	Ponderosa pine				Ponderosa pine-oak			
	Pregnant		Lactating		Pregnant		Lactating	
Species	Number (%)	Dates observed	Number (%)	Dates observed	Number (%)	Dates observed	Number (%)	Dates observed
Antrozous pallidus	—				4 (10.8)	21 June–27 June	29 (78.3)	29 June–24 July
Corynorhinus townsendii	—				—		1 (50.0)	28 June
Eptesicus fuscus	107 (65.2)	13 June–7 July	22 (13.4)	17 June–21 July	28 (29.2)	21 June–10 July	31 (32.3)	24 June–24 July
Idionycteris phyllotis	1 (8.3)	16 June	8 (66.7)	26 June–12 July	4 (30.1)	21 June–27 June	9 (29.2)	23 June–20 July
Lasionycteris noctivagans	—		—		—		—	
Lasiurus cinereus	—		—		—		—	
Myotis auriculus	—		—		11 (39.2)	21 June–6 July	8 (42.8)	4 July–24 July
M. californicus	—		—		—		—	
M. ciliolabrum	—		—		3 (75.0)	3 July–16 July	—	
M. evotis	31 (33.3)	13 June–8 July	19 (20.4)	28 June–20 July	7 (3.4)	21 June–16 July	11 (47.8)	3 July–22 July
M. occultus	6 (15.7)	15 June–11 July	6 (15.7)	30 June–15 July	14 (27.4)	21 June–7 July	25 (49.0)	25 June–22 July
M. thysanodes	12 (23.1)	13 June–27 June	22 (42.3)	21 June–20 July	—		7 (53.8)	29 June–17 July
M. volans	18 (9.9)	15 June–11 July	37 (20.3)	16 June–21 July	1 (14.3)	27 June	4 (57.1)	3 July–9 July
M. yumanensis	—		—		—		—	
Tadarida brasiliensis	—		—		—		—	

one notable exception. *Lasiurus cinereus* was captured more frequently in the earlier studies than in ours. Warner (1985), who surveyed bats in a small portion of our north study area in July and August, 1979 and 1980 also reported relative abundances similar to ours. However, in his study, *M. thysanodes* was the most frequently captured (42%) species (n = 520). We believe some species of concern, including *M. evotis, M. occultus,* and *M. volans* are more abundant in ponderosa pine habitats than previously thought. We recommend that additional intensive surveys be conducted in other habitats in the Southwest, such as riparian, piñon-juniper, and grassland habitats to further assess the status of these species.

Capturing only male *L. cinereus* and *L. noctivagans* may have been the result of geographic segregation. Segregation of the sexes in these two species has been reported during spring migrations and on summering grounds in other areas of North America (Vaughan and Krutzsch, 1954; Findley and Jones, 1964; Findley et al., 1975; Hoffmeister, 1986). Twenty-five of 26 *I. phyllotis* and all *A. pallidus* captured were female but we were unable to explain these gender differences. Perhaps these species segregate sexes with females occurring in ponderosa pine habitat in June and July.

Females of many species of bats were reproductively active in ponderosa pine habitats during the study period (June and July). Rabe et al. (1998) reported that clumps of large diameter ponderosa pine snags with peeling bark were the primary habitat components selected by pregnant and lactating *I. phyllotis, M. evotis, M. occultus, M. thysanodes,* and *M. volans* in our study areas. Because bats have low reproductive rates, intensive forest management practices in ponderosa pine habitats during summer months when bats are reproductively active may affect adversely their reproductive success.

We thank K. Yasuda, M. Tuttle, T. Merriman, B. Grantges, B. Yoder, W. Draper, R. Revis, B. Breyer, T. Snow, S. Castner, D. Crisp, T. Britt, E. McCann, R. Sinton, R. Stait, and A. Morrell for field assistance. We also thank W. Ballard and two anonymous reviewers for providing comments to the manuscript. This study was funded by an Arizona Game and Fish Heritage Grant, United States Forest Service, and Ball State University.

Literature Cited

Erickson, J. L., and S. D. West. 1996. Managed forests in the western Cascades: the effects of seral stage on bat habitat use patterns. In: Barclay, R. M. R., and R. M. Brigham, editors. Bats and forest symposium, October 19–21, 1995, Victoria, British Columbia, Canada. Research Branch, British Columbia Ministry of Forestry, Victoria, British Columbia Work Paper 23/1996. Pp. 215–227.

Findley, J. S., and C. Jones. 1964. Seasonal distribution of the hoary bat. Journal of Mammalogy 45: 461–470.

Findley, J. S., A. H. Harris, D. E. Wilson, and C. Jones. 1975. Mammals of New Mexico. University of New Mexico Press, Albuquerque.

Grindal, S. D. 1996. Habitat use by bats in fragmented forests. In: Barclay, R. M. R., and R. M. Brigham, editors. Bats and forest symposium, October 19–21, 1995, Victoria, British Columbia, Canada. Research Branch, British Columbia Ministry of Forestry, Victoria, British Columbia, Work Paper 23/1996. Pp. 260–272.

Hoffmeister, D. F. 1986. Mammals of Arizona. University of Arizona Press, Tucson.

Jones, C. 1965. Ecological distribution and activity periods of bats on the Mogollon Mountains of New Mexico and adjacent Arizona. Tulane Studies in Zoology 12:93–100.

Jones, C. 1966. Changes in populations of some western bats. American Midland Naturalist 76: 522–528.

Jones, C., and R. D. Suttkus. 1972. Notes on netting bats for eleven years in western New Mexico. Southwestern Naturalist 16:261–266.

Krusic, R. A., M. Yamasaki, D. N. Christopher, and J. P. Peter. 1996. Bat habitat use in White Mountain National Forest. Journal of Wildlife Management 60:625–631.

Thomas, D. W. 1988. The distribution of bats in different ages of Douglas-fir forests. Journal of Wildlife Management 52:619–626.

Rabe, M. R., T. E. Morrell, H. Green, J. C. deVos, Jr., and C. R. Miller. 1998. Characteristics of ponderosa pine snag roosts used by reproductive bats in northern Arizona. Journal of Wildlife Management 62:612–621.

Vaughn, T. A., and P. H. Krutzsch. 1954. Seasonal distribution of the hoary bat in southern California. Journal of Mammalogy 35:431–432.

United States Department of Agriculture Forest Service. 1987. Coconino National Forest plan. United States Department of Agriculture Forest Service, Southwestern Region, Flagstaff, Arizona.

Warner, R. M. 1985. Interspecific and temporal dietary variation in an Arizona bat community. Journal of Mammalogy 66:45–51.

Submitted 5 January 1998. Accepted 18 December 1998. Associate Editor was Mark D. Engstrom.

Appendix 1

Site name, Universal Transmercader Coordinates (UTM), elevation, width, length, and perimeter size of sites, general shape of water surface perimeter, and species abbreviations of bats captured at each site during this study on the Coconino National Forest, Arizona during June and July 1993 to 1995. Species abbreviations: *Antrozous pallidus* (Ap), *Corynorhinus townsendii* (Ct), *Eptesicus fuscus* (Ef), *Idionycteris phyllotis* (Ip), *Lasionycteris noctivagans* (Ln), *Lasiurus cinereus* (Lc), *Myotis auriculus* (Ma), *M. californicus* (Mca), *M. ciliolabrum* (Mci), *M. evotis* (Me), *M. occultus* (Mo), *M. thysanodes* (Mt), *M. volans* (Mv), *M. yumanensis* (My), *Tadarida brasiliensis* (Tb).

Site name	UTM E	UTM N	Elevation (m)	Width (m)	Length (m)	Perimeter (m)	Shape	Species abbreviations
North area								
Maxwell Flat Tank	427640	3904560	2,304	21	20	68	Round	Ef, Lc, Ln, Me, Mo, Mt, Mv
222A Tank	429185	3904850	2,315	—	—	—	Round	Ef, Lc, Me, Mo, Mv
222B Tank	429620	3905080	2,328	30	28.5	111	Round	Ef, Lc, Ln, Me, Mo, Mt, Mv
Little Wing Tank	431180	3902860	2,262	13	16	54.5	Round	Ef, Ma, Me, Mo, Mt, Mv
Stagecoach Tank	431380	3905240	2,325	11	15	45.5	Crescent	Ef, Me, Mv
Tailor Tank	431240	3904880	2,322	11	10	33	Round	Ef, Lc, Me, Mo, Mt, Mv
Pearson Tank	426600	3904120	2,286	14.5	14	52	Round	Ef, Me, Mo, Mt, Mv
South Wing Mt. Tank	427720	3902020	2,353	17.5	25	79	Rectangle	Ef, Ln, Mca, Me, Mo, Mt, Mv
Pipeline Tank	429810	3904234	2,310	61	16	149	Rectangle	Ef, Lc, Mci, Mo, Mv
Johnson Tank	428888	3901021	2,335	23	23	79	Triangle	Ef, Ln, Me, Mo, Mv
Veit Tank	433480	3906660	2,481	15.5	13	54	Round	Ef, Ip, Lc, Me, Mo, Mt, Mv
Michelbach Ranch	432100	3909620	2,572	16.5	16	60.5	Round	Ef, Lc, Ln, Mo
Veit Spring	435260	3907080	2,621	14.5	10	46	Rectangle	Ef, Ip, Ln, Mca, Mci, Me, Mo, Mt, Mv
Hot Shots Tank	434200	3905180	2,280	10	13	33	Round	Ef, Ip, Lc, Ln, Mci, Me, Mo, Mt, Mv
TNC Tank	433140	3911970	2,560	—	—	—	Round	Mv
Friedlein Prairie	437107	3905730	2,514	21.5	12	60	Rectangle	Ef, Lc, Mci, Me, Mo, Mt, Mv
South area								
Scooter Tank	445700	3861420	2,042	16.0	28.5	85.5	Triangle	Ap, Ct, Ef, Lc, Ln, Ma, Mca, Me, Mo, Mt, Mv
Lower Bedford Tank	453200	3860920	2,225	17.5	21.5	68	Round	Ef, Ip, Lc, Ln, Ma, Mci, Me, Mo, Mv, Tb
Pen Tank	453355	3862712	2,276	19.5	25	81	Round	Ef, Ip, Ln, Mci, Mo, Mt
Bert Tank	449678	3865257	2,176	18	20	59	Round	Ef, Me, Mo, Mv
Jones Tank	449213	3862674	2,188	18	25	75	Round	Ef, Ln, Ma, Mci, Me, Mo, Mt, Mv
T-six Tank	448460	3861080	2,097	18.0	21.0	63.5	Round	Ap, Ef, Ip, Lc, Ln, Ma, Me, Mo, Mt, Mv
Oak Grove Tank	449160	3856020	2,054	20.5	24.0	71	Round	Ap, Ef, Ip, Lc, Ln, Ma, Mca, Me, Mo, Mt, Mv, My, Tb
Fire Tank	449120	3857140	2,072	10.5	17.0	51	Round	Ap, Ef, Ip, Lc, Ln, Ma, Mca, Mci, Me, Mo, Mt, Mv
Hillside Tank	450483	3856717	2,079	10	10.5	33	Round	Ef, Ma, Mci, Me, Mo, Mv
Mike's Tank	447704	3856372	2,018	17.5	15.5	60.5	Round	Ef, Me, Mo
Lee Butte Tank	451920	3854895	2,146	—	—	—	—	Ef, Ip, Lc, Ln, Ma
Support Tank	449040	3854880	2,054	22.5	27.5	89	Round	Ap, Ef, Mci, Me, Mo, Mt, Mv,
Frank Tank	451611	3856518	2,170	27.0	43.0	16	Round	Ap, Ef, Ln, Ma, Me, Mo, Mt, My, Tb
Winsor Tank	454281	3864890	2,261	—	—	—	—	Ip
Bar M Creek	448160	3860090	2,063	—	—	—	—	Ef, Ln, Ma, Mo