

Topographic Home Ranges of White-tailed Deer in the Central Appalachians

TYLER A. CAMPBELL^{1,*}, BENJAMIN R. LASETER¹, W. MARK FORD²,
AND KARL V. MILLER¹

Abstract - Planimetric comparisons of home range sizes of white-tailed deer (*Odocoileus virginianus* Zimmermann) from across their range may not be appropriate due to regional differences in topography. We compare seasonal topographic diversity between male and female white-tailed deer home ranges in the central Appalachians using percent increase from planimetric to topographic areas as a measure. Mean percent increase in home range size for all deer-seasons combined was 3.1 (range = 1.3–6.4). No differences in percent increase in home range areas occurred between sexes or among seasons. The relatively low percent increase in home range area and lack of variation between sexes and among seasons validates the common practice of comparing planimetric home range sizes from different geographic areas.

Introduction

White-tailed deer (*Odocoileus virginianus* Zimmermann) home range sizes have been studied across their geographic range (Gavin et al. 1984, Labisky et al. 1999, Lesage et al. 2000), including mountainous habitats (Tierson et al. 1985). These investigations have provided natural resource managers with valuable information on deer behavioral ecology. However, in regions with complex and rugged topography, the question, “To what degree does topographic complexity influence home range size?” has not been addressed. This unknown brings into question the validity of regional comparisons of deer home range size. For example, comparisons of planimetric home ranges of deer from the flat Columbian White-tailed Deer National Refuge (Gavin et al. 1984) and the rugged Adirondack Mountains (Tierson et al. 1985) may not be appropriate due to differences in topography.

Recently, Stone et al. (1997) documented the use of a Geographic Information System (GIS) to formulate a topographic estimate of southern flying squirrel (*Glaucomys volans* Linnaeus) home ranges in the Ouachita Mountains of Arkansas. They discovered that topographic home range estimates were 8.5% larger than planimetric estimates. Similarly, in the central Appalachians, Castleberry et al. (2001) noted that topographic home ranges of Allegheny woodrats

¹Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602. ²USDA Forest Service, Northeastern Research Station, Box 404, Parsons, WV 26287. ^{*}Corresponding author - tcampbell@smokey.forestry.uga.edu.

(*Neotoma magister* Baird) were 6.4% larger than planimetric estimates, and used the former in all analyses.

Although Stone et al. (1997) reported mean percent increase in home range size (from planimetric to topographic) by sex, we are unaware of studies that use this percent increase as a response variable in comparisons of topographic diversity among demographic classes or seasons. Therefore, we compared seasonal topographic diversity between male and female white-tailed deer home ranges in the central Appalachians using percent increase from planimetric to topographic areas as a measure. Because deer use areas that maximize thermoregulatory efficiency during winter (Marchinton and Hirth 1984), we predicted that topographic diversity of winter home ranges would be less than during other seasons. Furthermore, we predicted that adult females (presumably with fawns) would have more topographically diverse home ranges during summer than males because female white-tailed deer use areas of greater slope during summer as a means of predator avoidance (Lingle 2002).

Field Site and Methods

Our study was conducted on the 3360-ha MeadWestvaco Corporation's Wildlife and Ecosystem Research Forest (MWWERF) in Randolph County, WV (38°42'N, 80°3'W). The MWWERF occurs in the Unglaciaded Allegheny Mountain and Plateau physiographic province (Fenneman 1938). Elevations range from 740 to 1200 m, and precipitation averages from 170 to 190 cm/year (Smith 1995). Topography consists of steep side slopes with broad, plateau-like ridgetops and narrow valleys with small, high-gradient streams. Forest cover is primarily an Allegheny hardwood-northern hardwood type that is managed using even-aged regeneration techniques. A detailed characterization of the study area is provided by Ford and Rodrigue (2001).

We used modified Clover traps (Clover 1954) and rocket nets (Hawkins et al. 1968) baited with whole kernel corn to capture deer during January–April of 1999–2002. We immobilized, radiocollared (Advanced Telemetry Systems, Isanti, Minnesota), and ear-tagged all deer upon capture. We used tooth eruption, replacement, and wear (Severinghaus 1949) to age deer as fawns, yearlings, or adults. We used both physical restraint and chemical (2.2 mg xylazine hydrochloride/kg body weight) immobilization techniques. For deer that were chemically immobilized, we used half intravenous and half intramuscular injections of yohimbine hydrochloride (0.3 mg/kg body weight) as a reversal agent. All capture and handling protocols were approved by the University of Georgia's Institutional Animal Care and Use Committee (Permit No. A2002-10119-0).

We collected radiotelemetry data from 3 hours before sunrise and sunset to 4 hours after sunrise and sunset during all months. We estimated deer locations from fixed geo-referenced telemetry stations using radio receivers, 4-element Yagi antennas, and compasses. To generate a location estimate, we obtained 3–8 bearings and recorded 2 simultaneous bearings that produced an angle of $90 \pm 40^\circ$. To generate UTM coordinates of estimated deer locations, we used CALHOME (Kie et al. 1996). We attempted to locate each deer 3–4 times/week and we considered individual deer locations ≥ 10 hr apart independent.

To assess the accuracy of our bearings, we randomly placed 5 transmitters at geo-referenced points in areas commonly used by radio-collared deer, but unknown to observers. Each observer ($n = 30$) recorded 5 compass bearings to each transmitter from 5 telemetry stations (i.e., $n = 125/\text{observer/test}$). Each observer completed 2 accuracy tests. Throughout our study, mean bearing error was -0.65° (SD = 8.41°), suggesting minimal bias in the telemetry protocol. Mean distance from estimated deer location to observer was 352.8 m. These data resulted in an estimated mean location error of 52.2 m. To increase accuracy we omitted all estimated locations that were ≥ 3 km from the observer.

We used the Animal Movement extension (Hooge and Eichenlaub 1997) of ARCVIEW® (Environmental Systems Research Institute 1999) to generate 95% planimetric home range areas (fixed-kernel method, Worton 1989). We used least square cross validation as the smoothing parameter on the kernel distributions (Silverman 1986). We generated home ranges for summer (May–Sep), fall (Oct–Dec), and winter (Jan–Apr) following Campbell (2003). We only included deer in the analyses if they were radio monitored throughout the duration of a given season.

Topographic home range areas were calculated from the planimetric 95% home range polygons using 3-D and Spatial Analyst extensions in ARCVIEW® (Fig. 1, Environmental Systems Research Institute 1999). Surface features were derived from a 30-m digital elevation model of the MWWERF (Adolph, WV, U.S. Geological Survey 7.5' quadrangle; Castleberry et al. 2001). The expression of surface features is computationally demanding, and we were unable to generate surface features for the entire MWWERF. We calculated the percent increase in home range area as:

$$I = [1 - (p/t)] * 100\%$$

where I is the percent increase in home range area (from planimetric to topographic), p is the planimetric home range area, and t is the topographic home range area. We considered percent increase values $> 5\%$ to be biologically significant.

We used one-factor analysis of variance (ANOVA) to test for differences in percent increase in home range area between sexes for fawns during winter. This analysis was selected because fawns were

not radio-collared during summer or fall. We used a two-factor ANOVA to test for differences in percent increase in home range area between sexes and among seasons within adult (≥ 1 -year-old) deer. The assumption of independence was maintained because individual

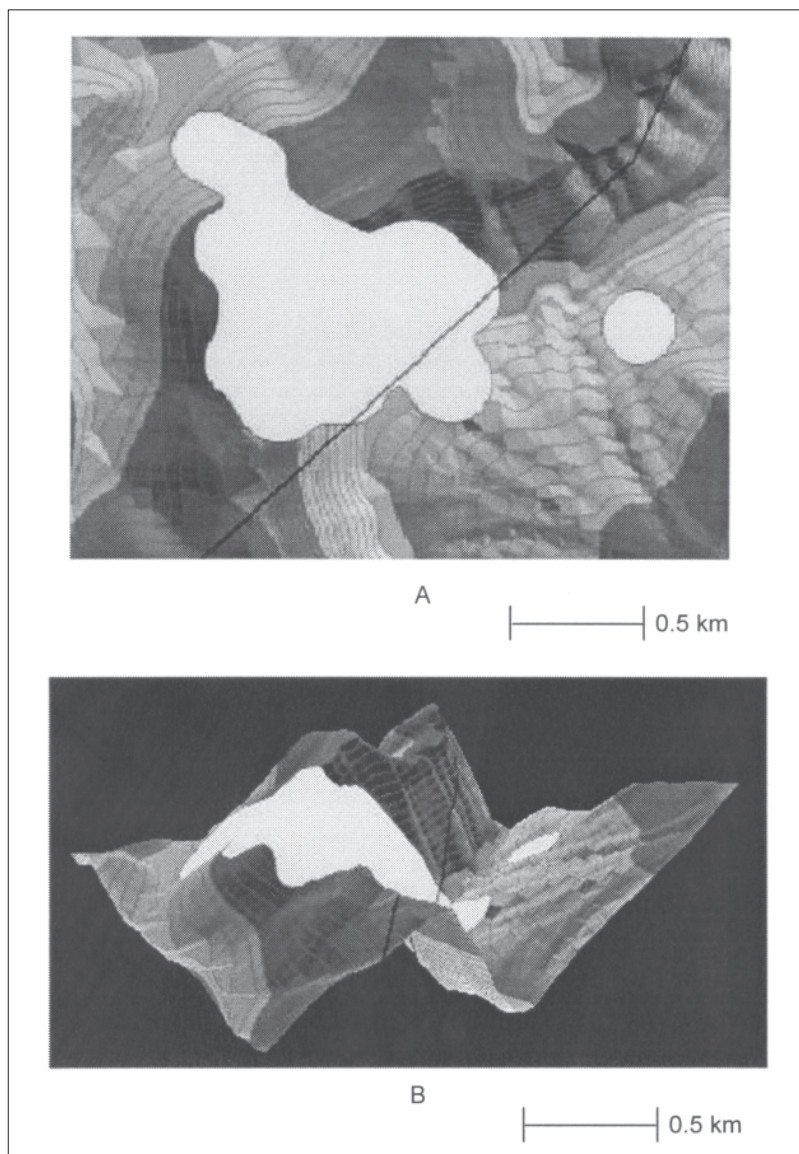


Figure 1. Home range of an adult male deer during winter: A) planimetric; B) topographic. Light gray polygon indicates 95% home range, and black line crossing polygon is the property boundary of the MeadWestvaco Wildlife and Ecosystem Research Forest, WV.

deer were not radio-monitored for > 1 year and each deer was only represented once per season. For all analyses, we determined statistical significance at $P = 0.05$. Means are reported with standard errors in parentheses. All statistical analyses were performed with SAS statistical software (SAS Institute 1989).

Results and Discussion

We estimated seasonal home ranges of 37 male and 57 female white-tailed deer from 7780 telemetry locations. We used 176 seasonal home ranges in analyses. Mean number of telemetry locations/deer/season was 42.2 (SE = 2.4). Mean percent increase from planimetric to topographic home range areas for all deer-seasons combined was 3.1 (SE = 0.1; range = 1.3–6.4). No difference ($F_{1,48} = 0.93$, $P = 0.34$) in percent increase in home range areas occurred between male and female fawns during winter (Table 1). Within adults, no difference (all $P > 0.64$) in percent increase in home range areas occurred between sexes ($F_{1,120} = 0.21$, $P = 0.64$), among seasons ($F_{2,120} = 0.05$, $P = 0.95$), or for their interaction ($F_{2,120} = 0.15$, $P = 0.86$).

The relatively low percent increase in home range area (despite the high degree of topographic relief) and lack of variation between sexes and among seasons validates the common practice of comparing planimetric home range sizes of white-tailed deer among different geographic regions. Obviously, in regions with steeper slopes than the MWWRF we would expect topographic home ranges to be substantially larger than planimetric home ranges. In the southeastern United States, such areas occur in the Blue Ridge Mountain and Ridge and Valley physiographic provinces (Fenneman 1938). Deer using the steep-

Table 1. Mean (SE) white-tailed deer seasonal planimetric and topographic home ranges (ha) and percent increase from planimetric to topographic areas on the MeadWestvaco Wildlife and Ecosystem Research Forest, WV, in 1999–2002.

Age	Season	Sex	<i>n</i>	Planimetric	Topographic	% Increase
Fawn	Winter ¹	M	33	141.2 (22.8)	146.0 (23.6)	3.2 (0.1)
		F	17	139.1 (30.2)	143.7 (31.5)	3.0 (0.1)
Adult (≥ 1-year-old)	Summer ²	M	25	98.0 (13.6)	101.2 (14.1)	3.1 (0.2)
		F	30	79.0 (8.7)	81.5 (9.0)	3.1 (0.1)
	Fall ³	M	8	227.8 (60.6)	235.3 (62.4)	3.0 (0.3)
		F	27	82.5 (23.2)	85.2 (23.9)	3.1 (0.2)
	Winter	M	5	64.3 (15.3)	66.3 (15.6)	3.0 (0.9)
		F	31	91.9 (11.6)	94.8 (11.9)	3.2 (0.1)

¹January–April.

²May–September.

³October–December.

est portion of the MWWERF had a percent increase in home range area of only 6.4, which we believe represents a near maximum percent increase in home range area for deer in the Unglaciaded Allegheny Mountain and Plateau physiographic province.

We hypothesized that deer would use less topographically diverse areas during winter to maximize thermoregulatory efficiency, and that adult female deer would use more rugged areas during summer as a means of predator avoidance. The lack of variability between sexes and among seasons in percent increase in home range area suggests that deer use areas without regard for topography. Other factors such as social aggregations (Laseter et al. 2002), philopatry (Campbell 2003), or food availability (Laseter et al. 2003) are apparently more important to deer in their seasonal use of habitats in the central Appalachians.

On the MWWERF, topographic home ranges were 6.4% larger than planimetric for Allegheny woodrats (Castleberry et al. 2001). Consequently, we were surprised by the low percent increase in home range area within deer. In fact, the deer displaying the maximum percent increase in home range area was approximately equal to the mean of woodrats. However, Allegheny woodrats reside almost exclusively in rocky and steep habitats and maintain comparatively small (1.5–11.4 ha) topographic home ranges (Castleberry et al. 2001). Relative to their home ranges, Allegheny woodrats use more steep habitats than deer, despite being sympatric.

We concur with the assertion of Stone et al. (1997) that topographic home ranges provide a more spatially explicit characterization of animal movement patterns. However, we demonstrated that in white-tailed deer from the central Appalachians (which maintain a comparatively large planimetric home range and do not migrate), the effects of topography on seasonal home range size are negligible. However, we expect topographic effects to be significant in species that are obligate to steep habitats. Due to the availability and ease of topographic home range analyses, we recommend that topography be incorporated into future investigations of species obligate to steep habitats.

Acknowledgments

Financial support was provided by the MeadWestvaco Corporation and the US Department of Agriculture, National Research Initiative Program (grant 00-35101-9284). We are grateful to the West Virginia Division of Natural Resources for their support. Editorial comments to earlier drafts of this manuscript were provided by R.J. Warren, J.P. Carroll, and R.L. Hendrick. We are indebted to the 30 field technicians who assisted in data collection as well as J.L. Crum, P.D. Keyser, and D.A. Osborn who provided logistical assistance. Deer were captured and handled under the auspices of Scientific Collection Permits 43-1999, 16-2000, 2001.008, and 2002.009 from the West Virginia Division of Natural Resources.

Literature Cited

- Campbell, T.A. 2003. Movement ecology of white-tailed deer in the central Appalachians of West Virginia. Unpublished Ph.D. Dissertation, University of Georgia, Athens, GA.
- Castleberry, S.B., W.M. Ford, P.B. Wood, N.L. Castleberry, and M.T. Mengak. 2001. Movements of Allegheny woodrats in relation to timber harvesting. *Journal of Wildlife Management* 65:148–156.
- Clover, M.R. 1954. A portable deer trap and catch-net. *California Fish and Game* 40:367–373.
- Environmental Systems Research Institute. 1999. ARCVIEW. Version 3.2. Environmental Systems Research Institute, Redlands, CA.
- Fenneman, N.M. 1938. Physiography of the Eastern United States. McGraw-Hill, New York, NY. 714 pp.
- Ford, W.M., and J.L. Rodrigue. 2001. Soricid abundance in partial overstory removal harvests and riparian areas in an industrial forest landscape of the central Appalachians. *Forest Ecology and Management* 152:159–168.
- Gavin, T.A., L.H. Suring, P.A. Vohs, Jr., and E.C. Meslow. 1984. Population characteristics, spatial organization, and natural mortality in the Columbian white-tailed deer. *Wildlife Monograph* 91.
- Hawkins, R.E., L.D. Martoglio, and G.G. Montgomery. 1968. Cannon-netting deer. *Journal of Wildlife Management* 32:191–195.
- Hooe, P.N., and B. Eichenlaub. 1997. Animal movement extension to ARCVIEW. Version 1.1. US Geological Survey, Anchorage, AK.
- Kie, J.G., J.A. Baldwin, and C.J. Evans. 1996. CALHOME: A program for estimating animal home ranges. *Wildlife Society Bulletin* 24:342–344.
- Labisky, R.F., K.E. Miller, and C.S. Hartless. 1999. Effect of Hurricane Andrew on survival and movements of white-tailed deer in the Everglades. *Journal of Wildlife Management* 63:872–879.
- Laseter, B.R., T.A. Campbell, D.A. Osborn, K.V. Miller, and W.M. Ford. 2002. Social groups of female white-tailed deer: How much seasonal movement occurs in the central Appalachians? *Proceedings of the 5th International Deer Biology Congress* 5:63.
- Laseter, B.R., T.A. Campbell, D.A. Osborn, K.V. Miller, and W.M. Ford. 2003. White-tailed deer browse preferences in clearcuts in the central Appalachians of West Virginia. *Proceedings of the Annual Southeastern Deer Study Group* 26:23–24.
- Lesage, L., M. Crête, J. Hout, A. Dumont, and J. Ouellet. 2000. Seasonal home range size and philopatry in two northern white-tailed deer populations. *Canadian Journal of Zoology* 78:1930–1940.
- Lingle, S. 2002. Coyote predation and habitat segregation of white-tailed deer and mule deer. *Ecology* 83:2037–2048.
- Marchinton, R.L., and D.H. Hirth. 1984. Behavior. Pp. 129–168, *In* L.K. Halls (Ed.). *White-tailed Deer Ecology and Management*. Stackpole Books, Harrisburg, PA. 870 pp.
- SAS Institute. 1989. SAS/STAT User's Guide. Version 6. Fourth Edition. SAS Institute, Cary, NC.
- Severinghaus, C.A. 1949. Tooth development and wear as criteria of age in white-tailed deer. *Journal of Wildlife Management* 13:195–216.

- Silverman, B.W. 1986. Density Estimation for Statistics and Data Analysis. Chapman Hall, London, UK. 175 pp.
- Smith, D.W. 1995. The southern Appalachian hardwood region. Pp. 173–225, *In* J.W. Barrett (Ed.). Regional Silviculture of the United States. John Wiley and Sons, Inc., New York, NY. 643 pp.
- Stone, K.D., G.A. Heidt, P.T. Caster, and M.L. Kennedy. 1997. Using Geographic Information Systems to determine home range of the southern flying squirrel (*Glaucomys volans*). American Midland Naturalist 137:106–111.
- Tierson, W.C., G.F. Mattfeld, R.W. Sage, Jr., and D.F. Behrend. 1985. Seasonal movements and home ranges of white-tailed deer in the Adirondacks. Journal of Wildlife Management 49:760–769.
- Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164–168.