A Preliminary Evaluation of Deer Behavior and Nontarget Animal Use Associated with the 4-Poster Tickicide Device on Long Island, New York

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ABSTRACT The 4-Poster device is a host-applied tick control technology. White-tailed deer (*Odocoileus virginianus*) are attracted to devices by whole kernel corn, and when feeding, each animal contacts rollers that apply an acaricide to the animal's head and neck. The blacklegged tick (*Ixodes scapularis*), and lone star tick (*Amblyomma americanum*), are both nuisance and medical pests on Long Island, and deer are a keystone host for both species. By targeting adult ticks where they are most commonly found, deer application is highly effective for concentrating acaricide in key target areas, compared to conventional lawn spraying of pesticides. However, attracting deer to baited stations may have negative impacts including: 1) potential damage to vegetation near the deployed stations in both natural and residential settings; 2) possible increases in deer road crossings, leading to more vehicle collisions; 3) increased deer survivorship or fecundity due to supplemental feeding or reduced tick pressure; and 4) impacts of feeding stations on nontarget wildlife. We are completing the first year of a multi-year project, and report nontarget wildlife use at 4-Poster devices, and deer home ranges for areas with, and without 4-Poster feeding stations. These data will provide management information concerning the collateral effects of deploying 4-Poster devices to reduce tick abundance.

KEY WORDS 4-Poster, behavior, deer, *Odocoileus virginianus*, ticks

The 4-Poster device is a passive feeding station designed to control ticks that use white-tailed deer (*Odocoileus virginianus*) as a host. As deer feed on bait (corn grain) at a device, acaricide-treated rollers brush against the animal's neck, head and ears where many adult ticks feed. Deer are a key host for adult blacklegged (*Ixodes scapularis*) and for immature and adult lone star ticks (*Amblyomma americanum*). Several studies (Carroll et al. 2002, Pound et al. 2000a, Pound et al. 2000b, Solberg et al. 2003) have shown large reductions in tick populations in the years following use of 4-Poster devices. In 2008, this study was initiated as a condition of the New York State Special Local Need Registration (SLN NY-070005) for the 4-Poster Tickicide (EPA Registration Number 39039-12) to investigate human and wildlife-associated risks. Our objectives were to: 1) monitor changes in deer movement and behavior from placement of 4-Poster devices, 2) document nontarget animal use at 4-Poster devices, 3) quantify permethrin residues in and on deer, and 4) evaluate the efficacy of this technology for control of blacklegged and lone star ticks. In this paper, we report a preliminary evaluation of 4-Poster device use by deer and nontarget wildlife as well as comparisons of deer home ranges within study (treatment) and control areas.

METHODS

Study Areas

The research was conducted on Shelter Island (Fig. 1; 3,263 ha [8,064 acres]), where 58 4-Poster devices were deployed during most months from late spring through 30 November 2008. Shelter Island is accessible only by ferry from the north or south. There were two intensive study sites

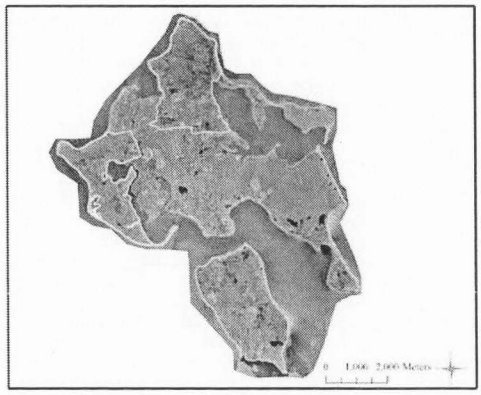

Figure 1. Shelter Island, New York, (large island) was the treatment area, and North Haven, New York, (smaller peninsula) was the control area for the 4-Poster Deer and Tick Control Study. Shelter Island included 2 intensive study sites; Area A (South) is located to the Southwest and outlined in white, and Area B (North) is located to the North and outlined in yellow. The control area, North Haven, is south of Shelter Island and outlined in grey.

(Area A, 466 ha [1,152 acres]; Area B, 622 ha [1,536 acres]) on Shelter Island where deer trapping, tagging and radio-collaring occurred (Fig. 1).

The village of North Haven (Fig. 1, 702 ha [1,735 acres]), a nearby peninsula, served as a control site where deer were marked, but no 4-Poster devices were deployed. Deer movement between Shelter Island and North Haven was limited by approximately 805 m (0.5 mi) of deep waterways with swift tidal currents. A bridge and narrow causeway connect North Haven to the South Fork of Long Island.

These coastal areas are intensely developed with seasonal-use homes occupied primarily during the summer months. A relatively small, year-round human population maintains residences interspersed within patches of forest and field. The southeast portion of Shelter Island includes Mashomack Nature Preserve, an 809 ha (2,000 acres) largely undeveloped property managed to maintain coastal oak forest (*Quercus* spp.), coastal shoreline, grassland, and wetland ecosystems.

White-tailed Deer Live-Capture and Telemetry

White-tailed deer were live-trapped, tagged, and collared on Shelter Island and North Haven during February–August 2008 using modified Clover traps (McCullough 1975), rocket nets (Hawkins et al. 1968), drop nets, and dart rifles. Chemical immobilization drugs and reversal agents were used to sedate all deer for safe handling. Deer were marked with uniquely numbered cattle ear tags and collared to monitor daily and weekly movements. VHF radio-transmitter collars (Telonics, Inc., Mesa, AZ) and GPS collars (Televilt, Followit Lindesberg AB, Sweden) were deployed to monitor deer movements. Deer handling protocols were reviewed by the Cornell Institutional Animal Care and Use Committee (Protocol #2007-0150) and the NYS Department of Environmental Conservation (LCP# 1211).

The movement of VHF-collared deer on Shelter Island and North Haven were monitored 3 to 4 times each week during April–December 2008. During January–April 2009, collared deer were located weekly to monitor for mortality signals and obtain geographic locations. GPS collars were programmed to record deer locations every hour from 1700 to 0600 hours (GMT) and once every 3 hours between 0600 to 1700 hours (GMT). The movements of GPS-collared deer were monitored weekly using the VHF transmitter beacon function to verify animal activity and proper collar function.

Location data obtained from VHF- and GPS-collared deer were used to document deer use of 4-Poster devices on Shelter Island and evaluate potential changes in suburban deer movements or home range and core area sizes. We compared deer movement in the treatment area (Shelter Island) to movement in the control area (North Haven). Deer home ranges (95% kernel density estimator [KDE]) and core

areas (50% KDE; Beyer 2004) were calculated to evaluate large-scale habitat use and potential changes resulting from 4-Poster device locations.

Temporary bait sites are reported as having no influence on the size of deer home ranges or core areas. However, the locations of core areas within home ranges may shift closer in proximity to bait sources (Kilpatrick and Stober 2002). To closely evaluate the influence of continuously available and renewed bait sources (4-Poster devices) on deer movements, we examined the size of home ranges and core areas, as well as verified (camera survey photo documentation) the number of 4-Poster devices used by each collared deer within the study area.

Wildlife Use of 4-Poster Devices: Deer, Nontarget Wildlife, & Deer-to-Deer Contact

Corn Consumption Records.– The amount of corn consumed from 4-Poster devices was recorded weekly during deployment. The estimated number of deer using devices was calculated based on a consumption average of 0.454 to 0.567 kg (1.0 to 1.25 lb) of corn per day per 45.36 kg (100 lb) of body weight (Pound et al. 2000a). Based on an average weight of 56.7 kg (125 lb) per deer using a device, the average corn consumption is approximately 0.68 kg (1.5 lb) of corn per day. The estimated number of deer using each device was calculated as the number of pounds of corn consumed per day divided by 0.68 kg (1.5 lb).

Estimates of the number of deer using 4-Poster devices were used to evaluate suitability of device locations. Adequate use of devices by deer, the target host for blacklegged and lone star ticks, was one of the first steps for ensuring effective acarcide treatment. Average corn consumption and estimated number of deer using 4-Poster devices will be used to evaluate and plan 4-Poster placement for future study years.

Infrared-Triggered Camera Census: Deer and Nontarget Wildlife.– During May through November 2008, 16 4-Poster devices were randomly selected and monitored with infrared-triggered cameras for 2 days each month (Jacobsen et al. 1997). Cameras were set at high sensitivity and programmed with a 4-minute delay between photos. Photos were downloaded at the end of each monthly survey and recorded in a database according to wildlife species present, and whether or not a species was observed feeding on corn. These data were used to evaluate deer and nontarget wildlife use of 4-Poster devices.

RESULTS

White-tailed Deer Live-Capture & Movement Monitoring

The 2008 and 2009 deer live-trapping seasons resulted in a total of 95 uniquely marked deer on Shelter Island (57 tagged females and 38 tagged males) and 39 uniquely marked deer on North Haven (27 tagged females and 12 tagged males).

During January 2008 through April 2009, deer mortalities primarily resulted from hunter harvest or deer-vehicle collisions (DVC). Thirteen mortalities of tagged deer occurred and two of the 13 mortalities were GPS-collared deer on Shelter Island. One tagged buck from Shelter Island and 1 tagged buck from North Haven were killed by vehicle collisions. The collision involving the tagged buck from Shelter Island occurred in Southold, New York, thus documenting movement by deer between Shelter Island and mainland eastern Long Island. Hunters reported harvesting 10 tagged deer on Shelter Island during 2008, while no tagged deer were harvested on North Haven.

Thirty deer from Shelter Island (15 GPS collars and 15 VHF collars) and 16 deer from North Haven (9 GPS and 7 VHF) were radio-collared to track daily movements. Five GPS collars malfunctioned during April 2008 through February 2009. One GPS-collared doe from North Haven established summer and winter home ranges within Mashomack Nature Preserve on the southeast portion of Shelter Island. One VHF-collared doe on Shelter Island occupied a summer home range within Mashomack Nature Preserve, and resided within Study Area B only during the winter (December–March).

Home range and core area estimates (95% KDE and 50% KDE, respectively) were calculated for collared deer on Shelter Island and North Haven using data obtained during 2008 (Beyer 2004, Table 1). The mean size of deer home ranges (95% KDE) on Shelter Island ($\bar{x}$ = 46 ha [113.0 acres], n = 12, SE = 14 acres) where 4-Poster devices were present did not differ from the mean size of deer home ranges on North Haven ($\bar{x}$ = 44.8 ha [110.7 acres], n = 4, SE = 6.3 acres) where 4-Poster devices were not present (t = -0.15, df = 13, P = 0.884). Mean core area (50% KDE) size on Shelter Island ($\bar{x}$ = 7.0 ha [17.4 acres], n = 12, SE = 2.0 acres) did not differ from the mean core area size occupied by deer on North Haven ($\bar{x}$ = 8.5 ha [21.1 acres], n = 4, SE = 2.2 acres; t = 1.24, df = 8, P = 0.249).

An average of 3 4-Poster devices were present within 95% KDE home ranges of collared deer during 2008 (n = 13 deer, range = 1–11 devices). Examination and analysis of home ranges, core areas, fine-scale movements, and 4-Poster use will begin during summer and fall of 2009.

Use of 4-Poster Devices by Deer and Nontarget Wildlife

Corn Consumption Records.– During 2008, total corn consumption on Shelter Island was 69,447 kg (153,105 lb) based on the interior (volume) gauge for all units and 72,978 kg (160,890 lb) based on reported use by the pesticide applicator. Measurement using the interior volume gauge was usually 5–10% less than the actual weight of corn added by the applicator and reported. Some 4-Poster devices expand noticeably when filled and corn varies in volume for a given weight. During the 13,184 device-days (total days all devices were deployed during the 2008 season), an average of 1,258 kg (2,774 lb) of corn or 5 kg (12.2 lb) of corn per day were added to each 4-Poster device. Approximately 108.6 liters (28.7 gallons) of tickicide (permethrin formulation) were used on 4-Poster devices throughout Shelter Island during 2008.

Based on corn consumption records from 4-Poster devices, an average of 8 deer (n = 1,836 device-days, SD = 5.16) used a device each day during the 2008 deployment season (March–November). Daily device use by deer, based on corn consumption records, varied by site, ranging from 0 deer to 29 deer per device each day. On average, 207 deer (potentially including multiple visits from the same animals) used a single device each month (range: 50–311 deer; Fig. 2).

Infrared-Triggered Camera Census: Deer and Nontarget Wildlife Use.– Camera survey data from 2008 indicated heavy wildlife visitation to 4-Poster devices throughout the 2008 season (Table 2). The highest use was by deer, raccoons (*Procyon lotor*), gray squirrels (*Sciurus carolinensis*), and birds during May–November 2008. Device visitation by birds and squirrels was highest during the spring, slightly declined during late summer, and gradually increased again in the fall (Fig. 3). During early fall 2008, a dramatic increase in 4-Poster device use by deer was observed. This initial peak

Table 1a. Home range and core area estimates calculated for VHF and GPS-collared does within the 4-Poster treatment area of Shelter Island (SI), New York using 95% KDE (home range) and 50% KDE isopleths (core area).
1b. Home range and core area estimates calculated for VHF and GPS-collared does within the control area of North Haven (NH), New York using 95% KDE (home range) and 50% KDE isopleths (core area).

a.

			KDE 50% Isopleth		KDE 95% Isopleth	
Tag	Study Area	n	Acres	Hectare	Acres	Hectare
A01	SI	89	15.77	6.38	97.05	39.28
A02	SI	89	15.87	6.42	113.99	46.13
A03	SI	80	33.04	13.37	145.46	58.87
A08	SI	2823	20.76	8.40	118.92	48.13
A11	SI	774	17.68	7.16	122.26	49.48
A12	SI	714	12.56	5.08	226.64	91.72
A13	SI	701	24.17	9.78	138.83	56.19
B02	SI	85	11.74	4.75	93.73	37.93
B03	SI	87	58.97	23.86	546.03	220.98
B05	SI	67	76.89	31.12	350.61	141.89
B10	SI	733	9.72	3.93	57.09	23.10
B11	SI	774	7.75	3.14	41.48	16.79
B12	SI	728	21.52	8.71	112.12	45.38
B13	SI	643	18.14	7.34	87.87	35.56

b.

			KDE 50% Isopleth		KDE 95% Isopleth	
Tag	Study Area	n	Acres	Hectare	Acres	Hectare
001	NH	34	15.05	6.09	124.09	50.22
002	NH	2601	25.62	10.37	118.99	48.16
003	NH	1051	21.07	8.53	99.69	40.35
004	NH	2389	28.94	11.71	452.61	183.17
005	NH	662	22.78	9.22	100.16	40.54

in deer visitation was followed by a noticeable decline in October and gradually increased as fall progressed into winter (Fig. 3). Similar to deer visitation, raccoons used devices heavily in the late spring and early summer but use declined considerably in late summer. The onset of fall marked the gradual increase of device visitation by raccoons, reaching a peak for the season in November (Fig. 3).

DISCUSSION

White-tailed Deer Live-Capture & Movement Monitoring

We observed no differences in the size of deer home ranges (95% KDE) or core areas (50% KDE) for radio-collared deer within our study area on Shelter Island (4-Poster treatment area) compared to radio-collared deer on North Haven (control area). Only a small number of deer were tagged and collared during 2008. Thus, the addition of

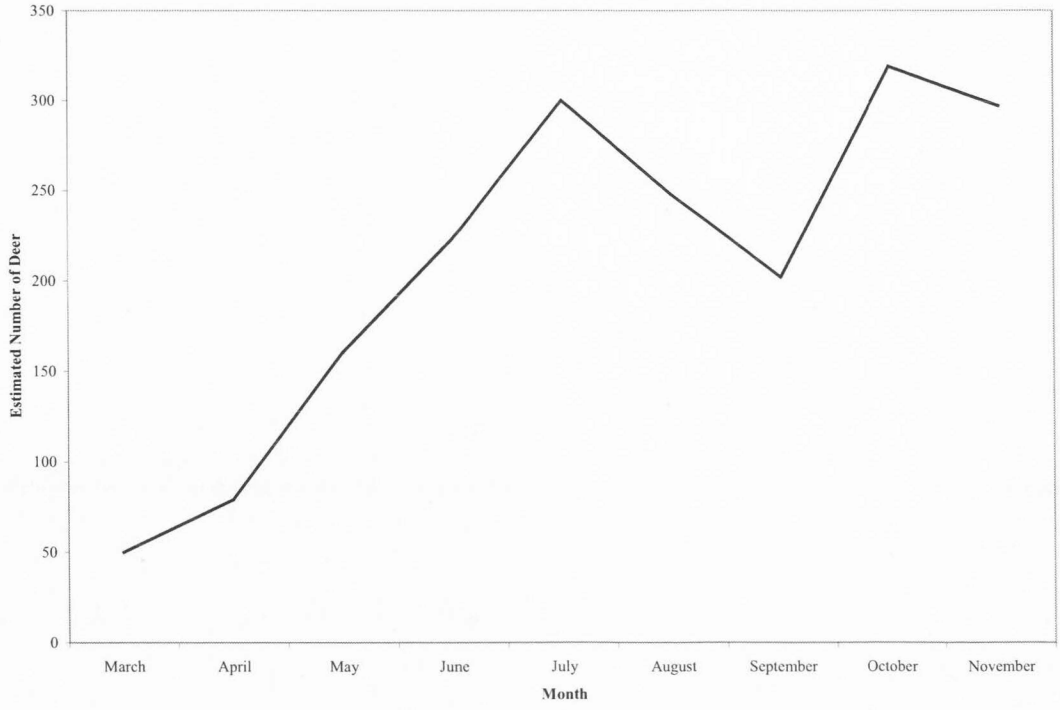

Figure 2. Average estimated number of deer using each 4-Poster device monthly during the 2008 deployment season on Shelter Island, New York. Numbers are approximate and based on records of corn consumption from each 4-Poster device.

tagged and collared deer to the marked population during winter 2009 was necessary for improving and enhancing deer home range estimates for further evaluation. However, initial assessment indicates the presence of 4-Poster devices as continuously available and renewed bait sources during March through early December does not influence the size of either home ranges or core areas occupied by deer and thus may not contribute to significant changes in deer movement.

Use of 4-Poster Devices by Deer and Nontarget Wildlife

Corn Consumption Records.– Estimates of 4-Poster device use by deer (based on corn consumption records) facilitated the evaluation of device effectiveness (i.e., the potential for direct tickicide application on deer) based on geographic location. In a suburban environment such as Shelter Island, the ideal number of deer (or percentage of the total deer population) using devices to ensure maximum effectiveness of the 4-Poster technology has not been examined to date. However, effective tickicide treatment is based on maximizing deer use of devices through proper geographic placement and distribution. Ideally during our study, at least 1 4-Poster device will be present within each home range of our collared study deer. Low-use devices (based on corn consumption) will be relocated to better deer habitat, or areas of higher deer density, to improve device visitation by deer. Devices will be distributed across the landscape in areas of high deer density to ensure effective application of tickicide treatment.

Corn consumption records do not provide information on the number of different deer using devices, or how frequently a single deer visits one or more 4-Poster devices. Although some of this information can potentially be obtained from

Table 2. Summary of wildlife use of 4-Poster devices on Shelter Island, New York, based on infrared-triggered camera surveys during May–November 2008. The total number of photos (percentage) documenting wildlife visitation by each type of animal are provided for each month.

Month	n	Deer	Raccoon	Gray Squirrel	Birds	Fox	Chipmunk	Turkey
May	1079	680 (63.02)	260 (24.10)	283 (26.23)	210 (19.46)	5 (0.46)	0 (0.00)	0 (0.00)
June	1800	1062 (59.00)	630 (35.00)	454 (25.22)	350 (19.44)	6 (0.33)	8 (0.44)	8 (0.44)
July	1531	1043 (68.13)	588 (38.41)	324 (21.16)	190 (12.41)	3 (0.20)	2 (0.13)	2 (0.13)
August	858	603 (70.28)	188 (21.91)	193 (22.49)	78 (9.09)	1 (0.12)	0 (0.00)	1 (0.12)
September	1529	1432 (93.66)	299 (19.56)	41 (2.68)	22 (1.44)	1 (0.07)	0 (0.00)	0 (0.00)
October	1161	587 (50.56)	866 (74.59)	174 (14.99)	33 (2.84)	2 (0.17)	4 (0.34)	2 (0.17)
November	1842	814 (44.19)	1432 (77.74)	457 (24.81)	127 (6.89)	4 (0.22)	2 (0.11)	7 (0.38)

infrared-triggered camera data, it will be difficult to thoroughly evaluate deer use. The short duration of monthly camera surveys (2 days) was adequate for general evaluation of device use by deer and nontarget wildlife species. However, additional sampling days (7 or more per month, Curtis et al. 2009) will be needed to adequately address the questions of number of individual deer using devices as well as frequency of device use by individual deer. The camera data, and the presence of a population of marked deer on Shelter Island, provides information for evaluating the percentage of the marked population using devices, and this will be carefully examined as the study continues.

Corn consumption by raccoons has been reported at 19 ± 13 grams (0.042 ± 0.029 lbs) of corn per feeding bout (Cooper et al. 2006). Deer may consume 454–567 grams (1.0–1.25 lb) of corn per 100 lb of body weight per day (Pound et al. 2000a). Initial review of corn consumption records from 4-Poster devices, and camera survey photo documentation of raccoon use, indicated that the actual corn consumption by raccoons may be relatively minimal. Although raccoon visitation to devices was frequent, the amount consumed per feeding bout was low. Thus, corn consumption by raccoons alone was not likely to influence estimates of the number of deer using each 4-Poster device.

Infrared-Triggered Camera Census: Deer and Nontarget Wildlife Use.– The diets of most wildlife species are influenced by food availability and seasonal protein and energy needs. With the approach of fall and cooler temperatures, feeding intensity commonly increases and high energy foods are sought to build fat reserves in preparation for winter. Fat reserves are relied on by many mammals for survival during winter when the availability of natural foods is limited. The high use of corn from 4-Poster devices by raccoons and deer in late spring and early summer corresponds with increased energetic demands associated with reproduction and lactation. For both species, corn use declined in late summer when their primary focus was likely abundant herbaceous vegetation, berries, and other natural food sources. The steady increase in device use by raccoons during September

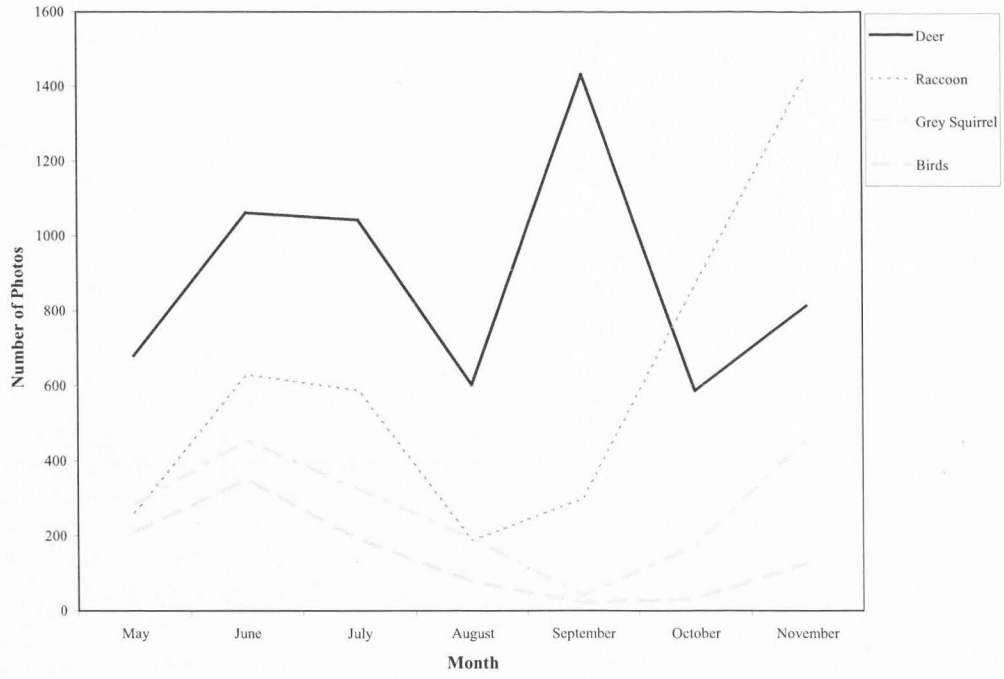

Figure 3. Total number of photos documenting wildlife visitation to 4-Poster devices on Shelter Island, New York. The highest amount of device use and visitation during 2008 was by deer, raccoon, squirrels, and birds.

through November 2008 was likely associated with increased caloric demands for building winter fat reserves. Deer also build fat reserves throughout spring, summer, and early fall, using these fat stores for overwinter survival when food resources are scarce. The dramatic increase in deer use during September can be attributed to the increase in 4-Poster use by fawns, changes in energetic demands associated with the breeding season, and the decrease of natural herbaceous vegetation. Although the mast crop provides deer with essential proteins and energy, the corn available from 4-Poster devices may have been an easily obtainable, reliable, and renewed food source. Deer use of corn from 4-Poster devices likely declined in October as mast became a primary food source, but device visitation increased again as fall progressed into winter.

Photos taken by infrared-triggered cameras indicated that direct contact with the tickicide-treated rollers primarily occurred by deer and raccoons, with occasional contact by squirrels. Although birds frequently visited devices, they have not been documented contacting the rollers. Birds primarily feed from corn spillage on the ground, and secondarily through feeding directly from the feed trough.

Camera observations also indicated that greater numbers of raccoons fed together simultaneously than any other animal observed using 4-Poster devices. Raccoons also fed at the devices for longer periods of time than other animals, thus more photos were collected documenting device use by raccoons. Although the 4-minute photo delay was suitable for individual deer observations, the time delay was too short to assume independence of observation for raccoons. This high re-observation rate must be considered when examining device visitation by raccoons. Future evaluation may consider using photos taken at time intervals of 20–30 minutes apart for analysis to ensure independence of photo

observations, and eliminate identical groups of raccoons being counted multiple times.

Estimates of the number of deer using devices based on corn consumption peaked in July and October 2008. Concomitantly, device use by all wildlife species was also greatest through July and then again during the fall. Although corn consumption by raccoons and other nontarget wildlife may typically be minimal, when devices are being used heavily by multiple species, the number of deer using devices based on corn consumption may be skewed during those months. A photo or instance of documented device visitation by a deer does not necessarily correspond with a feeding bout resulting in consumption of a known amount of corn (approximately 0.68 kg [1.5 lb] per day; Pound et al. 2000a). Multiple photos may correspond to the reported consumption of 0.68 kg (1.5 lb) of corn by a deer each day. Thus, the comparison of the high number of deer photos observed during the September camera survey reporting deer visitation at 4-Poster devices, and associated low estimate of deer use during September based on corn consumption, stresses the importance of using these methods as indices and not the actual number of deer (individuals) using 4-Poster devices throughout Shelter Island.

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