Integrating Lethal and Nonlethal Approaches for Management of Suburban Deer

JASON R. BOULANGER, *Cornell University, College of Agriculture and Life Sciences, Department of Natural Resources, Ithaca, NY, USA*
PAUL D. CURTIS, *Cornell University, College of Agriculture and Life Sciences, Department of Natural Resources, Ithaca, NY, USA*
MICHAEL L. ASHDOWN, *Cornell University, College of Agriculture and Life Sciences, Department of Natural Resources, Ithaca, NY, USA*

ABSTRACT Evaluations of white-tailed deer (*Odocoileus virginianus*) population management in suburban landscapes has included debate over lethal control (e.g., sharp-shooting and hunting). These management techniques are often stymied by political impediments, safety concerns, and public attitudes. We are implementing the novel use of surgical sterilization in combination with hunting to mitigate deer-related impacts on Cornell University lands near Ithaca, New York. The project lands are composed of 2 zones: a suburban core campus area (446 ha) and adjacent outlying areas that contain agricultural fields and natural areas where deer hunting is permitted (582 ha). Surgical sterilization will be the primary technique used to reduce deer abundance and associated impacts in the core campus zone. Population reduction in the hunting zone will focus on increased harvest of female deer. During 2007 to 2009, project staff sterilized 58 female deer; 39 adult does were marked with radio transmitters to monitor movement and survival. Ten additional control deer have been captured and radio-collared for a comparison of fawning rates and survival. Hunters harvested 69 deer in the first hunting season (Fall 2008). In spring 2009, infrared-triggered cameras (IRCs) were used to estimate deer abundance in the sterilization zone, which resulted in a density of 21 deer/km^2 (56 deer per square mile). In the hunting zone, deer populations will be monitored using a deer sighting log and by data collected at a mandatory deer check station. In both zones, ongoing deer browse and deer-vehicle accident (DVA) studies will ascertain changes in deer impacts throughout the study. Our goal is to determine if deer fertility control integrated with a controlled hunting program on adjacent lands can maximize the efficiency of both techniques. If this integrated management program is successful, it may have additional applications in other communities in New York State and the Northeast.

KEY WORDS control, *Odocoileus virginianus,* sterilization surgery, white-tailed deer

Overabundant, suburban white-tailed deer (*Odocoileus virginianus*) populations continue to challenge today's wildlife managers. Increased deer-related vegetation and ecosystem damage, and deer-vehicle accidents (DVAs) in these areas, frequently exceed the tolerance of local communities (Decker and Connelly 1989, Diamond 1992, McCullough et al. 1997, Curtis et al. 1998). Conventional methods of deer control such as hunting or sharp-shooting may be impractical in some communities for legal, safety, and ethical reasons (Decker and Connelly 1989, Wright 1993, McCullough et al. 1997), thus fostering interest in alternatives such as trap and relocation, hormone regulation, immunocontraception (McShea et al. 1997, Warren 1997), and surgical sterilization (Maclean et al. 2006). A paucity of potential release sites, stress and death during transport, and restrictions on deer movements related to disease transmission (e.g., chronic wasting disease), preclude translocation of deer (McCullough et al. 1997, Waas et al. 1999, Beringer et al. 2002). Predator reintroduction has also been proposed, but evokes safety concerns for some stakeholders (Diamond 1992). Immunocontraception has shown promise, but requires scheduled booster injections, a process that may be difficult in free-ranging white-tailed deer.

Previous model-based (Boone and Wiegert 1994, Barlow et al. 1997, Hobbs et al. 2000, Merrill et al. 2003) and field studies (MacLean et al. 2006) have suggested that sterilization has the potential to regulate or reduce overabundant ungulate populations. Unlike immunocontraceptive vaccines that require revaccination, surgical sterilization renders deer sterile after one operation. Merrill et al. (2006) suggest that sterilization in combination with lethal control may increase efficiency of white-tailed deer population reduction.

Increasing interactions between deer and various uses of Cornell University lands and other nearby properties have created the need to implement and evaluate a deer research and management program to reduce negative impacts. In 2007, an Integrated Deer Research and Management Program was initiated that combined hunting with surgical sterilization to maximize the effectiveness of both management tools. This involved surgical fertility control of deer in the areas of Cornell where hunting is not feasible, and requiring hunters to harvest more does in the areas where hunting is available. The increased doe harvest, termed the "Earn-a-Buck" program, requires the harvest of 2 female deer prior to harvesting a buck. The objective of this study is to reduce deer abundance using controlled hunting, and thus limit deer immigration into the central campus area where sterilization is used. During this 5-year research project, our goal is to reduce deer abundance and associated impacts by 75% and 50% in the sterilization and hunting zones, respectively.

STUDY AREA

The study area includes the Cornell University central campus, surrounding residential communities, agricultural land, natural areas, and woodlots in the Towns of Dryden and Ithaca, New York (Fig. 1). Within this area, two deer management zones and a control area were identified based on proximity to buildings, human use, and residences. First, a sterilization zone (446 ha) containing areas near the core campus where building density and unsafe shooting zones preclude hunting as a management tool was identified. Second, a hunting zone (582 ha) containing Cornell-owned agricultural and natural areas adjacent to campus that had been open to hunting for decades was identified. The hunting zone was further broken down into subzones described as archery only, and combined firearm (shotgun, handgun, muzzleloader) and archery areas. Under New York state law, hunters may not discharge weapons within 152 m (500 ft) of an occupied dwelling. Finally, a control area (194 ha) with similar suburban habitat was established south of the aforementioned zones for statistical comparisons among deer treatment groups.

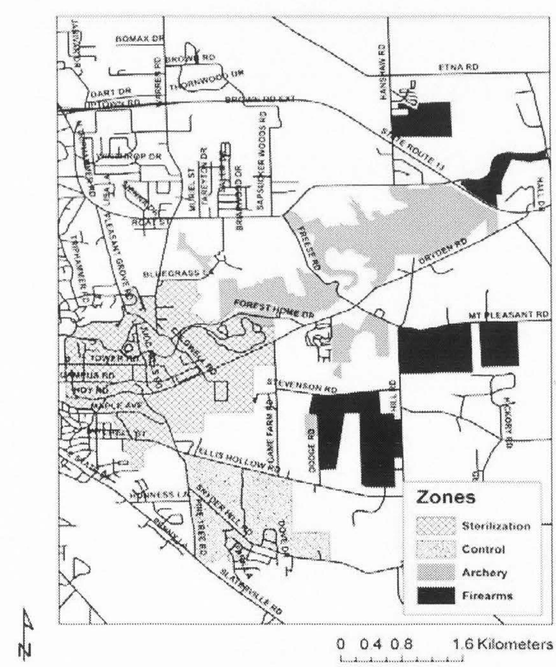

Figure 1. Cornell University Integrated Deer Research and Management Program sterilization, control, and hunting zones.

METHODS

Deer were captured for surgical sterilization using modified Clover traps (Clover 1954) or with dart rifles (Pneu-Dart Inc., Williamsport, PA; Kilpatrick et al. 1997) during late summer or winter from October 2007 through March 2009. However, bait and Clover traps were not deployed for trapping until after 1 January because state law prevents the use of baiting during hunting season, and because deer are not inclined to enter traps until natural foods are scarce. The use of Clover traps involved establishing sites in undisturbed woodlots on private property or Cornell University lands, and baiting them daily to habituate deer to enter the traps. When surgery time was available, the traps were set at dusk and then checked early morning on the day of the surgery to prevent deer from being in traps more than 12 hours.

All captured deer were fitted with individually numbered livestock ear tags (Premier1 Supplies, Washington, IA). Newly-captured female deer were anesthetized with an intramuscular injection of butorphanol-azaperone-medetomidine (BAM), butorphanol-bedetomidine (BM), ketamine/xylazine hydrochloride, or telazol, (Jessup and Jones 1983, Siegal-Willott et al. 2007). Most adult females were also fitted with VHF radio collars (Telonics, Inc., Mesa, AZ). Does captured in the control zone were ear tagged, fitted with VHF radio collars, reversed from sedation, and monitored until recovered at the capture site; bucks were ear tagged and released without sedation. The date at which the deer would be safe for human consumption was written on the back of the ear-tag with indelible ink.

Does captured in the sterilization zone were hobbled, fitted with a blindfold, and then transported to the Cornell University College of Veterinary Medicine (CVM) for surgery. All gravid deer received tubal ligation surgery; a procedure similar to that used by Maclean et al. (2006) which allows the deer to continue pregnancy through parturition that first spring. In the first year of the study, non-gravid deer received an ovariectomy surgery. However, this technique was replaced by tubal ligation, a less-invasive method favored by CVM surgeons. All procedures in this study conform to the requirements of Cornell University's Institutional Animal Care and Use Committee (Protocol No. 2007-0102).

Following surgery, does were fitted with ear tags and a collar, then transported by truck to the capture site, reversed from sedation, and monitored until completely recovered. Radio telemetry and sightings were used to evaluate deer movements and health during the first 48 hours after release. Telemetry started in September 2007 following the first successful surgery and will continue throughout the study. Collared deer were tracked using a directional telemetry antenna (Telonics, Inc., Mesa, AZ) and a digital receiver (Communications Specialists, Inc., Orange, CA). We used triangulation, homing, or combinations of these methods to plot each deer's location. The date, time, and field notes were logged and compiled. In the case of mortality, recovered deer were taken to the CVM for necropsy to determine the cause of death.

Following the methods of Curtis et al. (2009), a camera census was conducted in the sterilization zone to estimate deer density. Twelve infrared-triggered cameras (IRCs) were deployed over bait piles on campus in a grid system of 40-ha blocks. The cameras operated continuously for 7–10 days, after which deer in the photos were tallied. Statistical analysis was conducted using Program NOREMARK (White 1996).

Seventy New York State Department of Environmental Conservation (NYSDEC) Deer Management Assistance Program (DMAP) antlerless deer tags were made available for hunters. Hunters were required to sign-in, sign-out, keep a log of deer observed while on Cornell lands, and bring all harvested deer to a check station for documentation. Biological data were collected from deer harvested during the open hunting season and will provide an index to changes in deer abundance. Future deer harvest quotas will be set annually based on these indices, other deer population assessments, DVAs, and property damage complaints. A hunter orientation program was held in the fall prior to the deer seasons to inform sportsmen of the program.

Throughout this study, we will monitor the number of DVAs with the cooperation of Cornell University Police. Browse surveys will be used to evaluate deer impacts to vegetation.

RESULTS

To date, 58 sterilization surgeries were performed on white-tailed deer from the Cornell campus. Thirty-one females (6 fawns and 25 adults were captured between late October 2007 and early April 2008; these deer received 20 tubal ligations and 11 ovariectomies. Seventeen male deer were also captured; 2 epididymectomies and 1 vasectomy were performed on 3 bucks; all other bucks were released at the trap site. Twenty-two adult does were fitted with radio collars. Deer that received ovariectomy surgery were not observed with fawns the following spring and summer. Of the 20 deer receiving tubal ligations that were expected to fawn during spring 2008, 3 were never seen with fawns during the following spring and summer.

During early September 2008, we captured 3 deer for sterilization prior to the breeding season and twenty-four females (10 fawns and 14 adults) were captured between early January and late March 2009; all of these deer received tubal ligation surgery. Twenty-seven mature does were fitted with radio collars, including 10 control females. Twenty-one male deer were also captured in 2009 and released at the capture site. Thirteen adult females receiving tubal ligations are expected to bear fawns in summer 2009.

Eight tagged adult does and 2 bucks were reported dead and were recovered. Eight deer succumbed to DVAs, 1 yearling doe expired due to a congenital heart defect, and 1 buck was harvested during hunting season.

Home Range

Through May 2008, we obtained 1,729 locations from 21 tagged, adult female deer in and near the sterilization zone on campus. GIS software was used to create 95% kernel density estimate (KDE) home ranges for each deer (Laver and Kelly 2008, Worton 1989). Based on a 95% KDE, analysis of telemetry data through May 2008 resulted in an average home range size of 71 ha (175 acres) for radio-collared does.

Hunting

Prior to the hunting seasons, 161 hunters registered with the program, but only 97 (60%) actually hunted. Approximately 0.7 deer were seen per hunter day. A total of 2.1 known doe sightings were reported for every known buck seen. Hunters logged over 3,855 hours afield; on average, each hunter spent about 35 hours hunting in 2008. Hunters spent approximately 49 hours afield per deer harvested. On average, the proportion of hunters successful in harvesting at least one deer was 0.38. When taking into account staff time and supplies for the hunting program, each deer harvested cost the program, on average, about $16.00 during the pilot year. Program staff handled two cases of trespassing on Cornell University lands and one complaint regarding firearms discharge within 152 m of a home. Two small antlered bucks were harvested accidentally by hunters who were

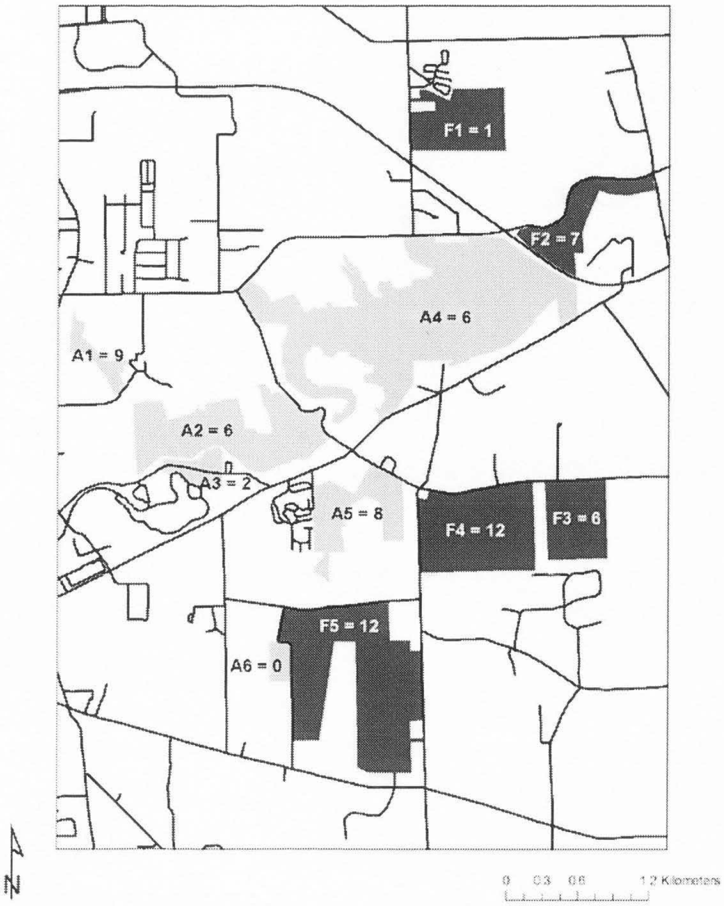

Figure 2. 2008 Cornell University Integrated Deer Management Program harvest (n = 69) map depicting deer harvest per zone. Zones A1–A6 are for archery-only hunting, while Zones F1–F5 are zones open to firearm or archery hunting during the firearms seasons.

not buck-eligible. Finally, there were 32 instances where hunters failed to sign out, resulting in incomplete data.

Hunters harvested 69 deer between 18 October and 16 December, 2008; 49 does, 14 fawns (10 female), and 6 bucks. Fourteen hunters became buck eligible by harvesting 2 antlerless deer. A total of 29 deer were harvested in archery season (25 does, 3 fawns), 33 deer in firearms season (19 does, 9 fawns), and 7 deer in the muzzleloader/late archery season (6 does, 1 fawn). Seventeen deer (13 does, 25%) were harvested from the zones closest to Cornell campus (Zones A1–A3; Fig. 2).

DISCUSSION

A paucity of literature precludes direct comparison among deer sterilization studies. Although Frank and Sajdak (1993) permanently sterilized male deer via vasectomy, the efficacy of sterilizing males to reduce the population of a polygamous breeding population is thought to be low (Barlow et al. 1997). Moreover, capturing nearly all males in a population would be difficult (Merrill et al. 2003). Tubal ligation, tubal transaction, or ovariohysterectomy have been used to sterilize female deer (Frank and Sajdak 1993, MacLean et al. 2006). Because omental fat and pregnancy can hinder laparoscopic procedures, tubal ligation by ventral laparotomy is the preferred surgical procedure (Maclean et al. 2006, Frank and Sajdak 1993). Unlike removing the ovaries, tubal ligation avoids interfering with normal hormonal activity. However, deer sterilized by tubal ligation will continue to cycle through the winter months, and how this affects behavior and survival is unclear.

In Highland Park, Illinois, a study was implemented to examine the long-term behavior and abundance consequences of permanently sterilizing female deer (Maclean et al. 2006). All but 3 of 67 female deer were sterilized via tubal ligation; 2 years later, no sterilized deer were observed with fawns. Home range size, movement within home ranges, and long distance movements were similar between sterilized and control animals, but higher mortality rates were observed in sterilized deer (Skinner 2007). This study suggested that a target population level of 2 deer/km^2 could be achieved by sterilizing 32% of female deer each year (Skinner 2007). The average cost of the sterilization was over $1,000 per deer.

In the Village of Cayuga Heights, New York, a community adjacent to Cornell University, we explored the impacts of surgical sterilization on deer population growth and home ranges. Between 2002 and 2004, 24 female deer underwent sterilization via tubal ligation (n=8), ovariectomy (n=15), and hysterectomy (n=1). Captured deer were fitted with numerical ear tags and radio collars, and IRCs (Jacobson et al. 1997) were used to estimate the number of deer in Cayuga Heights before and after surgical sterilization efforts. Program NOREMARK and Bowden's ratio estimator were used to estimate deer abundance (Curtis et al. 2009). The population estimates and 95% CI for 2000, 2002, and 2004 were 124 (104, 148), 157 (115, 214), and 87 (67, 113), respectively. Although deer numbers declined during this period, the harsh winters of 2002 and 2003 likely contributed to this decline. The cost of sterilization was over $1,000 per deer during this study, which included expendables (e.g., pharmaceutical supplies, anesthesia, equipment sanitizing, and laundry; $550 per surgery) and labor costs for capture and marking ($525 per deer). Surgery expenses were donated for Cornell veterinary staff and surgery resident training. Home range sizes for sterilized and control deer did not differ within or between years (Beaudette 2007).

Surgical sterilization, with or without a lethal component, remains expensive; start-up, surgeries, and deer capture comprise just a few of the costs associated with this technique (Merrill et al. 2003). These costs, however, are not constant. Initial deer captures come easily, but for the last percentile of the hardest to catch deer, costs may rise exponentially. A deer sterilization program requires a greater initial effort, but once a program enters the maintenance phase, fewer deer will need to be surgically treated, thus even with increased capture effort and cost per deer, overall program expenses will decrease.

The hunting program in this study will continue in 2009 with no major changes in format, except for the possible addition of new land areas opening up for hunting. Other deer management approaches, such as hunting with NYSDEC nuisance permits during periods outside of deer hunting seasons, may be considered if the proposed program fails to reduce deer-related impacts to a tolerable level within 5 years.

It has been suggested that once a deer population is reduced, efficacy of sterilization may be greater than lethal control in maintaining desired population levels (Merrill et al. 2003). We caution, however, that surgical sterilization may not be a panacea for suburban deer control. We will evaluate whether it is possible to integrate deer fertility management with a controlled hunting program to meet localized deer management objectives. The goal is to reduce overall deer abundance and associated impacts (e.g., plant damage, DVAs) on Cornell University lands during a 5-year period. If this integrated management program is successful, it may have additional applications in other suburban communities that have the political will and financial resources to lower deer populations and associated impacts.

ACKNOWLEDGMENTS

This research was funded by Cornell University, Cornell University College of Agriculture and Life Sciences, and Cornell University College of Veterinary Medicine. We thank Drs. J. Boesch, S. Fubini, R. Gilbert, R. Gleed, and R. Hackett of Cornell University College of Veterinary Medicine for their support and cooperation. We also thank G. Goff from Cornell University Department of Natural Resources for project guidance. A. Bleisch, E. Duprey, K. Kemink, A. Kusler, C. LaRow, B. A. Mosher, R. Stanley, A. Verrilli, and K. Walker provided valuable field assistance.

LITERATURE CITED

Barlow, N. D., J. M. Kean, and C. J. Briggs. 1997. Modeling the relative efficacy of culling and sterilization for controlling populations. Wildlife Research 24:129–141.

Beaudette, A. 2007. Effects of surgical sterilization upon home range area of a suburban white-tailed deer population. Senior Honor's Thesis, Department of Natural Resources, Cornell University, Ithaca, New York, USA.

Beringer, J., L. P. Hansen, J. A. Demand, J. Sartwell, M. Wallendorf, and R. Mange. 2002. Efficacy of translocation to control urban deer in Missouri: costs, efficiency, and outcome. Wildlife Society Bulletin 30:767–774.

Boone, J. L., and W. G. Wiegert. 1994. Modeling deer herd management: sterilization is a viable option. Ecological Modeling 72:175–186.

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

Curtis, P. D., A. N. Moen, and M. E. Richmond. 1998. When should wildlife fertility control be applied? Pages 1–4 *in* P. D. Curtis, editor. Workshop on the status and future of wildlife fertility control. The Wildlife Society Annual Conference, 4 September 1998, Buffalo, New York, USA.

Curtis, P. D., B. Boldgiv, P. M. Mattison, and J. R. Boulanger. 2009. Estimating deer abundance in suburban areas with infrared-triggered cameras. Human-Wildlife Conflicts 3:116–128.

Decker, D. J., and N. A. Connelly. 1989. Deer in suburbia – pleasures and pests. The Conservationist 43:46–49.

Diamond, J. 1992. Must we shoot deer to save nature? Natural History August:2–8.

Frank, E. S., and S. L. Sajdak. 1993. Sterilization as a method of controlling an urban white-tailed deer population. AAZPA Regional Proceedings 485–490.

Hobbs, N. T., D. C. Bowden, and D. L. Baker. 2000. Effects of fertility control on populations of ungulates: general, stage-structured models. Journal of Wildlife Management 64:473–491.

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

Jessup, D. A., and K. R. Jones. 1983. Immobilization of mule deer with ketamine and xylazine, and, reversal of immobilization with yohimbine. Journal of the American Veterinary Medical Association 183:1339–1340.

Kilpatrick, H. J., S. M. Spohr, and A. J. DeNicola. 1997. Darting urban deer: techniques and technology. Wildlife Society Bulletin 25:542–546.

Laver, P. N., and M. J. Kelly. 2008. A critical review of home range studies. Journal of Wildlife Management 72:290–298.

MacLean, R. A., N. F. Matthews, D. M. Grove, E. S. Frank, and J. Paul-Murphy. 2006. Surgical technique for tubal ligation in white-tailed deer (*Odocoileus virginianus*). Journal of Zoo and Wildlife Medicine 37:354–360.

McCullough, D. R., K. W. Jennings, N. B. Gates, B. G. Elliot, and J. E. Didonato. 1997. Overabundant deer populations in California. Wildlife Society Bulletin 25:478–483.

McShea, W. J., S. L. Monfort, S. Hakim, J. F. Kirkpatrick, I. K. M. Liu, J. W. Turner, Jr., L. Chassy, and L. Munson. 1997. Immunocontraceptive efficacy and the impact of contraception on the reproductive behaviors of white-tailed deer. Journal of Wildlife Management 61:560–569.

Merrill, J. A., E. G. Cooch, and P. D. Curtis. 2003. Time to reduction: factors influencing management efficacy in sterilizing overabundant

white-tailed deer. Journal of Wildlife Management 67:269–281.
Merrill, J. A., E. G. Cooch, and P. D. Curtis. 2006. Managing an overabundant deer population by sterilization: effects of immigration, stochasticity and the capture process. Journal of Wildlife Management 70:268–277.
Siegal-Willott, J., S. B. Citino, S. Wade, L. Elder, L. C. Hayek, and W. R. Lance. 2009. Butorphanol, azaperone, medetomedine anesthesia in free-ranging white-tailed deer (*Odocoileus virginianus*) using radiotransmitter darts. Journal of Wildlife Diseases 45:468–480.
Skinner, B. G. 2007. Surgical sterilization of female white-tailed deer in suburban Chicago, Illinois: social causes and biological impacts. Thesis, University of Wisconsin, Madison, Wisconsin, USA.
Waas, J. R., J. R. Ingram, and L. R. Matthews. 1999. Real-time physiological responses of red deer to translocations. Journal of Wildlife Management 63:1152–1162.
Warren, R. J. 1997. The challenge of deer overabundance in the 21st century. Wildlife Society Bulletin 25:213–214.
White, G. C. 1996. NOREMARK: population estimation from mark-resighting surveys. Wildlife Society Bulletin 24:50–52.
Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecological Society of America 70:164–168.
Wright, R. G. 1993. Wildlife management in parks and suburbs: alternatives to sport hunting. Renewable Resources Journal 11:18–22.