

Rosemary H. Leach,<sup>1</sup> Montana Cooperative Wildlife Research Unit,<sup>2</sup> University of Montana, Missoula, Montana 59812  
and

W. Daniel Edge, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon 97331

## Summer Home Range and Habitat Selection by White-tailed Deer in the Swan Valley, Montana

### Abstract

We studied summer habitat use by 13 adult and 5 yearling female white-tailed deer (*Odocoileus virginianus*) in the Swan Valley, Montana during 1980 and 1981. We used 515 radio relocations to evaluate use of habitats within home ranges and selection of home ranges within the study area. All deer used riparian habitats more, and upland habitats less than expected based on availability within their summer home ranges. Adult deer home ranges contained more logged riparian and unlogged upland habitat than randomly-placed polygons, called random home ranges. Adult home ranges also contained less logged upland habitat than random home ranges. Yearling home ranges generally resembled random home ranges in habitat composition; however, random home ranges contained less logged riparian habitat than did yearling home ranges. Based on selection for unlogged riparian habitat within home ranges and an inverse relationship between adult home range size and the availability of unlogged riparian habitat within their home range, it appeared that unlogged riparian habitat was seasonally important to deer in the Swan Valley. Based on our results, we recommend that riparian habitats, particularly unlogged ones, be managed conservatively by establishing buffer zones of no logging. Harvest should be limited to uneven-aged silvicultural systems. Quality upland cover should be maintained adjacent to riparian areas and other moist habitat components. Habitat diversity on a small scale should be a management goal and could be accomplished with uneven-aged silviculture and prescribed fire. Alternatively, when even-aged management is applied, cutting unit size should be minimized ( $\leq 12$  ha) and units dispersed over the landscape. Postlogging scarification should be limited to the minimum required for successful conifer regeneration in order to enhance shrub production for deer forage and cover.

### Introduction

White-tailed deer are an important big game species in northwestern Montana, where its distribution is strongly correlated with the distribution of coniferous forest habitat (Mundinger 1984). Summer habitat use by white-tailed deer has been described in various parts of North America (Allen 1968, Martinka 1968, Drolet 1976, Tierson *et al.* 1985). Although several previous studies focused on the winter ecology of white-tailed deer in the Swan Valley (Weckwerth 1958, Hildebrand 1971, Mundinger 1984), similar studies of summering deer in northwestern Montana have not been conducted. Increased timber harvest in northwestern Montana has also raised concerns about the impacts of forest practices to local white-tailed deer (Mundinger 1984).

Johnson (1980) recognized that selection occurs on several scales. Inferences from habitat selection analyses on 1 scale will likely differ from inferences made on another scale, and consequently, ecological interpretations and management

recommendations may be scale-dependent. Our objective was to identify preferred summer habitat of white-tailed deer in the managed forests of the Swan and Clearwater Valleys of Montana at 2 scales: the distribution of home ranges within the study area (2nd-order selection), and the selection of habitat categories within the home range (3rd-order selection).

### Study Area and Methods

The Swan-Clearwater summer range includes the southern half of the Swan Valley and the northern quarter of the adjacent Clearwater Valley. This area was described previously by Antos (1977) and Mundinger (1981). The study area was approximately 675 km<sup>2</sup> with elevations ranging from 1,060 m on the valley floor to 1,575 m on the mid-slopes of the mountains. Unique vegetative characteristics and habitat mosaics found within the study area result from the maritime climate and diverse soil moisture regimes. The major habitat types found on the study area were within the moist subalpine fir (*Abies lasiocarpa*), western red cedar (*Thuja plicata*), spruce (*Picea* spp.), and grand fir (*Abies grandis*) series (Pfister *et al.* 1977). However, most sites were dominated by seral species including lodgepole pine (*Pinus contorta*), Douglas-

<sup>1</sup>Current address: Wildlife Resource Management Program, Yakima Indian Nation, P.O. Box 151, Toppenish, WA 98948

<sup>2</sup>The Unit is jointly supported by the University of Montana, Montana Department of Fish, Wildlife, and Parks, the U.S. Fish and Wildlife Service, and the Wildlife Management Institute.

fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), and ponderosa pine (*Pinus ponderosa*). Timber harvest (clearcut or selection cut) was the dominant land use within the study area with clearcuts ranging from 2-260 ha in size and 1-25 years in age, located throughout the study area (Mundinger 1984). Approximately half of the study area had been logged.

Our analysis focused on deer use of 4 major habitat categories: unlogged and logged uplands, and unlogged and logged riparian areas. We classified an area as riparian if water (surface or sub-surface) influenced vegetation such that wet-site indicator plants were present (Pfister *et al.* 1977). Overstory species composition was similar between riparian and upland sites; however, trees associated with moist habitat types occurred with higher frequency in riparian habitats. We defined clearcuts, partial cuts, and second growth stands as logged habitat. There were no discernible differences in overstory species logged or harvest practices between riparian and upland habitats. Understory species were similar between logged and unlogged sites and between riparian and upland sites in general; however, moist-site indicator species were more common in riparian habitats.

Deer were captured in clover traps (Clover 1956) on winter range of the upper Swan Valley (Mundinger 1984). Thirteen adult and 5 fawn females were radiocollared and released. Radioed deer were relocated on summer ranges during 1980 and 1981 by aerial (25%) and ground (75%) tracking between 0800 and 1700 h. Aerial telemetry was done from a Cessna 182 according to the methodology of Gilmore *et al.* (1981), and relocation error was estimated to be approximately 100-150 m. Ground tracking included triangulated fixes (14%) and close-range tracking (86%) using a hand-held yagi antenna. Triangulations generally were based on 3 compass bearings and were used only when evidence indicated that the animal was within 100-600 m, when triangulation polygons were relatively small and contained only 1 discrete habitat category, and when no topographic barriers existed between the observer and the estimated position of the deer. Deer locations based on triangulations were in close proximity to those determined from close-range tracking. Close-range tracking was conducted until the animal was seen or disturbed enough to move.

All deer locations were plotted on 1:15,840 topographic maps and aerial photos. Summer home ranges were estimated using the minimum convex

polygon (MCP) method (Mohr 1947). Five adults and 5 yearlings were tracked for 1 summer, and 8 adults were followed for 2 summers. Summer home range estimates for the 8 deer tracked 2 summers were calculated for each summer separately in order to make these estimates comparable to those for deer tracked only 1 summer. The number of radiolocations obtained each summer for each deer averaged 19.8 (range = 9-36).

The interval between relocations ranged from 2 hours to 1 week; most relocations of the same individual were separated by  $\geq 24$  hours. One deer that was followed for 1 summer used inaccessible wilderness and could be relocated only after a lengthy hike. This deer was relocated repeatedly at relatively short intervals during wilderness stays that ranged from several hours to 2 days. These relocations would potentially be more prone to autocorrelation bias (Swihart and Slade 1985), and the size of her summer home range may have been underestimated; however, this female's habitat use data were similar to those of other adults based on tests of habitat selection by individual deer (Leach 1982) and were included in a pooled habitat use analysis on this basis. Three deer were relocated hourly for 24 hours to determine if they ventured beyond the home ranges delineated by relocations obtained at the more widely spaced intervals described above. All of the relocations from these tracking sessions fell within the home ranges delineated by the longer interval relocations.

We assessed the selection of home ranges within the study area (2nd-order selection; Johnson 1980) by comparing deer home ranges to 15 randomly selected areas called random home ranges. Random home ranges were of similar size, shape, and elevation as deer home ranges delineated during 1980. We constructed a grid of the study area and randomly selected coordinates that served as the center for each random home range. The availability of the 4 habitat categories was estimated on deer home ranges using a dot grid for discrete data (Marcum and Loftsgaarden 1980). The expected availabilities of the 4 categories in random home ranges was measured with a digital planimeter. The analysis then proceeded according to the methodology of Neu *et al.* (1974).

A habitat diversity index was calculated for each deer and random home range by summing the number of discrete habitat types ( $\geq 0.5$  ha) and riparian habitat polygons (e.g., seeps, ponds, potholes, creeks) and dividing by the overall deer or random home range. These indices were then

standardized on a 100-ha basis. An average standardized diversity index for deer and random home ranges was then calculated.

Third-order deer habitat selection (Johnson 1980) was analyzed by comparing use of the 4 habitat categories by all deer with the availability of the same categories from deer home ranges (8 adult ranges estimated from 2 summers of tracking and 5 adult and 5 yearling ranges from 1 summer of tracking) (Neu *et al.* 1974). The 4 habitat categories were mapped within home ranges, and availability was determined using a digital planimeter. Simultaneous 90% confidence intervals were determined for the pooled use (radiolocations) of the 4 categories. If the calculated confidence interval for deer use of a given component did not contain the true availability of that component, use was considered statistically significant, indicating either preference or avoidance of that component.

We used Mann-Whitney tests (Daniel 1978:82-86) to test for differences in home range size between yearling and adult deer, and for differences in diversity indices between deer and random home ranges. We related deer home range size to the proportion of each of the 4 habitat categories available using the Spearman rank coefficient ( $r_s$ ). We used nonparametric tests because data were not normally distributed.

## Results

### Home Range

We collected 515 radio relocations from May-September, 1980 and 1981. Deer summer home ranges were 6-40 km south of their winter home ranges. Unlike their winter distribution, deer summer home ranges were widely dispersed and adult ranges did not overlap. Four adult-yearling pairs had overlapping home ranges. Two of these pairs were clearly mother and daughter; the familial relationships of the other 2 were unknown.

Marked animals used the same area each summer. Home ranges of each of the 8 adults monitored for 2 summers overlapped an average of 44% between years, and their activity centers were the same (Gladfelter 1978). These animals also had used these same summering areas during 1979 (Mundinger, Mont. Dept. Fish, Wildlife, and Parks, unpubl. data).

Single-summer home ranges for adult deer averaged 70 ha (SE = 25.9) during 1980 (n = 10) and 71 ha (SE = 18.4) during 1981 (n =

11). The ranges of 5 yearlings averaged 91 ha (SE = 30.4) and did not significantly differ from those of 11 adults followed that year (Mann-Whitney test,  $P = 0.25$ ). Plots of home range size versus increasing numbers of relocations showed 17 of 26 single-summer home ranges had reached an asymptote, suggesting they were based on an adequate number of relocations (Odum and Kuenzler 1955). The remaining 9 single-summer home ranges may have been underestimated slightly. The average MCP estimate for these 9 home ranges was, however, similar to the average for the 17 adequately sampled home ranges.

### 2nd-Order Selection

The summer home ranges of adult deer differed from random home ranges relative to 3 habitat categories ( $P < 0.10$ ). Adults selected home ranges with more logged riparian, more unlogged upland and less logged upland than was available on the study area (Figure 1). In contrast, summer home ranges of yearling deer were similar to random home ranges except that yearling ranges contained more logged riparian habitat ( $P < 0.10$ , Figure 1). The proportion of unlogged riparian habitat within a deer home range was inversely correlated with home range size for adults ( $r_s = -0.43$ ,  $P < 0.05$ ), but was not correlated with home range size for yearlings ( $r_s = 0.425$ ,  $P > 0.10$ ). In contrast, the proportion of logged riparian habitat within summer home ranges was positively correlated with

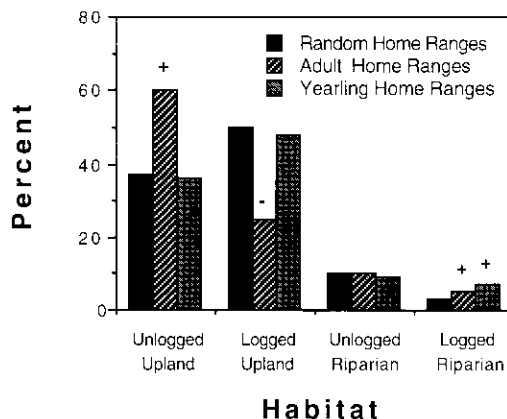


Figure 1. Percent habitat composition of 13 adult and 5 yearling white-tailed deer home ranges compared to 15 random home ranges in the Swan-Clearwater River Valleys, Montana, during 1980 and 1981. + or - indicates that deer home range habitat composition differs ( $P \leq 0.1$ ) from random home ranges.

home range size for adult deer ( $r_s = 0.48$ ,  $P < 0.05$ ), but not for yearlings ( $r_s = -0.63$ ,  $P > 0.10$ ). We found no correlation between home range size and the proportion of upland habitats within a home range for either age class. Summer home ranges of deer contained an average of 2 cutting units that averaged 12 ha/100 ha of home range for adults and 25 ha/100 ha of home range for yearlings.

Twenty-four different habitat types were found in deer summer home ranges. Habitat types representing cool, moist environments were most common. Sixteen were within the spruce, grand fir, western red cedar series, and mesic types within the subalpine fir series. Home ranges of adults contained an average of 9 habitat types/100 ha; yearling ranges ( $n = 4$ ) averaged 10 habitat types/100 ha. Twenty-two habitat types were found in random home ranges, 20 of which also were found in deer home ranges. The most common habitat types in deer home ranges were generally uncommon in random home ranges; common types in random home ranges were also uncommon in deer home ranges. Average diversity indices, 13.4 for adults and 14.8 for yearlings, were significantly higher than average indices for random home ranges (7.7) (Mann-Whitney test,  $P = 0.004$ ).

### 3rd-Order Selection

Collectively, use of habitat categories within home ranges by adults and yearlings was similar, but differed from availability for all 4 habitat categories ( $P < 0.10$ ) (Figure 2). Both adults and yearlings were relocated more frequently in riparian habitats (logged and unlogged) and less frequently in upland habitats than expected, based on habitat availability. No individual deer used a riparian component less than expected. Two deer (1 adult and 1 yearling) used logged riparian habitat more than expected. Unlogged riparian habitat was scarce on their ranges, and the logged riparian habitat had residual conifers and a dense cover of paper birch (*Betula papyrifera*), alder (*Alnus sinuata*), red-osier dogwood (*Cornus stolonifera*), and willows (*Salix* spp.). No deer used upland habitats more than expected.

### Discussion

White-tailed deer in the Swan-Clearwater region used the same summer home ranges each year. In addition, natal home ranges of female fawns defined their home range areas as adults. Both of

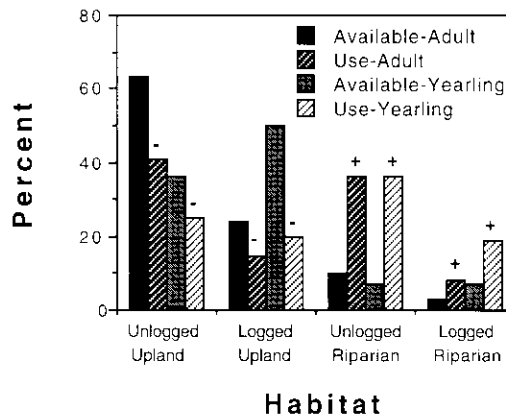


Figure 2. Percent use and availability of habitat categories within 13 adult and 5 yearling deer home ranges in the Swan-Clearwater River Valleys, Montana, during 1980 and 1981. + or - indicates that use differs ( $P \leq 0.1$ ) from availability.

these patterns have been documented elsewhere (Verme 1973, Hoskinson and Mech 1976, Janke 1977, Nelson 1979, Nelson and Mech 1981, Tier-son *et al.* 1985), and may contribute to enhanced survival and reproductive success.

Average home range size in this study was smaller than that reported in other studies (Sparrowe and Springer 1970, Hoskinson and Mech 1976, Janke 1977, Nelson and Mech 1981, Tier-son *et al.* 1985). Small home range size may have been related to the quality of habitats on the Swan-Clearwater summer range. Sanderson (1966) outlined 3 factors limiting home range sizes in animals that have been applied to summering white-tailed deer: (1) reduced mobility because of the constraints of young (Hawkins and Klimstra 1970, Gladfelter 1978, Ozoga *et al.* 1982); (2) social factors resulting from high population densities (Marchinton and Jeter 1966, Marshall and Whittington 1968, Smith 1970); and (3) high-quality habitat (Townsend and Smith 1933, Thomas *et al.* 1964, Marchinton and Jeter 1966, Sparrowe and Springer 1970). We did not address social factors, but they may have contributed to home range sizes and patterns we observed.

Deer in our study showed selection for both summer home range placement within the study area (2nd-order selection) and for use of specific habitats within those home ranges (3rd-order selection). The preference for riparian habitats may have been related to the abundance of high-quality forage located, the presence of free water, and

vegetative cover. Preference for riparian habitat for white-tailed deer has been documented elsewhere (Townsend and Smith 1933, Severinghaus and Cheatum 1956, Progulské and Duerre 1964, Allen 1968, Martinka 1968, Munding 1984).

The selection deer displayed for unlogged riparian habitat within their home ranges suggested that this was a preferred habitat category. Only 2 deer used logged riparian habitat more than expected, but their home ranges contained very little unlogged riparian habitat. Apparently, some preferred characteristics of riparian areas were still available following limited logging or habitat modification. However, unlogged riparian habitat appeared to be preferred when both logged and unlogged sites were available. In addition, as availability of unlogged riparian habitat increased, an individual's home range size decreased.

Deer used upland habitats less than expected, regardless of time of day (Leach 1982), abundance of upland habitats, or whether the stands were logged or unlogged. Our methods for detecting preferential habitat use may not have been sensitive to consistent albeit infrequent use of upland habitats. Johnson (1980) noted that time spent in a particular habitat does not always imply its value. Uplands, especially mature stands, no doubt have value for summering deer in the Swan-Clearwater area, but based on our results, the habitat values present in upland stands were of less importance to local deer than those found in riparian habitats.

Although adult deer did not select logged riparian habitat within their home ranges, this habitat category was important in home range establishment. Given fidelity of deer to home ranges, deer may be reluctant to relocate following logging activity in riparian habitats within their home range. Our results suggested that deer may have enlarged their summer home range as the ratio of logged to unlogged riparian habitat increased. Because home range location for female deer appears to be inherited, home range fidelity may have been established before the advent of logging. However, it was apparent that use of logged riparian habitat was highest where considerable deciduous cover and residual conifers remained following logging.

Home range distribution and use depends on social factors as well as habitat quality (Tierson *et al.* 1985). Adults and yearlings used habitats within their home ranges similarly, but there was evidence that yearling home ranges contained more

marginal habitat (less preferred) than did adult home ranges. Using adult habitat preferences as a standard for ranking, the order from most preferred to least preferred was: unlogged riparian, logged riparian, unlogged upland, and logged upland. Yearling deer occupied suboptimal habitats on our study area as did mule deer (*O. hemionus*) along the Missouri River Breaks of central Montana (Hamlin, Mont. Dept. Fish, Wildlife, and Parks, unpubl. data) and roe deer (*Capreolus capreolus*) in Denmark (Klein and Strandgaard 1972). This may have been the result of the dam's forcing yearlings out of preferred areas and naiveté of the yearlings.

Deer home ranges were located in areas with high habitat diversity where ecotones would be more common. Interspersion of diverse habitat types and riparian habitat polygons was common on deer ranges. Dahlberg and Guettinger (1956) and Progulské and Duerre (1964) stressed the importance of interspersion of openings and water as desirable components of deer summer range. Marchinton and Jeter (1966) concluded that the interspersion of foods changing in availability through time enabled deer to restrict movements to small home ranges.

Although our study did not evaluate the effects of specific silvicultural practices and forest management strategies on deer habitat, the following general guidelines seem warranted on deer summer range of the Swan-Clearwater. Riparian habitats, particularly unlogged ones, should be managed conservatively by establishing buffer zones of no logging. If logged, uneven-aged silvicultural systems should be used, to retain residual habitat. Quality upland cover should be maintained adjacent to riparian areas and other moist habitat components. A management goal should be habitat diversity on a small scale, accomplished with uneven-aged silviculture and prescribed fire. If even-aged management is applied, cutting unit size should be small ( $\leq 12$  ha) and dispersed over the landscape. Postlogging scarification should be limited to the minimum necessary for successful conifer regeneration, to enhance shrub production for deer forage and cover.

### Acknowledgements

We thank R. J. Mackie for project coordination. We also acknowledge J. G. Munding, I. J. Ball, S. M. McCorquodale, and several anonymous reviewers for advice on earlier manuscript drafts. The Flathead National Forest and the Montana

Cooperative Wildlife Research Unit provided financial and logistic support. This paper is a con-

tribution from Federal Aid Wildlife Restoration Project W-120-R.

## Literature Cited

- Allen, E. O. 1968. Range use, foods, condition, and productivity of white-tailed deer in Montana. *J. Wildl. Manage.* 32:130-141.
- Antos, J. A. 1977. Grand fir (*Abies grandis* [Dougl.] Forbes) forests of the Swan Valley, Montana. Univ. of Montana, Missoula. M.S. Thesis.
- Clover, M. R. 1956. Single-gate deer trap. *Calif. Fish and Game* 42:199-201.
- Dahlberg, B. L., and R. C. Guettinger. 1956. The white-tailed deer in Wisconsin. *Wisc. Conserv. Dept. Tech. Wildl. Bull.* 14. 281 pp.
- Daniel, W. W. 1973. Applied nonparametric statistics. Houghton Mifflin Co., Boston.
- Drolet, C. A. 1976. Distribution and movements of white-tailed deer in southern New Brunswick in relation to environmental factors. *Can. Field-Nat.* 90:123-136.
- Gilmore, D. S., L. M. Cowardin, R. L. Duval, L. M. Mechlin, C. W. Shaiffer, and V. B. Kuechle. 1981. Procedures for the use of aircraft in wildlife biotelemetry studies. U.S. Dept. Int. Resour. Publ. No. 140, Washington, D.C. 19 pp.
- Gladfelter, I. 1978. Movement and home range of deer as determined by radio telemetry. *Iowa Wildl. Res. Bull.* 23. 27 p.
- Hawkins, R. E., and W. D. Klinstra. 1970. A preliminary study of the social organization of white-tailed deer. *J. Wildl. Manage.* 34:407-419.
- Hildebrand, P. R. 1971. Biology of the white-tailed deer on winter ranges in the Swan Valley, Montana. Univ. of Montana, Missoula. M.S. Thesis.
- Hoskinson, R. L., and L. D. Mech. 1976. White-tailed deer management and its role in wolf predation. *J. Wildl. Manage.* 40:429-441.
- Janke, D. 1977. White-tailed deer population characteristics, movements, and winter site selection in western Montana. Univ. of Montana, Missoula. M.S. Thesis.
- Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. *Ecology* 61:65-71.
- Klein, D. R., and H. Strandgaard. 1972. Factors affecting growth and body size of roe deer. *J. Wildl. Manage.* 36:64-79.
- Leach, R. H. 1982. Summer range ecology of white-tailed deer in the coniferous forests of northwestern Montana. Univ. of Montana, Missoula. M.S. Thesis.
- Marchinton, B. L., and L. K. Jeter. 1966. Telemetric study of deer movement ecology in the southeast. *Proc. Southeast. Assoc. Game and Fish Comm.* 20:189-206.
- Marcum, C. L., and D. O. Loftsgaarden. 1980. A nonmapping technique for studying habitat preferences. *J. Wildl. Manage.* 44:963-968.
- Marshall, A. D., and R. W. Whittington. 1968. A telemetric study of deer home ranges and behavior of deer during managed hunts. *Proc. Southeast. Assoc. Game and Fish Comm.* 22:30-46.
- Martinka, C. J. 1968. Habitat relationships of white-tailed and mule deer in northern Montana. *J. Wildl. Manage.* 32:558-565.
- Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. *Am. Midl. Nat.* 37:223-249.
- Mundinger, J. G. 1981. White-tailed deer reproductive biology in the Swan Valley, Montana. *J. Wildl. Manage.* 45:132-139.
- . 1984. Biology of the white-tailed deer in the coniferous forests of northwestern Montana. In M. R. Meehan, T. R. Merrell, Jr., and T. A. Hanley, eds. *Fish and wildlife relationships in old-growth forests*. Am. Ins. Fish. Res. Biol. Pp. 275-284.
- Nelson, M. E. 1979. Home range location of white-tailed deer. U.S. Dept. Agric. For. Serv. Res. Pap. NC-173. North Cent. For. Exp. Sta., St. Paul, Minnesota. 10 pp.
- Nelson, M. E., and L. D. Mech. 1981. Deer social organization and wolf predation in northeastern Minnesota. *Wildl. Monogr.* 77. 53 pp.
- Neu, C. W., C. R. Byers, and J. M. Peck. 1974. A technique for analysis of utilization-availability data. *J. Wildl. Manage.* 38:541-545.
- Odum, E. P., and E. J. Kuenzler. 1955. Measurement of territory and home range size in birds. *Auk* 72:128-138.
- Ozoga, J. J., L. J. Verme, and C. S. Bienz. 1982. Parturition behavior and territoriality in white-tailed deer: impact on neonatal mortality. *J. Wildl. Manage.* 46:1-11.
- Pfister, R. D., B. L. Kovalchick, S. F. Arno, and R. C. Presby. 1977. Forest habitat types of Montana. U.S. Dept. Agric. For. Serv. Gen. Tech. Rep. INT-34. 174 pp.
- Progulske, D. R., and D. C. Duerre. 1964. Factors influencing spotlighting counts of deer. *J. Wildl. Manage.* 28:27-34.
- Sanderson, G. C. 1966. The study of mammal movements—a review. *J. Wildl. Manage.* 30:215-235.
- Severinghaus, C. W., and E. L. Cheatum. 1956. Life and times of the white-tailed deer. In W. P. Taylor, ed. *The deer of North America*. Stackpole Co., Harrisburg, Penn., and Wildl. Manage. Inst., Washington, D. C. Pp. 57-186.
- Smith, F. H., Jr. 1970. Daily and seasonal variations in movements of white-tailed deer on Eglin Air Force Base, Florida. Univ. of Georgia, Athens. M.S. Thesis.
- Sparrowe, R. D., and P. F. Springer. 1970. Seasonal activity patterns of white-tailed deer in eastern South Dakota. *J. Wildl. Manage.* 34:420-431.
- Swihart, R. K., and N. A. Slade. 1985. Influence of sampling interval on estimates of home range size. *J. Wildl. Manage.* 49:1019-1024.
- Thomas, J. W., J. C. Teer, and E. A. Walker. 1964. Mobility and home range of white-tailed deer on the Edwards Plateau in Texas. *J. Wildl. Manage.* 28:463-473.
- Tierson, W. C., G. F. Mattfield, R. W. Sage, Jr., and D. F. Behrend. 1985. Seasonal movements and home ranges of white-tailed deer in the Adirondacks. *Roosevelt Wildl. Bull.* 6:161-325.
- Townsend, M. T., and M. W. Smith. 1933. The white-tailed deer of the Adirondacks. *Roosevelt Wildl. Bull.* 6:161-325.
- Verme, L. J. 1973. Movements of white-tailed deer in upper Michigan. *J. Wildl. Manage.* 37:545-552.
- Weckwerth, R. 1958. Big game surveys and investigations—Swan Unit. *Mont. Dept. Fish, Wildl., and Parks. Fed. Aid Wildl. Restor. Proj. W-71-R-3.* 21 pp.

Received 12 October 1990

Accepted for publication 9 August 1993