Banisteria, Number 19, 2002

Home Range and Movement of the Allegheny Woodrat (*Neotoma magister*) in Virginia

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INTRODUCTION

The Allegheny woodrat (*Neotoma magister*) meets the criteria of "species of special concern" in Virginia as defined in Terwilliger (1991). The woodrat has been extirpated from New York and Connecticut, is endangered in New Jersey and Ohio, and is listed as threatened in Pennsylvania (Handley, 1991:550). Woodrat populations are generally considered to be stable in West Virginia and Maryland (Balcom & Yahner, 1996), but are declining in Virginia (Mengak, 2000). Reasons for the loss of some woodrat populations and decline in others are unknown. Numerous investigators have proposed several explanations, including habitat fragmentation, predation, defoliation of oaks (*Quercus* spp.) by gypsy moth (*Lymantria dispar*), transmission of a parasite from raccoons (*Procyon lotor*), forest management including clearcutting, human disturbance, climate change, and food shortage possibly due to increased mast utilization by white-tailed deer (*Odocoileus virginianus*) and black bear (*Ursus americanus*) (Handley, 1991; McGowen et al., 1994; Balcom & Yahner, 1996).

Little information is currently available on the home range or movements of woodrats in the Ridge and Valley Province of the southern Appalachian Mountains. This paper reports the results of a short-term study of woodrat home range using radiotelemetry. Movement data based on the capture and recapture of marked individuals are also presented.

STUDY AREAS

The results presented here are from two sources. The first is radiotelemetry data collected from collared woodrats. The study site was located approximately 11 km north of Callaway, Franklin County, Virginia on State Route 744. The Callaway site is atypical for woodrat habitat. Typical woodrat habitat consists of caves, cliffs, boulder fields, talus slopes and rock outcrops. The second source is from trapping data collected over 11 years from two sites in Giles and Bath counties, Virginia.

The Callaway site (37°06'N, 80°02'W) was privately owned and consisted of numerous anthropogenic structures including, a house foundation (the house was destroyed by fire several years prior to this study), an abandoned sawmill with several sawdust and sawed board piles, two abandoned vehicles, and two sheds. The area encompassed approximately 2 ha. The center of the study area was an old field that had not been grazed or mowed for approximately 4 years. Vegetation in the field was typical for this area – blackberry (*Rubus* spp.), honeysuckle (*Lonicera japonica*), pokeberry (*Phytolaca americana*), grasses and numerous annual and perennial species. Along the edge of the field, vegetation consisted of red and white oaks (*Quercus* spp.), pine (*Pinus* spp.), maple (*Acer* spp.), hickory (*Carya* spp.), cherry (*Prunus* spp.), beech (*Fagus* spp.) and other species with oaks and pines most abundant. The area was bordered on the east by a county maintained dirt road, on the south by a pasture grazed by dairy cattle, on the west by forest and a small first-order stream and on the north by forest. Several occupied houses and barns were within 1.0 km of the site. The sawmill had been abandoned for over 3 years. Elevation was 400 m.

The Giles County site (37°22'N, 80°37'W) was located approximately 15 km west of Mountain Lake. Elevation was 1300 m with a western exposure. The site consisted of a long cliff and talus field extending for over 800 m in a north-south direction. Tree vegetation varied from mountain ash (*Sorbus*

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americana), black birch (*Betula lenta*) and mountain maple (*Acer pennsylvanicum*) along the northern end to northern red oak (*Quercus rubra*), hickory, and sourwood (*Oxydendrum arboreum*) along the southern end. Understory vegetation included blueberry (*Vaccinium* spp.), mountain laurel (*Kalmia latifolia*), greenbrier (*Smilax* spp.), moss, and ferns and seedlings of the dominant trees.

The Bath County site (38°10'N, 79°45'W) was located along an unnamed ephemeral tributary of the Jackson River approximately 30 km north of Warm Springs, Virginia. The site was a deep cove with an eastern exposure. The cove was ringed with cliffs and caves along the top edge of the ridge. Tree vegetation consisted of white pine (*Pinus strobus*), eastern hemlock (*Tsuga canadensis*), basswood (*Tilia americana*), shagbark hickory (*Carya ovata*), northern red oak, and white oak (*Q. alba*). Understory vegetation included greenbrier, tree seedlings, mountain laurel, and numerous perennial herbs. Elevation was 680 m.

MATERIALS AND METHODS

At all three sites, woodrats were live captured using single-door, collapsible Tomahawk traps (No. 201) baited with apples. Captured animals were ear-tagged using No. 1 Monel sequentially numbered ear tags. Captured animals were weighed, sexed, examined for general body and reproductive condition, aged based on weight and pelage condition, and released at the capture site. Trapping occurred at numerous intervals throughout the year but the exact frequency varied due to weather conditions and other factors. Both the Giles and Bath county sites have been trapped at least 25 times between 1990 and 2000. Traps were placed at permanently numbered stations. Stations were located on a base map of each area and both station number and animal number were recorded at each capture. The Callaway site was trapped regularly from 1991 to 1993, sometimes at 2-week intervals but generally once per month.

Telemetry

Animals at the Callaway sites were fitted with radio collars placed around the neck and secured with a wire collar (A. C. Hicks, New York Department of Environmental Conservation, pers. comm.). The antenna trailed behind the animal. Hollow Hill Systems, Ontario, Canada, manufactured the radio collars. Collars weighed approximately 15 g, radio frequency was 150 MHz, battery life was estimated at 4-5 months, and range was estimated at 250-300 m (estimates provided by manufacturer). Tracking occurred from January through May 1993. Tracking took place from 0.5 h before sunset to midnight at least twice per week.

Animals were located by determining the direction from the observer to the animal along the line of the strongest audible radio signal. Compass bearings were taken from the telemetry station to the animal. Telemetry stations were established along the county road and at several locations within the field. Stations were surveyed with a tape and compass and located on a map of the area that included dominant landmarks, the road, buildings, a power line and intersections of the road with the power line, stream and driveways.

Telemetry readings were taken once per hour and at least three readings were taken on each animal per night. Time between readings on an individual could be kept to 8 minutes or less because the area was small. An attempt was made to locate each animal every hour. Since I was able to get relatively close to where the animals were located (generally within 30 m), I assumed signal bounce was not a factor and therefore no corrections were made to the compass readings. Readings were plotted on a map of the study area. Locations were accepted if they formed a triangle and if each leg of the triangle was 5 m or less in length. The animal was then assumed to be at the center of that triangle. A point, representing the animal's location was placed on the map and the points were connected using the Minimum Area Method to determine the home range. A dot grid was used to determine the area of the home range for each animal. Home ranges were determined by month and a home range was calculated based on all readings taken on an animal during each month. Monthly home ranges were determined only if there were a minimum of five acceptable readings for an animal during the month.

Trapping

Repeated captures of tagged individuals were used to determine home ranges at the sites in Giles and Bath counties sites. Only animals caught at a minimum of three different trap stations and a minimum of 60 days between first and last capture were used in this analysis. Home range was determined by plotting all capture locations on a map of the study area. The outermost trap stations were connected using the Minimum Area Method. A dot grid was used to compute home range size. I also computed a linear measure of movement. I defined furthest distance moved between locations as the distance between the two furthest trap stations where an animal was caught. This was determined by measuring, on a map of the study area, the straight-line distance between the most distant stations where the animal was caught. This measure gives insight into short-term movements of woodrats, presumably while foraging or seeking mates.

Neither capture records nor telemetry data give a complete accounting of the area used by woodrat. However, both methods provide a minimum estimate of home range size. Since I did not quantify habitat features, no inferences are made regarding habitat use versus availability.

All animals used in the analysis are independent of each other. Mean home range size was compared between months and between males and females using a Student's *t*-test. Statistical significance was set at $\alpha < 0.05$ unless otherwise noted.

RESULTS

Telemetry

From 12 January 1993 to 30 April 1993, five woodrats (4 females, 1 male) were equipped with radio transmitters. Two animals were monitored in January, five in February and March, and three in April and May. Woodrats at the Calloway sawmill site moved very little on cold January nights, preferring to remain in their shed or woodpile. Individuals had very small home ranges. The individual monthly home range varied from 0.003 ha to 0.041 ha. Over four months, the individual composite home range varied from 0.021 ha to 0.105 ha (Table 1). Average home range size for the four females during the study was 0.179 ha (SE = 0.003 ha).

Movements increased in February perhaps in relation to the onset of the breeding season. Radio number 131 was a male who lived most of the winter in the sawmill and had a home range overlapping three females (No. 150, No. 89 and ear tag 207). Not surprising, he had the largest home range in both March and April and the largest composite home range. He was radio-tracked beginning in February and was visually observed (in February) mating with a radio-collared female over 125 m from the sawmill that was in his normal home range. His last known location was a burned house foundation 15 m from the shed housing female number 70. On 21 May 1993, traps were set at the location of the strongest radio signal but he was not captured and his fate is unknown.

One adult female (No. 110) was tracked from January to March. Near the end of March, I obtained radiolocations indicating that she moved 150-175 m north along a small stream. Subsequent tracking lead me to believe she was not moving. A ground search located her remains (a tooth, fur, partial tail and radio collar). Presumably she was killed and eaten by a predator (owl, fox and feral cats are known to inhabit the area).

Radio number 150 was a small female (250 g) who lived all winter near the sawmill under 2-3 woodpiles. Her composite home range was the second largest among the four females (Table 1). She remained near the woodpiles until April when the landowner used a bulldozer to move the woodpiles. Female 150 temporarily moved to a woodpile 30 m away and just inside the woodlot that had been selectively logged in March 1993. Her last radio location was taken in late May and she had moved at least 0.7 km away, crossing three small streams and steep hills. Traps were set near where the radio signal was located but she was never captured. Her fate was unknown.

Table 1. Calculated monthly home range (hectares) and number of plotted locations (in parenthesis) of five radio-collared adult Allegheny woodrats in Franklin County, Virginia, 1993.

	Animal Number				
Month	70(♀)	89(♀)	110(♀)	150(♀)	131(♂)
January	0.005 (9)	---[1]	0.009 (10)	---[1]	---[1]
February	0.032 (17)	0.045 (14)	0.015 (7)	0.033 (12)	0.015 (12)
March	0.013 (18)	0.021 (15)	0.003 (12)	0.015 (18)	0.044 (17)
April	0.003 (10)	0.028[2] (9)	---[3]	0.011 (8)	0.041 (7)
Composite HR	0.037 (34)	0.069 (29)	0.021 (17)	0.054 (30)	0.105 (29)

[1] Not collared until late January or early February.

[2] Lost her collar in early April.

[3] Found dead in March.

Three animals remained in May 1993 (radio numbers 70, 131 and 150) and tracked to determine a final location before tracking ended and the batteries expired. Animal 70 had not appeared to move from under a shed for 3-4 weeks in late-April and early-May and was presumed to have died. A large ear-tagged male (410 g, tag 222/238) was caught five times in the shed where female 70 lived all winter.

Trapping – Giles County

Ten individuals were caught at least three times but at only two stations and could not be included in the home range analysis. Nineteen individuals were caught at least three times and at a minimum of three stations over the 11-year study. Ten were females and nine were males. The age (at first capture) distribution was: females-5 adults, 2 juveniles, and 3 subadults; males – 8 adults and 1 juvenile. All age categories were combined within gender for the analysis.

Mean number of captures was 9.1 and 6.2 times for females and males, respectively (Table 2). The longest distance moved between any two trap stations was by a female (No. 334) and covered a distance of 340 m. This movement occurred between two capture events only 66 days apart. In contrast, another adult female was trapped 11 times over nearly four years (Mengak 1997). Her greatest linear movement between any two captures was only 50 m but the captures were 457 days apart (8 July 1994 and 15 October 1995). The longest distance between any two captures was 340 m and 310 m for females and males, respectively.

Average distance between the furthest two capture locations was 169.7 m (SD = 108.3 m) and 190.6 m (SD = 92.3 m) for females and males, respectively. The difference was not significant ($t = -0.440$, $df = 17$, $P < 0.05$)

Home range size based on trapping observations was 0.189 ha (SD = 0.136 ha) for females and 0.234 ha (SE = 0.202 ha) for males. The difference was not statistically different ($t = -0.546$, $df = 12$, $P < 0.05$).

Trapping – Bath County

Thirteen individuals were caught three or more times but only at two trap stations and were excluded from further analysis. Nineteen individuals were used in the analysis – 14 females and 5 males. The age distribution (at first capture) for females was: 6 adults, 5 juveniles, and 3 subadults. The age distribution for males was 1 adult, 2 juveniles, and 2 subadults. Once again, all age categories were combined for analysis.

The longest distance between any two captures was 245 m and 180 m for females and males, respectively. The average distance between the furthest two capture locations was 102.1 m (SD = 68.8 m) and 104.0 m (SD = 68.1 m) for females and males, respectively. The difference was not significant ($t = 0.012$, $df = 16$, $P < 0.01$).

Home range size based on trapping observations was 0.068 ha (SD = 0.084 ha) for females and 0.063 ha (SE = 0.049 ha) for males. The difference was not statistically different ($t = 0.134$, $df =16$, $P < 0.05$).

DISCUSSION

Telemetry and trapping provided insights into the behavior of individual woodrats. At the Callaway site, the relationship between female 110 (collared) and female 209 (uncollared) is particularly interesting. Female 209 inhabited an abandoned car and shed in March/April 1992. Her last capture was on 23 April 1992. Female 110 was first caught near the abandoned car in September 1992 and repeatedly caught in the car

Table 2. Summary of measures (mean and standard deviation) used to assess movement of Allegheny woodrats in Virginia based on capture and recapture records, 1990-2000.

	Number of Individuals	Mean Number of Captures	Mean Home Range (ha)	Longest distance moved between any 2 captures (m)	Days between first and last capture
<u>Giles County</u>					
Females	10	9.1 (2.6)	0.189 (0.136)	169.7 (108.3)	596.6 (285.6)
Males	9	6.2 (3.2)	0.234 (0.202)	190.6 (92.3)	512.1 (383.9)
<u>Bath County</u>					
Females	14	10.4 (5.1)	0.068 (0.085)	102.2 (68.8)	429.5 (283.6)
Males	5	8.5 (4.1)	0.063 (0.049)	104.0 (68.1)	312.8 (199.1)

and shed through March 1993. Upon the death of animal 110 in late March, female 209 was again caught in the shed within 10 days of telemetry indicating that No. 110 had moved upslope along the stream to the site where she was found dead. It is assumed that 110 displaced 209 and occupied the area until her death. Woodrat 209 probably existed in the woods and brush piles near the car and shed but was never captured again until 110 was removed from the area. This raises questions concerning the apparent disappearance from the trappable population of other woodrats and leads me to suspect that displaced animals may exist on the fringe of the trap area.

Both eastern (*N. floridana*) and Allegheny woodrats are known to cache food items in autumn for overwinter use (Poole, 1940; Fitch & Rainey, 1956). Large food caches were obvious in several of the buildings known to house radio-collared individuals. Cached food items comprise the primary food supply during winter (Castleberry, 2000a) but limited foraging occurs presumably during periods of favorable weather. Caching allows access to food throughout the winter with minimal exposure to harsh weather or predators. The availability of cached foods helps explain the small home range size as determined by telemetry at the Callaway site.

Movements based on trapping records showed little pattern. Some animals made long movements, others moved very little. Sometimes the maximum movement occurred over a relatively short time interval. At other times, the animal was caught several times over many months but always at about the same trap station. Of course, there is no way to know the movements of the animals between trapping events. The data presented here suggest that, over time, most woodrats move relatively little. They may move larger distances but they seem to return to a "central" location where they are most often trapped.

Although males seem more likely to move longer distances over the total number of capture events, there is very little difference between males and females when considering distance moved between any two consecutive dates. This could mean that both males and females make considerable exploratory movements for feeding or breeding but males may travel further than females. This observation may receive support from the home range data on radio-collared woodrats, but only one male was radio tracked so the data are clearly incomplete at this time.

Zuck (Department of Forestry, West Virginia University, pers. comm.) used radio telemetry to assess juvenile dispersal of woodrats in West Virginia. During 1999-2000, they did not observe any juvenile dispersal. However, an ear-tagged male was recaptured approximately 2 km from his original capture site and other individuals were reported to have made movements > 400 m for their original capture location (range 500-2500 m). Castleberry et al. (2001) estimated spring and summer home range size of 34 radio-collared Allegheny woodrats as 6.5 ha and 2.2 ha for males and females, respectively. Castleberry et al. (2001) studied movements in relation to timber management and found that home range varied within timber harvest treatment from 1998 to 1999. For example, in clearcut areas, home range was 6.0 ha and 2.2 ha for all individuals in 1998 and 1999, respectively. Other treatments showed similar differences between the two years. Maximum nightly distance moved from the den during foraging forays ranged from 134.5 m to 186.4 m. These distances are similar to the trapping results in my study.

Castleberry et al. (2001) pointed out that their home range results are larger than any reported for most other *Neotoma* species. They suggested that home ranges are generally larger in spring and summer when the animals are actively foraging and seeking mates. Mengak (2002) found that most woodrat reproduction occurs in March-May in Virginia. Castleberry (2000b) failed to detect any influence of moon phase or illumination on the activity patterns of woodrats in his study. Castleberry et al. (2001) found that woodrats used forest and clearcut areas in proportion to their availability.

In my study, the Bath County site consisted of intact forest but the Giles County site had intact forest, open talus with no overstory and edge habitat along a field border. The juxtaposition of various habitat types (including the old field at the Callaway site) does not seem to negatively affect patterns of woodrat movements. Woodrats were caught in traps in the old field and in the open talus field, as well as under the forest canopy. Timber type, harvest activity, or edges do not seem to inhibit woodrat movements nor exclude woodrats from an area. Other environmental factors, such as food supply and competition, predation or disease, may have a greater impact on woodrat distribution, habitat occupancy, and colony persistence than human activity.

In conclusion, Allegheny woodrats in this study have small winter home ranges as determined by telemetry. Trapping results, though providing a small sample, seem to confirm that at my study sites across multiple years, individual resident woodrats are generally caught within a small area of the larger habitat. Because of the multiple years covered by this study, no information is available on home range overlap or territorial behavior. Small home ranges and the isolated nature of suitable woodrat habitat make this species very vulnerable to local extinctions. Issues related to recolonization of extirpated habitat and juvenile dispersal (and gene flow) remain unanswered but vital to a thorough understanding of woodrat ecology in Virginia and throughout the range.

ACKNOWLEDGMENTS

Fieldwork for this project was supported by the Pittman-Robertson Federal Aid to Wildlife Restoration Project-WE99R and the Virginia Department of Game and Inland Fisheries (VDGIF) Nongame Program, USFS George Washington/Jefferson National Forests (USFS GW/Jeff) and Ferrum College Life Science Division. S. Griep (USFS GW/Jeff) and R. Reynolds (VDGIF) provided funding, logistical support, and many helpful comments on this project. Funds for data analysis and manuscript preparation were provided by a summer fellowship from the Appalachian College Association. Numerous students in the Environmental Science Program at Ferrum College assisted with fieldwork throughout the study.

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