Human–Wildlife Interactions 7(1):107–113, Spring 2013

Deer-activated bioacoustic frightening device deters white-tailed deer

Aaron M. Hildreth,[1] University of Nebraska, School of Natural Resources, 3310 Holdrege Street, Lincoln, NE 68583, USA *hildreta@gmail.com*

Scott E. Hygnstrom, University of Nebraska, School of Natural Resources, 3310 Holdrege Street, Lincoln, NE 68583, USA

Kurt C. VerCauteren, U.S. Department of Agriculture, Wildlife Services' National Wildlife Research Center, 4101 LaPorte Avenue, Fort Collins, CO 80521, USA

Abstract: White-tailed deer (*Odocoileus virginianus*) damage urban and suburban plantings, as well as crops and stored feed. We tested the efficacy of a frightening device that played pre-recorded distress calls of adult female white-tailed deer when activated by an infrared motion sensor for a period of 13 days. This deer-activated bioacoustic frightening device reduced deer entry into protected sites by 99% (δ = -558, $P = 0.09$) and bait consumption by 100% (δ = -75, $P = 0.06$). The frightening device that we evaluated demonstrated potential for reducing damage in disturbed environments and agricultural settings.

Key words: bioacoustic, frightening device, human–wildlife conflicts, *Odocoileus virginianus*, white-tailed deer, wildlife damage management

Populations of white-tailed deer (*Odocoileus virginianus*) have increased across the United States in recent years (Côté et al. 2004). Concurrently, human populations have increased, and damage by deer has become more widespread (Connelly et al. 1987, Decker and Gavin 1987, Sayre et al. 1992, DeNicola et al. 2000). The number of deer in urban and suburban areas has increased where hunting is not allowed, and nonlethal methods are ineffective at controlling damage in disturbed environments (VerCauteren et al. 2003, DeNicola et al. 2008). Homeowners have experienced an increase in problems associated with deer browsing on gardens and ornamentals (McCullough et al. 1997, West and Parkhurst 2002). As a result, demand for effective nonlethal methods for deterring deer in these sensitive areas has increased.

Effectiveness of frightening devices for deterring deer from valued resources has varied (Curtis et al. 1997, Belant et al. 1998, Gilsdorf et al. 2004, VerCauteren et al. 2005). The major limitation of frightening devices has been habituation of animals to the stimuli (Gilsdorf et al. 2002), though habituation has been shown to be delayed when animal-activated devices are used (Belant et al. 1996, Beringer et al. 2003). Bioacoustic frightening devices are usually either of distress calls, such as those used by animals when they are restrained or physically traumatized (Sprock et al. 1967, Marchinton and Hirth 1984), or alarm calls, such as those used to warn other animals of potential danger (Sauer 1984). Using bioacoustics frightening devices provides 2 potential advantages over other frightening devices: (1) animals may not readily habituate to the calls because the sound is a distress call from a member of the same species; and (2) calls may be effective at low volumes, minimizing disturbance to neighbors in an urban or suburban setting (Gilsdorf et al. 2002, Gilsdorf et al. 2004). We developed a deer-activated bioacoustic frightening device (DABAFD) and tested its effectiveness for deterring deer from both entering an area and consuming bait.

Study area

We conducted our research at the 3,382-ha DeSoto National Wildlife Refuge (DNWR) northwest of Omaha, Nebraska, (41° 22′ 27″ N, 96° 0′ 58″ W). Agricultural crops including corn, soybeans, and winter wheat comprised 12% of the land cover; the remainder of the area consisted of eastern deciduous forest dominated by mature eastern cottonwood (*Populus deltoides*). The understory consisted of rough-leafed dogwood (*Cornus drummondii*), hackberry (*Celtis occidentalis*), mulberry (*Morus*

[1]Present address: University of Kentucky, 218 T. P. Cooper Building, Lexington, KY 40546, USA

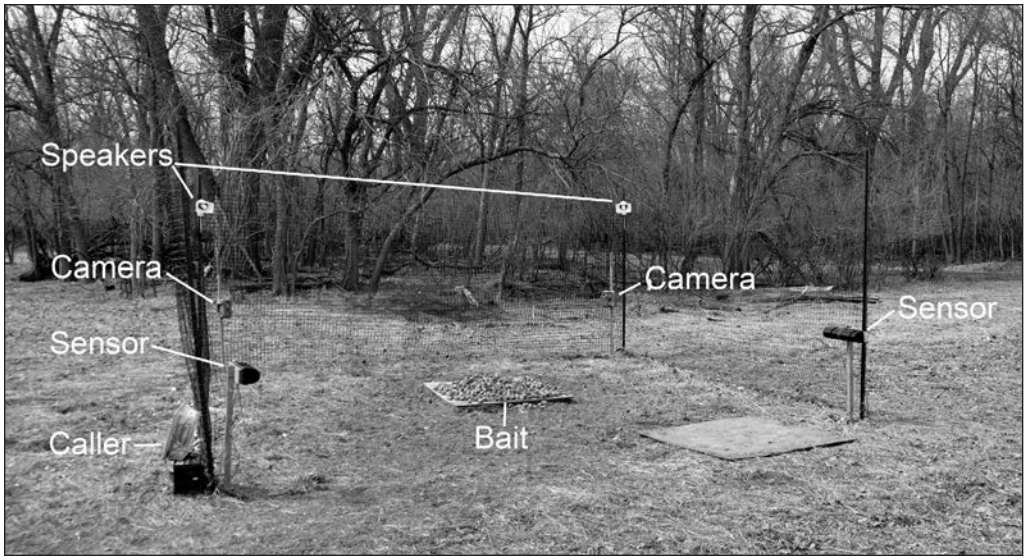

Figure 1. Layout of a 0.004-ha exclosure to evaluate the efficacy of a deer-activated bioacoustic frightening device for deterring white-tailed deer from bait in eastern Nebraska, USA, 2010.

rubra), and green ash (*Fraxinus pennsylvanica*). Poison ivy (*Rhus radicans*) and common scouring-rush (*Equisetum hyemale*) dominated the ground layer. Native grasses included big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and sideoats grama (*Bouteloua curtipendula*). Mean annual precipitation was 74 cm, with mean annual minimum and maximum temperatures of 5.3° C and 15.5° C, respectively (Pearce and Smith 1990). We estimated the density of deer at DNWR during winter 2009 to 2010 at 28 deer/km^2 (G. M. Clements, University of Nebraska–Lincoln, unpublished data).

Methods

We identified 6 sites (each 37.2 m^2) that were >0.6 km apart and constructed a U-shaped, 3-sided fence around the perimeter of each site. Each fence was 18.3 m long and constructed of 2.3-m polyethylene mesh deer netting (Benner's Gardens, Phoenixville, Pa.). Netting was secured to t-posts with 3 cable ties (0 m, 1.0 m, and 2.13 m above the ground), and a 0.16-m skirt was staked with 0.3-m stakes every 1.5 m to prevent deer from attempting to crawl under the fence (Figure 1).

Three of the sites were randomly selected and protected with a deer-activated bioacoustic frightening device (DABAFD). The audio system consisted of a microprocessor with amplifier and 2 speakers (model Super Pro PA4, Bird Gard LLC, Sisters, Oreg.). The frequency range of the device was 500 to 5,000 Hz, and each speaker was claimed by the manufacturer to protect 0.6 ha. We suspended a speaker 2.1 m above ground in each rear corner of the exclosure and directed it toward the opening (Figure 1). We used a quad-beam infrared detection system (model PB-IN200HF, PULNiX Security Sensors Inc., Sunnyvale, Calif.) to trigger the audio system. We installed the sensors at the 6.1-m opening of the exclosure and at the average height (71 cm) of an adult female deer's chest midline (Sauer 1984). The sensors were lowered to 61 cm on day 3 of the treatment phase to prevent fawns from crossing under the sensors. The sensors and installation height were selected to reduce triggering by smaller nontarget species. Four infrared beams were emitted from the transmitter and all 4 beams had to be broken simultaneously to activate the audio system. Each time the system was triggered a series of 8 prerecorded distress calls of adult female white-tailed deer were played. The distress calls were recorded during capture events where deer were caught in clover traps, physically restrained, and collared as part of a separate study. The microprocessor had a built in delay of 30 seconds after each trigger, after which the unit reset itself. All

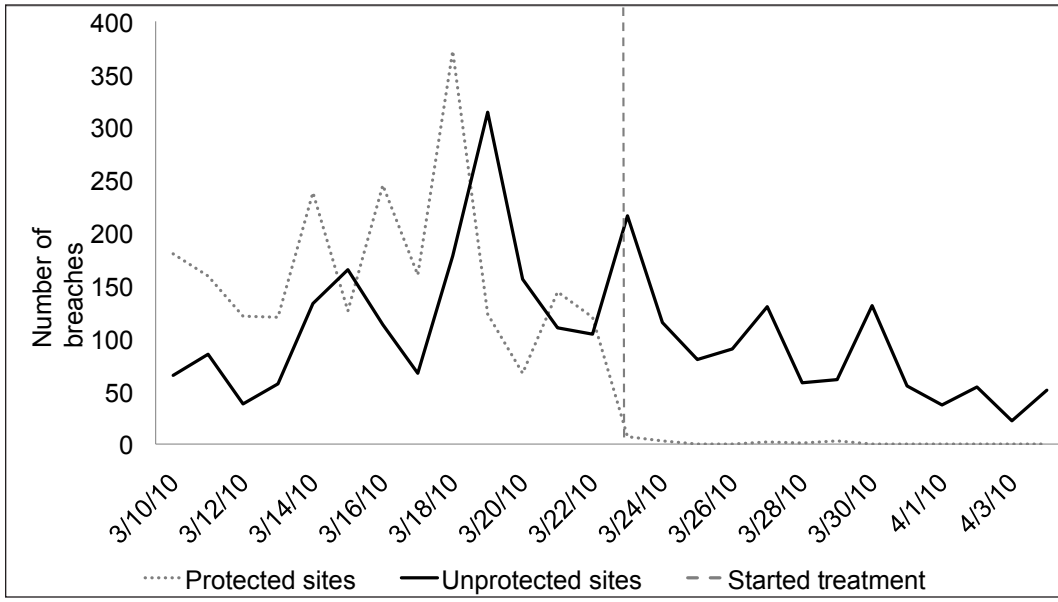

Figure 2. Total number of breaches during treatment and pretreatment periods by white-tailed deer to exclosures protected by a deer-activated bioacoustic frightening device and unprotected exclosures in eastern Nebraska, USA, 2010.

electronic components were powered by a single 12-V deep-cycle marine battery that was not changed during the study. We checked the system by triggering the DABAFD to ensure proper function each time sites were inspected. The remaining 3 sites were not protected with a DABAFD and served as controls. Control sites did not have sensors, speakers, or a caller. We do not believe this imparted any bias because the sensors, speakers, and caller were all present at protected sites from the start of the pretreatment period.

We baited each of the sites with >38 L of alfalfa cubes on February 28 and checked them every other day to ensure >38 L of clean and dry alfalfa cubes remained. We recorded the volume of feed consumed using 4-L buckets during each site inspection.

We mounted 2 animal-activated digital cameras (Reconyx Silent Image, La Crosse, Wis.) 0.75 m above ground level on t-posts to monitor the number of times deer entered the open side of the breached exclosure. A breach was defined as the crossing of the infrared sensors by a deer during a continuous series of time-coded pictures. In the event of multiple deer being present during a breach event, every effort was made to distinguish individual deer and only count those deer that entered the exclosure. Each deer could breach the exclosure only once per series of time-coded pictures in an effort to prevent double counting. We placed 1 camera in each rear corner facing the entrance and bait pile to ensure that we documented all deer entering the exclosure. We replaced memory cards and batteries in cameras when we replenished feed.

We allowed deer to locate study sites for a period of 10 days (period required for number of times deer entered each site to be ≥20 and feed consumption to be ≥10 L per week) from February 28 to March 9, 2010. We conducted a 13-day pretreatment phase from March 10 to March 22, 2010, to allow deer to acclimate to feed sites and exclosures. During the pretreatment phase, the DABAFDs were turned off. We conducted the 13-day treatment phase from March 23 to April 4, 2010, when the DABAFDs were turned on.

Response variables included number of breaches and feed consumption, which were total values measured for each site multiplied by period combination (all 13 days long). We considered these variables to be paired between periods within sites and defined response variables for analyses as period 1 (pretreatment) and period 2 (treatment) differences. We used general linear modeling (GLM procedure; SAS Institute Inc. SAS/STAT® 9.2, 2008, Cary, N.C.,) to estimate population means for each

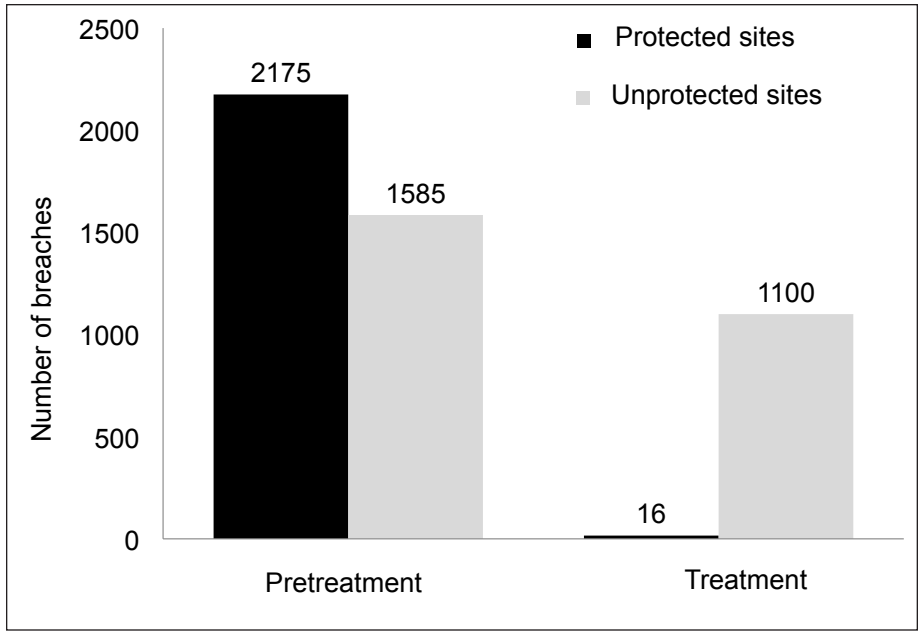

Figure 3. Total feed consumption in liters during treatment and pretreatment periods by white-tailed deer in exclosures protected by a deer-activated bioacoustic frightening device and unprotected exclosures in eastern Nebraska, USA, 2010.

protected group (δ_B and δ_C for bioacoustic and control (unprotected) groups, respectively, and the contrast between control and bioacoustic groups (δ_{C-B}) for each response variable, where a significantly negative value would indicate greater difference between periods for the bioacoustic treatment. Results were significant at the $P < 0.1$ level rather than $P < 0.05$ level, because of the small sample size (n = 3).

Results

During the pretreatment phase, the number of breaches ($\bar{x}$ ± SE) at protected sites (725 ± 343) was similar to the number of breaches at unprotected sites (528 ± 106, $t = 0.44$, $P = 0.35$; Figure 2). Mean number of per-site breaches at protected sites decreased from 725 breaches during the pretreatment phase to 5.33 breaches during the treatment phase (99.3% reduction, δ = -558, $P = 0.09$; Figure 3). The number of breaches per site ($\bar{x}$ ± SE) at unprotected sites during pretreatment (528 ± 106) was similar to the number of breaches during treatment (367 ± 101, $t = 1.10$; $P = 0.23$).

During the pretreatment phase, feed consumption at protected sites (91 L ± 35) was similar to feed consumption at unprotected sites (56 L ± 9, $t = 0.79$; $P = 0.26$; Figure 4). Mean feed consumption at protected sites decreased from 91 L during the pretreatment phase to 0 L during the treatment phase (100% reduction, δ= -75.20; $P = 0.06$). Feed consumption ($\bar{x}$ ± SE) at unprotected sites during pretreatment (56 ± 9) was similar to consumption during treatment (41 ± 14, $t = 0.94$; $P = 0.26$).

Of the 16 times that deer breached at protected sites during the treatment phase, thirteen were fawns and three were adults. All 13 fawns and 1 adult deer entered the exclosure without triggering the device, and the picture evidence from the cameras revealed no signs of distress or alarm by breaching or surrounding deer. By comparison, in all other breaching attempts where the DABAFD was triggered, the breaching deer and surrounding deer reacted to the sounds by fleeing the area near the exclosure.

Discussion

The DABAFD was nearly 100% effective at reducing the number of times deer entered protected sites and 100% effective at reducing feed consumption. We initiated the study during late winter, when food resources were severely limited, to maximize the motivation of deer to access the bait. Deer-use of the sites

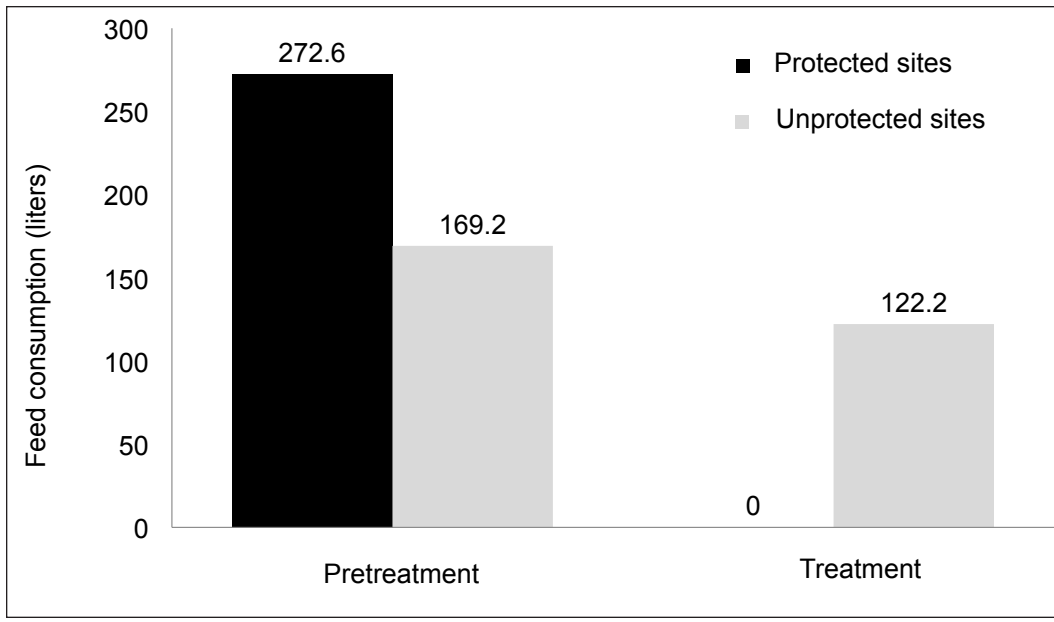

Figure 4. Total number of breaches per day by white-tailed deer to exclosures protected by a deer-activated bioacoustic frightening device and unprotected exclosures in eastern Nebraska, USA, 2010. Treatment started on March 23, 2010.

was high initially, but declined after March 20, likely due to the onset of spring green-up and increased access to alternative foods during the last week of study.

Camera images revealed that the tops of the fawns' backs were slightly lower than the level of the infrared sensors for the first 10 breaches. Once this was discovered, we lowered the devices to 61 cm to prevent further access without triggering the DABAFDs. Beringer et al. (2003) noted a similar problem using a sensor height >65 cm and suggested some breaches in their study may have been a result of fawns entering under the sensor beam. Eight of the fawns that breached the exclosure bolted out of the exclosure shortly after entering when other deer triggered the DABAFD. Two of the 3 breaches by adult deer resulted from the deer being scared into the exclosure by a triggering of the DABAFD, as was evidenced from the raised tail and bolting movement of the deer. We observed no nontarget species triggering the device.

On 6 occasions, we observed deer trigger the DABAFD, resulting in multiple deer fleeing from the area. Deer ran away from the exclosure and into dense cover or ran away from the exclosure, stopped, listened for up to 5 seconds, and then ran into dense cover. We also noticed deer within 50 m of the exclosure running away and into dense cover after a triggering of the DABAFD. The deer near the exclosure may have been reacting to the sight of the deer that triggered the DABAFD running, but it is more likely that they were reacting to the sound of the device. We did not see signs of deer habituating to the frightening device during our study, as we had no breaches in protected sites during the last 6 days of testing. However, more testing with bioacoustic and alternative sounds is encouraged to determine the efficacy of both methods at deterring deer and other animals. The bioacoustic frightening device in our study showed promise for use in deterring deer from areas that homeowners and land managers want to protect. We feel such a device would be effective in a wide variety of developed landscapes and agricultural settings, but further testing is warranted.

Acknowledgments

We thank the University of Nebraska–Lincoln School of Natural Resources and the of the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services' National Wildlife Research Center for providing the funding for the study. G. Phillips aided in statistical analysis and G.

Clements, D. Baasch, and S. Groepper helped with study design and field work. T. Cox, M. Sheets, and M. Cunard at DNWR provided study sites, assistance, and equipment. We thank M. Lavelle for helpful comments and review of the manuscript. Mention of companies or commercial products does not imply recommendation or endorsement by the University of Nebraska–Lincoln or the U.S. Department of Agriculture, nor does omission imply criticism. Product names are mentioned solely to report factually on available data and provide specific information.

Literature cited

Belant, J. L., T. W. Seamans, and C. P. Dwyer. 1996. Evaluation of propane exploders as white-tailed deer deterrents. Crop Protection 15:575–578.

Belant, J. L., T. W. Seamans, and L. A. Tyson. 1998. Evaluation of electronic frightening devices as white-tailed deer deterrents. Proceedings of the Vertebrate Pest Conference 18:107–110.

Beringer, J., K. C. VerCauteren, and J. J. Millspaugh. 2003. Evaluation of an animal-activated scarecrow and a monofilament fence for reducing deer use of soybean fields. Wildlife Society Bulletin 31:492–498.

Connelly, N. A., D. J. Decker, and S. Wear. 1987. Public tolerance of deer in a suburban environment: implications for management and control. Proceedings of the Eastern Wildlife Damage Control Conference 3:207–218.

Côté, S. D., T. P. Rooney, J. Tremblay, C. Dussault, and D. M. Waller. 2004. Ecological impacts of deer overabundance. Annual Review of Ecology, Evolution, and Systematics 35:113–147.

Curtis, P. D., C. Fitzgerald, and M. E. Richmond. 1997. Evaluation of the Yard Gard ultrasonic yard protector for repelling white-tailed deer. Proceedings of the Eastern Wildlife Damage Control Conference 7:172–176.

Decker, D. J., and T. A. Gavin. 1987. Public attitudes toward a suburban deer herd. Wildlife Society Bulletin 16:53–57.

DeNicola, A. J., K. C. VerCauteren, P. D. Curtis, and S. E. Hygnstrom. 2000. Managing white-tailed deer in suburban environments. Cornell University Cooperative Extension, Ithaca, New York, USA.

DeNicola, A. J., D. R. Etter, and T. Almendinger. 2008. Demographics of non-hunted white-tailed deer populations in suburban areas. Human–Wildlife Conflicts 2:102–109.

Gilsdorf, J. M., S. E. Hygnstrom, and K. C. VerCauteren. 2002. The use of frightening devices in wildlife damage management. IPM Reviews 7:29–45.

Gilsdorf, J. M., S. E. Hygnstrom, K. C. VerCauteren, G. M. Clements, E. E. Blankenship, and R. M. Engeman. 2004. Evaluation of a deer-activated bio-acoustic frightening device for reducing deer damage in cornfields. Wildlife Society Bulletin 32:515–523.

Marchinton, R. L., and D. H. Hirth. 1984. Behavior. Pages 129–168 *in* L. K. Halls, editor. White-tailed deer: ecology and management. Stackpole, Harrisburg, Pennsylvania, USA.

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

Pearce, E. A., and G. Smith. 1990. The Times books world weather guide: updated edition. New York Times, New York, New York, USA.

Sauer, P. R. 1984. Physical characteristics. Pages 73–90 *in* L. K. Halls, editor. White-tailed deer: ecology and management. Stackpole, Harrisburg, Pennsylvania, USA.

Sayre, R. W., D. J. Decker, and G. L. Good. 1992. Deer damage to landscape plants in New York State: perceptions of nursery producers, landscape firms, and homeowners. Journal of Environmental Horticulture 10:46–51.

Sprock, C. M., W. E. Howard, and F. C. Jacob. 1967. Sound as a deterrent to rats and mice. Journal of Wildlife Management 31:729–741.

VerCauteren, K. C., S. E. Hygnstrom, M. J. Pipas, P. Fioranelli, S. Werner, and B. Blackwell. 2003. Red lasers are ineffective at dispersing deer at night. Wildlife Society Bulletin 31:247–252.

VerCauteren, K. C., J. A. Shivik, and M. J. Lavelle. 2005. Efficacy of an animal-activated frightening device on urban elk and mule deer. Wildlife Society Bulletin 33:1282–1287.

West, B. C., and J. A. Parkhurst. 2002. Interactions between deer damage, deer density, and stakeholder attitudes in Virginia. Wildlife Society Bulletin 30:139–147.

Aaron M. Hildreth (above left) is a graduate research assistant in the Department of Forestry at the University of Kentucky investigating factors that affect the survival of elk being translocated out of Kentucky. He received his B.S. degree in fisheries and wildlife from the University of Nebraska–Lincoln. Areas of interest focus on ungulate damage and disease and ways to mitigate the problems they cause.

Scott E. Hygnstrom (above right) is a professor in the School of Natural Resources at the University of Nebraska−Lincoln specializing in wildlife damage management. He received a B.S. degree from the University of Wisconsin−River Falls, M.S. degree from the University of Wisconsin−Stevens Point, and Ph.D. degree from the University of Wisconsin−Madison. He is a certified wildlife biologist and is a past-chair of the Wildlife Diseases and Wildlife Damage Management Working Groups of The Wildlife Society.

Kurt C. VerCauteren conducts research to create novel means of managing the diseases of and the damage done by deer and elk, including protection of American agriculture. He is a project leader for the USDA/APHIS/Wildlife Services' National Wildlife Research Center. He received his B.S. degree from the University of Wisconsin–Stevens Point and his M.S. and Ph.D. degrees from the University of Nebraska–Lincoln. Much of his efforts are focused at the interface between free-ranging cervids and livestock. He is the chair of the Wildlife Damage Management Working Group of The Wildlife Society.