Cornell University

Integrated Deer Research and Management Study

2007–2010 Progress Report

Drs. Paul D. Curtis and Jay R. Boulanger

Department of Natural Resources,

Cornell University, Ithaca, New York

Team Members

Department of Natural Resources

Michael Ashdown

Dr. Jay Boulanger

Dr. Paul Curtis

Gary Goff

College of Veterinary Medicine

Dr. Jordyn Boesch

Dr. Susan Fubini

Dr. Robert Gilbert

Dr. Robin Gleed

Dr. Richard Hackett

Dr. Christine Wimer

Undergraduate Student Interns

Amy Bleisch	Erin Duprey	Mary Claire Eisel
Kaylan Kemink	Anny Kusler	Carolyn LaRow
Samantha Lovering	Brittany Ann Mosher	Rebecca Stanley
Ariana Verrilli	Katie Walker	

Executive Summary

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. Discussions and actions regarding deer damage to date reflect the University's goal of maintaining the value of Cornell lands for the University's mission, while being cognizant of related neighborhood impacts. The project has been implemented in an effective and cost-efficient manner, for the primary purposes of supporting the research, teaching, and outreach functions of Cornell University. Here we present a progress report for the benefit of the Cornell University community and surrounding neighborhoods.

We are using surgical sterilization in combination with hunting to mitigate deer related impacts on Cornell University lands and surrounding neighborhoods. For this study, Cornell lands have been divided into three zones: a suburban core campus area (sterilization zone; 1,133 acres), adjacent outlying areas that contain agricultural fields and natural areas where deer hunting is permitted (hunting zone; 2,544 acres), and an adjacent control zone (873 acres) used to compare fawning rates, movement, and survival. Surgical sterilization is the primary technique used in the core campus zone; increased harvest of female deer through an "Earn-a-Buck" (E-a-B) program is implemented in the hunting zone. In both zones, temporary electric and other fencing designs will be used to protect research plots and natural areas.

From September 2007 through February 2010, 77 sterilization surgeries have been performed on female white-tailed deer within the sterilization zone (57 adults and 20 fawns). Eleven ovariectomies and 66 tubal ligations and were performed on these deer. A total of 54 sterilized does were fitted with radio collars to monitor fawning rates, movement patterns, home range size, and survivorship. An additional 19 females were captured and radio-collared in the control zone near the periphery of campus. Deer are monitored through telemetry utilizing triangulation, homing, or a combination of the two methods. Average annual home range sizes have ranged from 175 acres in 2008 to 142 acres in 2010.

Hunters harvested 69 deer during the fall 2008 deer hunting seasons (mid-October–mid-December), which included 49 does, 14 fawns (10 female), and 6 bucks. In fall 2009, Cornell E-a-B lands expanded from 1,438 to 2,544 acres, resulting in an increased harvest of 112 deer (78 does, 28 fawns [16 female], and 6 bucks.

We are collaborating with Cornell University College of Veterinary Medicine anesthesiologists to evaluate novel immobilizing drug combinations (butorphanol-medetomidine with and without azaperone), designed to be more efficient than conventional capture drugs (e.g., ketamine:xylazine hydrochloride). We are also working closely with Cornell University's Ecology and Management of Invasive Plants Program to evaluate novel browse surveys to index and quantify deer impacts to university lands over time. Results from both of these cooperative studies will be submitted for publication in the peer-reviewed literature.

Infrared-triggered cameras (IRCs) are being used to estimate deer abundance. In spring 2009 and 2010 there were approximately 92 (52 deer/mile^2) and 82 deer (46 deer/mile^2) in the core campus sterilization zone, respectively. In the hunting zone, deer populations are monitored using a deer sighting log and by data collected at a mandatory deer check station. Ongoing deer-vehicle accident monitoring will also help ascertain deer impact levels. The results of this research could determine if fertility control combined with hunting is a viable, long-term approach to managing deer or other wildlife populations.

Cornell University Integrated Deer Research and Management Study

Introduction

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. Discussions and actions regarding deer damage to date reflect the University's goal of maintaining the value of Cornell lands for the University's mission, while being cognizant of related neighborhood impacts. The project has been implemented in an effective and cost-efficient manner, for the primary purposes of supporting the research, teaching, and outreach functions of Cornell University. This report details the progress of the program from its inception in the fall of 2007 through July 2010.

Background

Theoretical vs. Applied Use of Sterilization

In deer, some studies argue that fertility control may be more effective than culling because sterilized individuals are able to contribute to resource limitation and density-dependence in reproduction (Boone and Weigart 1994). Nielsen et al. (1997) and Hobbs et al. (2000) suggested that fertility control is an effective way to maintain desired population levels after lethal control has been implemented. Boone and Wiegert (1994) indicated that sterilization of deer could serve as an alternative to lethal methods of population control when used in conjunction with hunting pressure.

Merrill et al. (2003) reported that sterilization may be effective if a given percentage of reproductively active females were sterilized annually. Specifically, they found that sterilizing 25–50% of a hypothetical closed white-tailed deer population could lead to a 30–60% reduction in population size over 4–10 years. Practical experience has shown that rapid reduction in a suburban deer herd may require that 80–90% of the female deer be treated with a fertility control technique (DeNicola, pers. commun.). Sterilization would have a better chance of success if it was executed in a closed population, but this is unlikely except in experimental situations. Modeling in one study did not bode well for the feasibility of surgical sterilization as the sole tool for reducing open deer populations, especially if immigration offsets decreases in population size (Merrill et al. 2006).

Frank and Sajdak (1993) permanently sterilized male deer via vasectomy, but the efficacy of sterilizing males to reduce the population of a polygamous breeding population is low compared to sterilizing females (Barlow et al. 1997). It would also take a great deal of effort to capture nearly all males in the population. To sterilize female deer, tubal ligation, tubal transaction, or ovariohysterectomy have been used (Frank and Sajdak 1993, MacLean et al. 2006). Maclean et al. (2006) found that sterilization was possible with low mortality rates in deer. In that study, laparotomy was preferred over laparoscopic procedures because pregnancy made manipulating the uterus difficult with the latter technique. Moreover, omental fat may hinder laparoscopic procedures (Frank and Sajdak 1993). Sterilization by tubal ligation avoids interfering with normal hormonal activity, unlike removing the ovaries. Thus, females that are sterilized via tubal ligation are able to complete a current pregnancy, but they will not be able to conceive again.

In 2002, a study to examine the long-term behavior and abundance consequences of permanently sterilizing female deer was implemented in Highland Park, IL (Maclean et al. 2006). Sixty-seven female deer were sterilized via tubal ligation (n=64), tubal transaction (n=2), or ovariohysterectomy (n=1); two years later, no surgically altered females were observed with fawns. As part of this study, Skinner (2007) found that home range size, movement, and long distance movements were similar between sterilized and control animals, but higher mortality rates were observed in sterilized deer. The study found that the deer population could be regulated to a targeted 2 deer/km^2 by sterilizing 32% of reproductively active females each year (Skinner 2007). The average cost of sterilization per deer was over $1000.

In the Village of Cayuga Heights, Ithaca, NY, a study was initiated to examine the impacts of surgical sterilization on deer population growth and home ranges. Twenty-four female deer underwent sterilization (tubal ligation [n=8], ovariectomy [n=15], and hysterectomy [n=1]) between 2002 and 2004. Captured deer were fitted with numerical ear tags and radio collars. Following an infrared-triggered camera population estimate (Jacobson et al. 1997) over the course of four years (2000–2004), deer numbers appeared to be on the decline (Curtis et al. 2009). However, the harsh winters of 2002 and 2003 may have assisted in reducing the deer population. The cost of sterilization was over $1000 per deer, including $550 in costs associated with surgery.

Based on the aforementioned literature, we proposed a deer management strategy to mitigate deer damage. Adopting these suggestions, we are using controlled hunting to reduce immigration of deer into a core area where deer are treated with fertility control. To our knowledge, this is the first field experiment that integrates hunting and fertility control to maximize the potential effectiveness of both techniques.

The Integrated Deer Management Strategy

The University has developed an integrated approach to deer damage concerns that attempts to:

- Protect key areas of the campus from deer damage to support faculty and student research, living-teaching laboratories, and major university investments, including plant collections.
- Limit damage as much as practicable in areas of the campus not directly related to research or teaching, but with high aesthetic or landscaping value.
- Minimize the collateral impact of deer damage management actions on the surrounding neighborhoods and property owners.
- Consider short-term approaches that address the immediate deer damage problem in key areas, while also allowing University participation in a broader community discussion to develop long-term strategies that deal with both Cornell and non-Cornell properties, if the broader community engages in such a discussion.

The goal of Cornell University's *Integrated Deer Research and Management Program* (IDRM) is to integrate hunting and fertility control methods to maximize the effectiveness of both management tools. Hunters on Cornell University lands participate in the "Earn-a-Buck" program, which requires hunters to take two female deer prior to taking a buck. Fertility control

is being achieved by capturing and sterilizing female deer. Other deer management approaches such as hunting with New York State Department of Environmental Conservation (DEC) nuisance deer permits may be considered if the proposed program fails to reduce deer-related impacts to a tolerable level. Additional deer removal using these special nuisance permits may occur towards the end of the project if management goals are not being achieved. During this 5-year research and management project, we wish to reduce deer abundance and associated impacts by 75% and 50% in the sterilization and hunting zones, respectively.

Study Area

The study area contains the Cornell University campus and surrounding residential communities, agricultural land, and woodlots. The Cornell University campus and associated research farms and natural areas contain areas that are either closed or open for hunting depending on the location, human use, and building density. After the affected lands were identified, the campus was divided into two zones (Fig. 1). The sterilization zone (1,133 acres) contains areas near the core campus where building density and safe shooting zones preclude hunting as a management tool. Deer populations in the sterilization zone are primarily managed by fertility control (permanent surgical sterilization). The hunting zone (2,544 acres) contains agricultural fields, woodlots, and natural areas where archery and/or gun hunting is possible in areas that meet a state regulation that prohibits discharge of a firearm (including bow and arrow) within 500 feet of an occupied building without permission. Limited hunting has been allowed on some of these properties for decades; the goal of the Cornell University hunting program is to regulate, improve consistency of process, and increase effectiveness of hunting for deer management. A third study area (873 acres) was identified to capture and radio-collar control deer for statistical comparisons of fawning rates, movement, and survival (Fig. 1). The objective of this study is to reduce deer abundance using managed hunting in the hunting zone, and thus limit deer immigration into the central campus area where sterilization is used.

Fertility Control

Capture

Deer were captured using modified Clover traps or with dart rifles during late summer or winter from October 2007 through March 2010. The Clover traps were baited with apples, set at dusk, and checked early each morning. Trap gates were secured when the traps were not in use to prevent accidental capture, and bait was supplied several times weekly to habituate deer to entering the traps. Between six and eight traps were used simultaneously across the study area. The traps were located in undisturbed woodlots and on private property with permission from cooperating landowners. If a trap was successful in capturing a female deer, research staff collapsed the trap and restrained the animal. Male deer (bucks) and non-target species were released at the point of capture each morning. Each captured female deer was anesthetized with an intramuscular injection of butorphanol-azaperone-medetomidine (BAM), butorphanol-medetomidine (BM), ketamine, telazol, or xylazine hydrochloride. We are working closely with Cornell University College of Veterinary Medicine anesthesiologists to evaluate medetomidine-butorphanol with and without azaperone, immobilizing drug combinations designed to be more efficient than traditional drugs (e.g., ketamine:xylazine hydrochloride). Results from this drug study will be submitted in manuscripts for peer-reviewed journals. Dart rifles were used to anaesthetize deer based on weather conditions or success of Clover trapping. Deer were

monitored and recovered after being sedated (usually less than 15 minutes). Regardless of capture method, when the animal was recumbent, it was hobbled and fitted with a face mask covering its eyes to reduce stress in the unlikely event of an under dosage.

Surgery

Safely tranquilized, female deer were transported to the large animal surgery wing at the Cornell University College of Veterinary Medicine (CVM) and prepared for permanent sterilization surgery. Deer were intubated for gas anesthesia and monitored throughout the procedure. Deer were prepared for surgery by shaving incision areas, coating the bare skin with a betadine solution, and covering the deer with a sterile drape. Tubal ligation surgery was completed on known pregnant deer so pregnancy would not be prematurely terminated. Non-pregnant deer received an ovariectomy surgery in the first year, but this technique was subsequently replaced by tubal ligation, a simpler technique favored by the surgeons. Only three laparoscopic surgeries were performed due to the difficulty of the procedure.

Marking, Release, and Tracking

Following surgery, the deer were fitted with individually-numbered livestock ear tags bearing the date at which the animal would be safe for consumption (45 days post-capture). Captured bucks were also tagged to determine dispersal patterns. Most adult does were fitted with VHF radio collars. Following surgery, deer were transported by truck back to the site of capture and monitored until completely recovered. Radio telemetry was used to monitor deer movements and health during the first 48 hours after release.

Telemetry was conducted with the intent to find all radio-collared animals up to two days and two nights per week. Deer are found by triangulation, homing, or a combination of the two methods. The tracker, tag number, date, time, location, and sighting information are recorded. Any deer recovered postmortem are taken to the CVM and necropsied to determine the cause of death. This research conforms to the requirements of Cornell University's Institutional Animal Care and Use Committee (Protocol No. 2007-0102).

Population Estimates

Mark-recapture population assessments will continue each year. This requires a known population of individuals that are identifiable in photographs. Using the Cayuga Heights deer population (which is approximately 140 to 240 animals) as a guide for selecting our needed sample size (Boldgiv 2001), 70 marked and sterilized deer would be the minimum number maintained for the 5 years of the study that would result in a population reduction (Merrill et al. 2003, Seagle and Close 1996). Each spring, a camera census is conducted in the sterilization zone to determine the proportion of marked and unmarked deer (Curtis et al. 2009). Twelve infrared-triggered cameras are deployed over bait piles on campus in a grid system of 100-acre blocks. The intent is that each camera "captures" a large sample of the deer population in the sterilization zone. The cameras operate continuously for 7–10 days, after which each deer in the photos is tallied and the data are statistically analyzed. Program NOREMARK (White 1996) is used for the estimates.

The average number of deer seen and harvested afield is used as an index to changes in deer abundance. Data will be compared to the DEC bowhunter deer sighting log to examine trends

over time. We will work with Ed Kautz, DEC deer program modeler, to determine if the sighting data can be converted to density estimates.

Deer-Vehicle Accidents

Cornell University Police cooperation will continue through deer-vehicle accident (DVA) monitoring and reporting. In the last several years, DVAs have ranged from six in 2003 to 12 in 2007 (Fig. 2). However, previous research has suggested that half or more DVAs go unreported.

Results to Date

To date, 77 sterilization surgeries have been performed on female white-tailed deer captured within the sterilization zone. Thirty-one females (6 fawns and 25 adults [≥1.5years]) were captured between late October 2007 and early April 2008. Twenty tubal ligations and 11 ovariectomies were performed on these deer. Seventeen male deer were caught in the same capture season. Two epididymectomies and one vasectomy were performed on three of these bucks. A total of 23 adult does were fitted with radio collars.

We began the 2008–2009 captures during early September to treat as many female deer as possible prior to breeding season in mid-November. This would reduce fawn production the following spring. Twenty-seven females (10 fawns and 17 adults [≥1.5 years]) were captured between early September 2008 and late March 2009. All female deer received tubal ligation surgery. A total of 26 mature does were fitted with radio collars, including 10 control females captured near the periphery of the sterilization zone. Twenty male deer were also captured, but none of these animals were sterilized.

Twenty-eight females (4 fawns and 24 adults [≥1.5years]) were captured between mid August 2009 and late February 2010. We sterilized 19 female deer during this time. Twenty-two mature does were fitted with radio collars, including seven control deer. Seven male deer were captured, ear-tagged and released.

Population Estimates

In 2009, the sterilization zone was reduced from 1,781 to 1,133 acres to better account for actual deer habitat. The campus deer population estimates remained stable at 93 (53 deer/mile^2) and 99 (56 deer/mile^2) deer in 2009 and 2010, respectively. After the photos were further analyzed, it was determined that there was a strong edge effect from cameras close to the border where immigrating deer were challenging the sterilization zone. When the photos from five border cameras were removed from the analysis, the population estimates decreased to 92 deer (52 deer/mile^2) in 2009 to 82 deer (46 deer/mile^2) in 2010. Although this is not a significant decrease in estimated population size, it does demonstrate that there is a trend toward reduced deer density on the Cornell University campus as a result program efforts.

Telemetry and Marking

Average annual home range sizes have ranged from 175 acres in 2008 to 142 acres in 2010. Corrections, sighting information, and additional telemetry fixes have been added to each deer's file, and updated range maps are pending.

Mortality

To date, known mortality of study deer includes 27 females (23 sterilized and 4 controls) and 12 males. Nineteen deer succumbed to injuries sustained in vehicle accidents, 12 were harvested during legal hunting seasons, and one yearling doe expired due to a congenital heart defect. A doe fawn and an untagged buck were euthanized after sustaining skeletal injuries from dart impacts in 2009. Cause of death was indeterminable for two does and one buck fawn. Two males were found by hunters during the 2009 season and are believed to have been shot and not recovered. In concert with the Cornell University Police Department, ongoing deer-vehicle accident (DVA) monitoring will help ascertain levels of this deer impacts throughout the study.

Fawn Production

Seventeen deer receiving tubal ligations were expected to fawn during spring 2008. Five does are known to have had at least one fawn. Six does had at least two fawns. One doe is known to have given birth to triplet fawns. Another two does may have had triplets. One doe was expected to have fawns but was repeatedly observed with three bucks and no fawns. One doe was observed to have an udder but was never seen with fawns. Another doe was expected to have young, but was not observed between May and September 2008. No ovariectomy deer have been observed with fawns. Twelve adult females receiving tubal ligations were expected to bear fawns in spring 2009. Of these deer, four were not observed with fawns. Only one adult female is expected to bear fawns in spring 2010. Tubal ligation surgery failed on one adult doe (#225) in 2009, resulting in the birth of a fawn in both spring 2009 and 2010.

Cost of Capture and Sterilization

Surgical sterilization remains expensive; start-up, surgeries, and deer capture comprise just a few of the costs associated with this technique. The cost per deer is not constant. Initial captures tend to come easily, but cost per deer may increase exponentially for the last percentile of targeted deer, which are the hardest to catch. Capture costs are also related to behavioral responses. Trap-averse deer would result in lower recapture and sterilization rates, while trap-happy deer at baited capture sites would increase recapture costs. In the future, fewer deer will need to be surgically treated, lowering overall program expenses.

Surgery cost for expendables (e.g., pharmaceutical supplies, anesthesia, equipment sanitizing, and laundry) were approximately $550 per surgery. However, these costs may increase during the next fiscal year. Labor costs for capture and marking were an additional $525 per deer. Surgery expenses were donated to the project by CVM for veterinary staff and surgery resident training.

Earn-a-Buck Hunting Program

2008 Hunting Season

Controlled hunting includes procurement of DEC Deer Management Assistance Program (DMAP) permits. These permits, which allow the hunter to take only antlerless deer, are used to harvest female deer and lower the reproductive potential of the herd, which will ultimately reduce herd size and associated impacts. An “Earn-a-Buck” hunting program is used to manage the hunt. Biological information was collected from deer harvested during the open hunting

season. A hunter orientation is held each fall prior to the archery deer season to inform participants of program changes and progress to date. Deer harvest quotas are set annually based on deer population assessment and damage complaints.

Cornell University IDRM conducted a 2008 pilot hunting season. Hunters harvested 69 deer between October 18 and December 16, 2008; 49 does, 14 fawns (10 female), and 6 bucks. Fourteen hunters became buck eligible by harvesting two antlerless deer. A total of 29 deer were harvested in archery season (25 does, 3 fawns), 33 deer in firearm season (19 does, 9 fawns), and 7 deer in the muzzleloader/late archery season (6 does, 1 fawn). Age data were collected from most deer (Table 1). Seventeen deer (13 does, 26%) were harvested from the zones closest to Cornell campus (Zones A1, A2, and A3), which should help decrease immigration into the core campus where sterilization efforts are used to reduce the deer population and associated impacts.

Prior to the hunting seasons, 161 hunters registered with the program, but only 97 (60%) actually hunted. Hunters reported seeing 0.7 deer per day on average. A total of 2.1 known adult does were reported for every adult buck seen. Hunters are required to sign-in/sign-out, report deer seen using a sighting log, and report harvested deer at a mandatory deer check station. There were 32 instances where hunters failed to sign out, resulting in incomplete data. Hunters logged over 3,855 hours afield; on average, each hunter each spent about 35 hours hunting in 2008. Hunters spent approximately 49 hours afield per deer taken. 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. Because supplies have already been purchased, the cost per deer harvested will likely be less in subsequent years.

Program staff handled two cases of trespassing on Cornell University lands and one complaint regarding firearms discharge within 500 feet of a home. Two antlered bucks were harvested accidentally. In both instances, the mistakes were considered to be preventable.

2009 Hunting Season

Cornell University IDRM conducted its second Earn-a-Buck (E-a-B) hunting season in 2009. Additional lands were added to the program prior to the 2009 deer hunting season, resulting in an increased deer harvest from the previous year. The deer team was pleased with the harvest results and the program is expected to continue in 2010 with only minor changes in format.

Hunters harvested 112 deer between October 17 and December 22, 2009; 78 does, 28 fawns (16 female), and 6 bucks. A total of 62 deer were taken in archery season (4 bucks, 40 does, 18 fawns), 42 deer in firearm season (2 bucks, 31 does, 9 fawns), and 8 deer in the muzzleloader/late archery season (7 does, 1 fawn). Age data were collected from harvested deer (Table 1). Six adult bucks were harvested in 2009. Thirty-two deer (29%) were taken from the zones closest to Cornell campus (Zones A1–A3 and A7–A9), which should help decrease immigration into the core campus where sterilization efforts are used to reduce the deer population and associated impacts. Sixty-one out of 100 available DMAP antlerless deer tags were filled in 2009. Thirty hunters became buck eligible by taking two antlerless deer in 2009; 43 E-a-B hunters are currently buck eligible for 2010.

Prior to the hunting seasons, 435 hunters registered with the program, but only 187 (43%) actually hunted. On average, 1.3 deer were seen per hunter day. A total of 2.8 known adult does were reported for every adult buck seen. Hunters logged over 7,279 hours afield; on average, hunters each spent about 39 hours hunting in 2009. Hunters spent approximately 65 hours afield per deer taken. On average, the proportion of hunters successful in harvesting at least one deer was 0.28. These numbers are estimates, as there were 29 instances where hunters failed to sign out, resulting in incomplete data. See Table 2 for a comparison of 2008 and 2009 deer program data.

Program staff handled 10 cases of trespassing on Cornell University lands, two reports of stolen treestands, two cases of illegal baiting, and a neighbor's complaint of finding an arrow on private property. E-a-B hunters discovered 6 dead deer (3 adult bucks, 2 button bucks, and 1 doe) in the field that had been hit with arrows. One deer, an adult buck, was found with its antlers removed. An additional doe was discovered unclaimed on private property. Expulsion from Cornell IDRM remains an option for hunters who break university or state regulations. To date, one hunter has been banned from the E-a-B program. We thank our hunters for their tips on violations.

Table 1. Age distribution of harvested deer*

Age	Fawn	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5
2008 Harvest*	14	14	19	9	4	1	1	2	1
2009 Harvest	28	36	28	7	8	1	3	1	0

*Four adult does were not aged. Numbers include bucks.

Table 2. Comparison of E-a-B deer harvest results, 2008–2009.

	2008	2009
Acres available for hunting	1,438	2,544
Registered hunters	161	435
Hunters who actually hunted	97	187
Average hours hunted	35	39
Average hours hunted per harvest	49	65
Number of deer seen per hunter day	0.7	1.3
Ratio of known bucks to known does seen	1:2.1	1:2.8
Total deer harvested	69	112
Adult bucks harvested	6	6
Proportion of successful hunters who harvested at least one deer	0.38	0.28
Hunters who became buck eligible*	14	30

*There are currently 43 buck eligible hunters going into the 2010 season.

Cooperative Sentinel Seedling Study

We are working closely with Cornell University's Ecology and Management of Invasive Plants Program to evaluate novel browse surveys to index and quantify deer impacts to university lands over time. We are growing red oak seedlings in containers until they are ready to be planted into the field in the spring. Half of the seedlings in each environment will be protected from deer

herbivory with a mesh cage. Each seedling will be individually marked with a metal tag and their survival, growth (i.e., height, number of leaves), potential reproduction, and any herbivory will be assessed in regular intervals (weekly initially, then monthly). Our approach could deliver a powerful assessment tool that does not require expensive and time-consuming procedures to individuals, municipalities and land or wildlife management agencies. If successful, sentinel seedling techniques will be presented as extension outreach to inform stakeholders (e.g., landowners, deer hunters) interested in assessing the health of their lands at the individual, cooperative, or landscape level. Results from this study will be submitted for publication in peer-reviewed literature. Moreover, workshops on the sentinel seedling approach will be included as part of Cornell University Cooperative Extension (CUCE) Deer Management Workshops and through the annual Deer Hunter Orientation meetings sponsored by Cornell IDRM. A CUCE brochure will be published for distribution and a web page will be made for Cornell's deer program website. Based on the results of the sentinel seedlings procedure, deer hunters may adjust their deer take (e.g., increased female deer removal) accordingly to promote forest regeneration and biodiversity within their lands.

Outreach

To date, we have conducted 19 public presentations and workshops to surrounding communities regarding Cornell University IDRM. Cornell's deer program has been presented at 4 national and 2 regional conferences. Interviews have been conducted for the Cornell Chronicle, Cornell Daily Sun, The Ithaca Journal, and the Syracuse Post Standard. A deer program website has been developed and can be accessed at: http://wildlifecontrol.info/deer/.

Expected Outcomes

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 (primarily plant damage), and deer-vehicle accidents on and near the Cornell University campus. If this integrated management program is successful, it may have additional applications in other communities in New York State and the northeast. Results from the project will be submitted in manuscripts for publication in the peer-reviewed literature. Public presentations will continue to be made to share research results with interested communities.

Literature

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.

Boone, J. L., and W. G. Wiegert. 2004. Modeling deer herd management: sterilization is a viable option. Ecological Modeling 72:175–186.

Boldgiv, B. 2001. Estimation of abundance and movement patterns for white-tailed deer (*Odocoileus virginianus*) in Cayuga Heights, New York. Thesis. Department of Natural Resources, Cornell University, Ithaca, 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.

Frank, E. S., and S. L. Sajdak. 1993. Sterilization as a method of controlling an urban white-tailed deer population. American Association of Zoological Parks and Aquariums Regional Conference 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.

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.

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.

_____, _____, and _____. 2006. Managing an overabundant deer population by sterilization: effects of immigration, stochasticity and the capture process. Journal of Wildlife Management 70:268–277.

Nielsen, C. C., W. F. Porter, and H. B. Underwood. 1997. An adaptive management approach to controlling suburban deer. Wildlife Society Bulletin 25:470–477.

Seagle, S. W., and J. D. Close. 1996. Modeling white-tailed deer *Odocoileus virginianus* population control by contraception. Biological Conservation **7**6:87–91.

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.

White, G. C. 1996. NOREMARK: Population estimation from mark-resighting surveys. Wildlife Society Bulletin 24:50–52.

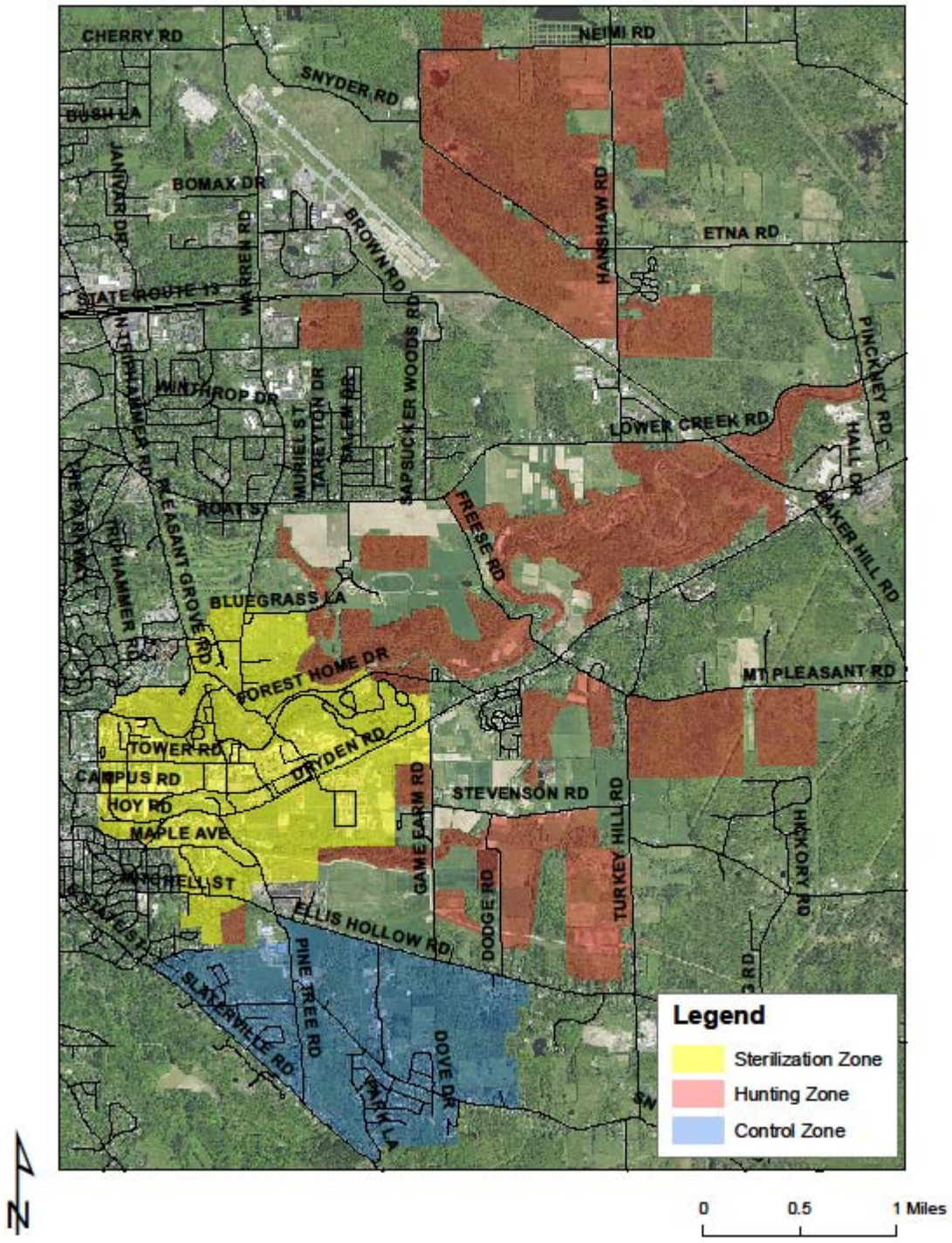

Figure 1. Sterilization, hunting (archery and firearms), and control management and study zones.

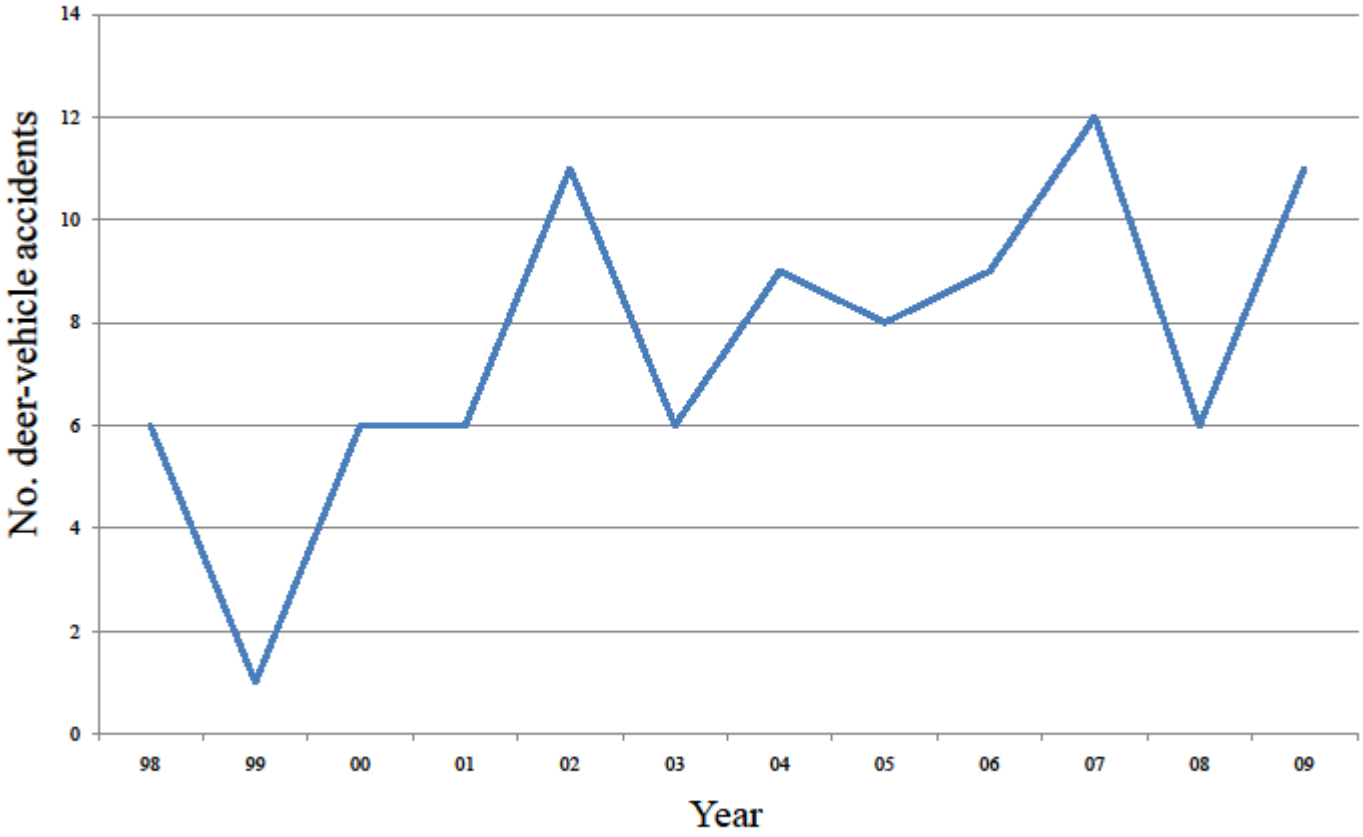

Figure 2. Deer-vehicle accidents on or adjacent to Cornell University lands as reported by the Cornell University Police, 1998–2009.