CSIRO PUBLISHING
www.publish.csiro.au/journals/wr *Wildlife Research*, 2006, **33**, 1–4

Movements of female white-tailed deer to bait sites in West Virginia, USA

Tyler A. Campbell[A,E], *Christopher A. Langdon*[B,C], *Benjamin R. Laseter*[A], *W. Mark Ford*[D], *John W. Edwards*[B] *and Karl V. Miller*[A]

[A]Daniel B. Warnell School of Forest Resources, University of Georgia, Athens, GA 30602, USA.
[B]Wildlife and Fisheries, Division of Forestry, Box 6125, West Virginia University, Morgantown, WV 26506, USA.
[C]Present address: United States Department of Interior, Bureau of Land Management, Roseburg District, 777 NW Garden Valley Boulevard, Roseburg, OR 97470, USA.
[D]United States Department of Agriculture, Forest Service, Northeastern Research Station, Box 404, Parsons, WV 26287, USA.
[E]Corresponding author. Email: Tyler.A.Campbell@aphis.usda.gov

Abstract. We present a comparison of movements of adult female white-tailed deer (*Odocoileus virginianus*) in response to seasonal bait sites in the central Appalachians of West Virginia, USA. Our objectives were to compare bait-site use among seasons, evaluate home-range and core-area sizes between baiting and non-baiting periods, and compare distance from the geographic centres of activity to nearest bait site between baiting and non-baiting periods. From June 2000 to May 2001, we radio-monitored 52 deer and determined their use of 29 seasonal bait sites with automated camera systems. We collected 6461 locations and 1333 photographic observations of radio-collared deer. Bait-site use did not differ among four seasonal baiting periods. Additionally, home-range and core-area sizes did not differ between baiting and non-baiting periods. However, deer shifted their centres of activity closer to bait sites during baiting periods. High variability in deer behaviour should be considered when implementing deer-management activities that require all deer to use bait sites, such as infrared-triggered camera surveys.

Introduction

For decades baiting has been used to fulfill numerous white-tailed deer management and research objectives, such as deer capture and to administer immunocontraceptive agents (Kilpatrick and Stober 2002). Additionally, many south-eastern states permit baiting to facilitate deer harvest (Annual Meeting of the Southeast Deer Study Group 2004). Despite increased harvest rates, minimised hunter effort and reduced kill distances (Synatzske 1981; Langenau *et al*. 1985) the maintenance of bait sites during the hunting season is a controversial activity owing to the potential for disease transmission (Williamson 2000) and to ethical concerns.

Common to the debate is whether bait sites attract deer from distant (or adjacent) areas where bait sites are not maintained. In South Carolina, Van Brackle *et al*. (1995) showed that 29% of harvested deer on properties adjacent to a 1862-ha baited property traveled up to 5.4 km to feed on biomarked bait. However, radio-telemetry investigations from a wildlife management area in Mississippi (Darrow 1993), and from suburban Connecticut (Kilpatrick and Stober 2002), suggested that baiting had little influence on home-range size and distance from home range to bait sites. Nonetheless, variability in deer responses to bait was common in these studies. For example, Kilpatrick and Stober (2002) noted four different responses within 16 adult female deer depending on bait-site placement relative to deer core areas. In addition, small sample sizes limited definitive conclusions. Darrow (1993) examined movements of 13 deer (6 males, 7 females), of which only seven of unspecified sex were known to use bait sites. Because of emerging disease, biological, and deer overabundance issues (Williamson 2000), additional study is needed to augment small sample sizes, high variability, and limited inference of previous work. This is particularly true for West Virginia where baiting is permitted, hunter recruitment is declining, and deer populations are generally expanding.

We present a comparison of female white-tailed deer movements in response to seasonal bait sites. Our objectives were to compare bait-site use among seasons, evaluate home-range and core-area sizes between baiting and non-baiting periods, and compare distance from the geographic centres of activity to bait sites between baiting and non-baiting periods.

Materials and methods

Study area

Our study was conducted on the 3360-ha MeadWestvaco Corporation's Wildlife and Ecosystem Research Forest (MWWERF) in south-western Randolph County, West Virginia, USA (38°42′N, 80°3′W). The MWWERF was established in 1994 to examine the influence of industrial forestry on ecological processes in the central Appalachians. Occurring within the Unglaciated Allegheny Mountain and Plateau Physiographic province, the MWWERF is characterised by steep side

 10.1071/WR04090 1035-3712/06/010001

slopes, narrow valleys, and broad plateau-like summits with elevations of 700–1200 m (Fenneman 1938). Precipitation averages 170–190 cm per year, with average snowfall >300 cm per year (National Oceanic and Atmospheric Administration 2002). Forest cover is primarily an Allegheny hardwood–northern hardwood type that is under both even-aged (75%) and uneven-aged (25%) management. Timber is harvested on 40–80-year rotations and clearcut and leave-tree harvests are 8–19 ha in size. Forest communities of American beech (*Fagus grandifolia*)–yellow birch (*Betula allegheniensis*)–maple (*Acer* spp.)–black cherry (*Prunus serotina*) dominate. Pre-harvest white-tailed deer densities and sex ratios during our study were estimated as 12–20 deer km^{-2} and 6–18 adult males per 100 adult females respectively (Langdon 2001). Abomasal parasite counts suggest that the deer population is at or near nutritional carrying capacity (Fischer 1996). Ford and Rodrigue (2001) provide a more detailed characterisation of the study area.

Methods

We captured deer from January to April in 1999 and 2000 using modified Clover traps (Clover 1954) and rocket nets (Hawkins *et al*. 1968) baited with whole-kernel corn. We chemically immobilised (2.2 mg xylazine hydrochloride per kilogram body weight) and ear-tagged all deer upon capture. We used yohimbine hydrochloride (0.3 mg per kilogram of body weight) as a reversal agent, administering half the dose intravenously and half the dose intramuscularly. We radio-collared all female deer (Advanced Telemetry Systems, Isanti, Minnesota, USA) and aged deer as fawns, yearlings, or adults via tooth eruption, replacement, and wear (Severinghaus 1949). All capture and handling procedures were approved by the University of Georgia's Institutional Animal Care and Use Committee (Permit No. A2002-10119-0).

We collected both diurnal and nocturnal radio-telemetry data. We estimated deer locations using radio-receivers and hand-held, 4-element Yagi antennas. We obtained compass azimuths from fixed geo-referenced telemetry stations. To generate deer location estimates, we recorded two simultaneous azimuths that produced an angle of 90 ± 40°. We used CALHOME (Kie *et al*. 1996) to generate UTM coordinates of estimated deer locations. We considered individual deer locations ≥10 h apart to be independent and attempted to locate each deer 2 or 3 times per week. We assessed the accuracy of our location estimates by randomly placing transmitters at geo-referenced points in areas commonly occupied by deer. Each observer then recorded compass bearings from five telemetry stations. Overall, mean bearing error was –0.65° (s.d. = 8.41°).

We used the fixed-kernel method (Worton 1989) to generate 95% annual home-range areas and 50% core areas using the Animal Movement extension (Hooge and Eichenlaub 1997) of ARCVIEW® (Environmental Systems Research Institute 1999). We used least-square cross-validation as the smoothing parameter on the kernel distributions (Silverman 1986). We only used adult (≥1-year-old) female deer radio-collared throughout the duration of the study in analyses. For individual deer, we generated home-range and core areas from all locations collected from June 2000 to May 2001 during baiting and non-baiting periods (see below). Home-range and core-area polygons were overlaid onto a coverage map of the MWWERF using MeadWestvaco's Forest Research Information System (FRIS®) and ARCVIEW. We used the minimum convex polygon (MCP) bootstrap function of Animal Movement to determine number of locations needed to obtain stable home-range areas. We randomly selected 30 deer and completed 100 iterations of home-range size as a function of number of locations (3–100). Mean number of locations needed to obtain a stable MCP area was 28 (s.e. = 0.3). Consequently, we omitted deer for which <28 locations per period were available. Unlike the kernel method, the MCP home-range estimator is sensitive to number of locations used (Jennrich and Turner 1969). Therefore, ≥28 locations represent a conservative lower limit for the kernel method.

We systematically placed 29 bait sites throughout the MWWERF on an 806-m grid oriented in cardinal directions (1 bait site per 65 ha). We baited sites with whole-kernel corn using tube feeders during summer (24 July 2000 – 13 August 2000), autumn (16 October 2000 – 5 November 2000), winter (13 January 2001 – 2 February 2001), and spring (9 May 2001 – 29 May 2001). At each bait site we placed an automated camera system (NX-500 and SX-500, Non-Typical Inc., Park Falls, WI, USA) and recorded photographic observations during the latter 14–16 days of each seasonal baiting period. We tallied daily visits for individual deer. During baiting periods, we visited bait sites at least every other day to change film, add bait, and ensure camera function. Langdon (2001) provided a detailed description of the bait sites and camera placement. For locations generated during baiting and non-baiting periods, distance from the geographic centres of activity to nearest bait site was quantified using ARCVIEW.

We used two test statistics to evaluate bait-site use among seasons. To compare the proportion of deer visiting bait sites among seasons, we used Chi-square analysis. We also compared visitation rates (the number of radiocollared deer photographed per day) among seasons with a one-way ANOVA where season was the main effect (SAS Institute 1989). To compare home-range and core-area sizes between baiting and non-baiting periods, we used a paired *t*-test (SAS Institute 1989). Similarly, we used a paired *t*-test to compare distance from the geographic centres of activity to bait sites between baiting and non-baiting periods. For all analyses, we considered significance at $\alpha = 0.05$.

Results

We generated 6461 radio-telemetry locations from 52 adult female deer during June 2000–May 2001. Mean locations during baiting and non-baiting periods were 29.8 (s.e. = 0.2) and 94.4 (s.e. = 0.4), respectively. We recorded 10 302 photographic observations during the four seasonal baiting periods, 1333 contained radio-collared deer. In all, 38 radio-collared deer had at least one bait site within a non-baiting home range; four of these were not photographed at a bait site. Fourteen deer did not have any bait sites within a non-baiting home range; 11 of these were photographed at a bait site.

The seasonal proportion of deer visiting bait sites did not differ ($\chi^2_3 = 0.02$, $P > 0.99$). During summer, 22 of 52 radio-collared deer were photographed at bait sites; during autumn, 28 of 52 radio-collared deer were photographed at bait sites; during winter, 32 of 52 radio-collared deer were photographed at bait sites; and during spring, 30 of 52 radio-collared deer were photographed at bait sites. Similarly, visitation rates by radio-collared deer did not differ seasonally ($F_{3,55} = 2.25$, $P = 0.093$). Mean seasonal visitation rates for summer, autumn, winter and spring were 6.0 (s.e. = 0.6), 4.9 (s.e. = 0.5), 6.7 (s.e. = 0.8), and 4.9 (s.e. = 0.5) radio-collared deer per day respectively.

Home-range ($t_{51} = 0.644$, $P = 0.522$) and core-area ($t_{51} = 0.228$, $P = 0.821$) sizes did not differ between baiting and non-baiting periods (Table 1). However, distance from the geographic centres of activity to the nearest bait site differed between baiting and non-baiting periods ($t_{51} = 3.247$, $P = 0.002$). Deer shifted their centres of activity closer to bait sites during baiting periods (Table 1).

Table 1. Home-range size, core-area size, and distance from the geographic centres of activity to the nearest bait site of adult female white-tailed deer during baiting and non-baiting periods on the MeadWestvaco Wildlife and Ecosystem Research Forest, West Virginia, USA, June 2000–May 2001
Data are means with standard errors shown in parentheses; $n = 52$ for both periods

	Baiting period	Non-baiting period
Home range (ha)	127 (21)	135 (20)
Core area (ha)	23 (4)	24 (4)
Distance (m)	485 (56)	568 (67)

Discussion

In central Texas, Koerth and Kroll (2000) found that use of bait sites by deer varied by month. Consequently, the lack of seasonal differences in bait site use by radio-collared deer in our study, as indicated by the proportion of deer visiting bait sites and the visitation rates, was somewhat surprising given the seasonality of snow and mast availability on our study area. However, Koerth and Kroll (2000) maintained bait sites continuously for longer than one year, whereas our bait sites were maintained seasonally during 3-week periods. Consequently, deer in our study had to 'relocate' bait sites during periods of baiting before use could be documented on film. A temporary baiting system more closely approximates most research and management scenarios (Kilpatrick and Stober 2002), particularly in West Virginia, which has a short (2 week) rifle hunting season.

Kilpatrick and Stober (2002) examined the influence of bait sites on white-tailed deer movements in suburban environments. Noteworthy discoveries were that deer did not use bait sites outside their home range, all deer with bait sites within their home range used the bait sites, shifts in core areas towards bait sites were common, and home-range and core-area sizes did not differ between baiting and non-baiting periods. Similar to Kilpatrick and Stober (2002), we observed (1) deer shifting centres of activity towards bait sites during periods of baiting, and (2) comparable home-range and core-area sizes between baiting and non-baiting periods. However, we observed 29 of 52 (56%) deer using bait sites outside their non-baiting home range (either exclusively or in addition to those inside their non-baiting home range). Though deer have been documented using bait sites outside their non-baiting home ranges (Darrow 1993), this high rate was unexpected. Still, movements to bait sites outside of non-baiting home ranges were short distance and most of these bait sites were within 100 m of non-baiting home ranges. Though high in occurrence, we believe deer use of bait sites outside non-baiting home ranges is not biologically significant because differences in home-range and core-area sizes did not differ between baiting and non-baiting periods. Our data suggest that the maintenance of seasonal bait sites within the central Appalachians of West Virginia does not function to attract deer from distant areas, though minor shifts of adjacent deer likely occur.

As with studies from other regions of the United States, deer displayed variable behaviours in response to baiting throughout our study. For example, some deer that had bait sites within their non-baiting home range did not use bait sites, some deer that did not have bait sites within their non-baiting home range used bait sites, and some deer used as many as four different bait sites within a 14–16-day period. We believe variability in deer behaviour should be considered when implementing deer-management activities that require all deer to use bait sites, such as infrared-triggered camera surveys (Jacobson *et al*. 1997). Also, our data suggest that control (e.g. sport hunting) or eradication (e.g. localised management) strategies that use seasonal bait sites have limited effect on deer distant to bait sites, but may concentrate those that naturally occur in areas near bait sites.

Acknowledgments

We appreciate the financial support provided by the MeadWestvaco Corporation, the West Virginia Division of Natural Resources, and the USA Department of Agriculture, National Research Initiative Competitive Grants Program (grant 00-35101-9284). We are grateful to J. L. Crum, P. D. Keyser and D. A. Osborn for providing logistical assistance. Helpful comments to earlier drafts of this manuscript were provided by C. E. Comer and J. D. Taylor. Deer were captured and handled under the auspices of Scientific Collection Permits 43-1999 and 16-2000 from the West Virginia Division of Natural Resources.

References

Annual Meeting of the Southeast Deer Study Group (2004). Southeastern deer harvest summaries for the 2002–2003 season. *Proceedings of the Annual Southeastern Deer Study Group* **27**, 56–61.

Clover, M. R. (1954). A portable deer trap and catch-net. *California Fish and Game* **40**, 367–373.

Darrow, D. A. (1993). Effects of baiting on deer movement and activity. M.Sc. Thesis, Mississippi State University, MS, USA.

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.)

Fischer, J. R. (1996). White-tailed deer herd health check on the Westvaco Wildlife and Ecosystem Research Forest. Final Report to the West Virginia Division of Natural Resources, Charleston, WV, USA

Ford, W. M., and Rodrigue, J. L. (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. doi:10.1016/S0378-1127(00)00597-1

Hawkins, R. E., Martoglio, L. D., and Montgomery, G. G. (1968). Cannon-netting deer. *Journal of Wildlife Management* **32**, 191–195.

Hooge, P. N., and Eichenlaub, B. (1997). Animal movement extension to ARCVIEW. Version 1.1. U.S. Geological Survey, Anchorage, AK, USA.

Jacobson, H. A., Kroll, J. C., Browning, R. W., Koerth, B. H., and Conway, M. H. (1997). Infrared-triggered cameras for censusing white-tailed deer. *Wildlife Society Bulletin* **25**, 547–556.

Jennrich, R. I., and Turner, F. B. (1969). Measurement of non-circular home range. *Journal of Theoretical Biology* **22**, 227–237.

Kie, J. G., Baldwin, J. A., and Evans, C. J. (1996). CALHOME: a program for estimating animal home ranges. *Wildlife Society Bulletin* **24**, 342–344.

Kilpatrick, H. J., and Stober, W. A. (2002). Effects of temporary bait sites on movements of suburban white-tailed deer. *Wildlife Society Bulletin* **30**, 760–766.

Koerth, B. H., and Kroll, J. C. (2000). Bait type and timing for deer counts using cameras triggered by infrared monitors. *Wildlife Society Bulletin* **28**, 630–635.

Langdon, C. A. (2001). A comparison of white-tailed deer population estimation methods in West Virginia. M.Sc. Thesis, West Virginia University, Morgantown, WV, USA.

Langenau, E. E., Jr, Flegerler, E. J., Jr, and Hill, H. R. (1985). Deer hunter's opinion survey, 1984. Michigan Department of Natural Resources Wildlife Division Report No. 3012, Lansing, MI, USA.

National Oceanic and Atmospheric Administration (2002). Climatological data, West Virginia, volume 110. Environmental Data Service, Asheville, NC, USA.

SAS Institute (1989). 'SAS/STAT User's Guide. Version 6.' 4th edn. (SAS Institute, Inc.: 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.)

Synatzske, D. R. (1981). Effects of baiting on white-tailed deer hunting success. Texas Parks and Wildlife Department, Federal Aid in Wildlife Restoration Report, Project W-109-R-4, Austin, TX, USA.

Van Brackle, M. D., Marchinton, R. L., Ware, G. O., Nettles, V. F., Linhart, S. B., Ruth, C. R., and Rogers, L. O. (1995). Oral biomarking of a supplementally-fed herd of free-ranging white-tailed deer. *Proceedings of the Annual Conference of the Southeast Association of Fish and Wildlife Agencies* **49**, 372–382.

Williamson, S. J. (2000). 'Feeding wildlife … just say no!' (Wildlife Management Institute Publications: Washington, DC.)

Worton, B. J. (1989). Kernel methods for estimating the utilization distribution in home-range studies. *Ecology* **70**, 164–168.

Manuscript received 6 October 2004, accepted 9 January 2006