

Small Nocturnal Mammals in Oak Woodlands: Some Considerations for Assessing Presence and Abundance¹

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Abstract: We live-trapped small, nocturnal mammals between 1993 and 1995 in three oak (*Quercus* spp.) woodland sites in eastern Fresno County, California. Interior live oak (*Quercus wislizenii*) and blue oak (*Q. douglasii*) were the dominant tree species. Tree canopy structure ranged from open and discontinuous to dense and continuous. Dusky-footed woodrats (*Neotoma fuscipes*) were captured in both Sherman and Tomahawk traps; almost all were taken at woodrat houses. California mice (*Peromyscus californicus*) and brush mice (*P. boylii*) were most successfully captured in Sherman traps both on trap grids and at woodrat houses. Most dusky-footed woodrat houses were either atypical or combination types.

Repeat live-trapping on sampling grids and determining abundance of various kinds of animal "sign" are commonly used methods for assessing presence and abundance of small mammals. Although such estimates are widely used, they are based on unconfirmed assumptions about animal movements and microhabitat associations. Different types of traps may bias trapping success toward some species and against others (Beacham and Krebs 1980, Boonstra and Krebs 1978, Boonstra and Rodd 1984, Bury and Corn 1987, Cockrum 1947, O'Farrell and others 1994, Singleton 1987, Slade and others 1993, Williams and Braun 1983, Willy 1985). Location of traps, especially in relation to cover, may also bias trapping success (Murray 1957, O'Farrell and others 1994, Sakai and Noon 1993). Placement of traps in undesirable habitat, exclusively on the ground, or away from normal travel paths, may bias trap success against some species and for others. Some animals are more likely to be associated with dense cover whereas others prefer open areas. Most sampling grids are located on the ground and are unlikely to adequately sample arboreal animals. Other animals follow discrete travel paths and will not be captured if traps are not located close to their routes of travel.

Indirect methods of assessing abundance of mammals, such as animal track and pellet counts, can also give unreliable results. Abundance of dusky-footed woodrats (*Neotoma fuscipes*) is sometimes estimated by counting their houses, but animal use may be incorrectly assessed if the sample area includes houses which are abandoned, used but not resided in, or difficult to detect.

In our investigations of dusky-footed woodrats and other nocturnal small mammals in oak (*Quercus* spp.) woodlands of the southern Sierra Nevada, we have encountered a number of problems in detecting and assessing abundance of different species. The objectives of this paper are to identify some of the problems associated with using (1) standard trap grid methods to assess the presence and abundance of small mammals, (2) particular types of live traps, and (3) house counts as an index of dusky-footed woodrat abundance.

Study Area

The study area consisted of three 2.25-ha oak woodland sites known as Pine Flat, Camp 4-1/2, and Secata, in the foothills of the Sierra Nevada in eastern Fresno County. Elevation ranged from 300 m to 450 m. All three sites were within 2 km

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of the Kings River. Pine Flat was the most densely vegetated site, with an overstory dominated by interior live oak (*Quercus wislizenii*) and gray pine (*Pinus sabiniana*), and with a thick understory of interior live oak, ceanothus (*Ceanothus* spp.), poison oak (*Toxicodendron diversilobum*), and manzanita (*Arctostaphylos* spp.). Camp 4-1/2 had a moderate overstory of blue oak (*Q. douglasii*), interior live oak, and California buckeye (*Aesculus californica*), and a relatively sparse understory of poison oak and ceanothus. Secata was the most open site, dominated by blue oak, with small patches of interior live oak and California buckeye. The understory was very sparse, consisting of ceanothus, chaparral honeysuckle (*Lonicera interrupta*), redberry (*Rhamnus crocea*), and manzanita.

Methods

Within each study site, we randomly positioned one 7-by-7 station trap grid with 15-m spacing. Beginning in 1993, one each of Sherman XLK folding traps (7.7 cm × 9.5 cm × 30.5 cm) and Tomahawk No. 201 steel mesh (1.25-cm × 2.5-cm mesh) traps (12.7 cm × 12.7 cm × 40.6 cm) were set at each trap grid station. Tomahawks were also set at woodrat houses, both on the ground and in nearby trees. Traps at the houses were positioned along obvious woodrat paths, if present. During the 1994 and 1995 trapping seasons, only Shermans were set on the grid (one trap at each station), but Tomahawks continued to be set at the houses. Additional trapping was done in autumn 1995, using a small number of Shermans for a few nights at woodrat houses, both on the ground and in nearby trees to determine if Sherman traps were capable of capturing dusky-footed woodrats.

Trapping ran from mid-spring to early summer and from late summer to mid-autumn in 1993, 1994, and 1995. Traps were set in the evening and checked the next morning. All small mammals captured were identified, measured, ear-tagged (using National Band and Tag Co. monel tags), and released. Trap nights (table 1) ranged from 4525 Sherman trap nights on trap grids to 10 Sherman trap nights in trees at woodrat houses.

Table 1—Number of nights, number of study sites, and number of years trapped for each combination of trap type (Sherman XLK or Tomahawk No. 201) and trap location

Trap location	Nights trapped	Study sites	Years
Sherman ¹ /Grid ²	4,525	3	3
Tomahawk ³ /Grid	2,064	3	1
Sherman/House ⁴	52	1	1
Tomahawk/House	2,106	3	3
Sherman/Tree ⁵	10	1	1
Tomahawk/Tree	1,877	3	3

¹Sherman XLK live traps
²On 7 × 7 station trap grids with 15-m spacing
³Tomahawk No. 201 live traps
⁴On the ground at woodrat houses
⁵In trees at woodrat houses

Capture rates per 1000 trap nights for dusky-footed woodrat, brush mouse (*Peromyscus boylii*), and California mouse (*P. californicus*) were determined for each trap type (Sherman or Tomahawk) and trap location (trap grid, at woodrat

houses on the ground, or at woodrat houses in trees) on each site for 1993, 1994, and 1995. Means and standard errors of capture rates for each combination of trap type and trap location were calculated and plotted.

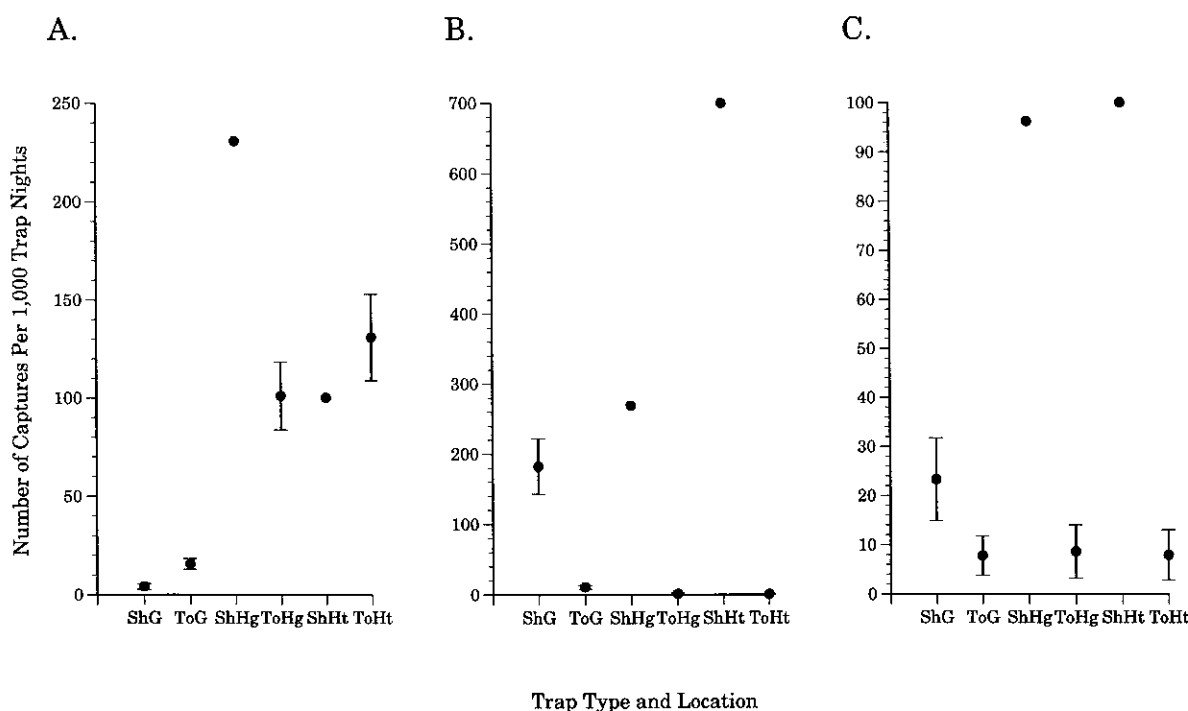
All sites were systematically searched for woodrat houses, which were marked, mapped, and classified as typical, atypical, or combination. Typical houses were composed of a large number of sticks, with the primary dwelling within the pile of sticks. Atypical houses contained very few to no sticks, with the primary dwelling within a tree cavity, rock crevice, log, or underground hole. Combination houses had characteristics of both typical and atypical houses. Abundance of each woodrat house type was determined for each site. Woodrat use of houses was determined by capturing woodrats at houses, observing woodrats to enter houses, determining the condition of houses, and the presence of woodrat urine or fecal pellets.

Woodrat activity was observed after they were released. Woodrat activities were also observed during days and evenings at several houses during the course of this study.

Results

Dusky-footed woodrats were most successfully captured in both trap types at houses on the ground or in nearby trees (*fig. 1A*). Very few woodrats were captured on the standard trap grids in either trap type. Brush mice were successfully trapped in Sherman traps, but were rarely captured in Tomahawk traps (*fig. 1B*). Capture rates increased when Shermans were set at woodrat houses. On the trap grid, our success in capturing California mice with Sherman traps was slightly better than with Tomahawks (*fig. 1C*). As with brush mice, capture rate increased with Shermans set at woodrat houses.

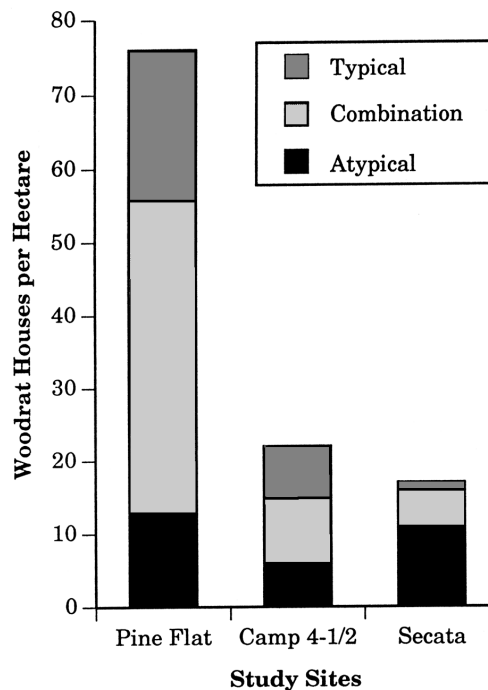
Figure 1—Numbers of (A) dusky-footed woodrat, (B) brush mouse, (C) California mouse captured/1000 trap nights $\pm$ 1 se. Trap codes are: Sh = Sherman XLK and To = Tomahawk No. 201. Location codes are: G = Grid, Hg = on the ground at woodrat houses, and Ht = in trees at woodrat houses.



A large number of traps were found empty with mouse-size fecal droppings and the bait missing and/or the door closed (127 closed and empty / 1000 traps). Tomahawk traps have 1.25-cm $\times$ 2.5-cm mesh openings and gaps between the doors of a sufficient size to permit the escape of brush mice and smaller California mice, especially juveniles, which could result in decreased trap success for these species.

The most obvious woodrat houses on our study sites were "stick-houses" we classified as typical. Locating atypical and combination houses was more difficult because of the lack of large piles of sticks normally associated with woodrat houses. Typical woodrat houses ranged from 32 percent of the houses found on Camp 4-1/2 to only 6 percent at Secata (fig. 2). Atypical houses, the most difficult to locate, ranged from 65 percent at Secata to 17 percent at Pine Flat.

Figure 2—Woodrat houses found on each study site (numbers of houses/ha).



Discussion

Trap type and placement can have substantial effects on assessments of the diversity and abundance of small mammals. If we had trapped only on the grid throughout this study, zero to very few dusky-footed woodrats would have been captured. Capture success for dusky-footed woodrats was greatly improved by placing Tomahawk traps at woodrat houses, both in nearby trees and on the ground. Although based on relatively few trap nights, capture rates for all three dominant rodent species increased when Sherman traps were set at the houses.

Our results show that capture success can be strongly influenced by trap type. Willy (1985) found that Tomahawk traps captured only woodrats whereas Shermans captured other species as well. In addition, Tomahawks captured woodrats at a higher rate than Shermans. O'Farrell and others (1994) found that wire mesh live traps captured 36 percent more animals than Sherman traps, and wire mesh traps captured nine of ten small mammal species detected, six of these

species more successfully than the Shermans. Shermans successfully captured seven species but were only slightly more effective than the wire mesh traps in capturing two species.

Trap location can also affect capture success because successfully trapping animals depends on microhabitat associations, and temporal and three-dimensional patterns of movement within specific home ranges. Murray (1957) found that species composition and richness varied significantly between parallel trap lines depending on vegetation species present and amount of cover. This suggested "...nonrandom distribution of the animals in relation to the trap lines such that small differences in placement of traps in these areas could seriously alter the results" (Murray 1957:449). In a conifer-deciduous forest ecotone, Kirkland and Griffin (1974) reported that meadow voles (*Microtus pennsylvanicus*) were closely associated with grassy areas and rock shrews (*Sorex dispar*) were found only in rocky areas. In desert communities, Price (1978) found that Bailey's pocket mouse (*Perognathus* [= *Chaetodipus*] *baileyi*) and desert pocket mouse (*P.* [= *C.*] *penicillatus*) were found most often in association with large bushes and trees, Merriam's kangaroo rats (*Dipodomys merriami*) most often in large open spaces, and Arizona pocket mouse (*P. amplus*) most often in small open spaces. In coastal oak woodlands, Tietje (1995) concluded that dusky-footed woodrats are associated with dense, shrubby understories. Sakai and Noon (1993) concluded that the dusky-footed woodrat's patchy distribution can affect abundance estimates from trap grids since the estimates depend on grid size and placement. We also found that dusky-footed woodrats were distributed nonrandomly as we captured animals more successfully in traps placed at woodrat houses than on the trap grids. If we had relied solely on grid trapping, woodrat presence and abundance would have been greatly underestimated, from zero to very few animals, depending on the site and time of year.

Density estimates of several species of *Peromyscus*, including pinyon mouse (*P. truei*) and California mouse, often parallel the densities of dusky-footed woodrats and their houses. These mice often construct their nests within woodrat houses and, upon release, individuals of both species often enter woodrat houses (Cranford 1982; Merritt 1974, 1978). Our findings, although based on relatively few trap nights, indicate that both brush mice and California mice are more successfully captured near woodrat houses. We did not search woodrat houses for *Peromyscus* nests and, therefore, cannot confirm nesting of either species in woodrat houses.

The extent to which members of a particular species, or individual animals, restrict their movements also affects trap success. Often, woodrats that were successfully captured at houses during a particular trapping session were not captured during a subsequent session on the grid, even when traps were positioned near, but not at, these same houses. This suggests that capture success was also affected by the woodrats' specific movements within their home ranges. Barnum and others (1992) found that white-footed mice (*Peromyscus leucopus*) usually used regular paths along logs of a specific size range and which were protected by vegetative cover. The dusky-footed woodrats we have studied also appear to use particular travel routes. Our study sites included several well-established ground trails between houses and under ground cover. However, observations of rats upon release, day and evening observations, and results from trapping at various openings of a house (both on the ground and in trees), showed that dusky-footed woodrats on our sites generally used paths along limbs which extend from their houses. Even when a direct route along the ground covered a shorter distance, woodrats almost always chose paths along limbs. Linsdale and Tevis (1951) also concluded that dusky-footed woodrats were quite arboreal, observing that arboreal routes were used in preference to ground trails. They also found that trails were usually under dense cover and

never found in grassland. Cranford (1977) determined through radiotelemetry that dusky-footed woodrat activity was greatest in 75 to 100 percent cover, and that 40 percent of telemetry fixes were from positions above the ground.

Abundance of animal "sign" is also used for assessing presence and abundance of animals. Dusky-footed woodrat presence is often determined by the presence of their stick-houses (Hammer and Maser 1973, Sakai and Noon 1993, Vogl 1967), which have been primarily described as large, conspicuous, conical piles of sticks with numerous passageways and chambers (Ashley and Bohnsack 1974, Cameron 1971, English 1923, Gander 1929, Linsdale and Tevis 1951, Vestal 1938). There are a few instances in the literature mentioning the use of atypical houses by dusky-footed woodrats; however, they were apparently not considered a common occurrence. Gander (1929) found dusky-footed woodrat houses made in hollow limbs and rock crevices. Davis (1934) found several houses built upon large rocks with deep fissures, including one house that was merely a nest chamber within a rock crevice. In our study, if counts of conspicuous houses were used to estimate dusky-footed woodrat numbers, they would have been seriously underestimated. As noted by Sakai and Noon (1993), estimates based on woodrat house counts are biased to the extent that cryptic (atypical) houses go uncounted. Within our study area, the majority of houses were combination or atypical. Some houses were so inconspicuous that they were found only after a woodrat was observed going into the house. These were usually houses that were built within the hollow of a tree with no apparent use of sticks. Owing to the inconspicuous nature of many houses, it is likely that some were not discovered during the study.

When using house counts to estimate the abundance of dusky-footed woodrats, it is assumed that each house is inhabited by only one woodrat, except when a female has young (English 1923, Gander 1929, Linsdale and Tevis 1956). However, more than one adult woodrat may occupy any house at any given time. For instance, during the breeding season, male and female woodrats will often occupy the same houses, however, once pregnant, the female will force the male to "move" to another house (English 1923, Linsdale and Tevis 1951). Not all woodrat houses are necessarily occupied. Houses may be recently abandoned or may be used only sporadically. According to Linsdale and Tevis (1951), "A rat will place cuttings on a house that it uses, but does not occupy permanently." We found that some woodrats, although repeatedly captured at a particular house, retreated into another house after being released.

Adequate assessment of animal populations is essential in developing successful conservation strategies for wildlife. Although estimates of absolute abundance of animals are desirable, they are often not achievable. Estimates of relative abundance can be useful substitutes, but assessment methods should be unbiased or biased equally among sites and species to be compared. Our results suggest that various trap types and trap locations capture different small mammal species at different rates. Trapping designs that reflect patterns of microhabitat use, spatial distributions, and movements of the small mammals of interest should provide more useful estimates of relative abundance. Development of such trapping designs may require careful searches of the study area to locate different microhabitats, woodrat houses and other habitat elements that small mammals use, and employ a combination of trap types in a variety of locations.

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References

- Ashley, Tom R.; Bohnsack, Kurt K. 1974. **Seasonal abundance of Acarine populations in the sleeping nests of the dusky-footed woodrat, *Neotoma fuscipes* Baird in southern California, U.S.A.** Proceedings of the 4th International Congress of Acarology 4: 615-621.
- Barnum, Sarah A.; Manville, Christiana J.; Tester, John R.; Carmen, William J. 1992. **Path selection by *Peromyscus leucopus* in the presence and absence of vegetative cover.** Journal of Mammalogy 73(4): 797-801.
- Beacham, Terry D.; Krebs, Charles J. 1980. **Pitfall vs. live-trap enumeration of fluctuating populations of *Microtus townsendii*.** Journal of Mammalogy 61(3): 486-499.
- Boonstra, Rudy; Krebs, Charles J. 1978. **Pitfall trapping of *Microtus townsendii*.** Journal of Mammalogy 59(1): 136-148.
- Boonstra, Rudy; Rodd, Helen F. 1984. **Efficiency of pitfalls versus live-traps in enumeration of populations of *Microtus pennsylvanicus*.** Canadian Journal of Zoology 62: 758-765.
- Bury, R. Bruce; Corn, Paul Stephen. 1987. **Evaluation of pitfall trapping in northwestern forests: trap arrays with drift fences.** Journal of Wildlife Management 51(1): 112-119.
- Cameron, Guy N. 1971. **Niche overlap and competition in woodrats.** Journal of Mammalogy 52(2): 288-296.
- Cockrum, E. Lendell. 1947. **Effectiveness of live traps versus snap traps.** Journal of Mammalogy 28(2): 186.
- Cranford, Jack A. 1977. **Home range and habitat utilization by *Neotoma fuscipes* as determined by radiotelemetry.** Journal of Mammalogy 58(2): 165-172.
- Cranford, Jack A. 1982. **The effect of woodrat houses on population density of *Peromyscus*.** Journal of Mammalogy 63(4): 663-666.
- Davis, A.C. 1934. **Notes on the insect inhabitants of wood rat houses in California.** Bulletin of the Southern California Academy of Sciences 33: 12-24.
- English, Pennoyer F. 1923. **The dusky-footed wood rat (*Neotoma fuscipes*).** Journal of Mammalogy 4(1): 1-9.
- Gander, Frank F. 1929. **Experiences with wood rats, *Neotoma fuscipes macrotis*.** Journal of Mammalogy 10: 52-58.
- Hammer, E. Wayne; Maser, Chris. 1973. **Distribution of the dusky-footed woodrat, *Neotoma fuscipes* Baird, in Klamath and Lake Counties, Oregon.** Northwest Science 47(2): 123-127.
- Kirkland, Gordon L., Jr.; Griffin, Rebecca J. 1974. **Microdistribution of small mammals at the coniferous-deciduous forest ecotone in northern New York.** Journal of Mammalogy 55(2): 417-427.
- Linsdale, Jean M.; Tevis, Lloyd P., Jr. 1951. **The dusky-footed wood rat.** Berkeley: University of California Press; 664 p.
- Linsdale, Jean M.; Tevis, Lloyd P., Jr. 1956. **A five-year change in an assemblage of wood rat houses.** Journal of Mammalogy 37(3): 371-374.
- Merritt, Joseph F. 1974. **Factors influencing the local distribution of *Peromyscus californicus* in northern California.** Journal of Mammalogy 55(1): 102-114.
- Merritt, Joseph F. 1978. ***Peromyscus californicus*.** Mammalian Species 85: 1-6.
- Murray, Keith F. 1957. **Some problems of applied small mammal sampling in western North America.** Journal of Mammalogy 38(4): 441-451.
- O'Farrell, Michael J.; Clark, William A.; Emmerson, F.H.; Juarez, Stephen M.; Kay, Fenton R.; O'Farrell, Theda M.; Goodlett, Tracy Y. 1994. **Use of a mesh live trap for small mammals: are results from Sherman live traps deceptive?** Journal of Mammalogy 75(3): 692-699.
- Price, Mary V. 1978. **The role of microhabitat in structuring desert rodent communities.** Ecology 59(5): 910-921.
- Sakai, Howard F.; Noon, Barry R. 1993. **Dusky-footed woodrat abundance in different-aged forests in northwestern California.** Journal of Wildlife Management 57(2): 373-382.

- Singleton, Grant R. 1987. **A comparison of the effectiveness of pitfall and Longworth live-trapping techniques in population studies of house mice.** Acta Theriologica 32(15): 245-259.
- Slade, Norman A.; Eifler, Maria A.; Gruenhagen, Ned M.; Davelos, Anita L. 1993. **Differential effectiveness of standard and long Sherman livetraps in capturing small mammals.** Journal of Mammalogy 74(1): 156-161.
- Tietje, William. 1995. **Woodrat abundance and habitat measurements in oak woodland at Camp Roberts, California: preliminary results.** Transactions of the Western Section of The Wildlife Society 31: 53-57.
- Vestal, Elden H. 1938. **Biotic relations of the wood rat (*Neotoma fuscipes*) in the Berkeley Hills.** Journal of Mammalogy 19(1): 1-36.
- Vogl, Richard J. 1967. **Wood rat densities in southern California manzanita chaparral.** Southwestern Naturalist 12(2): 176-179.
- Williams, Daniel F.; Braun, Suzanne E. 1983. **Comparison of pitfall and conventional traps for sampling small mammal populations.** Journal of Wildlife Management 47(3): 841-845.
- Willy, Allison G. 1985. **The habitat associations of the dusky-footed woodrat (*Neotoma fuscipes*) in Marin County, CA.** Berkeley: University of California; 66 p. M.S. thesis.