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Authors

Etter, Dwayne R.
Van Deelen, Timothy R.
Ludwig, Daniel R.
et al.

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MANAGEMENT OF WHITE-TAILED DEER IN CHICAGO, ILLINOIS FOREST PRESERVES

DWAYNE R. ETTER, and TIMOTHY R. VAN DEELEN, Center for Wildlife Ecology, Illinois Natural History Survey, 607 East Peabody Drive, Champaign, Illinois 61820.

DANIEL R. LUDWIG, and SCOTT N. KOBAL, Forest Preserve District of DuPage County, 120 East Liberty Drive, Wheaton, Illinois 60187.

RICHARD E. WARNER, College of Agriculture, Consumer and Environmental Sciences, University of Illinois, 211 Mumford Hall, Champaign, Illinois 61820.

ABSTRACT: The Forest Preserve District of DuPage County culled 2,826 white-tailed deer (*Odocoileus virginianus*), from 16 forest preserves in winters 1992-1998, including 1,786 from the 10 km² Waterfall Glen Preserve. Methods of culling included sharpshooting or capture with a rocket-net followed by euthanasia via a penetrating captive bolt. Operational field costs were \$119 to \$310/deer. Population reconstructions indicated a decrease in deer population density at Waterfall Glen Preserve from 751 deer in 1992 to 55 deer in 1998. This reduction resulted in a significant decrease ($r=0.9$, $P=0.001$, $n=7$) in reported deer-vehicle collisions on adjacent roads from 30 in 1992 to 4 in 1998. Mean plant height, percent vegetative ground cover, and number of plant species increased ($P<0.0001$) among years in six forest preserves experiencing deer population control. Culling was successful at reducing deer population density, decreasing deer-vehicle collisions, and assisting with the restoration of native ecosystems in DuPage County Forest Preserves.

KEY WORDS: culling, deer-vehicle collisions, indicator species, *Odocoileus virginianus*, population control, urban wildlife, white-tailed deer

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INTRODUCTION

Continued expansion of suburban development into remaining deer habitat in northeastern Illinois leads to isolation of deer populations in fragmented natural areas. This, in combination with artificial feeding, reduction of predation, and elimination of hunting by humans can lead to irruptive numbers of ungulates (McCullough 1997). In northeastern Illinois, most remaining deer habitat exists as public forest preserves. County forest preserve districts are mandated to restore, restock, protect, and preserve the flora, fauna, and the scenic beauty of these public lands. Preserves often serve as refugia for threatened species in the region, and overabundant deer are one of the primary threats to preservation and restoration of native ecosystems in the Chicago Region (Chicago Wilderness 1999).

Increasing deer populations in northeastern Illinois cause public safety concerns as the number of reported deer-vehicle collisions (RDVCs) rise. RDVCs summaries recorded annually by the Illinois Department of Transportation for the three Chicago metro counties (Cook, DuPage, and Lake) show an increase from 1,446 RDVCs in 1989 to 2,063 in 1992 (Jones and Witham 1992). The 1992 total included two human fatalities and 145 human injuries. An additional human fatality occurred in DuPage County in 1997.

The Forest Preserve District of DuPage County (FPDDC) initiated deer culling in 1992 because of increasing damage to native flora, increasing reports of deer-vehicle collisions, and increasing numbers of deer observed during aerial counts in forest preserves from

1986 to 1991. Objectives of culling were to reduce populations of deer in selected preserves from >50 to 4 to 6 deer/km². This paper outlines the culling operation and documents changes in the vegetation and numbers of localized RDVCs in response to deer population control.

STUDY AREA

DuPage County occupies 87,108 ha and is located west of downtown Chicago, Illinois. Land cover consists of urban/built-up land (46.3%), forested/woodland (15.7%), urban grassland (18.6%), cropland (7.3%), rural grassland (6%), wetland (4.7%), and open water (1.5%) (IDNR 1996). We conducted annual deer culling on portions of the 9,310 ha FPDDC. Forest preserves consisted of prairie grasslands (44%), forested/woodland (32%), pine plantations (3.4%), cropland (8.6%), disturbed or developed (6.5%), and open water (5.5%) (FPDDC unpubl. data). Individual preserves were 0.29 to 10 km². Corridors, including farmland, natural waterways, railroad grades, and utility easements provided travel routes for deer between preserves and private lands. Hunting is prohibited in preserves, but archery hunting is allowed on some surrounding private lands.

METHODS

We conducted annual helicopter counts of deer at Waterfall Glen Forest Preserve (WFGFP) at least once per winter (range 1 to 5) from 1985 to 1998 (Witham and Jones 1990). Counts typically detect 36 to 79% of deer present in brushy and wooded habitat types similar to

those in northeastern Illinois (Beringer et al. 1998; Ludwig 1981; Rice and Harder 1977). Habitat heterogeneity, topography, and dense pines hindered our ability to detect deer. We assumed a conservative detection rate of 66% and adjusted our counts accordingly. We estimated post-removal (April 1) population levels for WFGFP by subtracting the number of deer culled from the adjusted counts. Additionally, we derived Peterson-Lincoln estimates (Seber 1973) from spot-light counts using a sample of marked deer at WFGFP in spring from 1995-1997. We conducted annual helicopter counts of deer in all other preserves once per winter from 1985-1998. For the purpose of tracking population trends, we subtracted the number of deer culled from the counts to provide minimum estimates.

The DuPage County Department of Transportation annually records RDVCs for roads within the county. We tallied RDVCs on roads adjacent to WFGFP from 1988-1998 and predicted a positive relationship (1-tail) between RDVCs and deer density at WFGFP. We used simple linear regression to test this prediction at $\alpha = 0.05$ (Sokal and Rohlf 1995).

We culled deer from forest preserves during November to March, 1992-1998. Culling techniques included sharpshooting (1995-1998) or a combination of sharpshooting and capture with rocket nets followed by euthanasia via a penetrating captive bolt (1992-1994). The University of Illinois' Laboratory Animal Care Committee reviewed and approved euthanasia techniques.

Sharpshooting

We used Remington Model 700 rifles chambered in .243, 25.06, and .270 (Remington Arms Co., Madison, NC) as primary weapons. We used a Marlin Model 1894 chambered in .44 magnum (Marlin Firearms Co., North Haven, CT) and a Remington Model 870 12-gauge shotgun as follow up weapons in case of wounding. We equipped firearms with Leupold Vari-X III (Leupold and Stevens, Inc., Beaverton, OR) or Swarovski AV

(Swarovski Optik N.A., Surrey, England) rifle scopes and Harris Model 1A2-L bipods (Harris Engineering, Inc.). We spotlighted and shot deer at sites that were pre-baited with corn ≥ 1 week prior to culling. The Illinois Department of Natural Resources (IDNR; the regulatory agency for deer population control) inspected and approved all bait sites. Bait sites were located a safe distance from dwellings, provided a clear shooting lane, and had a backdrop of soft dirt. We shot deer from the bed of a 4x4 pickup or 1-ton trucks, a Kawasaki Model 2510 4x4 ATV (Kawasaki Heavy Industries, Ltd., Tokyo, Japan), and portable tree stands.

Capture and Euthanasia

We used rocket-nets (Wildlife Materials, Carbondale, IL) to capture deer (Hawkins et al. 1968) in 1992-1994. We pre-baited capture sites ≥ 1 week prior to capture. We euthanized deer via a single blow placed at a right angle to the skull and directed toward the center of the brain (American Veterinary Medical Association 1993) from a Schermer Model ME penetrating captive bolt (Karl Schermer and Co., Germany).

Vegetation Sampling

We placed one to two transects through upland woodlots in six preserves where deer were being culled. We started each transect at a randomly located point in the largest upland woodlot available. We ran transects in a north-south orientation if the woodlot was longer north to south relative to east to west, and vice versa for woodlots oriented east to west. We sampled ten evenly spaced 1 m² quadrants along the transects for mean percent ground cover, mean plant height, and number of indicator species in July 1994 and 1997-1999. Indicator species consisted of 11 native woodland forbs that were common in all preserves (Swink and Wilhelm 1994) and browsed by deer (FPDDC unpubl. data) (Table 1). We predicted an increase (1 tail) for the mean of the vegetation variables by year. We used a MANOVA with year and preserve as main effects, and tested for significance at $\alpha = 0.05$ (Everitt and Dunn 1992).

Table 1. Indicator species common in all DuPage County Forest Preserves. Nomenclature is from Swink and Wilhelm (1994).

Indicator Species	Scientific Name
Tall Agrimony	<i>Agrimonia gryposepala</i>
Enchanter's Nightshade	<i>Circaea lutetiana canadensis</i>
Wood Avens	<i>Geum canadense</i>
Wild Geranium	<i>Geranium maculatum</i>
Feathery False Solomon's Seal	<i>Smilacina racemosa</i>
Smooth Solomon's Seal	<i>Polygonatum canaliculatum</i>
Clustered Black Snakeroot	<i>Sanicula gregaria</i>
Orange Jewelweed	<i>Impatiens capensis</i>
Red Trillium	<i>Trillium recurvatum</i>
Woodland Knotweed	<i>Polygonum virginianum</i>
Common Carrion Flower	<i>Smilax lasioneura</i>

RESULTS

We culled 2,826 deer from 16 forest preserves (Table 2), including 1,786 from the 10 km² WFGFP. We used rocket-netting and euthanasia on 241 deer and sharpshooting on 2,585 deer. We donated 44,686 kg of ground venison to Chicago food banks (Table 2).

Table 2. Annual number of deer culled, cost per deer culled, and kilograms of venison donated from DuPage County Forest Preserves 1992-1998.

Date	Deer Culled	Cost Per Deer (\$)	Venison Donated (kg)
1992	253	269	4,196
1993	642	119	10,746
1994	431	207	6,864
1995	433	199	7,000
1996	362	205	5,415
1997	477	247	7,055
1998	228	310	3,411
Total	2,826	$\bar{x}=222$	44,686

Annual RDVCs on all roads adjacent to WFGFP increased during 1988-1992, prior to deer removal (Figure 1). Subsequent harvest intensities ranged from 16.6 to 56.6 deer/km² from WFGFP during 1992-1997 (Table 3). Post-removal (April 1) population levels indicated a decrease in deer density at WFGFP from 751 deer in 1992 to 55 deer in 1998 (Figure 1). Peterson-Lincoln estimates were similar to predicted post-removal population levels there by supporting our estimates. Reduced populations correlated with a decrease ($r=0.9$, $P=0.001$, $n=7$) in RDVCs on roads adjacent to WFGFP from 30 in 1992 to 4 in 1998 (Figure 1). Annual helicopter counts of deer in other preserves showed a similar, though variable downward trend from 1992-1998 (Figure 2). These results support the use of year as a main effect variable in the MANOVA model.

Costs, including commodities and personnel (not including administrative time), were \$269/deer culled in the first year (Table 2). Costs declined to \$119/deer culled in 1993 and stabilized at about \$200/deer during 1994-1996. Cost increased approximately \$50/deer in 1997 and 1998.

Mean percent ground cover, mean plant height, and number of indicator species had a significant positive response by year ($F=7.94$; 6, 694 df; $P<0.0001$) (Table 4 and Figure 3). This response was the result of

cumulative deer harvests and a subsequent declines in deer populations (Table 3, and Figures 1 and 2). Preserve effects were significant ($F=9.29$; 10, 694 df; $P<0.0001$) (Table 4). This result is expected because annual deer harvest intensity varied among preserves (Table 3).

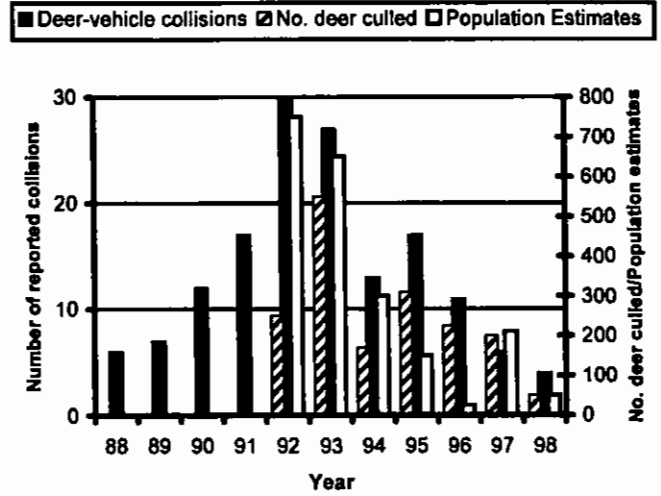


Figure 1. Annual number of deer culled, post-removal (April 1) population estimates, and the annual number of reported deer-vehicle collisions on roads adjacent to Waterfall Glen Forest Preserve, 1988-1998.

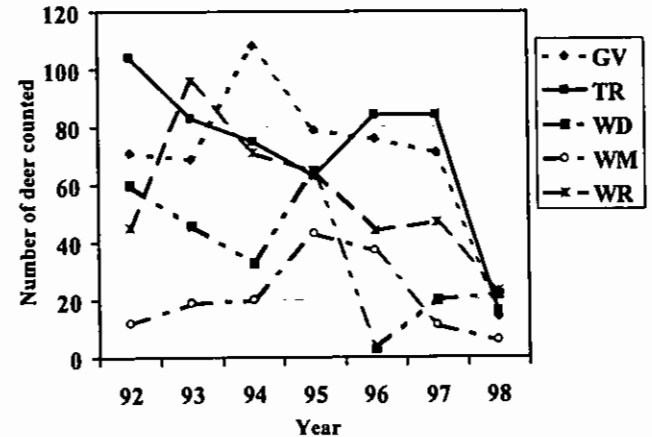


Figure 2. Number of deer counted in forest preserves during winter helicopter counts 1992-1998. Deer culling began in winter 1993 in Woodridge (WR) forest preserve and 1994 in all other preserves.

DISCUSSION

Operational costs

Cost was higher in the first year of culling relative to later years due to initial purchases of equipment (Table 2). A substantial decline in cost during 1992-1993 occurred because deer populations remained high and subsequent equipment expenditures were small. Increases in cost in later years reflect an increase in the effort required to locate and remove individual deer as population density declined. This relationship between cost and population density may mimic a Type 2 predator-prey relationship. Choquenot et al. (1999) evaluated helicopter shooting of feral pigs in Australia and determined that cost increased as a power function of declining pig density. Cost/effort relationships are critical for the management of overabundant deer because cost often constrains effort invested in population control. Our costs for culling were comparable to costs reported by others (Butfiloski et al. 1997; Drummond 1995; Jordan et al. 1995; Stradtman et al. 1995).

Sharpshooting

Sharpshooting could not be used outside of designated areas because of safety concerns. Three people (driver, spotter, and shooter) were required to operate from a truck, two persons (driver/spotter and shooter) operated

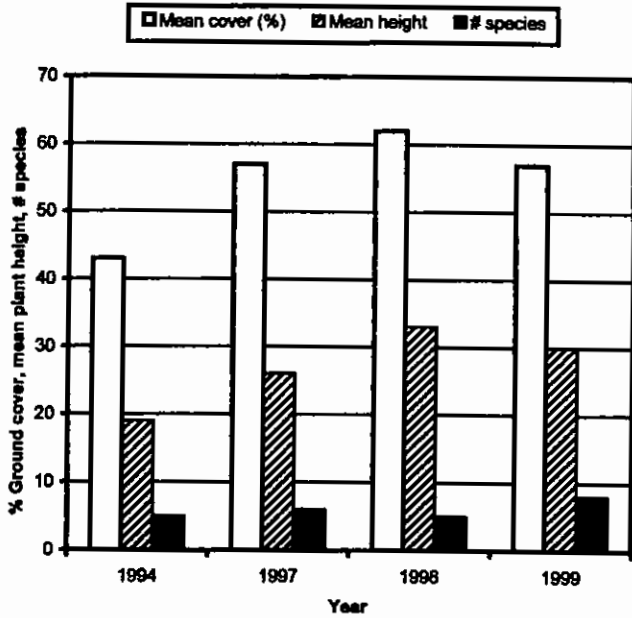


Figure 3. Mean percent vegetation ground cover, mean plant height, and number of indicator species found in DuPage County Forest Preserves experiencing deer population control.

Table 3. Deer harvested per km² and per forested km² from six DuPage County Forest Preserves 1992-1999.

Preserve	Area (km ²)	Annual Deer Harvest/km ²						
		1992	1993	1994	1995	1996	1997	1998
Greene Valley	Total area (5.78)	—	—	8.1	4.7	11.7	7.8	5.2
	Forested area (2.08)	—	—	24.0	13.8	34.7	23.0	15.3
Timber Ridge	Total area (4.30)	—	—	12.7	11.1	4.6	12.3	6.0
	Forested area (1.81)	—	—	30.4	26.5	11.0	29.3	14.4
Waterfall Glen	Total area (10.00)	25.3	56.6	16.6	32.3	23.1	19.7	5.0
	Forested area (5.87)	43.1	96.4	28.3	55.0	39.4	33.6	8.5
Woodridge	Total area (0.96)	—	13.5	17.7	6.3	6.3	32.3	51.0
	Forested area (0.81)	—	16.0	21.0	7.4	7.4	38.3	60.5
West DuPage	Total area (1.86)	—	—	24.6	16.0	6.4	11.8	4.3
	Forested area (1.16)	—	—	39.7	25.9	10.3	19.0	6.9
Winfield	Total area (1.37)	—	—	2.2	—	4.4	16.8	8.8
	Forested area (1.09)	—	—	2.8	—	5.5	21.1	11.0

from an ATV, and a single person shot deer from tree stands. Success and efficiency were greatest while operating from a truck, followed by an ATV, and lastly from tree stands. Advantages of operating from the truck were more efficient use of multiple bait sites, easier transport of equipment and deer carcasses, and a stable and easily positioned shooting platform.

Initial sharpshooting protocol specified head-shots only, but as deer became accustomed to culling they were less likely to present an immobile target. This behavioral response by deer increased the likelihood of cripples. Shooting occasionally resulted in wounding despite the persistent practice and patience of sharpshooters. Therefore, protocol was altered to include neck- and chest-shots. Most sharpshooters preferred neck-shots because they provided a larger target and resulted in immediate kills. Chest-shot deer often fled and needed to be tracked and transported considerably farther than head- or neck-shot deer.

Understanding deer behavior and social structure was important for successfully shooting multiple deer from a site. Social organization in female deer is based on matriarchal family groups (Hawkins and Klimstra 1970). Coe et al. (1980) concluded that the dominant adult doe in a group is most likely to be harvested by hunters, because she typically leads the group. Targeting the matriarchal doe first often resulted in subdominant deer remaining at the site, providing additional targets. This behavior reiterated the need to head- or neck-shoot deer whenever possible, as subordinate deer often followed chest-shot does that ran from the site.

Capture and Euthanasia

Netting allowed culling of large groups of deer, but not necessarily more than sharpshooting. The maximum number of deer captured and euthanized at one time was eight, compared to seven shot at a single site. A single person could set up and fire nets, but a minimum of two people were required to secure and euthanize deer with a penetrating captive bolt. No deer were injured during

capture prior to euthanasia. Rocket-nets could only be used in level areas large enough to contain the net. Netting limited culling to one or two sites per evening. Multiple captures from a single site the same evening were common at high-density, but unlikely at low density. We did not capture and euthanize deer during 1995-1998 when population levels were further reduced, but as population levels and group size declined the efficiency of this technique would likely have declined as well.

Vegetation Sampling

We found a positive response for mean percent ground cover, mean plant height, and the number of indicator species present in response to year (Table 4 and Figure 3). Deer are selective browsers, tending to choose taller, flowering plants which may be more nutritious (Anderson 1994; Balgooyen and Waller 1995). Anderson (1994) determined that unprotected white-flowered trillium from northern Illinois were significantly shorter than plants protected from deer. Tilghman (1989) reported decreases in blackberry (*Rubus spp.*) cover in northwestern Pennsylvania forests at densities >30 deer/km². In northern Wisconsin, the frequency of bluebead lily (*Clintonia borealis*) declined significantly in areas experiencing recent or historically high deer densities (Balgooyen and Waller 1995).

We documented upland boneset (*Eupatorium sessilifolium*) at WFGFP in summer 1996 after several years of intensive deer culling. Upland boneset is rare in Illinois, and this was the first recorded sighting of this species in DuPage County. We assumed that growth of the boneset was suppressed until high deer numbers were reduced, given the large size of this specimen and its location next to a trail frequently used by FPDDC ecologists. Bluebead lily, Canada mayflower (*Maianthemum canadense*), and wild sarsaparilla (*Aralia nudicaulis*) abundance remained low for several years after deer densities were reduced from sites in northern Wisconsin and the Apostle Islands (Balgooyen and Waller 1995).

Table 4. Results of MANOVA for mean percent vegetation ground cover, mean plant height, and number of indicator species as dependent variables with year and preserve as main effects.

Effects Variable	Wilk's Lambda	F-value	df	Prob > F (1 tail)
Whole Model	0.69	8.77	16,694	<0.0001
Preserve	0.77	9.29	10,694	<0.0001
Year	0.88	7.94	6,694	<0.0001

MANAGEMENT IMPLICATIONS

We based our goal density of 4 to 6 deer/km² on recommendations from a previous study (Tilghman 1989). Minimum population estimates suggested that we approached, but did not achieve goal density in preserves despite intensive annual deer harvests (FPDDC unpubl. data). Density dependent recruitment in deer makes it difficult to reach goal density as removal progresses (White and Bartmann 1997). Density dependence will continue to frustrate biologists and land managers attempting to reduce and maintain low-density populations. Nevertheless, deer culling reduced population levels and led to significant increases in mean percent vegetative ground cover, mean plant height, and number of native indicator species, achieving an important goal of FPDDC's deer removal program. A secondary result of deer culling at WFGFP was a significant decline in RDVCs on roads surrounding this preserve. Deer behavior, population density, habitat, access, proximity to dwellings, cost, and public sentiment must all be considered when planning lethal removal. Using multiple techniques synergistically will increase the effectiveness and ability to succeed at achieving management goals.

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