Shelter Island and Fire Island 4-Poster Deer and Tick Study

Final Report

May 2011

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ACKNOWLEDGEMENTS

Completion of this study would not have been possible without the generosity, dedication, assistance and participation of many individuals, civic organizations, businesses, elected officials and public agencies. We would like to acknowledge the support of the following in particular:

Vincent Palmer, Special Assistant to the Commissioner, NYS DEC
New York State Department of Environmental Conservation
New York State Department of Health
New York State Senator Ken Lavalle
New York State Office of Parks, Recreation and Historic Preservation, Robert Moses State Park
Suffolk County Executive Steve Levy
Suffolk County Legislators Ed Romaine and Jay Schneiderman
Suffolk County Community Advisory Committee
Suffolk County Department of Health Services
Dr. Scott Campbell, Laboratory Chief, Arthropod-Borne Disease Laboratory, Suffolk County Department of Health Services
Suffolk County Department of Public Works – Division of Vector Control
Dr. Ilia Rochlin, Entomologist, Suffolk County Department of Public Works – Division of Vector Control
Fire Island Wildlife Foundation
National Park Service - Fire Island National Seashore
Suburban Pest Management LLC
Hon. Bob Cox, Mayor, Incorporated Village of Saltaire
Mario Posillico, Village Administrator, Incorporated Village of Saltaire
John Pasquale, President, Dunewood Community Association
Gene Levy, President, Fair Harbor Community Association
Eileen O'Neil, Deputy Commissioner, Fair Harbor/Dunewood Medical District
Marija Beqaj
Shelter Island Town
Shelter Island Town Police Department
Shelter Island Town Highway Department
Shelter Island Deer and Tick Committee
Rae Lapides
Shelter Island Deer and Tick Management Foundation
The Nature Conservancy – Mashomack Nature Preserve
Group for the East End
East End Mayors and Supervisors Association
Hon. Laura Nolan, Village of North Haven
Participating landowners and caretakers of Shelter Island, Fire Island and North Haven
Dr. J. Mathews Pound, USDA - Agricultural Research Service
Dr. Howard Ginsberg, US Geological Survey, Patuxent Wildlife Research Center
Michael Ashdown, Department of Natural Resources, Cornell University
Nate Shampine, Department of Natural Resources, Cornell University
Wesley Smith
Jennifer Stress
Lea Loizos
Dominick Skabeikis
Ray Boissey
ESSCO Distributors, Inc.
Premier Pest Control, Inc
Andy Szulinski, C. R. Daniels/Dandux
A special note of thanks for the support and assistance of the late John Jason Cabral (10-29-79 to 02-14-10) provided at the Fire Island study site

INTRODUCTION

The 4-Poster device is a passive feeding station designed to control ticks that utilize 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 control of ticks and human- and wildlife-associated risks. Our objectives were to: (I) Assess human- and wildlife-associated risks due to changes in deer movement and behavior following placement of 4-Poster devices including documentation of potential impact on residential and natural vegetation, possible increases in deer-vehicle collisions, changes in contact between deer that enhance potential for disease transmission, effects upon deer mortality associated with feeding bait or reduced tick pressure, and non-target animal use at 4-Poster devices; (II) address possible increased human exposure to permethrin from handling and consuming treated deer by quantifying permethrin residues in and on deer; and (III) evaluate the efficacy of 4-Poster technology for control of blacklegged and lone star ticks in human-inhabited and –visited areas.

STUDY AREA

The primary research was conducted on Shelter Island (treatment area; Figure 1; 3,263 ha [8,064 acres]), where 60 4-Poster devices were deployed during most months from March-November of 2008-2010 (Figure 2). Shelter Island is accessible only by ferry from the north or south. There were two intensive study sites (SIA, 466 ha [1,152 acres]; SIB, 622 ha [1,536 acres]) within the treatment area where tick sampling, deer live-trapping, tagging and radio-collaring occurred (Figure 1). 4-Poster devices were also deployed in western portions of Fire Island including Robert Moses State Park (RMSP) and nearby the Fire Island National Seashore communities of Atlantique (2008 only), Fair Harbor and Saltaire where tick sampling was also done.

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

These coastal areas (excepting RMSP) 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 the Shelter Island treatment area includes Mashomack Nature Preserve, an 809 ha (2,000 acre), largely undeveloped, property managed to maintain coastal oak forest (*Quercus* spp.), coastal shoreline, grassland, and wetland ecosystems.

METHODS

Objective I: Human and wildlife-associated risks due to change in deer movement and behavior.

White-tailed Deer Live-Capture & Movement

White-tailed deer were live-trapped, tagged, and collared within the treatment and control areas during February-August 2008 and January-August 2009 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 with VHF radio-transmitter collars (Telonics, Inc., Mesa, AZ) and GPS collars (Televilt, Followit Lindesberg AB, Sweden) to monitor 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).

During 2008-2010, the movements of VHF-collared deer were monitored 3 to 4 times weekly during April-December and approximately 2 times weekly during January-March. Winter tracking (January-March) was conducted to monitor mortality signals and obtain geographic locations as time allowed. GPS collars were programmed to record geographic 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 beacons to verify animal activity and proper collar function. Geographic location data were remotely downloaded from each active collar at approximately 3 week intervals.

Geographic deer location data were used to evaluate suburban deer movements and potential changes in behavior or movements associated with 4-Poster devices. Deer home ranges and core areas were constructed using 95% and 50% kernel density estimators (KDE) and HRT in ArcGIS 9.2 (Rodgers et al. 2007). Home ranges and core areas were used to evaluate large-scale habitat use and potential changes resulting from 4-Poster device deployment. Changes in home range and core area sizes and geographic locations were examined over time (2008-2010) to evaluate behavioral responses by deer to 4-Poster devices within the treatment area compared to normal range fluctuation where no bait was present within the control area. Average home range and core area sizes were compared between years (2008, 2009, and 2010) for each area (treatment and control areas) using ANOVA and Tukey-Kramer pair-wise comparisons (SAS 9.2, SAS Institute, Inc.). Home range and core area size differences between collar type (VHF or GPS) and between area (treatment or control) were evaluated using t-tests (SAS 9.2). Shifts in the geographic locations of core areas were evaluated by calculating the percent overlap between each individual's core areas over time (2008-2009, 2008-2010, and 2009-2010). Core area overlap was calculated using polygon-in-polygon analysis in ArcGIS 9.2 (Hawth's Tools; Beyer 2004) and the percent overlap between years for each collared deer was calculated as,

$$\text{Percent Overlap} = [(\text{Area of Overlap}_{\alpha\beta} / \text{Core Area}_{\alpha}) * (\text{Area of Overlap}_{\alpha\beta} / \text{Core Area}_{\beta})]^{0.5} * 100$$

where core area$_{\alpha}$ was the core area size of the respective individual during one study year, core area$_{\beta}$ was the core area size of the same individual during a subsequent study year, and area of overlap $_{\alpha\beta}$ was the area common to both core areas (Atwood et al. 2009). A shift in core area use was considered significant for each individual deer if < 10% overlap of core area geographic boundaries occurred (Kilpatrick and Lima 1999). ANOVA and Tukey-Kramer pair-wise comparisons (SAS 9.2) were used to discern differences in percent overlap for any year time span (2008-2009, 2008-2010, and 2009-2010) between areas (treatment study areas (SIA and SIB) and the control) and a t-test (SAS 9.2) was used to evaluate the influence of collar type (VHF or GPS) on the percent overlap results observed throughout the study.

Estimates of the mean number of devices present within each collared deer home range and core area were calculated using ArcGIS 9.2 and compared between study years using ANOVA and Tukey-Kramer pair-wise comparisons between collar type (VHF or GPS) and treatment study area (SIA or SIB) using t-tests (SAS 9.2).

Emigration and Immigration

During 2008-2010, the movements of marked deer (ear tagged and/or collared deer) were monitored through visual observation, camera survey identification, radio-telemetry, and reported mortality locations. Using the marked deer population as an index, emigration and immigration, within the deer population on the treatment and control areas, were evaluated. Estimates of immigration into the deer populations on the treatment area were derived as the percentage of marked bucks and does that moved from the control area to the treatment area. Estimates of emigration from the deer population on the treatment area were derived as the percentage of marked bucks and does that moved off from the treatment area (i.e. relocating to mainland Long Island or to the control area).

Deer and Non-target Wildlife Use of 4-Poster Devices

During April through November of 2008-2010, 24, 4-Poster devices were randomly selected and monitored with trail cameras for roughly 3 days each month. Cameras were programmed to log photos at a 4 minute delay with a high sensitivity to motion. Photos were downloaded at the end of each monthly survey and recorded in a database according to wildlife species present. The total numbers of photos of each animal were used to provide estimates of the relative numbers of animals visiting devices. For each device monitored, the relative numbers of each animal were calculated based on sampling effort for each camera, where 1 camera day was equivalent to 24 hours and animal 1 represented 1 type of animal such as raccoon:

Sampling Effort of Camera 1 (Device 1) = Total Number of Photos of Animal 1 Collected at Device 1 / Total Number of Camera Days at Device 1

Relative Number of Animal 1 at Device 1 = Sampling Effort of Camera 1 * Average Number of Individuals of Animal 1 per Photo

Using the total sampling effort (all cameras), the relative numbers of animals using devices were recorded for each monthly camera survey during 2008-2010:

Total Sampling Effort = Total Number of Photos of Animal 1 / Total Number of Cameras Days

Relative Number of Animal 1 = Total Sampling Effort * Average Number of Individuals of Animal 1 per Photo

ANOVAs and Kruskal-Wallis tests (nonparametric analyses of variance) were conducted in SAS 9.2 (SAS Institute, Inc.) to compare the relative numbers of animals using devices between study years and seasons. Nonparametric analyses were used only when the variables were characterized by distinct non-normal distributions using histograms, box plots, normal probability plots, as well as significant non-normal Shapiro-Wilk tests. Significant differences between study years or seasons determined from analyses of variance were further investigated using pair-wise comparisons to indentify the sources of significance; Tukey-Kramer tests were performed for parametric estimates and Mann-Whitney U tests were conducted post-hoc in SAS 9.2 as necessary.

Estimates of Deer Device Use

Adequate use of devices by deer, the target host for blacklegged and lone star ticks, was one of the first steps to ensuring effective tickicide treatment. Estimates of the number of deer using 4-Poster devices were used to evaluate productivity of device locations. Deer use estimates were derived based on the rate of corn consumption at 4-Poster devices and the proportion of marked deer observed visiting devices in trail camera photos gathered throughout the study.

Corn Consumption Records

Evaluating corn consumption rates at 4-Poster devices provided insight into the number of deer using devices. Each week of device deployment throughout the study, the amount of corn consumed from each 4-Poster device was recorded. The estimated number of deer using devices was calculated based on a consumption average of 1.0 to 1.25 lbs (0.454 to 0.567 kg) of corn per day per 100 lbs (45.36 kg) of body weight (Pound et al. 2000a). Assuming an average weight of 125 lbs (56.70 kg) per deer, the average corn consumption was approximately 1.5 lbs (0.68 kg) of corn per day. Final estimates of the number of deer using each device were calculated as the number of pounds consumed per day divided by 1.5 lbs (0.68 kg). These estimates assumed negligible corn consumption by other non-target wildlife. Since both deer and raccoons frequently use devices, potential corn consumption by raccoons was estimated to ensure it did not skew deer-use estimates. Raccoon consumption was derived using corn consumption records, trail camera data to estimate the number of animals and feeding bouts, and the total amount of corn potentially consumed by raccoons based on literature reference (Cooper et al. 2006b).

ANOVAs were conducted in SAS 9.2 to compare the total amount of corn consumed and the average estimated number of deer using a device overall and seasonally between study years. Normal distributions were verified using histograms, box plots, normal probability plots, as well as Shapiro-Wilk tests. Significant differences between study years or seasons were further investigated using Tukey-Kramer pair-wise comparisons (SAS 9.2) to identify the sources of significance.

Proportions of Marked Deer

The proportions of marked deer using 4-Poster devices each season of each study year were summarized as indicators of use by the total deer population. For 3-4 days during April through November of each study year, 24, 4-Poster devices were selected and monitored with trail cameras. Using trail camera photos, the proportions of marked deer population observed using devices each study year were calculated as the total number of each individual marked deer visiting devices compared to the total number of marked deer present within the treatment area.

Monitoring Deer Populations

Deer abundance and density, reproductive success, mortality rates, and deer harvest trends were monitored within the treatment and control areas to evaluate potential impacts supplemental feeding may have had while 4-Poster devices were deployed during 2008-2010. Providing deer with supplemental food may contribute to enhanced reproductive success and increased deer densities. Starvation mortalities commonly result when population numbers are high and natural food resources become stressed or limited due to browsing pressure. However, supplemental food may suppress starvation mortalities and further contribute to increased deer densities (McCullough 1997, Schmitz 1990, McShea et al. 1997).

Monitoring Deer Population Growth

Deer population estimates were derived using spring and fall trail camera data collected within the treatment and control areas during 2008-2010; a capture-resight (Bowden's Model Estimation, NoRemark; White et al., 1982, White 1996) method and branch-antlered buck (BAB) method (Jacobson et al. 1997) were used. The capture-resight method was used to evaluate the appearance of marked deer compared to unmarked deer during spring and fall while the branch-antlered buck technique was used during fall when identification of individual, unique bucks (based on antler growth) was possible. These methods provided population estimates for the study areas and trail cameras were deployed at a density of roughly 1 camera/100 acres (range of deployment areas: 4.24 to 5.67 miles^2).

Mortality

The location, date, and cause of marked deer mortalities occurring within the treatment and control areas were recorded during 2008-2010. The percentages of marked deer mortality were derived by study year and cause of mortality. Changes in deer mortality were evaluated throughout the study (2008-2010).

Reproductive Success
Doe to fawn ratios were estimated for the treatment and control areas using fall trail camera data and techniques from the BAB population estimation (Jacobson et al. 1997); fall 2008-2010 ratios were evaluated. To further evaluate indices of reproductive success using the marked deer populations, fall trail camera photos were used to estimate the percentages of marked females (breeding age [> 2 years]) observed at camera bait sites that successfully reproduced each study year; these data were also used to evaluate the number of fawns each doe produced each year.

Dressed Deer Weights, Acorn Mast Crop, and Corn Consumption
*D*ressed weights obtained from adults, yearlings, and fawns harvested on Mashomack Nature Preserve (Shelter Island, treatment area) during the January special firearms seasons of 2005-2010 (TNC, Mashomack Nature Preserve) were used to evaluate weight changes as the study progressed. The dressed weights were evaluated as an additional indicator of the impact of supplemental feeding. Two-sample t-tests were conducted (SAS 9.2) to evaluate changes in weights for adults, yearling, and fawns between January 2008 (2007/2008 harvest season) and January 2010 (2009/2010 harvest season).

The acorn crop yield (seeds/meter^2) measured on Mashomack (TNC, Mashomack Nature Preserve and Marc Abram, Penn State University) was evaluated to document changes in acorn availability during 2007-2010; linear regression was used to identify trend strength. The total corn consumed (lbs) at 4-Poster devices during 2008-2010 was also examined. Acorn crop yield and corn consumption were evaluated as explanatory variables for changes observed throughout the study.

Assessments of Contact Rates and Potential Disease Transmission

Contact rates between deer may directly influence the establishment and spread of infectious diseases (Anderson and May 1986). Contact rates within free-ranging wildlife populations are influenced by social group structure, resource concentration (Miller et al. 2003, Gompper and Wright 2005, Wright and Gompper 2005), landscape structure (Fa et al. 2001, Guedlj and White 2004), and population density (Ramsey et al. 2002). Disease pathogens can be transmitted by direct contact, which requires close proximity spatially and temporally, or indirect contact, where close spatial proximity alone is common between animals. Some diseases such as bovine tuberculosis are transmitted through close physical proximity or near-simultaneous use of a site (O'Brien et al. 2002), thus the spread of this disease may increase with deer congregation at feeding sites (Miller et al. 2003, Palmer et al. 2004). Chronic Wasting Disease (CWD), a rare and fatal neurological disease, is transmitted through direct contact with saliva, urine, and feces as well as indirectly through contact with environmental contamination (i.e., shared food and water resources; Williams et al. 2002, Miller et al. 2004, Miller et al. 2006). Deer tend to aggregate in areas with high food availability (Miller et al. 2003, Gompper and Wright 2005, Wright and Gompper 2005) and contacts between animals are more likely in habitats where deer feed or seek cover and protection (Kjaer et al. 2008). Bait sites have also been shown to facilitate indirect and direct contact between deer and increase the potential for disease transmission (Williams et al. 2002, Miller et al. 2004, Mathiason et al. 2006). 4-Poster devices provide deer with supplemental food, contributing to direct and indirect contact between deer as they feed. Multiple deer feeding at bait (i.e., 4-Poster devices) increases the potential for disease transfer between animals (Quist et al. 1997).

Contacts (direct and indirect) between deer at 4-Poster devices within the treatment area were evaluated during 2008-2010 to identify the potential role of devices in facilitating disease transmission. Trail cameras obtained still-frame photos to monitor detectable indirect and direct contacts between deer at 4-Poster devices. A **direct contact** was considered simultaneous contact between a deer pair at a 4-Poster bait station. Direct contact involved touching such as nose-to-nose, sharing feeding ports, grooming behaviors, and sparring. An **indirect contact** between a deer pair at a device was recorded by the presence of 2 or more deer in a photo but no clear evidence of direct, simultaneous contact. Pearson's chi-square tests were conducted in SAS 9.2 (SAS Institute, Inc.) to discern differences between the number of contact types (no contact, direct contact, or indirect contact) for season, study year, device, sex, and age class. Direct and indirect contact probabilities between deer were calculated for individual marked deer observed in trail cameras photos and for each 4-Poster device deployed throughout the study. Contact probabilities were calculated as the number of direct or indirect contacts involving a marked deer divided by the total number of observations of device use by that marked deer. For each device deployed throughout the study, deer contact probabilities were calculated as the number of direct or indirect contacts divided by the total number of observation of deer using the device. Direct and indirect contact probabilities at each 4-Poster device were displayed using graduated symbols and examined spatial across the treatment area landscape using ArcGIS 9.2. For comparison, estimates of deer use per device, derived from trail camera photos and corn consumption records, were also displayed and spatially examined in ArcGIS 9.2.

Deer were baited into camera sites within the control area during 2 months (1 during spring and 1 during fall) each study year using corn piles available on the ground (open bait). To investigate if contacts between deer differed at open bait compared to 4-Poster devices, the deer contacts observed within the control area were compared with deer contacts within the treatment area for 2008-2010. Direct and indirect contact probabilities were calculated using trail camera data obtained from the control area and the treatment area during 1 month in spring and 1 month in fall each year to evaluate contact variation between different bait sources. Pearson's chi-square tests were conducted in SAS 9.2 to identify differences between contact types (no contact, direct contact, or indirect contact) at different bait sources (4-Posters within the treatment areas or open bait within the control) as well as relative to sex (male or female) and age class (adult, yearling, or fawn).

Using deer movement data obtained from GPS collars, interactions (potential contact events) between collared deer were examined. A potential contact event between a collared deer pair was defined by spatial and temporal matching of location data using ArcGIS 9.2 and SAS 9.2; the locations for each deer in a contact pair ocurred within 15 meters of each other and no more than 5 minutes apart. The 15 m spatial distance was determined based on GPS collar accuracy evaluation (Kjaer et al. 2008); location logging accuracy was evaluated in 4 different cover types and 2 season (leaf-on versus leaf-off). The average probabilities per contact pair were calculated and compared between the treatment and control areas. For contact pairs occurring within the treatment area, the probabilities of those contacts occurring at a 4-Poster device were evaluated.

Deer Vehicle Collisions

Supplemental feeding sites (i.e., 4-Poster devices) have been linked to increased deer activity and concentrated deer numbers in areas within close proximity to the bait source (McCullough 1997). Increasing deer activity near 4-Poster devices and altered movements to and from devices may have negative impacts on residential communities such as increased deer-vehicle collisions (DVCs).

DVC Trends

The number of DVCs that occurred yearly, between March and November, on the treatment and control areas prior to 4-Poster deployment (2005-2007) and during deployment (2008-2010) were obtained from the Shelter Island Police Department and North Haven Village officials to identify potential concerns related to device use within suburban environments. To identify changes in the number of DVCs occurring over time for the treatment and control areas, the numbers of DVCs were summarized and trends throughout time (2005-2010) were identified using linear regression in SAS 9.2 (SAS Institute, Inc.). Yearly traffic volume (AADT or average vehicles/day; Suffolk County and New York State DOT), yearly total number of deer harvested (Shelter Island Police Department, NYS DEC, and North Haven Village), mean road density (derived per km^2 using 2010 Census Tiger Line shape-files and ArcGIS 9.2), and traffic speed limits (mph) were summarized for the treatment and control areas as additional explanatory variables.

4-Poster Influence on DVC Occurrence

Using ArcGIS 9.2, DVCs were spatially paired with corresponding site variables including distance to the nearest 4-Poster device, nearest 4-Poster device identification number, road speed limit, traffic volume, percent of forest canopy, percent of impervious landscape features, density of roads, density of homes (homes/km^2 derived through digitization and analysis in ArcGIS 9.2), annual number of deer harvested, treatment type (treatment or control), and period (pre-treatment or during treatment). The pre-treatment period included DVCs occurring during 2005-2007 and the treatment period included DVCs occurring during 2008-2010 (Figure 19a).

Within ArcGIS 9.2, a layer of pseudo 4-Poster devices was created and overlaid on the control area (Figure 20a) based on legal device placement criteria (i.e., 300 feet from public roads, etc.), the same best management practices Cornell used for Shelter Island device placements (i.e., roughly a minimum of 20 ft from water sources), and the same device deployment density used on Shelter Island (Figure 20b). During the pre-treatment period (2005-2007), the 4-Poster device locations used on the treatment area during 2010 were considered pseudo 4-Poster devices for the treatment area; 4-Poster devices were actively used within the treatment area during 2008-2010 (Figure 2). Pseudo-devices were used during evaluation of the distances of DVCs occurrence to device locations.

Two-sample t-tests and ANOVAs (SAS 9.2, SAS Institute Inc.) were used to discern differences between the proximity DVCs occurred to the nearest actual or pseudo 4-Poster device within the treatment and control areas and over time (pre-treatment period, 2005-2007 and treatment period, 2008-2010).

Linear mixed model regression was conducted (SAS 9.2) to assess the impact of 4-Poster device presence on the distance DVCs occurred to the nearest device or pseudo-device within the treatment or control areas. The distance DVCs occurred to the nearest 4-Poster was used as the response variable and explanatory variables included road speed limit, traffic volume, the interaction between road speed limit and traffic volume, percent of forest canopy, percent of impervious landscape features, density of roads, density of homes, annual number of deer harvested, treatment type, period, the interaction between treatment type and period, and season (spring, summer, or fall). A final model was assessed using only significant explanatory variables. These analyses involved 2 levels of treatment type (treatment [4-Posters] or control [no 4-Posters] and 2 levels of period (pre-treatment [2005-2007, no 4-Posters] and during treatment [2008-2010, 4-Posters)]. The ID of the 4-Poster device (each device had a unique number) located nearest to each DVC was used as a random factor to account for clustering of DVCs. Linear mixed models were followed by pairwise comparisons for the interaction between treatment type and period using the LSMEANS statements of SAS 9.2; these comparisons specifically identified how the distance DVCs occurred to devices differed between periods (pre-treatment and during treatment) on the control area as well as on the treatment area. SAS 9.2 was used to ensure all residuals were normally distributed and verify no transformations were necessary (Zar 1999).

Vegetation Damage

Supplemental food sources can contribute to increased deer damage on vegetation near the available food source (Doenier et al. 1997, Schmitz 1990). 4-Poster devices provide deer with supplemental food that may alter movements and behavior, potentially contributing to negative impacts on the natural environment and the residential community where devices are deployed. Evaluation of deer browse damage on natural vegetation and landscaping within the control area and near 4-Poster devices within the treatment area, facilitated impact assessment of 4-Poster technology on deer feeding behaviors.

Natural Vegetation

White-tailed deer browse intensity sampling occurred at 12, 4-Poster devices within the treatment area (6 within SIA and 6 within SIB) and 6 locations within the control area during March and April of 2009 and 2010. Sampling sites were selected within the control area based on accessibility and permissions as well as known deer use. One 4-foot (1.2 meter) radius plot was established at distance classes of 0-33 ft (0-10 m; plot 1), 36-328 ft (11-100 m; plot 2), 331-656 ft (101-200 m; plot 3), and 659-984 ft (201-300 m; plot 4) from each sampling location. Each sampling plot was semi-permanent; the center of the plot was marked with a flag and the geographic coordinates of the location were recorded for use in subsequent years. Sampling plots were established within woodland edges or within woodlands where visible sign of deer use (i.e., scat and trails) was present.

Within each 4-ft radius plot, deer browsing impacts were characterized by sampling tree saplings and woody shrubs within the 0.5-6.0 ft (0.15 to 1.8 m) height class (deCalesta and Pierson 2005). Within each plot, all plants within a plot were sampled and the intensity of browsing on each plant was recorded as light, moderate, heavy, or severe (deCalesta and Pierson 2005). Light browsing intensity was defined as deer browse evidence on less than 50% of twigs in the 0.5-6.0 ft height interval. Moderate was defined as more than 50% of the twigs in the 0.5-6.0 ft height interval were browsed but the seedlings were not hedged and heavy intensity was defined as more than 50% of twigs in the 0.5-6.0 ft height interval were browsed and hedged (> 0.5 ft tall). Severe browsing intensity was defined as more than 50% of stems were browsed and seedlings were hedged to less than 0.5 ft tall (deCalesta and Pierson 2005). Within a plot, multiple seedlings of the same plant were characterized collectively; the browsing intensity for the plant species was determined based on intensity of 75% or more of the seedlings. The absence of browsing impact or lack of regeneration was recorded as no impact or no regeneration.

Ornamental Vegetation
Deer browse impact sampling on ornamental vegetation occurred at 12 homes within the treatment area and 6 homes within the control area during March and April of 2009 and 2010. Within the treatment area, homes located approximately 400-500 ft from a 4-Poster device and within the geographic boundaries of SIA (6 homes) and SIB (6 homes) were selected for sampling. Within the control area, 6 homes were selected for browse intensity sampling based on accessibility and permissions.

At each home, deer browsing impacts were recorded for all woody ornamental species. Browse intensity was evaluated on vegetation within a radius of up to 200 ft from residential structures (i.e., homes and garages). Browsing intensity was recorded as light, moderate, heavy, or severe, following the same sampling techniques detailed for natural vegetation (deCalesta and Pierson 2005).

To evaluate the impact 4-Poster devices may have had on the amount of deer damage occurring on natural and ornamental plants, the proportion of plots within the control and the treatment area containing high preference deer browse species and the proportion of plots containing low preference plants were evaluated. The proportion of plots in which no regeneration was observed was also examined. The percentages and total counts of natural and ornamental plants sampled within each area under each browse intensity category were examined for the 2009 and 2010 study years. Pearson's chi-square tests were used to discern differences between total counts of plants for each browsing intensity category for treatment type (treatment or control areas), distance class, and indicator species (plant species that are indicative of deer browsing preference).

Objective II: Investigation of Permethrin Residues

The investigation of permethrin residues addressed concerns of potential human exposure to permethrin via handling and consuming deer from 4-Poster treatment areas. Residue sampling was conducted during 2008, 2009, and 2010 to detect permethrin on deer hide and within deer muscles or organs. The results obtained from these investigations were intended to identify potential risks associated with hunting and consuming venison from areas where 4-Poster devices were deployed.
Sampling included collection of coat swabs, muscle tissues, and organ samples from deer on Shelter Island (treatment area) and North Haven, New York (control area). Samples were collected from the treatment area to identify potential permethrin residues hunters and their families may be exposed to when handling or consuming deer meat collected from areas where 4-Poster devices were used as a tick control method. Sample collection from deer on the control area, where no 4-Poster devices were used, was intended to identify permethrin residues that may be present on or within deer due to environmental exposures other than 4-Poster devices (i.e., broadcast lawn spraying as a tick control method).

Sampling protocols were established each study year with NYS DEC and NYS DOH input and review (Appendix 1). The Cornell Animal Health Diagnostic Center conducted all permethrin residue analyses for the 4-Poster Deer and Tick Control Study using standard minimum detection limits (mdl) of 10 ppb for muscle and liver analyses and 0.010 µg for coat swab analyses (Appendix 1). The protocol used for residue sample collection differed during each study year. During 2008, sample collections were conducted by Cornell staff following a careful and controlled protocol and included a coat swab (swabs of the neck hide to detect surface residues), neck muscle, and liver tissue (Appendix 1). The sampling protocol involved localized neck muscle sample collection and liver removal without skinning the hide from the entire deer. Additionally, a clean glove and scalpel exchange occurred during each sampling step and before each sample was collected (Appendix 1).

During 2009, sample collections were again conducted by Cornell staff and included a coat swab, neck muscles (both the left and right side of the neck pooled from each sampled deer), hindquarter muscle, and liver tissue. The sampling protocol involved carefully skinning the entire deer prior to muscle and liver sample collection. A clean glove and scalpel exchange occurred during each sampling step and before each sample was collected (Appendix 1). The final 2010 sampling season incorporated an additional protocol amendment to better inform the potential for residue presence when a hunter follows standard, safe deer handling and processing guidelines (Appendix 2). The safe handling guidelines were prepared by Cornell and reviewed by NYS DOH and NYS DEC officials prior to use. Samples were collected by a local hunter/meat processor, following the safe handling guidelines provided to him (Appendix 2). The process involved skinning the entire animal prior to muscle collection, a clean glove exchange between skinning and handling the meat or samples, and cleaning or exchanging knives between skinning and processing meat for consumption (i.e., sample collection). The samples collected included a coat swab, neck muscles (left and right), and hindquarter muscle; hindquarter muscle replaced the liver tissue collection to provide additional information for a muscle of highest human consumption.

Device use by identifiable, sampled deer was evaluated through trail camera photos. Using these photos, estimates of frequency and duration of device use, last date of known device use, devices used and potential amounts of tickicide exposure, were summarized. Device use information for each identifiable, sampled deer was evaluated and compared with residue detections on or within coat swabs and muscle samples. Additionally, the amounts of permethrin detected on coat swabs were compared with the amounts of permethrin detected within corresponding neck muscles to elucidate any correlation between known residue presence on the surface (dermal exposure) and presence within the muscles.

Objective III: Efficacy of 4-Poster System

4-Poster devices were deployed in up to 60 locations around Shelter Island and up to 8 locations around western Fire Island from late March through late November or early December, the period coinciding with combined activity of lone star (*Amblyomma americanum*) and blacklegged (deer) ticks (*Ixodes scapularis*). During late winter in early 2008 an informational brochure explaining the Study was prepared and distributed to the public on Shelter Island at the Town Hall, posted to the Town website and placed at the Robert Moses State Park (RMSP) main office. The study was also publicized though Shelter Island Town's Deer and Tick Committee, eastern Long Island newspaper reports and fundraisers, and several Shelter Island community meetings. Informative signage was placed at RMSP by park staff. From late 2007 through mid-2008 Cornell staff selected 4-Poster placement sites considering criteria such as compliance with Tickicide label restrictions (e.g. placement at least 300' away from homes, apartments, playgrounds and other areas where unsupervised children may be present), landowner permissions, evidence of deer activity (e.g. trails, browse damage to vegetation), accessibility to the applicator, obvious environmental risk (e.g. wetlands), ground site conditions and deer access (level surface, away from obstructions), and public visibility. Devices also must be at least 300' from public highways in New York State in accordance with the requirements of the SLN registration and New York State Environmental Conservation Law 11-0505(8) which states: "Interference with fish and wildlife … No person shall place, give, expose, deposit, distribute or scatter any substance with the intent to attract or entice deer to feed within three hundred feet of a public highway. Normal agricultural practice of planting, cultivating or harvesting and the feeding of deer held captive for agricultural purposes or the feeding of deer held captive in zoos and wildlife parks shall not be considered attracting or enticing deer to feed for the purposes of this section." New York State Vehicle and Traffic Law 134 defines "public highway" as "any highway, road, street, avenue, alley, public place, public driveway or any other public way. Extensive brush clearing for access was necessary in some cases. In May 2008 a Tickicide Supplemental label permitted devices to be placed within 100 yards of a home, apartment, playground or other place where children may be present without adult supervision, providing specific fencing and signage requirements were met. Several locations or relocations within the 100-yard limit of residences were used with landowner permission, provided with fencing and signage, during the remaining period of the study. Over the course of the study devices were serviced weekly (replenished with corn and Tickicide, rollers changed as needed – usually 5 – 7 sets required per unit) by or under supervision of New York State Category 8 licensed professional applicators; in 2009 and 2010 40 units outside Mashomack

Preserve on Shelter Island were serviced twice a week. Some units on Fire Island were also serviced a second time each week from late summer through fall. A Cornell staff person also visited Shelter Island devices weekly to check on servicing, provide repairs, and assist with maintenance and other issues. Devices on Fire Island were visited less often, usually every four to six weeks, during the deployment period. Applicators were asked to provide service records regularly to Cornell. Device locations were adjusted as needed based upon site conditions, citizen complaints, applicator access, minimize interference with hunting, or other issues. A Suffolk County exemption was secured in 2009 for continued deployment of units (devices 2, 4, 5, 6, 7, 21, 55) located on Suffolk County- or joint New York State/Suffolk County-owned properties. Suffolk County Code Chapter 380 (L.L. 34-1999) mandates a phase-out of pesticides in County buildings and properties by 2003 but exemptions can be granted by petition for health or other reasons. Devices were removed from the field in late fall, power-washed, trough covers or feed ports and posts removed, springs and other parts replaced as needed, then stored dry until the following season. Device locations, deployment dates, corn and Tickicide use and relocation sites are shown in Table 18. A list of project applicators is in Appendix 5.

Tick Sampling Methods

The Scope of Study called for fifteen one-minute flagging samples to be taken at each of three distances (‘tiers’, 10-100, 101-200, and 201-300 m) from three 4-Poster stations in each treated area with similar sampling to be done at control sites, conducted in June and again in July. After discussions with Dr. Scott Campbell (Laboratory Chief, Arthropod-Borne Disease Laboratory, Suffolk County Department of Health Services) and Dr. Howard Ginsburg (Research Ecologist, USGS Patuxent Wildlife Research Center, Kingston, RI), it was agreed to use 30 30-second samples (fewer ticks lost during shorter flagging while maintaining the total sampling time) at six locations and at the three distances from 4-Posters in each primary study site (Shelter Island North, Shelter Island South, North Haven); four sites with 4-Posters were also chosen and similarly sampled on Fire Island (three at Robert Moses State Park, one in Saltaire/Fire Island National Seashore). Repeat sampling in July, though desirable, was not done due to the expanded number of sites and to time and resource limitations. Sampling was timed to coincide with the period of nymphal activity of both tick species of concern, lone star (*Amblyomma americanum*) and blacklegged (deer) ticks (*Ixodes scapularis*).

Care was taken in randomly selecting sites in study areas from habitat with evidence of deer activity, where ticks were likely to be found, in areas unlikely to be disturbed (mowing, construction) and where access would be allowed throughout the study. The same sites for sampling were used each year, designated on a printed map for future reference and with GPS coordinates taken in or adjacent to the area. No attempt was made to selectively sample from only wooded or exposed sites, but consideration was given to include a variety of representative locations at all study sites within the distance selection constraints and preferably near but relatively undisturbed by human activity. Locations on North Haven were similarly chosen, starting from sites that might be used for deploying 4-Posters (i.e. met label requirements). Preliminary or historic data on tick abundance was not available to use in selecting sampling locations or for use in the analysis.

Sampling was conducted using a 32” x 48” (0.8m x 1.2m) flagging cloth of double-sided wide-wale white cotton corduroy material. This enabled sampling closer to the ground around common vegetation in shrubby and wooded sites where the originally specified $1m^2$ drag would not have worked. Although only data on nymph stages were called for, data were also collected on adults and larvae of both tick species, adults of American dog tick (*Dermacentor variabilis*) and habitat type (wooded, shrubby, grassy, herbaceous). In cases where two persons were conducting the sampling together data collection was divided equally (30 samples each). Sampling typically began around mid-morning after vegetation had dried, with flags changed as needed. Flags were washed in clear water only with no other material, dried and stored covered in a clean box to minimize risk of contamination. Sampling was initiated after early June and completed in as short a time as possible, starting on Shelter Island and proceeding to North Haven and finally Fire Island. Sampling was completed by early July in all cases.

Tick sampling data for all three years were formatted, checked for errors and provided to Dr. Ilia Rochlin, Entomologist with Suffolk County Dept. of Public Works, Division of Vector Control, who provided the analysis testing for significance at $p<0.05$. Data were analyzed by population (all stages combined) for each species, with separate analyses performed on lone star and blacklegged nymphs. Data on American dog tick (only adults were found) were extremely limited and not included in the analysis. The analysis was reviewed and lightly edited for flow and clarity.

Ears were taken each year from deer that had been used for residue analysis or from hunters, road kills or other sources (most in fall) and examined for ticks. Ticks found were classified by species and stage; data are reported in Table 19.

RESULTS

Objective I: Human and wildlife-associated risks due to change in deer movement and behavior.

White-tailed Deer Live-Capture & Movement

The 2008 and 2009 deer live-trapping seasons resulted in 97 marked deer within the treatment area (59 females and 38 males) and 41 marked deer within the control area (29 females and 12 males; Table 1). Thirty-two of the marked does were collared within the treatment area (17 GPS and 15 VHF) and 18 were collared within the control area (11 GPS and 7 VHF; Table 2). VHF locating error was estimated at 75 meters and GPS collars were logging locations with an approximate error of 15 meters.

Home range and core area estimates were derived for each collared deer within the treatment and control area during 2008-2010 (Table 3). Throughout the study, the mean home range size within the treatment area ($\bar{x}$ = 106.30 acres, n = 59) was larger than the mean home range estimate obtained from deer within the control area ($\bar{x}$ = 67.61 acres, n = 29; df = 85, P = 0.0063) while mean core area size did not differ between the treatment and control areas ($\bar{x}$ = 18.62, n = 59 and $\bar{x}$ = 14.47 acres, n = 29, respectively; df = 78, P = 0.1146). Further evaluation of size differences for each study year revealed the mean home range estimates did not differ between the treatment and control areas during 2008 ($\bar{x}$ = 108.50, n = 7 and $\bar{x}$ = 72.87, n = 3, respectively; df = 8, P = 0.6123) or 2010 ($\bar{x}$ = 98.81, n = 23 and $\bar{x}$ = 70.15, n = 12, respectively; df = 33, P = 0.1523). Core area estimates also did not differ between the treatment and control areas during 2008 ($\bar{x}$ = 20.97, n = 7 and $\bar{x}$ = 15.87, n = 3, respectively; df = 8, P = 0.711) or 2010 ($\bar{x}$ = 18.10, n = 23 and $\bar{x}$ = 14.21, n = 12, respectively; df = 33, P = 0.4088). However, during 2009, the mean home range estimate within the treatment area was significantly larger ($\bar{x}$ = 111.70, n = 29) than the estimate within the control area ($\bar{x}$ = 64.30, n = 14; df = 41, P = 0.0311), but the mean core area size did not differ between treatment and control ($\bar{x}$ = 18.47, n = 29 and $\bar{x}$ = 14.39, n = 14, respectively; df = 41, P = 0.3135). Mean home range and core area sizes were evaluated for each treatment type (treatment or control area) between study years (2008-2010). The analysis revealed no change in sizes within each area throughout the study (P > 0.8771, Table 4).

Throughout 2008-2010, movement data obtained within the treatment area from GPS collars provided significantly larger home range and core area estimates ($\bar{x}$ = 155.6 and 24.92 acres, n = 23 respectively) compared to VHF collars ($\bar{x}$ = 74.83, n = 36, P = 0.0004 and $\bar{x}$ = 14.60 acres, n = 36, P = 0.0067, respectively). Similarly within the control area, GPS home range and core area estimates ($\bar{x}$ = 99.10 and 21.76 acres, n = 13, respectively) were significantly larger than those obtained using VHF technology ($\bar{x}$ = 42.03 acres, n = 16, P < 0.0001 and $\bar{x}$ = 8.54 acres, n = 16, P < 0.0001, respectively).

For each individual collared deer, the percent overlap between core area geographic boundaries was evaluated between study years (Table 5). The minimum percent overlap calculated for the control area was 27.22% while the minimum percent overlap calculated for either treatment study area was slightly greater, 31.80% on SIA and

41.26% on SIB (Figure 3b). Within both treatment study areas and the control, no significant (< 10% overlap, Kilpatrick and Lima 1999) shifts in core areas were observed throughout the study.

The percent overlap observed for core areas did not differ between the treatment study areas and the control (SIA, SIB, and NH) for year time spans throughout the study (2008-2009, 2008-2010, and 2009-2010; df = 2, Mean Square = 177.60, P = 0.5177; Figure 3a,b). The mean percent overlap of core areas was 60.61% (n = 12) within the control area, 57.10% (n = 21) within SIA, and 53.10% (n = 13) within SIB. Differences in the percent overlap of core areas derived using data from GPS versus VHF collars were evaluated; GPS collars resulted in a mean percent overlap of 70.78% (n = 15) compared to VHF collars with a mean percent overlap of 50.16% (n = 31). GPS collars provided core area estimates that overlapped between study years significantly more than core area estimates derived using VHF data (df = 44, P < 0.0001).

On average, 1, 4-Poster device was found within the home range and core areas of collared deer during 2008 (n = 7) and during both 2009 (n = 29) and 2010 (n = 23), 2 devices were found within home ranges and 1 device within core areas; no significant differences in the number of 4-Poster devices located within either home ranges or core areas were observed between 2008-2010 study years (df = 2, Mean Square = 0.1934, P = 0.9208 and df = 2, Mean Square = 0.0142, P = 0.9816, respectively). The mean number of devices found within home ranges and core areas of collared deer from SIA ($\bar{x}$ = 2, n = 33 and $\bar{x}$ = 1, n = 33, respectively) and SIB ($\bar{x}$ = 2, n = 26 and $\bar{x}$ = 1, n = 26, respectively) did not differ (df = 57, P = 0.7640 and df = 57, P = 0.6995, respectively). The type of collar, GPS compared to VHF, had a significant impact on the number of devices found within home ranges and core areas. Throughout the study, more devices were found within GPS collared deer home ranges ($\bar{x}$ = 2, n = 23) compared to VHF collared deer home ranges ($\bar{x}$ = 1, n = 36; df = 57, P = 0.0008). Similarly, more devices were found within GPS collared deer core areas ($\bar{x}$ = 1, n = 23) compared to VHF core areas ($\bar{x}$ = 0.47, n = 36; df = 57, P = 0.0090). The maximum number of devices found within a home range was 7 and 4 within a core area. The minimum number within both home ranges and core areas was 0; 1 GPS collared doe and 7 VHF collared does did not incorporate 4-Poster devices into their ranges throughout the study (Figure 4).

Emigration and Immigration

Minimal emigration and immigration was observed within the marked deer populations within the treatment and control areas during 2008-2009 and none was observed during 2010. During 2008, no marked deer left the treatment area and 1 marked doe (25%, N = 4) left the control area for permanent relocation to Mashomack Nature Preserve (within the treatment area). During 2009, 3 marked males (3%, N = 94) and 0 marked females left the treatment area; marked males relocated to mainland (eastern Long Island) or the control area. Also, during 2009, 3 marked males (8%, N = 39) left the control area for Mashomack Nature Preserve and 2 marked does (5%, N = 39) traveled temporarily from the control area to other areas on the south fork of eastern Long Island.

Deer and Non-target Wildlife Use of 4-Poster Devices

Throughout 2008, 2009, and 2010, feeding activities at devices were dominated by deer, raccoons, squirrels, and birds (Figure 5). Photos suggested deer and raccoons consistently contacted the permethrin treated rollers when feeding from devices while squirrels infrequently contacted the rollers and birds were never observed making contact.

Wildlife use of devices was monitored during 2008-2010 and differences in relative use estimates for each animal were examined between study years. The relative numbers of deer using 4-Poster devices significantly differed between study years (F-value = 3.76, df = 2, P = 0.0240; Table 6). A greater relative number of deer used devices each month during 2010 ($\bar{x}$ = 43.95, n = 186) compared to 2008 ($\bar{x}$ = 35.46, n = 150, P = 0.0176) but use did not differ between any other years (Table 6, Figure 5). Although device use by squirrels and birds remained consistent each study year, the relative number of raccoons using devices differed (χ^2 = 15.29, df = 2, P = 0.0005, Table 6). Monthly device use by raccoons was significantly lower in 2010 ($\bar{x}$ = 24.18, n = 186) than in 2009 ($\bar{x}$ = 41.38, n = 186, P < 0.0001) and marginally lower than 2008 ($\bar{x}$ = 45.83, n = 150, P = 0.0932; Table 6, Figure 5).

Throughout the study, some seasonal variation in device use by deer, raccoons, squirrels, and birds was observed. During the spring seasons, squirrel (χ^2 = 30.64, df = 2, P < 0.0001) and bird (χ^2 = 9.11, df = 2, P = 0.0105) device use varied significantly while use by raccoons and deer did not (Table 7, Figure 6). The relative number of squirrels and birds observed using devices in 2009 ($\bar{x}$ = 25.97, n = 45, and $\bar{x}$ = 14.02, n = 45, respectively) was significantly higher than in 2008 ($\bar{x}$ = 7.75, n = 19, P = 0.0017 and $\bar{x}$ = 6.41, n = 19, P = 0.0051, respectively) or 2010 ($\bar{x}$ = 2.38, n = 48, P < 0.0001 and $\bar{x}$ = 4.66, n = 48, P = 0.0051, respectively; Table 8, Figure 6). The summer seasons were characterized by the greatest observed variation in device use by deer (F-value = 3.76, df = 2, P = 0.0249) and raccoons (χ^2 = 19.05, df = 2, P < 0.0001; Table 7, Figure 7). The relative number of deer observed using devices was higher during the summer of 2010 ($\bar{x}$ = 47.72, n = 71) than in 2008 ($\bar{x}$ = 34.99, n = 71, P = 0.0182) but did not differ from deer use observed during 2009 ($\bar{x}$ = 41.82, n = 71, P = 0.4111; Table 8, Figure 7). The relative number of raccoons using devices was highest in 2009 ($\bar{x}$ = 40.85, n = 71) compared to 2008 ($\bar{x}$ = 21.88, n = 70, P = 0.0003) and 2010 ($\bar{x}$ = 24.51, n = 71, P = 0.0002; Table 8, Figure 7). During the fall, the most significant differences in device use were observed by raccoons (χ^2 = 10.57, df = 2, P = 0.0051) and squirrels (χ^2 = 26.84, df = 2, P < 0.0001; Table 7, Figure 8). The relative number of raccoons using devices during fall 2010 ($\bar{x}$ = 23.21, n = 67) was substantially lower than observed in 2008 ($\bar{x}$ = 82.72, n = 61, P = 0.0024) and 2009 ($\bar{x}$ = 42.28, n = 70, P = 0.0412; Table 8, Figure 8). The relative number of squirrels observed using devices during fall was significantly lower during 2009 ($\bar{x}$ = 0.66, n = 70) than in 2008 ($\bar{x}$ = 8.30, n = 61, P < 0.0001) and 2010 ($\bar{x}$ = 2.99, n = 67, P = 0.0002; Table 8, Figure 8).

During each study year, differences in 4-Poster device use were evaluated between the spring, summer, and fall seasons. During 2008, the relative number of deer, squirrels, and birds using devices remained similar throughout the spring, summer, and fall (Table 9, Figure 9). However, the relative number of raccoons (χ^2 = 8.47, df = 2, P = 0.0145; Table 9) using device peaked in the fall ($\bar{x}$ = 82.71, n = 61) compared to use during both spring ($\bar{x}$ = 15.62, n = 19, P = 0.0724) and summer ($\bar{x}$ = 21.88, n = 70, P = 0.0066; Table 8, Figure 9). Throughout the 2009 study year, device use by deer and all other non-target wildlife remained consistent while in 2010, the relative number deer (F-value = 9.92, df = 2, P < 0.0001), squirrels (χ^2 = 11.35, df = 2, P = 0.0034) and birds (χ^2 = 16.32, df = 2, P = 0.0003) varied significantly between seasons (Table 9, Figure 9). The relative number of deer observed using devices was lowest in the spring ($\bar{x}$ = 28.62, n = 48) compared to use in summer ($\bar{x}$ = 47.72, n = 71, P = 0.0010) and fall ($\bar{x}$ = 50.90, n = 67, P = 0.0001; Table 8, Figure 9). Squirrel use was highest during the summer ($\bar{x}$ = 5.78, n = 71) compared to spring ($\bar{x}$ = 2.48, n = 48, P = 0.0394) and fall ($\bar{x}$ = 2.98, n = 67, P = 0.0015) while device use by birds was considerably lower in the fall ($\bar{x}$ = 2.76, n = 67) than in spring ($\bar{x}$ = 4.66, n = 48, P = 0.0004) or summer ($\bar{x}$ = 5.02, n = 71, P = 0.0015; Table 8, Figure 9).

Estimates of Deer Device Use

Corn Consumption Records

The total amount of corn consumed increased significantly between 2008 and 2009 (P < 0.0001) and then stabilized between 2009 and 2010 (P = 0.8509); 152,465 lbs of corn were consumed during 2008, 291,717 lbs during 2009, and 294,677 during 2010 (Figure 10a). Seasonally, the greatest consumption of corn occurred during summer of 2009 and 2010 (139,802 lbs and 145,764 lbs, respectively), and fall of 2008 (69,815 lbs; Figure 10b). Corn consumption was lowest during the spring season of each study year (range: 17,068 – 59,689 lbs; Figure 10b).

Similar to total corn consumption, the average estimated number of deer using a device increased significantly between 2008 ($\bar{x}$ = 223) and 2009 ($\bar{x}$ = 405, P < 0.0001) but no increase was observed between 2009 and 2010 ($\bar{x}$ = 409, P = 0.8509; Figure 11). Significant differences in the average estimated numbers of deer using a device were apparent between each season throughout a study year (P < 0.0001, Figure 11); summer typically had the highest estimated average number of deer using a device. During spring, the average estimated number of deer was lower in 2008 ($\bar{x}$ = 96) than either 2009 ($\bar{x}$ = 256) or 2010 ($\bar{x}$ = 246, P < 0.0001) and highest in 2009 (P = 0.0363). Both summer and fall estimates were significantly lower during 2008 ($\bar{x}$ = 259 and 277, respectively) than in 2009 ($\bar{x}$ = 518 and 392, respectively) or 2010 ($\bar{x}$ = 540 and 351, respectively, P < 0.0001; Figure 11). However, the average estimated number of deer using a device during summer and fall remained stable between 2009 and 2010 (P = 0.06940 and 0.2779, respectively; Figure 11).

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

Proportions of Marked Deer
The decimal proportion of marked deer observed using 4-Poster devices declined throughout the study (Figure 12). Roughly 85% of the marked deer population were observed visiting devices in trail camera photos during 2008 (*n* = 34 deer), 73% during 2009 (*n* = 93 deer), and 52% during 2010 (*n* = 75 deer). Seasonally, device use by marked deer was lowest during spring (range: 32 – 48% of the marked population; Figure 12). When comparing visitation by marked males and marked females, the percentage of marked females using devices were consistently higher (Figure 12).

Monitoring Deer Populations

Monitoring Deer Population Growth
Bowden and branch-antlered buck (BAB) population estimation methods revealed increasing deer abundance between 2008 and 2010 within the treatment and control areas (Table 10, Figure 13). On the treatment area, the Bowden method provided rough estimates of 53 deer/mi^2 in spring and 95 in fall of 2008 increasing to 171 in spring and 306 in fall of 2010 (Table 10). On the control area, the number of marked deer was too low to conduct a trail camera survey and derive a Bowden estimate during 2008. However, Bowden estimates were derived for 2009 and 2010; these estimates ranged from 92 deer/mi^2 in spring and 115 in fall of 2009 to 101 in spring and 165 in fall of 2010 (Table 10). The confidence intervals (95%), derived using Bowden estimation, were consistently wide, suggesting that actual deer densities could vary considerably from the estimated values (Table 10). Although deer density estimates derived using BAB methods provided similar increasing trends over time as compared with Bowden estimates (Figure 13), BAB estimates were consistently lower than Bowden estimates on the treatment and control areas during 2008-2010 (Table 10).

Mortality
During 2008-2010, a 34% mortality rate was observed for our marked deer population on the treatment area (n = 109) and a 9% rate on the control area (n = 55); hunter harvest (73% and 60%, respectively) and deer-vehicle collisions (DVC; 14 % and 40 %, respectively) accounted for majority of mortality observed throughout the study. On the treatment area, mortality within our marked deer population remained stable each year with the exception of 2010; 7 marked deer were killed (n = 41, 17% mortality) during 2008 while 20 were killed during 2009 (n = 94, 21% mortality) and 3 were killed during 2010 (n = 75, 4% mortality). Hunter harvest resulted in all of the mortalities accounted for during 2008 and 2010 but only 60% during 2009; DVC was the second highest cause of mortality during 2009 and accounted for 25%. On the control area, mortality within our

marked population remained stable throughout the study as well; 0 marked deer died during 2008 (n = 5, 0% mortality), 2 deer were killed during 2009 (n = 41, 5% mortality), and 1 deer died during 2010 (n = 37, 3% mortality). Nutritional stress was not observed as a source of mortality within our marked deer populations on either the treatment or control area.

Reproductive Success
Doe to fawn ratios remained stable on the treatment and control areas during 2008 (2:1 and 1:1, respectively), 2009 (1:1 and 1:1, respectively), and 2010 (1:1 and 1:1, respectively). Trail camera photos collected within both areas during September revealed the percentage of successfully reproducing marked does remained high during 2008 (86%, n = 7 and 100% n = 4, respectively) and 2009 (100%, n = 22 and 93%, n = 14) but declined slightly in 2010 (69%, n = 26 and 76%, n = 21). Within the treatment area, the percentage of the marked does with 1 fawn was higher than those observed with 2 fawns during 2008 (71% and 14%, respectively) and 2010 (39% and 31%, respectively); during 2009, a higher percentage of the does (64%) were observed with 2 fawns rather than 1 (36%). A similar trend was observed on the control area where the highest percentage of marked does had 1 fawn rather than 2 during 2008 (75% and 25%, respectively) and 2010 (43% and 33%, respectively) compared to 2009 (43% and 50%, respectively). Throughout the study on the treatment and control areas, no marked fawns were observed successfully reproducing during their first year. Marked does were never observed with more than 2 fawns per doe.

Annual Deer Harvest
The annual total number of deer harvested on the treatment area decreased during 2008 (245 deer) compared to the 2007 and 2006 harvest seasons (352 and 650 deer, respectively); an increased in harvest numbers were recorded during the 2009 season (423 deer; Figure 14). On the control area, the total number of deer harvested has fluctuated each year (Figure 15) but declined noticeably between 2007 (97 deer), 2008 (83 deer), and 2009 (46 deer; Figure 15).

Dressed Deer Weights, Acorn Mast Crop, and Corn Consumption
Subtle increasing trends were observed for the dressed weights of adult deer, yearlings, and fawns harvested on Mashomack Nature Preserve on Shelter Island during the January special firearms seasons of 2005-2010 (Figure 16). The mean dressed weights (lbs) for adult, yearling, and fawn males and females were significantly higher during the January 2010 season compared to those recorded during January 2008 ($P \leq 0.0347$; Table 11).

The acorn crop yield (seeds/m^2) also increased significantly between 2007 and 2010 (R^2=0.7161; Figure 17) while total corn consumption increased between 2008 (152,465 lbs) and 2009 (291,717 lbs) but leveled off into 2010 (294,677 lbs; Figure 10b).

Assessments of Contact Rates and Potential Disease Transmission

The percentage of no, direct, or indirect deer contact events differed between study years with 2008 being characterized by the greatest amount of no contact between deer at devices while indirect contacts increased substantially into 2009-2010 ($\chi^2 = 764.42$, $P < 0.0001$). Direct contacts between deer were consistently low throughout the study. In 2008, 63% (n = 1647 of 2599) of trail camera observations involved no contact between deer, 1% (n = 31) involved direct contact, and 35% (n = 921) involved indirect contact. During 2009, 39% (n = 3344 of 8473) of observations involved no contact, 3% (n = 229) involved direct contact, and 58% (n = 4900) involved indirect contact. Similar trends were observed in 2010 with 32% (n = 1849 of 5790) of observations involving no contact, 2% (n = 108) involving direct contact, and 66% (n = 3833) involving indirect contact between deer at devices.

Similarly, seasonal (spring, summer, and fall) differences were observed relative to deer contacts at 4-Poster devices ($\chi^2 = 386.45$, $P < 0.0001$). The percentages of no contacts, direct, and indirect contacts were all considerably higher in the fall (44%, n = 3017 of 6840; 61%, n = 225 of 368; 59% n = 5668 of 9654, respectively) compared to spring (27%, n = 1818; 20%, n=73; 22%, n=2107, respectively) or summer (29%, n = 2005; 19%, n = 70; 19%, n = 1861, respectively). Within a season, indirect contacts between deer were generally the greatest while direct contacts were substantially lower, occurring in no more than 3% of the observation of device use by deer.

The percentage of contact events between deer differed significantly at all 4-Poster devices distributed across the treatment area landscape ($\chi^2 = 1725.33$, $P < 0.0001$; Table 12). Of the 60 devices, 23 had higher percentages of no contacts occurring between deer compared to direct and indirect while 19 devices had the highest percentages of indirect contacts between deer compared to the other contact types. Direct contacts were consistently the lowest deer interaction type observed at all devices, occurring in 0-9% of the observations of deer use at all 60 devices (Table 12).

Sex and age class differences were also observed relative to deer contacts at devices ($\chi^2 = 32.40$, $P < 0.0001$ and $\chi^2 = 63.15$, $P < 0.0001$, respectively). The percentage of direct contacts between deer was highest when direct contacts involved females (85%, n = 264 of 310) and lowest when males were involved (5%, n = 15). Similarly, the percentage of indirect contacts was highest involving females (72%, n = 6100 of 8518) compared to males (12%, n = 1009). For both sexes, indirect contacts were the most common, occurring in greater than 95% of all observations. The highest percentage of direct deer contacts involved interactions between adults and fawns (53%, n = 196 of 368) while the highest percentage of indirect contacts occurred between adults (52%, n = 5034 of 9654). For all age classes, indirect contacts were most commonly (> 95%) observed compared to no contacts or direct contacts.

Bait source type (open bait piles versus 4-Poster devices) had little influence on interactions observed between deer within the control and treatment areas. Similarly on both the control and treatment areas, the percentages of no contacts, direct, and indirect contacts between deer significantly differed ($\chi^2 = 176.01$, $P < 0.0001$). Within the control and treatment areas, the highest percentages of deer interactions over either bait source type involved indirect contacts (71%, n = 6607 of 9266 and 62%, n = 6148 of 9873, respectively), followed by no contacts (27%, n = 2483 and 35%, n = 3496, respectively); the lowest percentages involved direct contacts (2%, n = 176 and 2%, n = 229, respectively). Additionally, on both the control and treatment areas, the percentages of direct contacts differed relative to the sex of the deer observed ($\chi^2 = 20.94$, $P < 0.0001$). Similarly, within the 2 areas, the percentages of indirect contacts also differed relative to the sex of the deer ($\chi^2 = 121.18$, $P < 0.0001$). The highest percentage of direct contacts involved females within both the control and treatments areas (67%, n = 105 of 157 and 86%, n = 168 of 195, respectively) while the lowest percentages involved males (13%, n = 21 and 3%, n = 6, respectively). Similar trends were observed for indirect contacts; the highest percentages involved females within the control and treatment areas (65%, n = 3923 of 6080 and 71%, n = 3824 of 5419, respectively) while the lowest percentages involved males (9%, n = 567 and 12%, n = 632, respectively).

The percentages of direct ($\chi^2 = 35.15$, $P < 0.0001$) and indirect contacts ($\chi^2 = 120.87$, $P < 0.0001$) occurring between deer on the control and treatment areas also differed relative to age class. The highest percentage of direct contacts observed on the control area involved adults (63%, n = 110 of 176) while the highest percentage of direct contacts on the treatment area involved adult to fawn interactions (52%, n = 120 of 229). The highest percentage of direct contacts between adult deer was observed on the control (59%, n = 110 of 186) compared to the treatment area (41%, n = 76) and the highest percentage of direct contacts involving adult to fawn or fawn to fawn interactions occurred on the treatment area (71%, n = 120 of 168 and 65%, n = 33 of 51, respectively) compared to the control area (29%, n = 48 and 35%, n = 18, respectively). The percentage of indirect deer interactions was the highest between adults on the control area (64%, n = 4201 of 6607). Similar trends were observed on the treatment area, with the highest percentage of contacts occurring between adult deer (54%, n = 3324 of 6148). Percentages of indirect adult to adult, adult to fawn, and fawn to fawn interactions were consistent between the control area (56%, n = 4201 of 7525, 46%, n = 1886 of 4058, and 44%, n = 502 of 1172, respectively) and treatment area (44%, n = 3324, 54%, n = 2172, and 56%, n = 652, respectively).

Evaluations of deer movement data obtained from GPS collars provided too few spatial-temporal matching pairs to analyze. Of the 16 potential collared deer pairs monitored on the treatment area during 2008, 3 spatial-temporal matching contact events occurred and of the 55 potential pairs monitored during 2009, 28 spatial-temporal matching contact events were detected. Similarly low contacts events occurred between collared deer pairs monitored within the control area, preventing further analysis and comparisons. One deer pair was evaluated during 2008 within the control area and 16 spatial-temporal matching contact events occurred between these deer; during 2009, 17 pairs were monitored and 19 spatial-temporal matching contact events were observed (all between the same deer pair). Contacts between collared deer were rare on both the treatment and control areas.

The probability of direct contact between deer at 4-Poster devices was consistently lower than the probability of indirect contact between deer. The average probability of direct contacts observed between marked deer throughout the study was 0.018 while the indirect contact probability was higher, 0.433. Throughout the study, the average probability of direct contact per 4-Poster device was 0.019, ranging from 0 to 0.091. The indirect contact probability per device was higher with an average of 0.441 and range of 0 to 0.800. Direct contact probabilities were consistently much lower over the treatment area landscape (Figure 18a) compared to indirect contact probabilities (Figure 18b). Indirect contact probabilities for each device corresponded with deer use indices derived for each device throughout the study; the devices with the highest deer use estimates derived from corn consumption records (Figure 18c) or from trail camera survey estimations (Figure 18d) were consistently located in the same areas with the highest probabilities of indirect contact between deer (Figure 18b). Also, areas (devices) with the highest probabilities of indirect contact between deer corresponded with knowledge of areas of the highest deer densities. A similar trend was observed for the direct contacts but the probabilities per device (Figure 18a) do not correspond as strongly with the deer use estimates (corn and trail camera; Figure 18c,d). Some sites were observed with high deer use estimates but low direct contact probabilities while other sites within Mashomack Nature Preserve had low deer use estimates but high direct contact probabilities (Figure 18a,c,d). However, typically the devices with the highest direct contact probabilities correspond to areas of known high deer densities and high device use by deer.

Within the control area, where open bait was available during 1 spring month and 1 fall month throughout the study, the probability of both direct and indirect contact between deer did not differ from the probabilities observed between deer at 4-Poster devices within the treatment areas during the same time frame. The average probability of direct contact per bait pile within the control area was 0.018, ranging from 0 to 0.034 and the average for indirect contacts was 0.691, ranging from 0.490 to 0.867. Within the treatment area, the average probability of direct contact per device was 0.018, ranging from 0 to 0.046 and the average indirect contact probability was 0.557, ranging from 0.129 to 0.798. The indirect contact probabilities observed within the treatment area were slightly lower compared with those observed within the control area.

Deer Vehicle Collisions

DVC Trends

On average, 52 DVCs occurred between March and November each year during 2005-2007 and 34 occurred each year during 2008-2010 within the treatment area (Figure 21). Within the control area, an average of 14 DVCs occurred each year during 2005-2007 and 13 each year during 2008-2010 (Figure 21). Within the treatment area, the number of DVCs significantly decreased over time (2005-2010; $n = 6$, Adj. R-Sq = 0.7127, Regression Coefficient = -0.1302, $P = 0.0216$; Figure 21). However, within the control area, no significant change in the number of DVCs occurring over time (2005-2010) was detected ($n = 6$, Adj. R-Sq = 0.0004, Regression Coefficient = -0.1375, $P = 0.3735$; Figure 21).

The traffic volume documented within the treatment area and control area increased each year between 2005 and 2007, peaking during 2007 with an average of 15,329 vehicles/day within the control area and 15,308 vehicles/day within the treatment area. A decline in traffic volume was recorded into 2008 within both areas but volume continued to decrease within the control area into 2010 while within the treatment area, traffic volume recovered and stabilized (Figure 22; NYS and Suffolk County DOT). The average road density was 3,372 roads/km^2 and the maximum was 16,017 roads/km^2 within the treatment area while within the control area, the average was 5,038 roads/km^2 and the maximum was 11,607 roads/km^2. Within both areas, the traffic speed limits range from 25 to 40 mph with higher traffic volumes typically occurring on roads characterized by faster speed limits.

The total number of deer harvested within the treatment area declined between 2006 (n = 650 deer) and 2008 (n = 245) and increased again into 2009 (n = 423; Figure 23). Within the control area, the number of deer harvested has fluctuated between 2005 and 2009, dropping from 98 deer during 2005 to 57 deer in 2006, increasing again during 2007 (n = 97) and 2008 (n = 83), and decreasing in 2009 (n = 46; Figure 23).

4-Poster Influence on DVC Occurrence

During the pre-treatment period, 2005-2007, the distances DVCs occurred to the nearest pseudo-device were significantly greater within the treatment area ($\bar{x}$ = 417.80 meters, n = 156) compared to the control area ($\bar{x}$ = 318.50, n = 42; df = 132, P < 0.0001). During the treatment period, 2008-2010, the distances DVCs occurred to 4-Poster devices deployed within the treatment area ($\bar{x}$ = 465.30 m, n = 103) did not differ from the distances DVCs occurred to pseudo-devices within the control ($\bar{x}$ = 380.90 m, n = 38; df = 139, P = 0.1813).

Within the treatment area, the distances DVCs occurred to the nearest devices during 2008-2010 ($\bar{x}$ = 465.30 m, n = 103) did not differ from the distances DVCs occurred to the nearest pseudo-devices during 2005-2007 ($\bar{x}$ = 417.80 m, n = 156; df = 153, P = 0.1955). Similarly, within the control area, the distances DVCs occurred to the nearest pseudo-devices during 2008-2010 ($\bar{x}$ = 380.90 m, n = 38) did not differ from the distances during 2005-2007 ($\bar{x}$ = 318.50 m, n = 42; df = 44, P = 0.2712).

Between 2005, 2006, and 2007, the distances DVCs occurred to the nearest pseudo-devices within the treatment area did not differ ($\bar{x}$ = 415.46 m, n = 65; $\bar{x}$ = 409.51 m, n = 49; $\bar{x}$ = 431.00 m, n = 42; df = 2, Mean-Square = 5520.97, P = 0.8779). However, between 2008, 2009, and 2010 within the treatment area, the distances DVCs occurred to the nearest 4-Poster devices were significantly different between years (df = 2, Mean-Square = 619124.20, P = 0.0029). The distances observed during 2008 were significantly greater ($\bar{x}$ = 625.23 m, n = 32) than distance during either 2009 ($\bar{x}$ = 369.68m, n = 40; P = 0.0027) or 2010 ($\bar{x}$ = 423.54, n = 31; P = 0.0339) but distances did not differ between 2009 and 2010 (P = 0.7564).

Within the control area, the distances to the nearest pseudo-devices did not differ between 2005 ($\bar{x}$ = 306.28 m, n = 19), 2006 ($\bar{x}$ = 338.72 m, n = 14), and 2007 ($\bar{x}$ = 312.72 m, n = 9; df = 2, Mean-Square = 4430.02, P = 0.6791). However, the distances DVCs occurred to the nearest pseudo-devices were significantly different between 2008, 2009, and 2010 (df = 2, Mean-Square = 381795.99, P = 0.0255). During 2010, the distances ($\bar{x}$ = 792.67 m, n = 4) were significantly greater than those observed in 2008 ($\bar{x}$ = 346.58 m, n = 15; P = 0.0360) or 2009 ($\bar{x}$ = 321.21 m, n = 19; P = 0.0218) but the 2008 and 2009 distances did not differ (P = 0.9687).

Road speed limit, traffic volume, the interaction between road speed limit and traffic volume, density of roads, treatment type, period, and the interaction between treatment type and period were identified as significant variables and used in the final mixed model (Table 13a). Percent forest canopy, percent impervious surfaces, density of homes, total number of deer harvested, and seasons had insignificant contributions to the model and were removed. The final model identified traffic volume and density of roads as significant continuous variables explaining the distance DVCs occurred to 4-Posters (P = 0.0567 and 0.0074, respectively; Table 13a). Slight increases in both traffic volume and road density are associated with an increase in the observed distance a DVC occurred to a 4-Poster (Table 13a). Treatment type (treatment or control) was a categorical variable that significantly explained the distance of DVC occurrence (P < 0.0001, Table 13a) and although period (pre-treatment, 2005-2007 or during treatment, 2008-2010) and the interaction between all treatment types and periods combined did not have significant fixed effects, the interaction between treatment type and period was a variable of importance when assessing 4-Poster impact and was evaluated for each pair combination (Table 13b). Pairwise comparisons derived using LSMEANS identified no significant differences between the distances DVCs occurred to pseudo devices within the control areas during the pre-treatment and during treatment periods (P = 0.9601; Table 13b). However, within the treatment area the distances DVCs occurred relative to 4-Poster devices were significantly different between the pre-treatment and during-treatment periods (P = 0.0388, Table 13b). The distances were significantly greater during treatment ($\bar{x}$ = 563.23 meters, df = 67.3, P < 0.0001) than pre-treatment ($\bar{x}$ = 501.68, df = 56.7, P < 0.0001; Table 13b).

Vegetation Damage

Natural Vegetation
Between 2009 and 2010, the percentages of unbrowsed natural plants sampled within the control area (49%, n = 62 of 127 and 51%, n = 65) and SIA (46%, n = 142 of 308 and 54%, n = 166) remained stable while within SIB, significantly less unbrowsed vegetation was observed as the study progressed (65%, n = 335 of 513 and 35%, n = 178, respectively; χ^2 = 32.78, P < 0.0001, Figure 24). No changes in the percentages of lightly browsed natural vegetation were observed within the control or treatment study areas between 2009 and 2010 (χ^2 = 1.56, P = 0.4583, Figure 24). The percentages of moderately and heavily damaged vegetation significantly differed between study years (χ^2 = 11.52, P = 0.0031 and χ^2 = 13.01, P = 0.0015, respectively). Although the percentages of moderately browsed vegetation remained stable within the control and SIB between 2009 and 2010 (45%, n = 9 of 20 and 55%, n = 11; 48%, n = 62 of 129 and 52%, n = 67, respectively), the highest percentage increase between 2009 and 2010 was observed in SIA (17%, n = 6 of 46, and 83%, n = 30, respectively; Figure 24). Heavily browsed percentages showed similar trends; percentages remained stable within the control area between 2009 (49%, n = 72 of 147) and 2010 (51%, n = 75) while SIA and SIB had higher percentages of heavily browsed plants sampled during 2010 (77%, n = 44 of 57 and 69%, n = 24 of 35, respectively) compared to 2009 (22%, n = 13 and 31%, n = 11 of 35, respectively; Figure 24). In all areas, too few plants were sampled with severe damage for statistical comparisons between study years.

For natural indicator species classification, oaks (*Quercus* spp.) were considered high preference indicator species, cherry (*Prunus* spp.) were medium preference, and American beech (*Fagus grandifolia*) were low preference. Limited data were available for high preference and low preference species within all areas each study year thus no statistical analysis was possible. For the medium preference natural indicator, not enough data was available for the light, moderate, heavy, and severe browse intensity classifications to obtain valid statistical conclusions. However, evaluation of the not browsed classification revealed no significant differences between the percentages of unbrowsed medium preference indicators sampled between 2009 and 2010 in either SIA or SIB (χ^2 = 3.25, P = 0.0713, Figure 25); no unbrowsed medium preference data was available for the control area.

Within the control area, high preference natural plants were present in 8% of plots sampled during 2009 (2 of 24) and 2010 (2 of 24). Similarly low percentages were present within both treatment study areas; 0% within SIA and 8 and 4% within SIB between 2009 and 2010. The proportion of plots containing low preference plants did not change between study years for the control area or the treatment areas; 8% of plots contained low preference species within the control area during 2009 and 2010, 25% of 2009 plots and 17% of 2010 plots within SIA, and 25% of plots within SIB during both 2009 and 2010. The proportion of plots containing non-preferred plants was much higher in all areas. Roughly 75% of plots within the control, 88% of plots within SIA, and 96% of plots with SIB contained non-preferred deer browse species; the proportion of plots did not change throughout the study. The control area had the highest proportion of plots with no regeneration (21%, n = 5 of 24 plots; Figure 29) while SIA had 8% and SIB had 0%; the proportion of plots with no regeneration did not change throughout the study. Regeneration of low preference or non-preferred plants was the only evidence of regeneration in all areas each year.

Within the treatment area, the percentages of unbrowsed plants differed for plots (distance classes) between study years (2009 – 2010; χ^2 = 37.26, P < 0.0001). The percentages decreased in plots 1, 2, and 4 between 2009 (65%, n = 107 of 166, 71%, n = 142 of 201, and 57%, n = 144 of 254, respectively) and 2010 (36%, n = 59, 29%, n = 59, and 43%, n = 110, respectively) but increased within plot 3 (42%, n = 84 of 200 and 58%, n = 116). The percentages of lightly browsed and moderately browsed plants also differed for plots between study years within the treatment area (χ^2 = 17.59, P = 0.0005 and χ^2 = 37.48, P < 0.0001, respectively). The percentages of lightly browsed plants decreased in plots 3 (60%, n = 78 of 131 and 41%, n = 53, respectively) and 4 (57%, n = 122 of 215 and 43%, n = 93, respectively) increased in plot 2 (37%, n = 46 of 126 and 63%, n = 80, respectively), and remained stable in plots 1 between 2009 and 2010 (48%, n = 44 of 92 and 52%, n = 48, respectively). An increase in the percentages of moderately browsed plants was observed within plots 1 and 2 between 2009 and 2010 (29%, n = 21 of 73 and 71%, n = 52; 10%, n = 3 of 29 and 90%, n = 26, respectively) and a decrease in plots 3 and 4 was observed between study years (75%, n = 6 of 8 and 25%, n = 2; 69%, n = 38 of 55 and 31%, n = 17, respectively). Within each plot (distance class) there were no differences in the percentages of heavily browsed plants observed between 2009 and 2010 ($\chi^2 = 1.26$, $P = 0.5336$) and too few severely browsed plants were recorded during field surveys for meaningful statistical evaluation.

Within the control area, the percentages of unbrowsed and heavily browsed plants recorded within plots did not differ between 2009 and 2010 ($\chi^2 = 0.3523$, $P = 0.9499$ and $\chi^2 = 0.3430$, $P = 0.9517$). During field sampling, too few lightly, moderately, and severely browsed plants were recorded within individual plots on the control area during 2009 and 2010; no statistical evaluation was possible.

Comparisons between all areas revealed that the treatment study areas consistently had significantly higher percentages of unbrowsed, lightly browsed, and moderately browsed plants within all plots (distance classes) compared to the control area ($\chi^2 = 111.32$, $P < 0.0001$, $\chi^2 = 28.91$, $P < 0.0001$, and $\chi^2 = 65.97$, $P < 0.0001$, respectively). However, the percentages of heavily browsed plants were significantly higher within all plots in the control area compared to the treatment study areas ($\chi^2 = 30.05$, $P < 0.0001$). Severely browsed plants were sampled too infrequently to conduct statistical analyses. Evaluation of the percentages of plants sampled as unbrowsed, lightly, moderately, or heavily browsed, across plots (distance classes) for each area revealed no discernable trends across distance classes nor differences between areas (Table 14, Figure 26).

Ornamental Vegetation

Of the ornamental plants that were recorded as not browsed by deer during 2009, the percentages were highest within the control area (39%, n = 350 of 893) and SIB (43%, n = 387) compared to SIA (17%, n = 156; $\chi^2 = 15.53$, $P = 0.0004$, Figure 27a). Similar trends were observed during 2010, with higher percentages of unbrowsed ornamentals found within the control (32%, n = 367 of 1131) and SIB (52%, n = 589) compared to SIA (15%, n = 175; $\chi^2 = 15.53$, $P = 0.0004$, Figure 27b). Light browsing damage by deer on ornamental plants did not differ between areas in 2009 or 2010 ($\chi^2 = 3.56$, $P = 0.1685$, Figure 27). Of the moderately browsed ornamental plants surveyed during 2009 and 2010, the percentages of plants browsed significantly differed between areas ($\chi^2 = 51.66$, $P < 0.0001$). During 2009, the percentages of plants browsed were significantly lower within the control (19%, n = 25 of 132) and SIB (28%, n = 37) compared to SIA (53%, n = 70, Figure 27a). However, during 2010, the greatest percentage of moderately browsed ornamentals was sampled within the control area (59%, n = 114 of 194) compared to SIA (29%, n = 57) and SIB (12%, n = 23, Figure 27b). Heavy browse damage on ornamental plants also differed between areas during 2009 and 2010 ($\chi^2 = 77.93$, $P < 0.0001$, Figure 27). During 2009, the highest percentage of heavily browsed plants was sampled within SIA (40%, n = 88 of 220) compared to the control (28%, n = 61) and SIB (32%, n = 71, Figure 27a). During 2010, differences between areas were more discernable; the highest percentage of heavily browsed ornamentals was observed within the control area (71%, n = 133 of 187) compared to both SIA (19%, n = 36 of 187) and SIB (10%, n = 18, Figure 27b). Throughout the study, severe damage to ornamental plants was significantly different between areas ($\chi^2 = 10.94$, $P = 0.0042$, Figure 27). During 2009, the percentage of severely browsed plants documented within the control area (60%, n = 68 of 113) was significantly greater compared to SIA (25%, n = 28) and SIB (15%, n = 17, Figure 27a). However, during 2010 fewer severely damaged plants were observed and the percentages varied minimally between the control (31%, n = 14 of 45), SIA (44%, n = 20), and SIB (24%, n = 11, Figure 27b).

For ornamental indicator species classification, rhododendrons and azaleas were considered high preference indicator species, viburnum spp. were medium preference, and boxwood spp. were low preference. The browse damage levels on high preference indicator plants were evaluated between areas and study years revealing that too few high preference plants were recorded with no evidence of browsing damage or light browsing damage for statistical evaluation (Figure 28). For moderate, heavy and severe levels of damage no differences were detected between study years and area ($\chi^2 = 3.05$, P = 0.2173; $\chi^2 = 1.28$, P = 0.5262; and $\chi^2 = 0.7194$, P = 0.6979, respectively; Figure 28). However, sample sizes of high preference species were low in each area due to a heavy history of damage by overabundant deer. Sample sizes were also too low for adequate analysis of differences in browse intensity between areas and study years on the medium preference ornamental indicator species; too few plants of medium preference were sampled under each browse intensity category for all areas (Figure 28). For the low preference ornamental indicator, the percentages of unbrowsed plants did not differ between areas and study years ($\chi^2 = 0.5456$, P = 0.7613); samples sizes were too low for all other browse intensity categories (light, moderate, heavy, and severe; Figure 28).

Objective II: Investigation of Permethrin Residues

Permethrin residue investigations occurred during 2008-2010; 39 deer from the treatment area and 15 deer from the control area, were harvested and sampled.

During 2008-2010, 36 of 39 deer sampled from the treatment area had positive detections of permethrin on the coat swabs, 6 of 39 deer had positive detections within the neck muscles, 0 of 29 had positive detections in the livers, and 0 of 23 had positive detections within the hindquarter muscles (Table 15a). Of the 6 positive neck muscle detections, 3 occurred during the 2008 sampling season, and 3 occurred during the 2010 sampling season (Table 15a).

Of the 15 deer sampled from the control area during 2008-2010, 10 of 15 had positive detections on the coat swabs, 0 of 15 had positive neck muscles, 0 of 11 had positive hindquarter muscles, and 0 of 10 had positive livers (Table 15b).

Coat Swab Detections

The highest amounts of permethrin (µg) detected on coat swabs during 2008-2010 ranged from 281.88 to 5,296 µg (Table 16). The majority of samples obtained throughout the study were collected from deer observed in trail camera photos using 4-Poster devices at least once during a monthly (3-4 days per month) survey. The residue levels detected on coat swabs obtained during 2010 were lower than those collected during both 2008 and 2009 (Tables 15 and 16). Although deer use of 4-Poster devices did not differ during fall each year (df = 2, P = 0.0925; Table 7 and Figure 8), we had very few identifiable deer (unique identifier present such as ear tags, antler development, or injuries) using devices on a consistent basis during fall 2010. Corn consumption records indicated slightly less corn being consumed during fall 2010 compared to Fall 2008 and 2009 (Figure 30), and the number of acorns available to deer as natural forage was plentiful during both 2009 and 2010 compared to 2008 (Figure 17).

Muscle Detections

The amount of permethrin (ppb) detected within muscle samples ranged from 11.2 to 270.3 ppb (Table 15a). Permethrin was detected in muscle samples only during 2008 and 2010, and the highest muscle detection occurred during 2008. Only muscle samples collected from the neck regions of sampled deer resulted in positive permethrin detection during laboratory analysis. There were no positive detections in hindquarter muscles.

There were no consistent associations between coat swabs results and positive neck muscle detections (Figure 34). Of the 39 deer sampled, 2 deer (2008) had elevated levels of permethrin on both the coat swabs and corresponding neck muscles (Table 15a and Figure 34). However, trends were not evident for any other samples, and high coat swab detections were often associated with no permethrin detections within corresponding muscle samples (Figure 34).

Deer Device Use & Residue Correlation

Limited device use information was available for each identifiable deer sampled (Appendix 4). Although the frequency of device visitation and feeding durations could be compared with coat swab detections, results were variable. The limited amount of device use information available for each deer sampled made it difficult to conclusively associate more frequent visitation and longer feeding durations with higher coat swab amounts (Figures 31 and 32). The number of days between the last known device use and sample collection also yielded variable results when compared with coat swab detection amounts. There was no strong evidence linking higher coat swab amounts with shorter time durations between the last device visitation and sample collection (Figure 33).

When possible, supplemental information obtained from trail cameras, deer harvest records, and 4-Poster device maintenance records were used to evaluate trends. Specifically, we examined the amount of permethrin detected either on coat swabs or within muscle samples and the number of days between when the deer was harvested and when it was last observed using a device, or the number of days between harvest and when the device was last treated with permethrin (this device was based on either last device used as observed in trail camera photos, or assumed based on closest device at the time of harvest; Table 17). The number of days between harvest and when the deer last used a device, or when a device was last treated with permethrin did not correspond with either the presence or amount of permethrin detected on coat swabs or within muscles (Figures 35 and 36).

Objective III: Efficacy of 4-Poster System

4-Posters

Observations from 4-Poster deployment in 2008 indicated that rollers were becoming dry between weekly servicing, sometimes within a short period after applicator visits. The commercial applicator contract for Shelter Island was revised for 2009 – 2010 to call for servicing twice a week for the 40 units outside Mashomack Nature Preserve. Suffolk County Dept. of Public Works, Division of Vector Control staff serviced the 20 Mashomack units in 2009 - 2010, where corn consumption tended to be lower on average, and continued to provide weekly servicing. Additional weekly servicing of 4-Posters on Fire Island was provided during high consumption periods. Vandalism and disturbance of 4-Posters was low during the study period. Some Shelter Island community opposition to the study was expressed based on costs, concern for permethrin residues in groundwater and on deer, and interference with hunting; these issues were addressed by NYS Department of Environmental Conservation, NYS Department of Health, and Cornell staff at public meetings, in reports, and in hunter handling guidelines. Based on discussions with community members, particularly after questions were answered, most were in support of the study and its objectives. Although there seemed to be a general awareness of high tick populations on Shelter Island, a relatively high local incidence of Lyme disease, and general use of landscape applications for tick control in the community, there was little understanding of the extent to which permethrin or other pyrethroid insecticides were already used and the potential for 4-Poster technology as an alternative approach.

Excluding second (doubled) units, in 2008 on Shelter Island corn use ranged from 4.0 to 19.9 lb/device-day (mean 12.2 lb). The deployment period and Tickicide use averaged 236.2 days and 1840 ml (0.49 gal) per device, respectively, using 1000 to 5235 lb corn (mean 2769 lb) for all units. On Fire Island, excluding doubled units, corn use in 2008 ranged from 14.6 to 20.4 lb/device-day (mean 17.8 lb). 4-Posters were deployed there an average of 262.3 days using 3027 ml (0.80 gal) Tickicide and from 3915 to 5245 lb corn (mean 4680 lb).

In 2009 consumption tended to be higher at all locations. On Shelter Island there were no doubled units in 2009 primarily due to servicing twice during the week at locations outside Mashomack where demand tended to be highest; corn use ranged from 5.3 to 35.4 lb/device-day (mean 19.8 lb) and the deployment period averaged 260.1 days using 3909 ml (1.03 gal) Tickicide per device and 1250 to 9250 lb corn (mean 5159 lb) among all units for the season. On Fire Island, excluding the doubled unit, corn use ranged from 19.7 to 37.1 lb/device-day (mean 27.3 lb); the deployment period averaged 267.9 days per unit using 5044 ml (1.33 gal) Tickicide for each 4-Poster and 5425 to 9899 lb (mean 7284 lb) for the season.

In 2010 consumption was similar to 2009 levels. On Shelter Island corn use ranged from 9.1 to 33.6 lb/device-day (mean 20.0 lb) and 2300 to 8510 (mean 5058 lb) overall for all units. The deployment period and Tickicide use averaged 252.3 days and 3848 ml (1.02 gal) respectively. On Fire Island, excluding the doubled unit, corn use ranged from 22.0 to 40.6 lb/device-day (mean 28.2 lb). The deployment period and Tickicide use there averaged 248.1 days and 4420.5 ml (1.17 gal) respectively, using 5400 to 10225 lb corn (mean 7008 lb) overall.

Within each year corn consumption generally increased from initial placement into early September, sharply declining with acorn fall and remaining relatively low until late October, when consumption gradually increased.

A number of issues were encountered with the 4-Poster device technology during this study. The applicator gun is a notably weak point, at least when used to the extent in this study. A modified livestock drenching gun, it frequently failed for various reasons (usually the adjustment dial separated from the housing) for the applicator on Shelter Island. Occasionally a plunger seal would wear out with use (in one instance it disintegrated entirely shortly after put into service). Printed dosage markings on some models wore off with time and as rollers become somewhat compressed after the first week of use the applicator hood extends beyond the roller nap during treatment, requiring the gun to be carefully angled to assure material is dripped onto the roller (one applicator retrofitted posts with a 1" escutcheon, placed under rollers and oriented to catch drips). Rollers can be inverted but this is only temporarily helpful. During application the top edge of the rollers is treated; it is understood that over time material moves down through gravity and capillary action but under the heavy use in the trial areas the lower portion of the rollers were often dry. The post springs are undersized for the task. Nearly all failed within the first year, usually from overextension. Inexpensive stock replacement springs (13/16" dia x 4" x 0.120", safe working load 61.7 lb) from a local hardware supply were found to fit without modification and have rarely failed. This also corrects the problem of posts resting at an angle due to normal expansion of the spring coils in the original installation, and reduces corn packing and binding in the post 'joint.' A simple tool was improvised and found helpful to use in the field for quick replacement of springs.

Other modifications to the device design could also reduce maintenance time. Periodically chewed corn and debris build up behind the vertical feed ports requiring the trough cover to be removed (9 screws, each side) to access for cleaning. The device is designed to allow ports to be lifted with the removal of two screws but this is not practical when devices are loaded with corn. The screws are fastened into metal inserts molded into the unit housing; these inserts easily strip out (particularly as screws begin to corrode) making for a complicated repair job. The trough cover might be tabbed in to the hopper base on the hopper side (which may help with minimizing water intrusion from this seam) and fastened at the trough side with two panel fasteners (e.g. Dzus™) to make access simple and quick. Rodent damage, presumably from squirrels, was a constant issue particularly during the first year and included chewing of component edges and holes chewed through the hopper cover. The fit between hopper and base is not quite tight along the sides; corn falls from the gap and appears to incite chewing damage to this area. Nearly all plastic feed ports were heavily chewed and required replacement with metal ones by the second year. Although it is understood that locating 4-Posters in wooded areas or under tree canopies tends to increase problems with squirrel damage, there are very limited areas on Shelter Island where devices can be located; sites were chosen away from public view as possible while maintaining access for deer. Squirrel damage was repaired in the field using ordinary aluminum flashing and adhesive. Squirrel damage was not an issue on Fire Island, and some units were located there with visibility less a concern or even used for public education purposes.

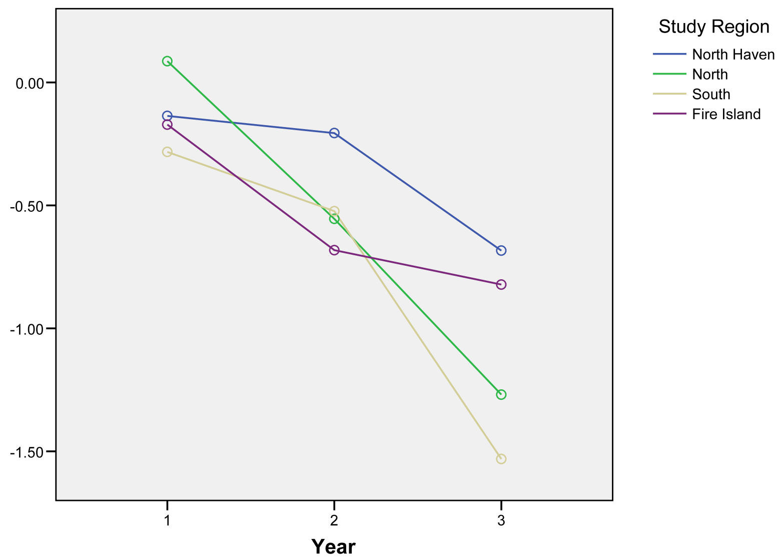
Tick Sampling

Study Sites

The average tick abundance per device and tier was compared by repeated measures ANOVA with years (=2008, 2009, and 2010) as a within-subject factor. The average tick abundances were log-transformed to dissociate the variance from the mean and to meet the assumptions of normality, homogeneity of variances, and sphericity. Sphericity was assumed violated if Mauchly's test was significant at $p<0.05$ and if found, the violations were indicated in the text.

Both the main effect of Year, $F(2,118)= 219.4$, $p<0.001$, and the interaction term Study Site * Year $F(6,118)= 14.9$, $p<0.001$ were significant suggesting differences among the three years and among the study sites within each year. Tick abundance differed among the study sites, $F(3,59)= 6.8$, $p=0.001$. The *a priori* contrasts between the reference study site (North Haven) and each of the three treatment sites (North, South, and Fire Island) were all significant at $p<0.05$ (not shown) suggesting that the tick abundance at the reference study sites differed from tick abundances at the treatment study sites over the three year period (also see the profile aka trend plot below).

Profile Plots of Tick Abundance by Site Year (1=2008, 2=2009, 3=2010)



The temporal trends (2008 – 2009 – 2010) in tick abundance within each study site were compared by repeated measures ANOVA followed by pairwise comparisons among the three years at $p<0.05$ adjusted for multiple comparisons. The level of overall statistical significance for ANOVA was also Bonferroni-adjusted for multiple comparisons (n=4) at $\alpha=0.0125$. All three treatment sites, but not the reference site, experienced significant declines in tick abundance in 2009 compared to 2008 (Table A). All sites experienced significant declines in 2010 compared to both 2008 and 2009.

Table A. Tick abundances by study area and trends over time

Site	**Significant differences among Years at adjusted p<0.0125**	**Pairwise comparisons at adjusted p<0.05**
North Haven	$F(2,34)= 29.9$, $p<0.001$	2008=2009; 2009>2010; 2008>2010
North	$F(2,32)= 96.6$, $p<0.001$	2008>2009; 2009>2010; 2008>2010
South	$F(2,30)= 86.0$, $p<0.001$	2008>2009; 2009>2010; 2008>2010
Fire Island	$F(2,22)= 41.5$, $p<0.001$	2008>2009; 2009>2010; 2008>2010

The spatial trends (among study sites) in tick abundances at the study sites within each year were compared by univariate ANOVA. The level of overall statistical significance for ANOVA was Bonferroni-adjusted for multiple comparisons (n=3) at $\alpha=0.0167$. If the omnibus test was significant at $p=0.0167$, each treatment study site (North, South, or Fire Island) was then compared to the reference site (North Haven) by *a priori* planned contrasts. Tick abundances were similar among the study sites in 2008 (Table B). In 2009, all three 4-Poster study sites had significantly lower tick abundances compared to the reference site. In 2010, two treatment sites (North and South) had had significantly lower tick abundances compared to the reference site, while tick abundances at Fire Island (treatment) and North Haven (reference) sites were statistically similar.

Table B. Tick abundances by year and comparisons with North Haven

Year	Significant differences among study sites at adjusted p<0.0167	Planned contrasts at p<0.05
2008	F(3,62)= 2.8, p=0.045	None (omnibus test not significant)
2009	F(3,62)= 6.3, p=0.001	North Haven>North; North Haven>South; North Haven>Fire Island
2010	F(3,62)= 19.7, p<0.001	North Haven>North; North Haven>South; North Haven=Fire Island

DEVICES WITHIN EACH STUDY SITE

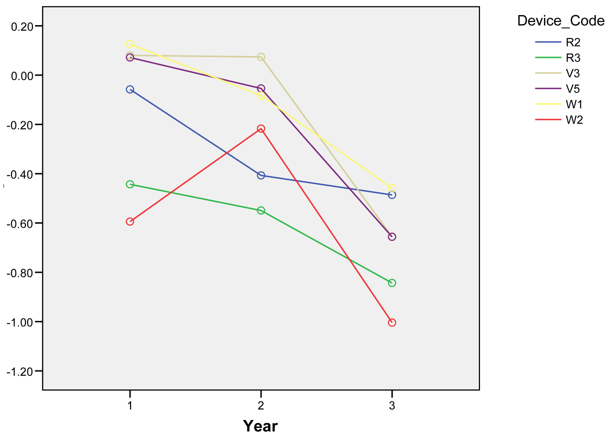
Within each study site, the temporal trends in tick abundance were compared by repeated measures ANOVA for each device at each site separately, followed by pairwise comparisons between different devices at adjusted p<0.05. The level of statistical significance for ANOVA was Bonferroni-adjusted for multiple comparisons at α=0.0125. There were significant differences in tick abundances at all sites among the three years (Table C, and Year, main effect and profile plots). With the exception of the treatment area North (likely due to device #11 Gardiner's Bay CC, west of shed, see the profile plot), there were no significant differences among devices within each Year (Table 3: Year*Device interaction term). Overall, annual differences among the 4-Poster devices within each study site were not significant for all sites (Table 3: Between Subjects), so no pairwise comparisons were performed. In other words, although within each of the study sites tick levels varied significantly from year to year, within the same year the levels were similar among all devices within that study area with the exception of the North Study area. Inside each study area, when comparing how tick levels changed among devices, there appear to be no significant differences.

Table C. Tick abundances within each study site – effect of year, device and interaction

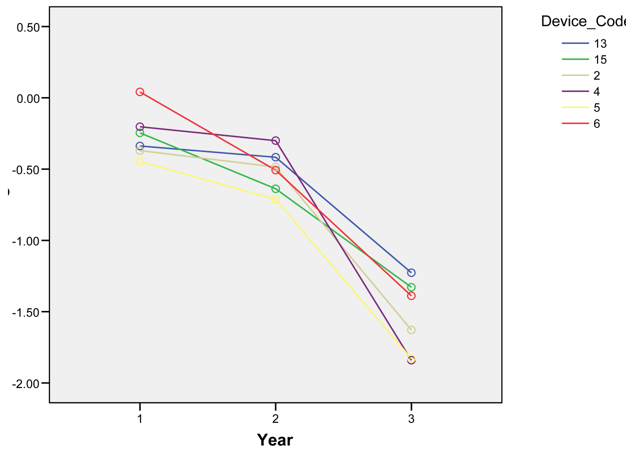
Site	Year	Year*Device	Between subjects (Device)
North Haven	F(2,24)=37.9, p<0.001	F(10,24)=1.9, p=0.093	F(5,12)= 2.2, p=0.118
North	F(2,22)= 85.0, p<0.001	F(10,22)= 4.3, p=0.002	F(5,11)= 3.1, p=0.055
South	F(2,20)= 86.7, p<0.001	F(10,20)= 1.0, p=0.495	F(5,10)= 0.84, p=0.552
Fire Island	F(2,16)=33.6, p<0.001	F(6,16)= 0.3, p=0.928	F(3,8)= 3.6, p=0.065

Profile Plots of Tick Abundance by Device at each Study Site by Year (1=2008, 2=2009, 3=2010).

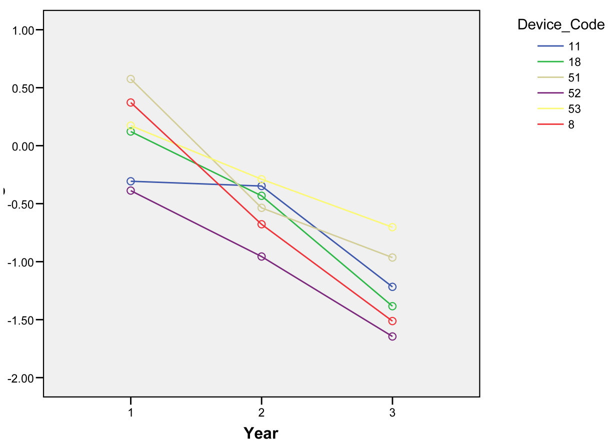
North Haven



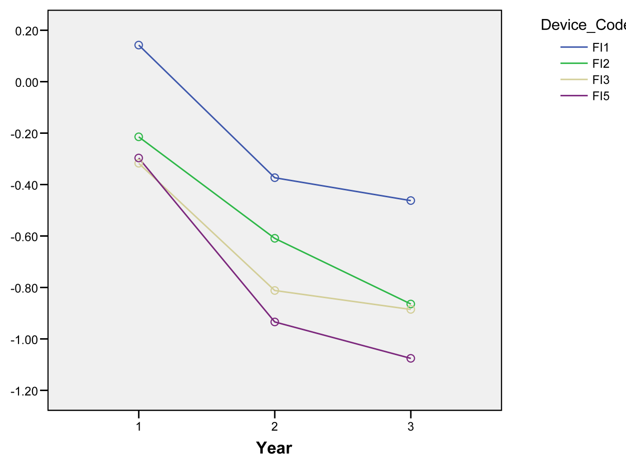
Shelter Island South



Shelter Island North



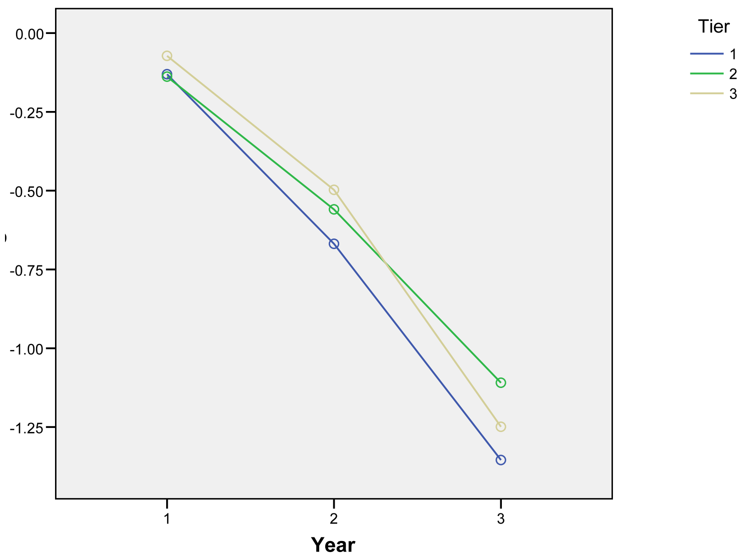
Fire Island



COMPARISON AMONG TIERS (4-POSTER SITES ONLY)

The annual difference in tick abundance by tier (i.e., distance from 4-Poster, combined for the 4-Poster treatment sites only and excluding the reference site) was compared by repeated measures ANOVA. The main effect of Year was significant, $F(2,84)= 134.5$, $p<0.001$, while the interaction term Tier * Year, $F(4,84)= 0.76$, $p=0.556$ and the Between Subjects Tier term, $F(2,42)= 0.78$, $p=0.468$ were not significant. These results suggest that average tick abundances were similar in all three Tiers undergoing the same temporal trends from year to year (see the Profile Plot).

Profile Plots of Tick Abundance by Tier at the Three Treatment Study Sites (combined) by Year (1=2008, 2=2009, 3=2010).



TICK SPECIES/DEVELOPMENTAL STAGE COMPOSITON

To determine the contribution of tick species (*Amblyomma americanum* and *Ixodes scapularis*) at each developmental stage (larva, nymph, or adult) to the observed differences in the overall tick abundance, a tick species/developmental stage*Study Site*Year matrix was compared by multivariate non-parametric tests in the Primer/Permanova+ statistical software package (Primer-E Ltd, Plymouth, UK). Permutational ANOVA or PERMANOVA (Anderson, Gorley, & Clarke, 2008) is a nonparametric analog to multivariate analysis of variance (MANOVA) utilizing a multivariate permutation procedure that analyzes both composition and abundance. The procedure calculates a similarity measure and a similarity matrix (Bray-Curtis in this report) that allows for the objective identification of samples (i.e. study sites, years) that have similar (or dissimilar) tick communities in terms of tick species/developmental stages. PERMANOVA was used as an omnibus test to identify main and interaction effects followed by pairwise comparisons including planned contrasts between each treatment and the reference sites. Monte Carlo permutation tests were run 9999 times and were then used to derive p-values. The datasets were not transformed prior to the analyses.

For pair-wise comparisons that are significant (i.e., have dissimilar tick species/developmental stages composition) it is desirable to know what contribution(s) the individual tick species/developmental stages made to the overall dissimilarity. The proportion of the overall dissimilarity that was contributed by individual tick species/developmental stages was calculated using the Similarity Percentages routine (SIMPER) and the Bray-Curtis similarity measure (Clarke & Gorley, 2006). The outcome is a list of tick species/developmental stages ranked in order of their percent contribution to the dissimilarity between significant pairwise comparisons.

The PERMANOVA results are shown in Table D. The main effects of Study Site, Year, and their interaction terms were significant in all cases. All planned contrasts between the treatment sites and the reference site were also significant suggesting statistically significant differences in the tick community among the sites through time. North Haven and Fire Island were the least dissimilar in this respect, at p=0.0488

Table D. Contribution of tick species and developmental stage to overall abundance.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique permutations
Study Sites	3	28892	9630.5	6.7956	0.0001	9890
N Haven vs North	1	11593	11593	7.9371	0.0001	9940
N Haven vs South	1	10526	10526	7.3427	0.0002	9941
N Haven vs FI	1	9451.9	9451.9	8.0179	0.0002	9932
Year	2	87775	43888	30.968	0.0001	9937
Study Site x Year	6	35743	5957.1	4.2035	0.0001	9898
(N Haven vs North)xYr	2	16274	8137.1	5.5711	0.0001	9916
(N Haven vs South)xYr	2	15628	7814.2	5.4508	0.0001	9930
(N Haven vs FI)xYr	2	4996	2498	2.119	0.0488	9941
Residual	177	2.51E+05	1417.2			
Total	188	4.06E+05				

Pairwise comparisons within each Study Site by Year (Table E) indicate that the tick community composition was different each year with the exception of the reference North Haven site (no difference between 2008 and 2009) and the treatment Fire Island site (no difference between 2009 and 2010)

Table E. Comparisons of tick levels within each Study Site by Year

Study Site	2008 vs 2009	2009 vs 2010	2008 vs 2010
North Haven	t(34)=1.1, p=0.281	t((34)=2.7, p<0.001	t((34)=3.4, p<0.001
North	t(32)=3.4, p<0.001	t(32)=3.5, p<0.001	t(32)=4.4, p<0.001
South	t(30)=1.8, p=0.028	t(30)=3.7, p<0.001	t(30)=4.4, p<0.001
Fire Island	t(22)=3.3, p<0.001	t(22)=1.2, p=0.224	t(22)=3.9, p<0.001

Comparing Study treatment sites within each Year to the North Haven reference site indicated that the tick community composition at the treatment North site was significantly different from the reference site every year (Table F). The treatment South site was similar to the reference site in 2008 and different in 2009 and 2010. The treatment site Fire Island was similar to the reference site in 2008, significantly different from the reference site in 2009, and borderline similar (p=0.053) to the reference site in 2010.

Table F. Comparisons of tick levels within each year, 4-Poster sites vs North Haven

Year	N Haven vs North	N Haven vs South	N Haven vs Fire Island
2008	t((33)=2.0, p=0.008	t((32)=1.1, p=0.264	t((28)=1.1, p=0.290
2009	t((33)=2.4, p=0.005	t((32)=1.8, p=0.026	t((28)=2.9, p=0.001
2010	t((33)=3.0, p<0.001	t((32)=3.4, p<0.001	t((28)=1.6, p=0.053

The SIMPER analysis determined the individual species/developmental stage contribution to the observed statistically significant differences identified by PERMANOVA. The larger the relative contribution of the species/developmental stage, the more important the differences in its abundance were in discriminating between the two groups. Table G compares Years within each Study Site (i.e., temporal variation within each site), while Table H compares the treatment Study Sites to the reference Study Site within each Year (i.e., spatial variation within each year).

Table G. Tick community composition: *Different Years by Site*

	Average tick species/developmental stage abundance*			Relative contribution to the observed significant difference, %		
	2008	2009	2010	2008-2009	2009-2010	2008-2010
North Haven						
AmbF	0.31	0.35	0.26	ns	6.8	5.5
AmbM	0.31	0.42	0.23	ns	6.5	5.3
AmbN	5.74	4.2	1.36	ns	62.0	73.7
AmbL	0.23	0.58	0	ns	7.2	3.6
IxoF	0	0	0	ns	0.0	0.0
IxoM	0	0	0	ns	0.0	0.0
IxoN	0.74	0.91	0.27	ns	17.2	11.0
IxoL	0.07	0.01	0	ns	0.2	1.0
North						
AmbF	0.5	0.33	0.11	4.3	11.8	4.8
AmbM	0.51	0.31	0.1	3.8	11.6	5.3
AmbN	5.81	1.8	0.21	41.3	60.7	49.6
AmbL	7.57	0	0	42.5	0.0	34.8
IxoF	0	0	0	0.0	0.3	0.1
IxoM	0	0	0	0.1	0.4	0.1
IxoN	0.82	0.4	0.16	7.2	14.0	5.2
IxoL	0.07	0.04	0	0.7	1.2	0.3
South						
AmbF	0.31	0.32	0.03	7.5	11.7	7.0
AmbM	0.24	0.36	0.04	7.2	13.9	5.5
AmbN	4.01	1.98	0.21	68.4	58.6	75.5
AmbL	0.44	0	0	6.7	0.0	4.9
IxoF	0	0	0	0.2	0.3	0.0
IxoM	0	0	0	0.1	0.1	0.0
IxoN	0.36	0.32	0.05	9.8	15.2	7.1
IxoL	0	0	0	0.1	0.2	0.1
Fire Island						
AmbF	0.17	0.2	0.1	3.4	ns	3.1
AmbM	0.17	0.11	0.09	3.0	ns	3.0
AmbN	6.15	1.73	1.2	90.9	ns	89.0
AmbL	0.06	0	0.22	0.7	ns	3.5
IxoF	0	0	0	0.0	ns	0.0
IxoM	0	0	0	0.0	ns	0.0
IxoN	0.06	0.06	0.04	1.9	ns	1.5
IxoL	0	0	0	0.0	ns	0.0

ns – differences not significant by PERMANOVA pairwise comparison
* number per 30-second sweep sample
Amb=*Amblyomma*, Ixo=*Ixodes*, F=female, M=male, N=nymph, L=larva

Table H. Tick community composition: *Treatment Sites vs Reference Site Each Year*

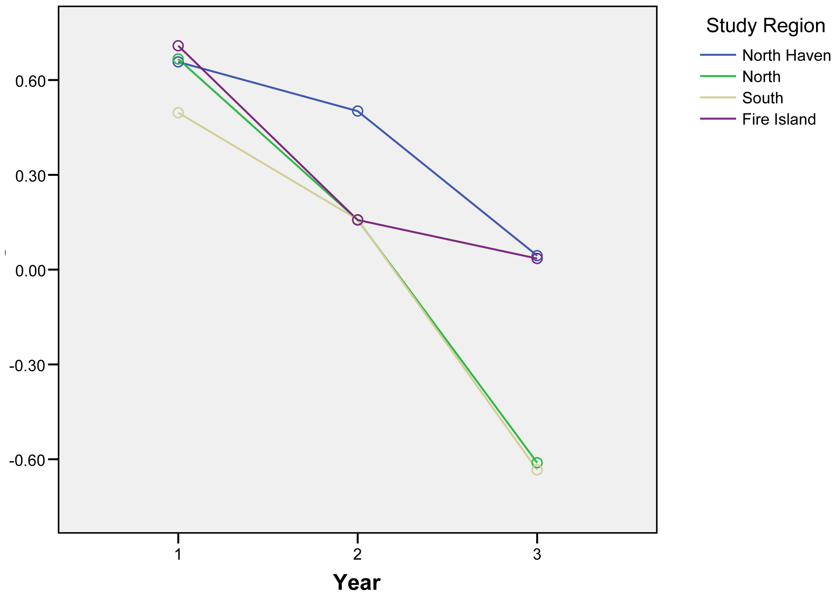
	Average tick species/ developmental stage abundance*				Relative contribution to the observed significant difference, %		
	North Haven	North	South	Fire Island	N Haven-North	N Haven-South	N Haven-Fire Island
2008							
AmbF	0.31	0.5	0.31	0.17	3.9	ns	ns
AmbM	0.31	0.51	0.24	0.17	4.1	ns	ns
AmbN	5.74	5.81	4.01	6.15	40.0	ns	ns
AmbL	0.23	7.57	0.44	0.06	43.3	ns	ns
IxoF	0	0	0	0	0.0	ns	ns
IxoM	0	0	0	0	0.0	ns	ns
IxoN	0.74	0.82	0.36	0.06	7.9	ns	ns
IxoL	0.07	0.07	0	0	0.9	ns	ns
2009							
AmbF	0.35	0.33	0.32	0.2	6.0	6.8	5.7
AmbM	0.42	0.31	0.36	0.11	5.3	6.3	7.2
AmbN	4.2	1.8	1.98	1.73	60.3	62.0	59.9
AmbL	0.58	0	0	0	7.4	7.4	7.2
IxoF	0	0	0	0	0.1	0.1	0.0
IxoM	0	0	0	0	0.1	0.1	0.0
IxoN	0.91	0.4	0.32	0.06	19.9	17.0	19.8
IxoL	0.01	0.04	0	0	0.9	0.2	0.2
2010							
AmbF	0.26	0.11	0.03	0.1	12.7	13.3	ns
AmbM	0.23	0.1	0.04	0.09	11.2	11.6	ns
AmbN	1.36	0.21	0.21	1.2	59.1	60.0	ns
AmbL	0	0	0	0.22	0.0	0.0	ns
IxoF	0	0	0	0	0.3	0.0	ns
IxoM	0	0	0	0	0.3	0.0	ns
IxoN	0.27	0.16	0.05	0.04	16.1	14.9	ns
IxoL	0	0	0	0	0.4	0.1	ns

ns – differences not significant by PERMANOVA pairwise comparison
* number per 30-second sample
Amb=*Amblyomma*, Ixo=*Ixodes*, F=female, M=male, N=nymph, L=larva

Lone Star Tick Nymphs
The average *Amblyomma* nymph abundance per device and tier was compared by repeated measures ANOVA with years (=2008, 2009, and 2010) as a within-subject factor. The average lone star nymph abundances were (log +0.1) transformed to dissociate the variance from the mean and to meet the assumptions of normality, homogeneity of variances, and sphericity. Sphericity was assumed violated if Mauchly's test was significant at $p<0.05$ and if found, the violations were indicated in the text.

Both the main effect of Year, $F(2,118)= 186.4$, $p<0.001$, and the interaction term Study Site * Year, $F(6,118)= 8.6$, $p<0.001$, were significant suggesting differences among the three years and among the study sites within each year. Lone star nymph abundance differed among the study sites, $F(3,59)= 9.1$, $p<0.001$. The *a priori* contrasts between the reference study site (North Haven) and two of the three 4-Poster treatment sites (North and South) were significant at $p<0.05$ (not shown) suggesting that the lone star nymph abundance at the reference study sites differed from lone star nymph abundances at these two treatment study sites over the three year period (also see the profile [trend] plot below). However, the reference study site was similar to Fire Island treatment site ($p=0.087$).

Profile Plots of Lone Star Nymph Abundance by Site Year (1=2008, 2=2009, 3=2010)



The temporal trends in lone star nymph abundance within each study site were compared by repeated measures ANOVA followed by pairwise comparisons among the three years at $p<0.05$ adjusted for multiple comparisons. The level of overall statistical significance for ANOVA was also Bonferroni-adjusted for multiple comparisons (n=4) at $\alpha=0.0125$. All three treatment sites, but not the reference site, experienced significant declines in lone star nymph abundance in 2009 compared to 2008 (Table I). All sites but Fire Island treatment site experienced significant declines in 2010 compared to both 2008 and 2009.

Table I. Lone star nymph levels in each study area - trends over time

Site	**Significant differences among Years at adjusted p<0.0125**	**Pairwise comparisons at adjusted p<0.05**
North Haven	$F(2,34)= 24.9, p<0.001$	2008=2009; 2009>2010; 2008>2010
North	$F(2,32)= 87.5, p<0.001$	2008>2009; 2009>2010; 2008>2010
South	$F(2,30)= 61.5, p<0.001$	2008>2009; 2009>2010; 2008>2010
Fire Island	$F(2,22)= 50.2, p<0.001$	2008>2009; 2009=2010; 2008>2010

The spatial trends in lone star nymph abundances at the study sites within each year were compared by univariate ANOVA. The level of overall statistical significance for ANOVA was Bonferroni-adjusted for multiple comparisons (n=3) at $\alpha=0.0167$. If the omnibus test was significant at $p=0.0167$, each treatment study site (North, South, or Fire Island) was then compared to the reference site (North Haven) by *a priori* planned contrasts. Lone star nymph abundances were similar among the study sites in 2008 (Table J). In 2009, all three treatment study sites had significantly lower lone star nymph abundances compared to the reference site. In 2010, two treatment sites (North and South) had significantly lower lone star nymph abundances compared to the reference site, but lone star nymph abundances at Fire Island (treatment) and North Haven (reference) sites were statistically similar.

Table J. Lone star nymph abundance by year and comparisons with North Haven

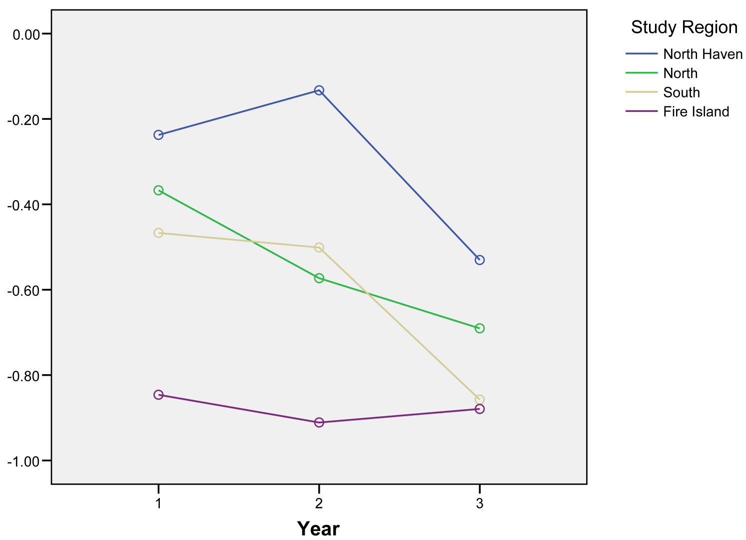
Year	**Significant differences among study sites at adjusted p<0.0167**	**Planned contrasts at p<0.05**
2008	$F(3,62)= 1.2, p=0.317$	None (omnibus test not significant)
2009	$F(3,62)= 4.0, p=0.011$	North Haven>North; North Haven>South; North Haven>Fire Island
2010	$F(3,62)= 23.9, p<0.001$	North Haven>North; North Haven>South; North Haven=Fire Island

Blacklegged Tick Nymphs

The average *Ixodes* nymph abundance per device and tier was compared by repeated measures ANOVA with years (=2008, 2009, and 2010) as a within-subject factor. The average *Ixodes* nymph abundances were (log +0.1) transformed to dissociate the variance from the mean and to meet the assumptions of normality, homogeneity of variances, and sphericity. Sphericity was assumed violated if Mauchly's test was significant at $p<0.05$ and if found, the violations were indicated in the text.

Both the main effect of Year, $F(2,118)=25.0$, $p<0.001$, and the interaction term Study Site * Year, $F(6,118)=4.3$, $p=0.001$, were significant suggesting differences among the three years and among the study sites within each year. *Ixodes* nymph abundance differed among the study sites, $F(3,59)= 237.1$, $p<0.001$. The *a priori* contrasts between the reference study site (North Haven) and all of the three treatment sites (North, South, and Shelter Island) were significant at $p<0.05$ (not shown) suggesting that the *Ixodes* nymph abundance at the reference study site differed from *Ixodes* nymph abundances at the treatment study sites over the three year period (also see the profile [trend] plot below).

Profile Plots of Blacklegged Nymph Abundance by Site Year (1=2008, 2=2009, 3=2010)



The temporal trends in blacklegged nymph abundance within each study site was compared by repeated measures ANOVA followed by pairwise comparisons among the three years at $p<0.05$ adjusted for multiple comparisons. The level of overall statistical significance for ANOVA was also Bonferroni-adjusted for multiple comparisons (n=4) at $\alpha=0.0125$. At Fire Island nymph levels were very low and there were no significant differences among the three years (Table K). All other sites showed significant declines in nymph levels from 2008 to 2010, but no significant differences between 2008 and 2009. North Haven and Shelter Island South each had lower populations in their respective areas in 2010 compared to 2009 also, but this was not the case in the Shelter Island North study site for the same period.

Table K. Blacklegged nymph levels in each study area - trends over time

Site	**Significant differences among Years at adjusted p<0.0125**	**Pairwise comparisons at adjusted p<0.05**
North Haven	$F(2,34)= 16.5$, $p<0.001$	2008=2009; 2009>2010; 2008>2010
North	$F(2,32)= 9.2$, $p=0.002$	2008=2009; 2009=2010; 2008>2010
South	$F(2,30)= 10.7$, $p<0.001$	2008=2009; 2009>2010; 2008>2010
Fire island	$F(2,22)= 1.0$, $p=0.388$	None (omnibus test not significant)

The spatial trends in blacklegged nymph abundances at the study sites within each year were compared by univariate ANOVA. The level of overall statistical significance for ANOVA was Bonferroni-adjusted for multiple comparisons (n=3) at α=0.0167. If the omnibus test was significant at p=0.0167, each treatment study site (North, South, or Fire Island) was then compared to the reference site (North Haven) by *a priori* planned contrasts. Within each year blacklegged tick levels significantly differed among study sites (Table L). Levels in the Shelter Island North site were similar to North Haven in 2008 and 2010, but significantly lower in 2009. Blacklegged nymph levels at the Shelter Island South site were similar to North Haven in 2008 but significantly lower in 2009 and 2010. Levels on North Haven were significantly and consistently higher in all three years than those on Fire Island.

Table L. Blacklegged nymph abundance by year and comparisons with North Haven

Year	**Significant differences among study sites at adjusted p<0.0167**	**Planned contrasts at p<0.05**
2008	F(3,62)= 5.7, p=0.002	North Haven=North; North Haven=South; North Haven>Fire Island
2009	F(3,62)= 11.0, p<0.001	North Haven>North; North Haven>South; North Haven>Fire Island
2010	F(3,62)= 7.0, p<0.001	North Haven=North; North Haven>South; North Haven>Fire Island

North Haven vs 4-Poster sites: tick densities, percent differences, levels of control
Table M shows actual mean tick counts per device and tier from each of the study regions for each year, by entire tick population (both species, all stages), for *Amblyomma* nymphs alone and for *Ixodes* nymphs alone.

Table M. Mean number of ticks per 30-sec. sweep sample by device and tier

	2008		**2009**		**2010**	
Study Region	Mean	Standard Error of Mean	Mean	Standard Error of Mean	Mean	Standard Error of Mean
Both species, all stages						
North Haven	0.92	0.14	0.81	0.12	0.27	0.04
North	1.91	0.41	0.36	0.07	0.08	0.02
South	0.67	0.12	0.37	0.07	0.04	0.01
Fire Island	0.83	0.14	0.26	0.06	0.21	0.06
Amblyomma nymphs						
North Haven	5.74	0.98	4.20	0.78	1.36	0.26
North	5.81	1.00	1.80	0.37	0.21	0.07
South	4.01	0.80	1.98	0.46	0.21	0.07
Fire Island	6.15	1.06	1.73	0.42	1.20	0.27
Ixodes nymphs						
North Haven	0.74	0.18	0.91	0.16	0.27	0.06
North	0.82	0.36	0.40	0.22	0.16	0.06
South	0.36	0.08	0.32	0.07	0.05	0.02
Fire Island	0.06	0.03	0.06	0.05	0.04	0.02

Table N shows percent differences in tick levels between 4-Poster treatment sites and the baseline tick densities at the North Haven reference site using Abbotts's formula (Abbott, 2005) (e.g. %=[1-North 2008÷NorthHaven 2008]*100). Although the North study site began with a notably higher density of ticks, the difference with North Haven was not significant. However, the level of blacklegged nymphs was significantly lower on Fire Island that year, almost certainly a consequence of the limited woodland habitat there. Reductions compared with North Haven in 2009 were all significant and continued to increase in 2010 in most cases, reaching 72% in the North study site and 85% in the South for all tick species and stages combined. Only a 22% reduction was noted on Fire Island, and the difference was not statistically significant. For *Amblyomma* nymphs alone, reductions compared with North Haven were 84 – 85% on Shelter Island in 2010; the reduction on Fire Island was only 12% and not significant. For *Ixodes* nymphs in 2010, levels were significantly lower in the South and Fire Island study areas but the reduction in the North study site (41%) was not significant.

Table N. Percent difference (reduction) in tick levels in 4-Poster treatment areas compared with North Haven reference site (after Abbott [1925])

Study Region	2008	2009	2010
Both species, all stages			
North	-107	55 *	72 *
South	27	54 *	85 *
Fire Island	11	68 *	22
Amblyomma nymphs			
North	-1	57 *	84 *
South	30	53 *	85 *
Fire Island	-7	59 *	12
Ixodes nymphs			
North	-11	56 *	41
South	52	65 *	82 *
Fire Island	91 *	94 *	84 *

ns=not significant
* significant for planned contrasts at $p<0.05$
Negative values indicate that tick levels were higher than or increased relative to the reference site

Henderson and Tilton's (1955) formula can be used to derive estimates of percent control between years relative to the reference site. Figures are shown in Table O comparing 2008 with 2009, 2009 with 2010, and 2008 with 2010. Highest levels of control in each 4-Poster treatment site for all species and stages combined were seen on Shelter Island (79 and 86%) from 2008 to 2010 and on Fire Island (64%) from 2008 to 2009. Results were similar for *Amblyomma* nymphs, with highest levels on Shelter Island from 2008 to 2010 (78 and 85%) and on Fire Island from 2008 to 2009 (62%). Highest levels with *Ixodes* nymphs were in the North study site (61%) and on Fire Island (30%) from 2008 – 2009, and in the South study site from 2008 – 2010. There were some increases in tick levels compared with North Haven especially from 2009 – 2010 (Fire Island, both species and all stages, *Amblyomma* nymphs and *Ixodes* nymphs, 142%, 115% and 170% respectively). *Ixodes* nymph levels also increased from 2008 to 2010 compared with North Haven (90%). As noted earlier, *Ixodes* levels tended to be relatively low (limited favorable habitat available/sampled) on Fire Island, and 2010 was overall an 'unfavorable' year for ticks, with reductions noted including in North Haven.

Table O. Percent control of ticks in 4-Poster treatment areas compared with North Haven reference site (after Henderson and Tilton [1955])

Study Region	2009 vs. 2008	2010 vs. 2009	2010 vs. 2008
Both species, all stages			
North	78	37	86
South	36	67	79
Fire Island	64	-142	12
Amblyomma nymphs			
North	58	63	85
South	33	68	78
Fire Island	62	-115	18
Ixodes nymphs			
North	61	-35	47
South	28	49	63
Fire Island	30	-170	-90

Negative values indicate that decline in tick levels at the treatment site was at a lesser magnitude than at the reference site

DISCUSSION

Objective I: Human and wildlife-associated risks due to change in deer movement and behavior.

White-tailed Deer Live-Capture & Movement

Geographic deer location data were used to evaluate suburban deer movements and potential changes in behavior or movements associated with 4-Poster devices. Changes in home range and core area sizes and geographic locations were examined over time (2008-2010) to evaluate behavioral responses by deer to 4-Poster devices within treatment areas compared to normal range fluctuation where no bait was present within the control area. Temporary bait sites are reported to have no influence on the size of deer home ranges or core areas (Kilpatrick and Stober 2002, Campbell et al. 2006, Cooper et al. 2006a). However, the locations of core areas may shift closer in proximity to bait sources if the bait were made available within the animal's home range (Kilpatrick and Stober 2002).

No significant differences in home range and core area sizes were observed between the treatment and control area; larger home ranges were observed within the treatment area during 2009 likely due to substantially increasing the sample size of collared deer between 2008 and 2009 and the inherent landscape differences between the 2 areas. The treatment area was characterized by greater area of undeveloped and unfragmented, forested habitat ($\bar{x}$ = 52% forest canopy, NLCD), less development ($\bar{x}$ = 6.27% impervious surfaces) and similar housing densities (range: 0 – 1.5 homes/acre) thus greater amounts of natural deer habitat, compared to the control area ($\bar{x}$ = 40% forest canopy, $\bar{x}$ = 9.82% impervious surfaces, range: 0 – 1.13 homes/acre, respectively). A reduction in home range sizes has been correlated to increased home density (Vogel 1989) and seasonal home ranges for urban-suburban areas have been reported roughly 80-85% smaller than home ranges in more forested or agricultural habitats (Kilpatrick and Spohr 2000). Additionally, no changes in home range or core area size occurred throughout the study, further suggesting 4-Poster devices had minimal influence on deer movement and range establishment. GPS collars provided larger range estimates due to the amount of data collected compared to VHF collars. GPS collars enabled us to track deer movements at a finer scale and thus likely provided more detailed estimates of habitat use and range delineations. However, data obtained from both collar types suggested similarities in range sizes between treatment and control areas and over all study years; range size estimates suggested devices had minimal influence on deer behavior and movement. A change in the distribution of one basic life resources (e.g., food) is unlikely to greatly alter home range or core area sizes. Kilpatrick and Stober (2002) found that temporary changes in food distribution through supplemental bait sites failed to alter home range sizes. Long-term studies have shown that the provision of permanent water sources did not change home range sizes of ungulates (Krausman and Etchberger 1995). The inherent social structure and site fidelity behaviors deer exhibit (Mathew and Porter 1993) further suggest that supplemental food availability would have minimal discernable impact on home range or core area sizes.

Throughout the study, the degree of overlap between individual collared deer core areas further suggested minimal influence of 4-Poster devices on deer behavior and core area use. The percent of core area overlap observed on the treatment and control areas did not differ and no significant shifts (<10% core area overlap) were observed. GPS collars provided core area estimates that showed significantly greater degrees of overlap or stronger site fidelity between study years than VHF collars. The greater amount of data collected from GPS collars was likely the primary factor contributing to these differences. However, the core area overlap observed for both collar types suggested a strong degree of site fidelity on both the treatment and control areas thus 4-Poster influence appeared minimal over 2008-2010. Deer have been observed shifting core areas to encompass bait sites (Kilpatrick and Stober 2002 and Campbell et al. 2006) and concentrating activity within smaller core areas when supplemental feed is available (Cooper et al. 2006a). Although concentrating activity around bait could enhance fitness through reduced energetic costs associated with foraging (Moen 1973), 4-Poster devices were not associated with any shift in core area to incorporate devices or changes in locations throughout the study. For many deer, devices were located on the periphery of home ranges and core areas and although the supplemental food offered at these devices is used, the core areas appear to be selected mainly for cover and security in the suburban landscapes.

One to 2, 4-Poster devices were typically present within the home ranges and core areas of collared deer and this remained constant throughout the study. We did not observe range expansion to incorporate more devices and several deer did not incorporate devices into their home ranges. 4-Poster devices present on the periphery of home range or core area boundaries did not result in shifting or enlargement allowing the deer to use those devices and in some cases, trail cameras provided no evidence of device use.

A small number of collared deer traveled much larger distances than others, had larger home ranges, and incorporated more devices in their home ranges and core areas. Although relatively few collared deer exhibit these large movements and most remain in much smaller areas each year, these are important behaviors to consider when employing effective tick management strategies at small scale levels. The movement data for these deer suggested that devices (corn) are not likely the primary factor contributing to their movements. In biological terms of least-cost path (minimizing the cost or energy required to reach a destination or achieve some benefit [corn]), deer would be expected to minimize travel distances to obtain corn from the close and easily accessible devices. However, these deer encountered devices at much shorter distances than the maximum distances traveled (approximately 6 -10 miles). Spatial and temporal examination of movement data revealed seasonality (or phenology) may play a significant role in these movements. Larger distances were traveled during late April or early May when they are preparing to give birth to fawns and those locations were used until mid- to late July or later. Deer migratory behaviors are adaptive with deer inheriting the ability to learn and mimic long-distance movements (Nelson 1998). Learned site fidelity and matriarchal social structures could contribute to range differences and large movements observed within the treatment area (Nelson 1998 and Mathews and Porter 1993).

Emigration and Immigration

Minimal movements of marked deer were detected off the treatment area suggesting very limited concern for hunter contact with permethrin residues that may be present on the deer hide where 4-Poster devices were used. Some, however limited, male deer were observed moving from the control area onto the treatment area. These movements may contribute to an influx of ticks into the population on the treatment area. However, the low number of marked deer observed suggested this influx would not contribute to substantial concern and likely have negligible impact on the tick population.

Deer and Non-target Wildlife Use of 4-Poster Devices

Three years of trail camera data obtained from monitoring deer and non-target wildlife use of 4-Poster devices provided significant evidence that this technology can be efficiently used to lure deer and raccoons for tickicide treatment on a regular basis each season. Based on device use indices alone, it appeared a substantial amount of corn and tickicide were used on both deer and raccoons. Although squirrels and birds regularly used devices as a food source, the effectiveness of this device in treatment of these animals with tickicide appeared minimal.

Deer use of devices increased throughout the study (2008-2010). Although deer use likely improved over time as deer became habituated to the devices, the increase in deer density throughout the study (Figure 13) may have contributed to the apparent increase in relative deer numbers observed using devices between 2008 and 2010. Although raccoon use peaked during 2009, it dropped to a low in 2010. Large fluctuations in use from year to year by the primary target host (deer) could be a concern for effective tick control. Since raccoons are also known to use devices heavily, it could be beneficial to consider large use fluctuations when evaluating the effectiveness of the devices to control ticks between study years.

Device use can vary each year and seasonally; these variations were likely due to natural fluctuations in yearly population numbers for each species as well as seasonal availability of natural food resources. Typically, the acorns available during the fall are an important seasonal food resource for deer and can influence movement behaviors as deer seek acorns as a primary, fall food (Stafford et al. 2009). However, throughout this study, acorn availability increased from 2008-2010 (Figure 17) but fall device use indices indicated deer use remained consistent between study years. These results reaffirm that deployment throughout fall was good for device use by deer and effective tickicide treatment of this target host during an important season for control of blacklegged ticks. Additionally, device use by raccoons was greater in the fall than in any other season. This use index further supported deployment continuation throughout the fall. Deer use of devices during spring was lower than most other seasons but this is likely due to reduced total population numbers post harvest and prior to recruitment as well as fawning reducing the mobility of does during the later part of the spring season. Consistently high use by deer and raccoons occurred in the summer when lone star ticks were most active suggesting potentially good host treatment. Based on device use indices derived on a seasonal basis each year, it appears the duration of 4-Poster deployment used throughout this study provided a sufficient time frame to maximize the number of animals using devices on a regular basis.

Estimates of Deer Device Use

The increased amount of corn consumed from devices and the increased estimated number of deer using devices throughout the study coincided with the increased relative number of deer observed using devices in trail cameras photos as the study progressed. This increase likely reflected habituation of deer to device presence within their natural habitat as well as an increase in deer density throughout the study (Figure 13). Corn consumption rates and deer use estimates suggested summer and fall are the primary seasons of wildlife use and thus likely the optimal time frames for maximizing the number of animals treated with tickicide. The lower rate of consumption and deer use observed during the spring suggested this season is not optimal for tickicide treatment. However, deployment during the spring does target smaller subsets of the wildlife population thus some blacklegged tick control does occur during the spring.

Corn and deer use estimates can be used to better inform future device placements to maximize deer use and tickicide treatment. Adequate use of devices by deer, the target host for blacklegged and lone star ticks, was one of the first steps to ensuring effective tickicide treatment. The seasonal variability of device use may guide financial planning for future 4-Poster management plans with the goal of optimizing device effectiveness while reducing associated costs.

Evaluating device use by the marked deer populations revealed high percentages (73-85%) visiting devices. The decline in the percentage of marked deer using devices occurring between 2008 and 2009 resulted as we increased our marked deer population size from 34 to 94 deer; increasing the marked population provided more information and a better representation of use by the total deer population. Although the percentage of marked deer using devices continued to decline into 2010, this decline likely reflected a skewed total number of marked deer available to monitor with trail cameras due to unreported marked mortalities or unknown movements of marked deer off the treatment area throughout the study. Evaluation of device visitation by the sexes revealed female visitation was higher than male visitation. Estimates of device use by males were reduced because male tags are very small and difficult to discern and males have larger ranges, making it more likely they were undetected during trail camera surveys. Additionally, the majority of deer reported or observed emigrating and immigrating were male, making it more likely that the marked male population present on the treatment area was lower than the number used to derive estimates. The percentage of marked deer using 4-Poster devices was lowest during spring, highest during summer, and either remained stable or dropped slightly in the fall; these data are similar to trends observed using trail camera and corn consumption data. The percentage of use by marked deer likely provides accurate estimates of the percentage of the total deer population using 4-Poster devices each year.

Monitoring Deer Populations

Deer density estimates derived using population estimators revealed an increase in deer numbers since 4-Posters were first used between 2008 and 2010 on the treatment area. These estimates alone suggest 4-Poster use may have impacted population growth. However, deer density also increased in the control area (North Haven), where no 4-Poster devices were present, and large 95% confidence intervals associated with the estimators suggested the actual deer densities on both the treatment and control areas may vary greatly from the densities derived using estimators. Additionally, the numbers of deer harvested in both areas declined throughout the 4-Poster study which was likely the primary factor contributing to the population growth observed. Deer harvest declined in both areas as the public reacted to permethrin being detected on the deer hides and within neck muscles during the initial permethrin residue investigations (2008). Despite NYS DOH public health announcements stating there is very low concern for human consumption of meat containing permethrin at the levels detected, many individuals expressed continued concerns about hunting and consumption.

Although supplemental food (corn) was available to deer during 2008-2010, acorns, an important natural fall food resource, were more plentiful during 2009 and 2010 when compared to previous years. It is difficult to quantify the impact these resources directly had on population growth but dressed weights collected on Shelter Island between 2005 and 2010, suggest an increase in weight for both sexes and all age classes since the study began in 2008. It is likely that both a greater abundance of acorns and supplemental corn contributed to the increased weights recorded on Mashomack Nature Preserve within the treatment area.

The primary causes of mortality on the treatment and control areas were hunter harvest and DVC. On both areas, no significant changes in yearly mortality rates were observed throughout the study. However, during 2010, a reduction in deer mortality on the treatment area was observed; the reduction likely resulted from unknown mortalities, unreported hunter harvests, and using incorrect total marked population numbers for 2010 due to poor mortality reporting during the 2 prior study years. The amount of mortality observed on the treatment area is higher than on the control area due to greater amounts of hunting activity.

The doe to fawn ratios and percentage of marked does successfully reproducing did not fluctuate considerably throughout the study on either the treatment or control area. Throughout the study, greater than 69% of marked does successfully fawned in both areas. Despite supplemental food availability and increased abundance of acorns during 2009 and 2010, the marked does were observed with no more than 1-2 fawns and never successfully produced fawns before 2 years of age, suggesting 4-Poster influence on reproductive success was minimal.

Short-term monitoring of the deer populations on the treatment and control areas revealed no substantial changes in deer mortality and productivity while 4-Posters were deployed. These results suggest the devices may have minimal impact on deer survival, reproduction, and population growth in these areas. However, the increase in deer densities observed throughout the study can have significant negative impacts on future tick control efforts, natural and ornamental vegetation damage, and DVCs; deer management programs ensuring yearly deer harvest quotas are attained will be essential to maintain a balance between the 4-Poster tick control system and the overabundant deer numbers presents in these areas.

Assessments of Contact Rates and Potential Disease Transmission

Contact rates within free-ranging wildlife populations are influenced by social group structure, resource concentration (Miller et al. 2003, Gompper and Wright 2005, Wright and Gompper 2005), landscape structure (Fa et al. 2001, Guedlj and White 2004), and population density (Ramsey et al. 2002). Disease pathogens can be transmitted by direct contact, involving close spatial and temporal proximity, or indirect contact, involving only common spatial proximity. Bait sites may facilitate indirect and direct contact between deer and increase the potential for disease transmission (Williams et al. 2002, Miller et al. 2004, Mathiason et al. 2006). 4-Poster devices provide deer with supplemental food, contributing to direct and indirect contact between deer as they feed. Multiple deer feeding at bait sites (i.e., 4-Poster devices) increases the potential for disease transfer between animals (Quist et al. 1997).

Throughout the study, 4-Poster devices were typically associated with no contact or indirect contact between deer; direct contacts infrequently occurred between deer at devices. Interactions between deer at devices were highest during the fall; the increased contact probability during this season was attributed to increased use of devices by deer and normal changes in deer foraging and mating behaviors. High contact probabilities in forest habitat during fall (rut) and winter (gestation and limited food availability) possibly reflect deer use of forest habitat for concealment and thermal cover during those seasons, or due to aggregation of deer acquiring seasonal food resources (i.e., acorns in fall; Miller et al. 2003, Kjaer et al. 2008). Evaluation of interactions at each individual device revealed similar trends, suggesting that no contacts or indirect contacts were most consistently associated with deer use of 4-Poster devices rather than direct contacts between deer.

The interactions observed between deer at devices were commonly between females rather than males, but primarily involved indirect contacts rather than direct. Some diseases such as CWD have been shown to be more prevalent in adult males than adult females (Farnsworth et al. 2005). The group social structure of female deer has been linked to increased inter-group contact rates and potential disease transmission; congregation of multiple social groups at supplemental feeding sites has the potential to increase contact rates (Hawkins and Klimstra 1970, Comer et al. 2005). 4-Poster device use was often predominated by multiple social groups of female deer creating the potential for increased risk of disease transmission. However, the higher prevalence of CWD in males may suggest that predominately female device use may contribute to slightly slower initial transmission throughout the entire deer population. Consistent with normal, natural behaviors, the greatest amount of interactions between deer at devices occurred between adults to fawns. Some diseases such as CWD are more prevalent among adults than yearlings or fawns (Williams et al. 2002). Photo evidence suggested deer interactions at devices were typical of suburban deer populations and social groups and devices were not observed regularly resulting in large congregations of deer around the food source. The 4-Poster design restricts food access per feeding port (Pound et al. 2009) and typically only one deer is able to access a port at one time, serving to reduce direct interactions between many deer.

The type of bait source had minimal influence on deer contacts. The use of either bait source, 4-Poster devices as a tick management strategy or open bait piles as a deer management tool, contributed to similar interactions between deer, likely suggesting similar potential roles in disease transmission. The substantially longer duration of deployment of devices compared to deer management baiting may contribute to interactions between increased numbers of different individuals. However, open bait piles were associated with slightly higher percentages of direct contacts between adult deer, whereas the 4-Poster device interactions typically reflected more natural behaviors commonly between adults and fawns. The open bait sources may have increased interactions between adults because more deer can access the supplemental food at one time compared to 4-Poster devices.

The data collected from GPS collars monitoring deer movement within the treatment and control areas further suggested minimal changes in normal deer movements and interactions in response to the 4-Poster bait source. The very limited amount of interactions between collared deer suggested that although these deer make use of the devices, their use was not contributing to substantially increased interactions with other collared deer to obtain the bait.

The probability of direct contact between deer at 4-Poster devices was consistently lower than the probability of indirect contacts. These probabilities suggest that while 4-Poster devices contribute to increased indirect contact between deer at a shared food source, the amount of deer congregating at the food source is limited, minimizing direct contacts.

The comparison of different bait sources (open bait piles within the control area, and 4-Poster devices within the treatment site) suggested no differences between direct contact probabilities. Similar to investigations within the treatment area, the probability of direct contact between deer was less than the probability of indirect contact for both the 4-Poster devices and open bait. The probability of indirect contact between deer at 4-Poster devices ($\bar{x}$ = 0.557, range = 0.129 – 0.798) was slightly lower compared to the indirect contact probability observed at open bait ($\bar{x}$ = 0.691, range = 0.490 to 0.867). This difference may also be attributed to 4-Poster device design; small feeding ports prevent access by many deer at one time and have been observed limiting the number of deer congregating near the bait source. The area of natural habitat available within the control area is lower

($\bar{x}$ = 40% forest canopy, $\bar{x}$ = 9.82% impervious surfaces) than within the treatment area ($\bar{x}$ = 52% forest canopy, $\bar{x}$ = 6.27% impervious surfaces) and housing densities are similar (range: 0 – 1.13 homes/acre, range: 0 – 1.5 homes/acre, respectively); these differences in landscape features may have contributed to increased interactions between deer on a regular basis as well as at bait sources within the control area. Studies examining CWD prevalence have found the disease occurring more often in mule deer (*Odocoileus hemionus*) within developed areas than in undeveloped areas, attributing the differences to higher contact rates between animals on developed lands (Farnsworth et al. 2005). Additionally, the still-frame photos obtained from trail cameras may not have captured all direct contacts occurring between deer at devices or open bait resulting in underestimation the direct contact probabilities for each site. If further investigations are deemed necessary, video clips would provide more detailed record of deer use over time and likely provide better estimates of direct contact probabilities.

The indirect contact probabilities observed at each device throughout the treatment area typically corresponded with device use estimates by deer as well as known areas of high deer density (Figure 18). These results were expected and likely indicate that trail camera data provided reasonable estimates of indirect deer interactions at 4-Poster devices. The direct contact probabilities were consistently much lower over the treatment area landscape compared to indirect contact probabilities likely due to 4-Poster design hindering multiple deer from accessing the same feeding port. The higher direct contact probabilities observed in Mashomack despite low deer use estimates for those devices may be due to greater use by does and fawns; deer interactions at devices more commonly involved does to fawns during direct contacts than when bucks were present at devices (Figure 18). These differences would be due to normal behaviors and interactions between different sexes and age classes of white-tailed deer.

Although direct contact probabilities associated with 4-Poster use are comparatively low, as each deer feeds from a device, it indirectly contacts all other deer that used the same device as a food source. Both direct and indirect contact represents potential for disease transmission thus using 4-Poster technology may be a concern in areas where infectious and contagious diseases are endemic. 4-Poster technology on Shelter Island and other areas of eastern Long Island would likely contribute to an increase in indirect contact between deer but direct contacts would be minimized.

The potential for disease transmission exists through deer use of food plots, agriculture crops, or even contact between wild and farmed cervids along fence lines (Vercauteren et al 2007). The landscape of eastern Long Island is composed of a matrix of residential environments, agricultural land, and woodland habitat. Agricultural land constitutes a significant portion of habitat used by deer on eastern Long Island and deer contacts occurring naturally are frequent. The high deer densities throughout the area combined with habitat structure create ideal conditions for the spread of transmissible diseases. Additionally, some areas on eastern Long Island use baiting as a tool to increase nuisance deer harvest and manage the high deer densities commonly found throughout the island. High densities of free-ranging wildlife populations have been associated with increased contact rates among individuals (Ramsey et al. 2002). As deer densities increase, the indirect and direct contact rates increase between one group of deer and all the neighboring social groups (Schauber et al. 2007). Thus, on Long Island, 4-Poster devices may contribute to both frequency-dependent (artificial feeding source contributing to more frequent interactions between individuals) and density-dependent (higher densities contribute to higher rates of contact, thus the higher the deer population the more likely interactions will occur at an artificial bait source) potential transmission of disease throughout the deer population (McCallum et al. 2001, Schauber and Woolf 2003, Schauber et al. 2007). Studies have suggested density-dependent transmission is associated with a decline in infection as the population decreases, potentially allowing the population to rebound and stabilize (Anderson and May 1978). Frequency-dependent transmission has contributed to continuation of high levels of infection within deer populations due to social behaviors; deer within social groups make frequent contacts regardless of the total population density (Getz and Pickering 1983, Altizer et al. 2003). Thus, wildlife managers would still have concerns for frequency-dependent disease transmission risks when using 4-Poster technology within environments characterized by lower deer densities. However, while open bait sources and agriculture crops allow easy access by many deer at one time, 4-Poster devices are designed to restrict use by many deer at once through small feeding ports and restricted corn flow.

Using still-frame photos, we found limited differences in direct contact probabilities between deer using 4-Poster devices compared to open bait and indirect contact probabilities may be slightly higher at open bait. The 4-Poster design may result in fewer deer congregating at the device at one time but issues of indirect contact between deer using devices will likely remain a concern and must be considered during management planning.

Deer Vehicle Collisions

DVC Trends
The number of DVCs within the treatment area continued to decline through 2010 despite 4-Poster use which began in 2008. As expected, the control area experienced no change in the number of DVCs occurring each year. These results suggested 4-Poster devices did not contribute to increased interactions between deer and roads. However, many variables contribute to DVCs such as annual deer harvest, traffic volume, and traffic speeds. Traffic volumes and vehicle speeds are thought to have major impacts on the number and locations of DVCs (Pojar et al. 1975, Bashore et al. 1985). Additionally, population dynamics has been argued to confound the relationship between DVCs and traffic volume (Bruinderink and Hazebroek 1996). Deer management efforts reducing populations in areas characterized by high deer densities have also been associated with decreasing DVCs (McCullough 1997, Iverson and Iverson 1999, Joyce and Mahoney 2001, Nielsen et al. 2003, Seiler 2004, Rutberg and Naugle 2008). Throughout 2005-2010, traffic volume remained relatively stable within the treatment area but declined within the control area. Although road densities were somewhat higher within the control area compared to the treatment area, speed limits were similar. On the treatment area, traffic and road features likely had minimal influence on the declining trend in DVCs over time. However, the annual deer harvest was marked by a considerable decline in deer population numbers between 2006 and 2007 within the treatment area; this initial high deer harvest was the primary factor responsible for the decreasing number of DVCs over time (Figures 21 and 23). Despite a moderate decline of harvest numbers during 2008 (the first year of active 4-Poster use), the number of DVCs did not rebound which further suggested 4-Poster device use within the treatment area had minimal influence on DVCs. Instead, DVCs continued to decline throughout the study (2008-2010). Within the control area, the number of deer harvested each year remained relatively stable. Stable traffic volume (Figure 22) and deer management efforts (Figure 23) were likely principal factors contributing to stable DVCs over time (Figure 21).

4-Poster Influence on DVC Occurrence
Although distances of DVCs to the nearest 4-Poster devices within the treatment area were significantly greater during 2008 compared to 2009-2010, the distances during this treatment period (2008-2010) did not differ from distances during the pre-treatment period (2005-2007; $p = 0.1955$). These results suggest device deployment and placement likely had minimal impact on where DVCs occurred. The greater distances observed during 2008 were potentially due to where devices were placed compared to 2009 and 2010; device deployment and distribution was slightly different between 2008 and 2009 to further maximize deer use and tickicide treatment. Within the control area, the significantly greater distance of DVCs to pseudo-devices during 2010 compared to 2008 ($p = 0.0360$) and 2009 ($p = 0.0218$) was accounted for by a considerably small number of DVCs occurring ($n = 4$) compared to preceding years ($n = 15$ and 19, respectively). More importantly, just as observed within the treatment area, where 4-Poster devices were actively used, no differences were observed within the control area when evaluated between the pre-treatment period (2005-2007) and the treatment period (2008-2010). Overall, when evaluating the proximity of DVCs to devices or pseudo-devices within the treatment and control areas and between years as an indicator of impact, the comparisons revealed no significant impact of active device use on the occurrence of DVCs.

Seasonal deer behavior has been identified as an important variable in DVC occurrence (Allen and McCullough 1976); spring dispersal and fall breeding behaviors have been linked to increasing numbers of DVCs seasonally throughout a year (Puglisi et al. 1974, Feldhamer et al. 1986, Marchinton and Miller 1994, Bruinderink and Hazebroek 1996). Despite seasonal effects having significant influence on DVC occurrence in other studies, season did not significantly impact our model and did not play a role in the proximity of DVCs to 4-Poster devices. Additionally, we detected no significant impacts of landscape features including percent forest canopy or impervious surfaces and housing density, on the proximity of DVCs to 4-Poster devices, suggesting these factors had minimal influence on DVC occurrence before or during the study. Studies examining the role of landscape features on DVCs have had varying results with some suggesting that many DVCs concentrate around woodland-field interfaces in open habitat (Bashore et al. 1985) while others found DVCs were randomly distributed in areas of extensive woody cover (Bellis and Graves 1971, Bashore et al. 1985) or no relationship between DVCs and habitat type (Allen and McCullough 1976).

When assessing the influence of roadway characteristics on DVC occurrence, increased traffic volume and road density were associated with increasing distances between DVCs and devices. Some studies have shown that DVCs decrease with increased number of residences or buildings, decreased speed limits, decreased distances to woodland or fencing, and minimum driving visibility (Pojar et al. 1975, Case 1978, Bashore et al. 1985); these studies further suggested that increases in DVCs occurred in areas of high driving visibility where drivers increased their speeds. Some studies suggested increased traffic volume was correlated with increased DVCs (Allen and McCullough 1976), while others have found no significant relationship (Hubbard et al. 2000). Our results suggested that 4-Posters did not contribute to increased DVCs where traffic volumes and road densities are highest. Legal criteria for 4-Poster placement on the landscape (i.e., >300 ft from a road or residence) likely influenced the results obtained.

Further evaluation of the effect of treatment type (treatment/4-Poster devices or control/no 4-Poster devices) and period (pre-treatment, 2005-2007 or treatment, 2008-2010) suggested that 4-Poster devices did not influence the spatial locations or contribute to clustering patterns of DVCs. Within the control area, the proximity of DVCs to pseudo-devices remained consistent from 2005-2010. However, within the treatment area, DVCs occurred farther from devices during active device use (2008-2010) compared to the pre-treatment period (2005-2007) and no clustering of DVCs around individual devices was detected.

Study results suggested 4-Poster devices have had minimal contributions to the number and distribution of DVCs throughout the treatment area thus, use of this technology in a similar suburban environment would not be likely to cause negative consequences on the residential community. Areas with lower traffic volume and lower road densities may be areas of greater concern for DVCs in suburban areas due to habitat features and pockets of higher deer densities. Despite high deer densities and studies linking bait sources to increased DVCs (McCullough 1997), the use of 4-Poster devices providing deer with supplemental food, did not appear to have a negative impact on the residential community through increased DVCs or creation of DVC hot-spots around particular devices.

Vegetation Damage

Within the natural forest habitat, levels of deer browsing damage remained similar throughout the study within all areas. Fewer natural plants sustained no browsing, and more suffered moderate and heavy damage within the treatment study areas as the study progressed, whereas the percentages of these browse intensity levels remained similar within the control area. These results suggested deer browsing continued within these areas throughout the study and thus, supplemental feed offered through 4-Poster use did not contribute to a decline in natural vegetation damage by deer. The increase in moderate and heavy damage may reflect browsing preferences for the natural plants available within the sampling plots, thus further evaluation of high, medium, and low preference natural indicator species was conducted. The sample sizes available for high, medium, and low preference natural indicator species were too low for meaningful statistical evaluation in any area (control or treatment) due to high levels of deer damage prior to the start of study. However, these low sample sizes are reflective of the poor health of the natural forest ecosystem within the control and treatment areas caused by a history of high deer densities and extensive deer browsing. Field surveys revealed very little browse available below 6 feet in height, and even less species of nutritional value or preferred by deer. Studies have shown that the overabundance of white-tailed deer in the northeastern Unites States has had negative impacts on human health and natural ecosystems for decades. Overabundant deer populations and preferential browsing by deer have been linked to significant decreases in forest species diversity and regeneration; and increases in the growth of unpalatable, often invasive plants (Conover et al. 1995, Ward 2000, and Magnarelli et al. 2004).

During 2009 and 2010 we observed low plant diversity in the natural forest ecosystem and a multi-year history of heavy to severe deer browsing. Although few plant species were observed with heavy and moderate browse damage, and a larger number of plant species were observed with light to no browse damage, sampling plots either lacked regeneration or were dominated by vegetation that was low preference deer browse. The resulting forest structure was comprised of mature trees and sparse understory primarily of low preference species such as oriental bittersweet, autumn olive, tartarian honeysuckle, multiflora rose, or *Rubus* spp. The forest overstory was primarily comprised of oak (scarlet, white, black, red, chestnut, post), American beech, and black cherry with maples (primarily red), black locust, hickory (*Carya* spp.) and sassafras as secondary components. Little to no regeneration of these tree species was present within sampling plots. The proportion of plots containing no regeneration was low in all areas; regeneration of low, medium, and high preference browse was rarely or never observed. These results further suggested that the high deer densities observed within the control and treatment areas prior to the study have contributed to heavy-severe vegetative damage and making it difficult to thoroughly elucidate 4-Poster influence on damage.

As the study progressed (2009-2010) within the treatment area, the percentage of moderately browsed plants was greater at closer distances to 4-Posters, however no noticeable trends were detected for lightly, heavily, or severely browsed plants. Additionally, lower percentages of plants with no damage were recorded closest and farthest from 4-Posters within the treatment area. Evaluation of differences across distances classes within the control area, where no 4-Posters were used, suggested that distance class had no impact on browse intensities by deer. These results suggested 4-Posters may be associated with slightly more deer damage in close proximity to devices within the treatment area. Supplemental feed, such as those offered to deer through 4-Poster devices, can contribute to increased deer damage on vegetation near the available food source (Doenier et al. 1997, Schmitz 1990). Browsing pressure around supplemental feeding sites has been shown to contribute to concentration of deer foraging activities around feeders (Cooper et al. 2006a). Deer browse vegetation within the vicinity of supplemental feed while in route to and from feeders, or while waiting to utilize feeding sites. The implications of these feeding patterns is potential over-browsing of palatable or preferred plants available near the supplement food sources (Cooper et al. 2006a).

Further evaluation of browse-intensity data indicated the treatment area also had higher percentages of plants browsed under all damage classes, except heavily browsed, when compared to the control area. These results suggested devices were not contributing to heavier browsing intensities, but more likely reflected site and deer habitat use differences inherent to the control and treatment areas. Small samples sizes within many browse-intensity categories make reliable statistical analysis difficult (Table 14). However across distance classes, the percentages of plants browsed under each browse-intensity category within the control and treatment study areas did not appear to show significant trends closer to, or further from devices (Figure 26). Many natural plots within the control area had nothing growing, or contained plants that were not preferred or unpalatable to deer, due to past over-browsing (Figure 29). Within the control and treatment areas, plots were typically characterized by undamaged plants because these were unpalatable, heavily browsed plants because these were palatable deer choices or no plants because the area had been previously over-browsed by deer. Increases in deer densities and browsing pressure can have lasting effects on palatable plants species within a landscape (Anderson and Katz 1993, Augustine and Jordan 1998), and these impacts were readily observed within both the treatment and control areas.

Ornamental landscape plantings have been regarded as important food resources for deer in urban and suburban environments (Kilpatrick and Spohr 2000). Studies have shown that deer feeding activities and food options are significantly greater near homes (Swihart et al. 1995) and areas characterized by high deer densities often suffer economic damage on both agricultural crops and landscaping plants (DeNicola et al. 2000, Ward 2000). Browse-intensity evaluation on ornamental vegetation within the control and treatment areas revealed more undamaged ornamentals within SIA compared to the control and SIB throughout the study, but plants with light deer damage did not differ between areas. More intense deer damage (moderate, heavy, and severe) was observed within the control area compared to the treatment area as the study progressed. Results do not suggest that deer use of supplemental food offered at 4-Poster devices resulted in increased damage to ornamental vegetation at homes within the 4-Poster treatment areas. Fewer ornamental plants with heavy and severe deer damage were sampled during 2010 in all areas potentially suggesting some vegetative recovery during the study. However, the deer management programs established within the control and treatment areas prior to the study (2005 and 2006, respectively) reduced deer densities and the impact of the management efforts may be reflected in these results.

No change in deer damage levels on high preference ornamental species were observed as the study progressed in the control or treatment. However, sample sizes of high preference species were low in each area due to a heavy history of damage by overabundant deer making it difficult to thoroughly evaluate impact by deer and changes over a short time period (2 years). Limited numbers of medium preference ornamental indicator plants were sampled under each browse intensity category for the control and treatment areas. Not only can high deer numbers put considerable browsing pressure on all plants, regardless of browse preference, but landowners often respond to costly deer damage through the use of deer-resistant (unpalatable) ornamental landscaping or completely enclosing preferred plants, making them inaccessible. These techniques were used extensively within both the control and treatment areas and were likely the primary factors contributing to the results we observed with high-preference and medium-preference plant sampling. Low-preference ornamental plants (i.e., boxwoods) were commonly found throughout all areas. No changes were observed in percent damage to these low-preference plants in the control and treatment areas throughout the study. Samples sizes for all other browse-intensity categories (light, moderate, heavy, and severe) were too low for analysis. These results suggested boxwoods sustained minimal damage by deer, even in areas with high deer densities, and these results did not change despite 4-Poster use within the treatment area. The landscaping practices established within all 3 study areas, as well as the history of heavy deer damage and high deer densities, were reflected in the results obtained. The 4-Poster devices did not appear to have noticeable impacts to plant damage during the 2 years of survey. However, further evaluation in a landscape with lower deer densities and less initial vegetation damage may provide additional insight.

As a response to heavy deer pressure on gardens and amenity plants, many residents choose to use deer-resistant varieties around their homes. Deer browse intensity sampling at homes provided evidence that a large number of property owners are selecting amenity plants that are not preferred by deer such as boxwoods, barberry, Andromeda, osmanthus, American holly, leucothoe, dwarf Alberta spruce, and many others. However, many ornamental plants have been heavily and severely damaged by deer and these include azalea, juniper spp., cherry and mountain laurel, Japanese holly, euonymus, privet, as well as others. Deer damage varied between sites and in some sites, plants (e.g., rhododendrons and forsythia) were heavily damaged by deer but in other locations minimal damage was evident on the same plant species. Variability in browse intensity was also observed within plant genera during ornamental vegetation sampling. For example, Pfitzer juniper was often not browsed while torulosa juniper was severely browsed and although American and English hollies are good choices to plant to avoid deer damage, Japanese and grape hollies were often heavily and severely browsed. In addition to selecting deer resistant ornamental plants, fencing was also widely used to prevent or reduce deer browse damage within the treatment and control areas. A fence (≥ 6 ft) was observed as one of the most reliable methods for controlling deer damage. At sampling sites where fencing was present and highly preferred plants were growing close to the fence, deer pushed in on the fencing and browsed accessible branches.

Overall, some increase in deer browsing on natural vegetation in close proximity to 4-Poster devices was evident but the heaviest browsing intensities were not shown to increase. The 4-Poster devices did not appear to have a significant impact on deer damage to ornamental plants near homes within treatment areas. The legal setback requirements for device placement (i.e., 300 ft from homes or 100 ft with fencing) may have had some role in the browsing patterns established by deer and the lack of increased impact seen near homes. However, further evaluation for longer duration and within an environment with lower deer densities and less initial vegetative deer damage may provide additional insight.

Objective II: Investigation of Permethrin Residues

Positive neck muscle results obtained during 2008 and 2010 from deer within the treatment area suggested residue transfer from the deer hide to the neck muscle can occur, even when exchanging clean gloves and meat processing tools. However, the positive results obtained during the 2008 study year were reviewed the NYS DOH and officials concluded that "results of preliminary sampling for permethrin indicate that the health risks of handling and of consuming venison or liver from deer that have visited a 4-Poster device on Shelter Island are very low"(Appendix 3).

Positive coat swab detections obtained from the control area suggested that environmental exposures other than 4-Poster devices likely resulted in permethrin accumulation on the hides of deer. As deer feed and move throughout the natural landscape, they are likely exposed to permethrin from physical contact with vegetation treated via methods such as broadcast lawn spraying. The lack of positive detection in any of the internal muscle or organ samples collected from deer within the control area suggested exposures are minimal, and limited to exterior accumulation only, or that residue transfers are not likely to occur during processing when coat swab amounts are 0.3 µg or less (Table 15b).

Corn consumption records suggested a decrease in corn consumption during the fall of 2010 compared to fall 2008 or 2009 (Figure 30) and acorns availability was plentiful during both 2009 and 2010 compared to 2008 (Figure 17). Reduced 4-Poster use by wildlife results in lower corn consumption and thus, less tickicide applied to the rollers on a device. The reduction in the amount of fresh tickicide present on rollers could contribute to decreased amounts of tickicide each deer was exposed to while feeding at a device. The lower coat swab results detected during 2010 may reflect the reduced tickicide application regime.

Evaluation of device-use information showed no correlations between feeding duration or frequency of device visitation and the amount of permethrin detected on corresponding coat swabs samples, but limited information was available. However, comparisons of device-use information (visitation frequency and feeding duration by deer) and coat swab detections for some sampled deer, indicated that more detailed records of device use may result in positive correlations between the number of visits to a device each day and the amount of permethrin detected on the corresponding coat swab (Figure 32). Device-use records do not sufficiently provide documentation of all the different devices used by each sampled deer, and all devices were not continuously monitored with trail cameras, thus there are potentially large periods of unknown deer use (visits/day).

Evaluations of positive neck muscle results with corresponding coat swab amounts and device use patterns suggested the permethrin detections within the neck muscles of 6 deer sampled within the treatment area were likely transferred from the outer hide of each animal, either through direct or indirect contact between the meat and hair.

Comparisons of deer device use, harvest information, and device maintenance records did not conclusively link positive permethrin detections (on coat swabs or within muscles) with any potential factors contributing to the positive results. The information obtained from trail cameras limits our ability to understand the complete device-use history for each sampled deer, and how that may influence permethrin detections on coat swabs or within muscles.

The permethrin residue investigations conducted during 2008-2010 provided sufficient evidence to conclude that the presence of permethrin on the hide of deer is expected when 4-Poster devices are being regularly used as part of a tick management strategy. Hunters and other individuals handling deer should always wear protective gloves as a standard safety measure to reduce exposure to permethrin residues that may be present on the hide of a harvested deer (Appendix 2). The residues detected on the hides of deer harvested from the control area, where no 4-Poster devices were used, provided sufficient evidence to indicate deer are accumulating surface residues from environmental exposure. We recommend that individuals handling deer should always wear protective gloves. Although permethrin may not translocate within a deer (i.e., entry via the bloodstream resulting in accumulation in the organs and muscles), low-level residues can be present on or within neck muscles collected from deer that have used 4-Poster devices. Further evaluation would be required to adequately and conclusively determine whether translocation of permethrin (i.e., entry via the bloodstream resulting in accumulation in the organs and muscles) occurs due to dermal exposure via 4-Poster device use. Residues detected within muscle samples likely resulted from permethrin being inadvertently transferred from the deer hide to the meat during handling and meat processing steps, even when safe handling procedures were carefully followed (Appendix 2). Although residues were detected when safe handling guidelines were followed, each hunter and meat processor should always follow the recommended safe handling guidelines, as these steps significantly reduce the likelihood of permethrin residue transfer (Appendix 2). The NYS DOH previously addressed concerns about the low-level residues detected in neck muscle samples, concluding that human health risks from consumption are very low (Appendix 3). Those individuals with concerns after careful consideration of the NYS DOH's human health review can elect not to consume venison obtained from the neck region of deer harvested from 4-Poster treatment areas or from areas where permethrin is used in landscape applications.

Objective III: Efficacy of 4-Poster System

4-Posters

With the relatively high deer populations in this study, 4-Posters performed as expected though some modifications in the design would simplify maintenance and improve durability in the field. Some issues with the design may be less important where few devices are deployed but become apparent in cases like this study where larger numbers are used. The relatively high cost for maintenance (applicator, corn and Tickicide) may be issues for many landowners or public health projects. Legitimate questions and issues were raised, beyond the scope of this study to address, concerning numbers of units needed with respect to the deer and human populations, how often and where 4-Posters need to be deployed to maintain tick populations at low levels while providing optimum benefits to the human population, the risk of populations of either tick species developing resistance to permethrin also considering the almost exclusive use of pyrethroid insecticides in landscape applications for tick control, alternative pesticides or materials for tick control for 4-Poster or landscape application, alternative host treatment methods, the need for community education on personal protection and risk, and impacts of 4-Poster technology on tick-borne disease and on use of preventive or curative drug therapy in humans and pets. Shorter buffer areas between placement sites and public roads, particularly where lower speed limits are in force, would offer more sites for placement in or near residential communities and may help address public exposure to ticks in these areas.

Ticks

In the baseline year 2008, overall tick abundance was similar between treatment study sites compared to the reference site. Tick community composition in the North treatment site differed from that at the North Haven reference site mostly due to higher abundances of *Amblyomma* immatures (larvae and nymphs, about 80% of the difference), and also due to higher abundance of *Ixodes* nymphs (about 8% of the difference). In 2009 (the first treatment year), the average tick abundances declined significantly in all treatment sites compared to 2008, but remained statistically similar to 2008 at the reference site.

At the North treatment site, the decline in tick abundance in 2009 as compared to 2008 was mostly due to reductions in *Amblyomma* immatures (larvae and nymphs, ~80% of the observed difference) and in the *Ixodes* nymphs (~7% of the observed difference). Compared to the North Haven reference site in 2009, the North treatment site had significantly lower overall tick abundance due mostly to lower abundances of *Amblyomma* nymphs (~60% of the observed difference) and *Ixodes* nymphs (~20% of the difference), i.e. the opposite situation from that observed in 2008.

At the South treatment site, the decline in tick abundance in 2009 as compared to 2008 was mostly due to the reduction in *Amblyomma* nymphs (~68% of the observed difference) and in *Ixodes* nymphs (~10% of the observed difference). However, there was also a slight increase in *Amblyomma* adult abundance contributing ~15% to the observed difference between 2009 and 2008. Compared to the reference site in 2009, the South treatment site had significantly lower overall tick abundance due mostly to lower abundances of *Amblyomma* nymphs (~62% of the observed difference) and *Ixodes* nymphs (~17% of the difference). Overall, South and North treatment sites trends were similar, with the exception of finding a much higher *Amblyomma* larval population at the North site in 2008 (and the subsequent greater decline in 2009).

At the Fire Island treatment site, the decline in tick abundance in 2009 as compared to 2008 was almost entirely due to reduction in *Amblyomma* nymphs (~90% of the observed difference). Compared to the reference site in 2009, the Fire Island treatment site had significantly lower overall tick abundance due mostly to lower abundances of *Amblyomma* nymphs (~60% of the observed difference) and *Ixodes* nymphs (~20% of the difference). There was a reduction in the *Amblyomma* nymphs in 2009, while *Ixodes* nymphs were low in 2008 and remained low into 2009.

In 2010, the overall tick abundance declined significantly at all study sites including both treatment and reference sites and compared to both 2008 and 2009, possibly due to environmental factors. Compared to the reference site, the decline in tick abundance in 2010 was significantly greater in North and South treatment sites (SI), but the overall tick abundance was similar between the North Haven reference site and the Fire Island treatment site in 2010.

In 2010, lower overall tick abundance at the reference site (North Haven) compared to 2008 and 2009 was due to the decline in *Amblyomma* nymphs (~67% of the difference on average) and to the decline in *Ixodes* nymphs (~14% of the difference on average).

At the North treatment site, the decline in tick abundance in 2010 as compared to 2009 was mostly due to reduction in *Amblyomma* nymphs and adults (~61% and ~23%, respectively, of the observed difference) and the reduction in *Ixodes* nymphs (~14% of the observed difference). *Amblyomma* larvae were present in 2008, contributing ~35% of the observed significant difference between 2010 and 2008. They were virtually absent in both 2010 and 2009, therefore did not contribute to any difference between those years. Additionally, there were lower abundances of *Amblyomma* nymphs (~50% of the observed difference), adults (~10% of the observed difference), and *Ixodes* nymphs (~5% of the observed difference) in 2010 compared to 2008. Compared to the North Haven reference site in 2010, the North treatment site had significantly lower average tick abundance due mostly to lower abundances of *Amblyomma* nymphs and adults (~59% and ~24% of the observed difference, respectively) and *Ixodes* nymphs (~16% of the difference).

At the South treatment site, the decline in tick abundance in 2010 as compared to 2009 was mostly due to the reduction in *Amblyomma* nymphs and adults (~59% and ~25%, of the observed difference, respectively) and the reduction in the *Ixodes* nymphs (~15% of the observed difference), very similar to the North site. *Amblyomma* larvae were virtually absent in both 2009 and 2010, but were low to begin with in 2008, therefore contributing only ~5% of the observed significant difference between 2010 and 2008 (unlike the North site, which had much higher *Amblyomma* larval populations at sampling in 2008). Thus, the main differences in the South site between 2008 and 2010 were due to the lower abundances of *Amblyomma* nymphs (~76% of the observed difference), followed by *Amblyomma* adults (~12% of the observed difference), and *Ixodes* nymphs (~7% of the observed difference). Compared to the reference site in 2010, the South treatment site had significantly lower average tick abundance due mostly to lower abundances of *Amblyomma* nymphs and adults (~60% and ~25% of the observed difference, respectively) and *Ixodes* nymphs (~15% of the difference), again, almost identical to the North site.

At the Fire Island treatment site, the overall tick abundance declined in 2010 compared with 2008, but the tick species/developmental stage compositions were similar between 2009 and 2010. Significant decline in 2010 tick populations versus 2008 was mostly due to the reduction in *Amblyomma* nymphs (~89% of the observed difference) and adults (~6% of the observed difference). However, in 2010 there was also an increase in *Amblyomma* larval abundance (unlike the Shelter Island treatment sites) contributing ~4% of the observed difference. The average tick abundance and the species/developmental stage compositions were similar between the Fire Island treatment site and the reference site in 2010.

Analysis of *Amblyomma* nymph data alone generally parallels that for the entire data set. Nymph levels were similar across sites in 2008. Within each of the treatment areas nymph levels were significantly lower in 2009 than 2008, but the same decline was not observed in North Haven over that same period. From 2008 to 2010 and from 2009 to 2010 tick levels significantly declined in North Haven and both Shelter Island study sites, but not in Fire Island. In 2009 lone star nymph populations were significantly lower in all 4-Poster treatment sites compared with North Haven; in 2010 levels were again lower than North Haven but only in the Shelter Island North and South study sites.

Ixodes nymph data indicate abundances over the three-year period in North Haven differed significantly from the 4-Poster treatment sites. Levels on Fire Island were generally quite low, with no significant changes over the three-year period. There were significant declines in all other sites from 2008 to 2010, but not from 2008 to 2009. Levels in Shelter Island North and South also significantly declined from 2009 to 2010. Compared with North Haven figures, tick levels in the Shelter Island North and South sites were similar in 2008 but significantly lower than North Haven in 2009 and (in Shelter Island South only) in 2010. *Ixodes* nymphs were significantly higher in North Haven compared with Fire Island for all three years.

Despite a relatively unfavorable year for ticks in 2010, significant reductions were noted from 2008 levels compared with North Haven for combined species and stages, and for *Amblyomma* nymphs in both Shelter Island treatment sites, and for *Ixodes* nymphs in the Shelter Island South and Fire Island treatment sites.

In summary, clear-cut tick abundance at all 4-Poster treatment sites in 2009 significantly declined from 2008 levels and was lower in 2009 compared with the reference site that year. The main contributor to the decline was *Amblyomma* nymphs (all treatment sites), followed by *Ixodes* nymphs (only Shelter Island sites; Fire Island *Ixodes* abundance in samples was very low throughout the study period), and *Amblyomma* larvae (at the North site only). However, 2010 was not a good year for ticks, with lower abundance measured at all sites including North Haven. Still, there were significant tick density declines in 2010 at the Shelter Island sites (North and South) compared to 2009, 2008, and the reference site in 2010. Again, the main contributor to the differences was lower abundance of *Amblyomma* nymphs, followed by *Amblyomma* adults and *Ixodes* nymphs. Also, at the North site, *Amblyomma* larvae were virtually absent in both 2009 and 2010, while found in 2008. Unlike the other 4-Poster treatment sites in 2010, Fire Island was similar to the reference site in the average tick abundance. Although tick abundance at the Fire Island site that year was lower than in 2009, the species/stage composition was similar. The main difference between 2008 and 2010 was the decline in *Amblyomma* nymphs. However, there was also an increase in *Amblyomma* larvae in 2010, unlike what was observed in the Shelter Island treatment sites. Generally, there were similar temporal trends around different devices or within the three distance tiers in each treatment study site, showing no apparent effect on tick levels related to distance from a 4-Poster device. Tick levels in 4-Poster study sites significantly declined compared with North Haven from 2008 to 2009, and in most cases from 2008 to 2010.

Data on tick levels found on ears of deer (Table 9) are not sufficient to infer any conclusions and pre-study levels were not examined, but the high numbers of immature *Amblyomma* seen in 2008 in Shelter Island samples were not found in samples from subsequent years taken from there.

MANAGEMENT IMPLICATIONS

Previous studies have suggested 4-Poster technology has contributed to large reductions in tick populations in the years following use of 4-Poster devices (Carroll et al. 2002, Pound et al. 2000a, Pound et al. 2000b, Solberg et al. 2003). Within a suburban environment, we also observed successful reduction of high tick populations during the 3 year study. However, this management tool requires baiting of wildlife and also uses permethrin for dermal wildlife treatment to control ticks. There is concern for device use related to baiting of wildlife and the potential spread of transmissible diseases. While direct contact between wildlife is minimized at the supplemental feed offered through 4-Poster devices, we observed devices contributing to increased indirect wildlife contact. In areas where transmissible diseases are endemic, use of these devices would not be recommended. Within environments where transmissible disease are not yet a concern, managers should use caution and consider establishing yearly or bi-yearly pathology testing programs to evaluate disease status (i.e., rabies and chronic-wasting disease) within the local wildlife populations. The use of permethrin on wildlife did result in positive laboratory detection of permethirn presence on (dermal) deer and within neck meat. These positive detections indicate that residents should be notified in 4-Poster deployment areas.

We observed minimal movement of deer between our treatment site and other surrounding areas. However, our treatment site was a relatively closed environment (island), thus if 4-Posters are used in other areas, surrounding residential communities should be informed of the use of the technology and potential avenues for permethrin exposure. Deer browsing damage on natural vegetation was also observed slightly greater in close proximity to 4-Poster devices. However, the extensive damage caused by deer within our treatment area prior to the study confounds these results. In areas with lower deer densities, device deployment strategies should consider their forest ecosystem health (i.e., areas of special concern or sensitive vegetation) when developing device deployment strategies.

Although we saw no change in the deer population status (population growth, reproductive success, or mortality), incidence of deer-vehicle collisions, or deer movement and behavior, managers should carefully evaluate the natural and residential landscape structure as well as the local deer and tick populations before actively using this technology. We found, in a closed (island), suburban environment, this technology could effectively reduce high tick numbers while causing minimal disturbance to the residential community. Transmissible wildlife disease are not endemic and the closed (island) nature of the study area limited the movement of permethrin-treated wildlife between areas where 4-Poster devices were used and where they were not, thus minimizing potential human exposure. Additionally, in areas where deer densities are lower, managers using 4-Poster technology may potentially be concerned with more visible deer and deer damage to natural vegetation and will need to plan device deployment strategies to minimize deer disturbance to the natural environment while maximizing deer use for effective tickicide treatment.

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Table 1. The 2008 and 2009 white-tailed deer live-trapping seasons resulted in a total of 97 marked deer on Shelter Island, New York (treatment area; 59 tagged females and 38 tagged males) and 41 on North Haven, New York (control area; 29 tagged females and 12 tagged males).

Capture Date	Capture Study Area	Ear Tag ID	Approximate Age	Sex	Radio Frequency	Collar Type	Estimated Weight
2/25/2008	Shelter Island	A51	Fawn	Male			85
2/25/2008	Shelter Island	A52	Adult	Male			120
2/29/2008	Shelter Island	A01	Adult	Female	150.010	VHF	100
2/29/2008	Shelter Island	A53	Fawn	Male			85
2/29/2008	Shelter Island	B001	Fawn	Female			65
3/2/2008	Shelter Island	B02	Adult	Female	150.390	VHF	130
3/2/2008	Shelter Island	B03	Adult	Female	150.730	VHF	125
3/2/2008	Shelter Island	B04	Adult	Female			100
3/2/2008	Shelter Island	B051	Fawn	Male			80
3/6/2008	Shelter Island	A02	Adult	Female	150.870	VHF	115
3/13/2008	Shelter Island	A03	Adult	Female	150.590	VHF	115
3/13/2008	Shelter Island	A04	Adult	Female			110
3/21/2008	Shelter Island	A05	Fawn	Female			65
3/25/2008	Shelter Island	B05	Adult	Female	150.330	VHF	120
3/28/2008	Shelter Island	A58	Fawn	Male			80
3/29/2008	Shelter Island	A07	Fawn	Female			70
3/29/2008	Shelter Island	A08	Adult	Female	150.035	GPS	115
3/29/2008	Shelter Island	A59	Fawn	Male			70
3/31/2008	Shelter Island	A09	Fawn	Female			60
4/9/2008	Shelter Island	A63	Fawn	Male			100
4/9/2008	Shelter Island	B53	Fawn	Male			80
4/10/2008	Shelter Island	B09	Fawn	Female			75
4/16/2008	Shelter Island	B54	Fawn	Male			80
4/24/2008	Shelter Island	B55	Adult	Male			130
8/4/2008	Shelter Island	B10	Adult	Female	150.410	GPS	90
8/5/2008	Shelter Island	A11	Yearling	Female	150.610	GPS	115
8/7/2008	Shelter Island	A12	Adult	Female	150.850	GPS	115
8/10/2008	Shelter Island	A13	Adult	Female	150.510	GPS	115
8/13/2008	Shelter Island	B13	Adult	Female	150.230	VHF	100
1/8/2009	Shelter Island	A014	Fawn	Female			40
1/8/2009	Shelter Island	A066	Fawn	Male			40
1/9/2009	Shelter Island	A015	Adult	Female	150.530	GPS	110
1/9/2009	Shelter Island	A016	Adult	Female	150.910	GPS	115
1/9/2009	Shelter Island	A017	Fawn	Female			50
1/10/2009	Shelter Island	A018	Fawn	Female			40
1/10/2009	Shelter Island	A019	Adult	Female	151.310	GPS	140
1/10/2009	Shelter Island	A068	Fawn	Male			45
1/10/2009	Shelter Island	A069	Fawn	Male			45
1/11/2009	Shelter Island	A020	Fawn	Female			50
1/11/2009	Shelter Island	A021	Fawn	Female			50
1/11/2009	Shelter Island	A070	Fawn	Male			55
1/13/2009	Shelter Island	A022	Adult	Female	151.510	GPS	130
1/14/2009	Shelter Island	A023	Yearling	Female	150.070	VHF	130
1/14/2009	Shelter Island	A024	Yearling	Female			110
1/14/2009	Shelter Island	A025	Fawn	Female			50
1/14/2009	Shelter Island	A026	Fawn	Female			50

Table 1. Continued

Capture Date	Capture Study Area	Ear Tag ID	Approximate Age	Sex	Radio Frequency	Collar Type	Estimated Weight
1/14/2009	Shelter Island	A071	Yearling	Male			115
1/15/2009	Shelter Island	A027	Yearling	Female	151.990	GPS	125
1/15/2009	Shelter Island	A028	Fawn	Female			45
1/15/2009	Shelter Island	A072	Fawn	Male			50
1/15/2009	Shelter Island	A073	Fawn	Male			50
1/16/2009	Shelter Island	A026	Fawn	Female			50
1/16/2009	Shelter Island	A029	Yearling	Female	151.950	GPS	135
1/17/2009	Shelter Island	A030	Adult	Female	151.560	VHF	130
1/17/2009	Shelter Island	A074	Fawn	Male			50
1/17/2009	Shelter Island	A075	Fawn	Male			50
1/18/2009	Shelter Island	A067	Fawn	Male			50
1/19/2009	Shelter Island	A068	Fawn	Male			50
1/20/2009	Shelter Island	A031	Yearling	Female			120
1/20/2009	Shelter Island	A076	Yearling	Male			120
1/21/2009	Shelter Island	A032	Fawn	Female			40
1/22/2009	Shelter Island	A077	Fawn	Male			45
1/23/2009	Shelter Island	A033	Adult	Female	151.770	VHF	140
1/23/2009	Shelter Island	A034	Fawn	Female			50
1/27/2009	Shelter Island	B014	Yearling	Female	151.650	VHF	140
1/29/2009	Shelter Island	B015	Adult	Female	151.530	GPS	145
2/3/2009	Shelter Island	B056	Yearling	Male			140
2/6/2009	Shelter Island	B016	Fawn	Female			40
2/11/2009	Shelter Island	B057	Fawn	Male			40
2/11/2009	Shelter Island	B058	Fawn	Male			50
2/13/2009	Shelter Island	B059	Yearling	Male			140
2/17/2009	Shelter Island	B060	Fawn	Male			60
2/17/2009	Shelter Island	B061	Yearling	Male			140
2/20/2009	Shelter Island	B017	Adult	Female	151.410	VHF	155
2/20/2009	Shelter Island	B062	Fawn	Male			55
2/24/2009	Shelter Island	B018	Adult	Female	151.850	VHF	165
2/24/2009	Shelter Island	B019	Fawn	Female			55
2/24/2009	Shelter Island	B020	Fawn	Female			60
2/25/2009	Shelter Island	B021	Adult	Female	151.360	GPS	135
2/25/2009	Shelter Island	B022	Fawn	Female			60
2/25/2009	Shelter Island	B063	Fawn	Male			65
2/25/2009	Shelter Island	B064	Fawn	Male			55
3/2/2009	Shelter Island	B023	Adult	Female	150.550	GPS	165
3/4/2009	Shelter Island	B024	Adult	Female	151.260	GPS	160
3/4/2009	Shelter Island	B025	Yearling	Female	151.730	VHF	150
3/4/2009	Shelter Island	B065	Fawn	Male			55
3/4/2009	Shelter Island	B066	Fawn	Male			60
3/4/2009	Shelter Island	B067	Fawn	Male			60
3/4/2009	Shelter Island	B068	Fawn	Male			60
3/5/2009	Shelter Island	B026	Adult	Female	150.970	VHF	175
3/5/2009	Shelter Island	B069	Adult	Male			160
3/5/2009	Shelter Island	B070	Fawn	Male			65

Table 1. Continued

Capture Date	Capture Study Area	Ear Tag ID	Approximate Age	Sex	Radio Frequency	Collar Type	Estimated Weight
3/6/2009	Shelter Island	B027	Fawn	Female			60
3/6/2009	Shelter Island	B028	Adult	Female			150
3/12/2009	Shelter Island	B029	Adult	Female			170
9/9/2009	Shelter Island	B030	Adult	Female	150.750	GPS	135
9/23/2009	Shelter Island	B031	Yearling	Female	150.150	GPS	130
4/30/2008	North Haven	001	Adult	Female	150.210	GPS	140
5/6/2008	North Haven	002	Adult	Female	150.170	GPS	150
5/7/2008	North Haven	003	Adult	Female	150.190	GPS	100
5/13/2008	North Haven	004	Adult	Female	150.110	GPS	140
5/16/2008	North Haven	051	Yearling	Male			75
8/11/2008	North Haven	005	Adult	Female	150.150	GPS	110
1/15/2009	North Haven	006	Yearling	Female	151.910	VHF	130
1/23/2009	North Haven	052	Fawn	Male			45
1/27/2009	North Haven	055	Yearling	Male			180
1/27/2009	North Haven	053	Fawn	Male			50
1/29/2009	North Haven	007	Adult	Female			140
1/29/2009	North Haven	008	Fawn	Female			50
1/29/2009	North Haven	054	Fawn	Male			50
1/29/2009	North Haven	009	Yearling	Female	151.060	GPS	130
1/30/2009	North Haven	011	Yearling	Female			110
1/30/2009	North Haven	056	Fawn	Male			50
1/30/2009	North Haven	010	Adult	Female	150.830	VHF	140
2/2/2009	North Haven	012	Fawn	Female			50
2/4/2009	North Haven	013	Fawn	Female			40
2/4/2009	North Haven	057	Yearling	Male			140
2/5/2009	North Haven	014	Fawn	Female			40
2/5/2009	North Haven	058	Fawn	Male			50
2/6/2009	North Haven	015	Adult	Female	151.030	VHF	150
2/7/2009	North Haven	060	Adult	Male			190
2/17/2009	North Haven	017	Yearling	Female	150.990	VHF	125
2/17/2009	North Haven	016	Adult	Female	151.970	GPS	160
2/17/2009	North Haven	018	Fawn	Female			55
2/17/2009	North Haven	062	Fawn	Male			65
2/21/2009	North Haven	061	Fawn	Male			65
2/21/2009	North Haven	063	Fawn	Male			100
2/21/2009	North Haven	020	Yearling	Female			145
2/21/2009	North Haven	019	Adult	Female	151.810	VHF	155
3/2/2009	North Haven	021	Adult	Female	151.210	GPS	155
3/6/2009	North Haven	022	Fawn	Female			60
3/6/2009	North Haven	023	Adult	Female	151.110	VHF	155
3/31/2009	North Haven	025	Fawn	Female			80
3/31/2009	North Haven	024	Fawn	Female			80
4/1/2009	North Haven	026	Adult	Female	151.460	GPS	180
4/7/2009	North Haven	027	Yearling	Female	150.790	VHF	170
8/19/2009	North Haven	030	Adult	Female	150.190	GPS	130
9/1/2009	North Haven	031	Yearling	Female	150.710	GPS	130

Table 2. During the 2008 and 2009 white-tailed deer live-trapping seasons, 32 deer on Shelter Island (treatment area; 17 GPS collars and 15 VHF collars) and 18 deer on North Haven (control area; 11 GPS and 7 VHF) were collared.

Capture Date	Capture Study Area	Ear Tag ID	Approximate Age	Sex	Radio Frequency	Collar Type	Estimated Weight
2/29/2008	Shelter Island	A01	Adult	Female	150.010	VHF	100
3/2/2008	Shelter Island	B02	Adult	Female	150.390	VHF	130
3/2/2008	Shelter Island	B03	Adult	Female	150.730	VHF	125
3/6/2008	Shelter Island	A02	Adult	Female	150.870	VHF	115
3/13/2008	Shelter Island	A03	Adult	Female	150.590	VHF	115
3/25/2008	Shelter Island	B05	Adult	Female	150.330	VHF	120
3/29/2008	Shelter Island	A08	Adult	Female	150.035	GPS	115
8/4/2008	Shelter Island	B10	Adult	Female	150.410	GPS	90
8/5/2008	Shelter Island	A11	Yearling	Female	150.610	GPS	115
8/7/2008	Shelter Island	A12	Adult	Female	150.850	GPS	115
8/10/2008	Shelter Island	A13	Adult	Female	150.510	GPS	115
8/13/2008	Shelter Island	B013	Adult	Female	150.230	VHF	100
1/9/2009	Shelter Island	A015	Adult	Female	150.530	GPS	110
1/9/2009	Shelter Island	A016	Adult	Female	150.910	GPS	115
1/10/2009	Shelter Island	A019	Adult	Female	151.310	GPS	140
1/13/2009	Shelter Island	A022	Adult	Female	151.510	GPS	130
1/14/2009	Shelter Island	A023	Yearling	Female	150.070	VHF	130
1/15/2009	Shelter Island	A027	Yearling	Female	151.990	VHF	125
1/16/2009	Shelter Island	A029	Yearling	Female	151.950	GPS	135
1/17/2009	Shelter Island	A030	Adult	Female	151.560	VHF	130
1/23/2009	Shelter Island	A033	Adult	Female	151.770	VHF	140
1/27/2009	Shelter Island	B014	Yearling	Female	151.650	VHF	140
1/29/2009	Shelter Island	B015	Adult	Female	151.530	GPS	145
2/20/2009	Shelter Island	B017	Adult	Female	151.410	VHF	155
2/24/2009	Shelter Island	B018	Adult	Female	151.850	VHF	165
2/25/2009	Shelter Island	B021	Adult	Female	151.360	GPS	135
3/2/2009	Shelter Island	B023	Adult	Female	150.550	GPS	165
3/4/2009	Shelter Island	B024	Adult	Female	151.260	GPS	160
3/4/2009	Shelter Island	B025	Yearling	Female	151.730	VHF	150
3/5/2009	Shelter Island	B026	Adult	Female	150.970	VHF	175
9/9/2009	Shelter Island	B030	Adult	Female	150.750	GPS	135
9/23/2009	Shelter Island	B031	Yearling	Female	150.150	GPS	130
4/30/2008	North Haven	001	Adult	Female	150.210	GPS	140
5/6/2008	North Haven	002	Adult	Female	150.170	GPS	150
5/7/2008	North Haven	003	Adult	Female	151.150	GPS	100
5/13/2008	North Haven	004	Adult	Female	150.110	GPS	140
8/11/2008	North Haven	005	Adult	Female	151.010	GPS	110
1/15/2009	North Haven	006	Yearling	Female	151.910	VHF	130
1/29/2009	North Haven	009	Yearling	Female	151.060	GPS	130
1/30/2009	North Haven	010	Adult	Female	150.830	VHF	140
2/6/2009	North Haven	015	Adult	Female	151.030	VHF	150
2/17/2009	North Haven	017	Yearling	Female	150.990	VHF	125
2/17/2009	North Haven	016	Adult	Female	151.970	GPS	160
2/21/2009	North Haven	019	Adult	Female	151.810	VHF	155
3/2/2009	North Haven	021	Adult	Female	151.210	GPS	155
3/6/2009	North Haven	023	Adult	Female	151.110	VHF	155
4/1/2009	North Haven	026	Adult	Female	151.460	GPS	180
4/7/2009	North Haven	027	Yearling	Female	150.790	VHF	170
8/19/2009	North Haven	030	Adult	Female	150.190	GPS	130
9/1/2009	North Haven	031	Yearling	Female	150.710	GPS	130

Table 3. Home range and core area estimates were derived using 95% and 50% kernel density estimators and HRT in ArcGIS 9.2 for each collared deer within Shelter Island (treatment area) or North Haven, New York (control area) during 2008-2010. Collared deer surviving more than one year are counted in multiple years for home range analysis (i.e. some deer have multiple home range estimates across years).

						Core Area			Home Range		
Year	Treatment Type	Area	Collar Type	Tag	N	Acres	Miles^2	Hectares	Acres	Miles^2	Hectares
2008	Treatment	SIA	GPS	A08	3862	17.78	0.03	7.19	96.08	0.15	38.88
2008	Control	NH	GPS	003	1484	12.06	0.02	4.88	52.87	0.08	21.39
2008	Control	NH	GPS	002	3294	27.76	0.04	11.23	123.55	0.19	50.00
2009	Treatment	SIA	GPS	A12	4113	12.21	0.02	4.94	77.34	0.12	31.30
2009	Treatment	SIA	GPS	A16	4213	23.41	0.04	9.47	122.06	0.19	49.40
2009	Treatment	SIA	GPS	A19	4342	21.02	0.03	8.51	108.83	0.17	44.04
2009	Treatment	SIB	GPS	B15	4238	30.42	0.05	12.31	201.34	0.31	81.48
2009	Treatment	SIB	GPS	B23	4303	44.42	0.07	17.98	474.60	0.74	192.06
2009	Treatment	SIA	GPS	A13	4228	27.11	0.04	10.97	178.74	0.28	72.33
2009	Treatment	SIA	GPS	A11	4113	20.94	0.03	8.47	107.03	0.17	43.31
2009	Treatment	SIA	GPS	A08	4225	22.17	0.03	8.97	95.23	0.15	38.54
2009	Control	NH	GPS	026	3883	23.18	0.04	9.38	91.54	0.14	37.05
2009	Control	NH	GPS	021	4093	20.07	0.03	8.12	96.53	0.15	39.07
2009	Control	NH	GPS	003	3881	25.68	0.04	10.39	96.38	0.15	39.01
2009	Control	NH	GPS	002	4267	21.19	0.03	8.57	112.00	0.17	45.32
2009	Control	NH	GPS	009	4077	5.57	0.01	2.25	35.55	0.06	14.39
2009	Control	NH	GPS	016	4195	35.33	0.06	14.30	128.97	0.20	52.19
2009	Treatment	SIB	GPS	B10	4006	14.33	0.02	5.80	121.43	0.19	49.14
2009	Treatment	SIA	GPS	A15	3540	28.23	0.04	11.42	160.68	0.25	65.02
2009	Treatment	SIA	GPS	A22	4329	37.56	0.06	15.20	264.54	0.41	107.05
2009	Treatment	SIB	GPS	B21	3081	31.58	0.05	12.78	189.83	0.30	76.82
2009	Treatment	SIB	GPS	B24	4249	19.49	0.03	7.89	117.87	0.18	47.70
2010	Treatment	SIB	GPS	B23	4182	58.51	0.09	23.68	283.16	0.44	114.59
2010	Treatment	SIA	GPS	A19	3002	20.62	0.03	8.34	109.25	0.17	44.21
2010	Treatment	SIA	GPS	A16	3355	16.18	0.03	6.55	155.64	0.24	62.98
2010	Treatment	SIA	GPS	A13	4070	23.21	0.04	9.39	128.12	0.20	51.85
2010	Treatment	SIA	GPS	A12	2322	17.78	0.03	7.20	97.33	0.15	39.39
2010	Treatment	SIA	GPS	A11	4170	24.06	0.04	9.74	123.24	0.19	49.87
2010	Treatment	SIA	GPS	A08	3853	21.37	0.03	8.65	110.56	0.17	44.74
2010	Control	NH	GPS	026	4110	23.74	0.04	9.61	91.37	0.14	36.98
2010	Control	NH	GPS	021	3936	21.52	0.03	8.71	109.54	0.17	44.33
2010	Control	NH	GPS	003	3665	22.78	0.04	9.22	106.13	0.17	42.95
2010	Control	NH	GPS	030	3896	19.88	0.03	8.04	111.19	0.17	45.00
2010	Control	NH	GPS	031	3653	24.14	0.04	9.77	132.63	0.21	53.67
2010	Treatment	SIB	GPS	B31	3133	16.88	0.03	6.83	126.92	0.20	51.36
2010	Treatment	SIA	GPS	A29	3979	23.79	0.04	9.63	128.27	0.20	51.91
2010	Treatment	SIB	VHF	B26	112	6.55	0.01	2.65	31.10	0.05	12.58
2010	Treatment	SIB	VHF	B25	113	6.64	0.01	2.69	45.66	0.07	18.48
2010	Treatment	SIB	VHF	B18	109	13.14	0.02	5.32	64.18	0.10	25.97
2010	Treatment	SIB	VHF	B14	114	18.46	0.03	7.47	116.74	0.18	47.24
2010	Treatment	SIB	VHF	B13	114	8.30	0.01	3.36	38.76	0.06	15.69

Table 3. Continued

Year	Treatment Type	Area	Collar Type	Tag	N	Core Area Acres	Core Area Miles^2	Core Area Hectares	Home Range Acres	Home Range Miles^2	Home Range Hectares
2010	Treatment	SIB	VHF	B05	113	37.99	0.06	15.37	216.09	0.34	87.45
2010	Treatment	SIB	VHF	B02	113	3.60	0.01	1.46	25.62	0.04	10.37
2010	Treatment	SIA	VHF	A33	113	17.35	0.03	7.02	76.46	0.12	30.94
2010	Treatment	SIA	VHF	A30	112	54.09	0.08	21.89	251.75	0.39	101.88
2010	Treatment	SIA	VHF	A27	114	3.51	0.01	1.42	20.01	0.03	8.10
2010	Treatment	SIA	VHF	A23	113	6.50	0.01	2.63	30.15	0.05	12.20
2010	Treatment	SIA	VHF	A03	112	9.17	0.01	3.71	46.05	0.07	18.64
2010	Treatment	SIA	VHF	A02	114	5.00	0.01	2.02	28.32	0.04	11.46
2010	Treatment	SIA	VHF	A01	114	3.51	0.01	1.42	19.28	0.03	7.80
2010	Control	NH	VHF	027	115	4.66	0.01	1.89	32.24	0.05	13.05
2010	Control	NH	VHF	023	113	16.46	0.03	6.66	92.48	0.14	37.42
2010	Control	NH	VHF	019	115	9.09	0.01	3.68	38.82	0.06	15.71
2010	Control	NH	VHF	017	114	15.61	0.02	6.32	61.32	0.10	24.81
2010	Control	NH	VHF	015	114	2.76	0.00	1.12	15.33	0.02	6.21
2010	Control	NH	VHF	006	116	4.51	0.01	1.83	26.72	0.04	10.81
2010	Control	NH	VHF	001	58	5.32	0.01	2.15	24.03	0.04	9.73
2009	Control	NH	VHF	001	46	9.19	0.01	3.72	49.59	0.08	20.07
2009	Control	NH	VHF	006	96	3.56	0.01	1.44	23.95	0.04	9.69
2009	Control	NH	VHF	010	96	4.70	0.01	1.90	27.57	0.04	11.16
2009	Control	NH	VHF	015	95	2.17	0.00	0.88	16.12	0.03	6.53
2009	Control	NH	VHF	017	96	10.69	0.02	4.33	49.07	0.08	19.86
2009	Control	NH	VHF	019	97	7.70	0.01	3.11	35.22	0.06	14.25
2009	Control	NH	VHF	023	95	29.37	0.05	11.88	119.04	0.19	48.17
2009	Control	NH	VHF	027	93	3.08	0.00	1.24	18.71	0.03	7.57
2009	Treatment	SIA	VHF	A01	95	2.95	0.00	1.19	17.13	0.03	6.93
2009	Treatment	SIA	VHF	A02	96	5.19	0.01	2.10	33.43	0.05	13.53
2009	Treatment	SIA	VHF	A03	94	10.22	0.02	4.14	48.75	0.08	19.73
2009	Treatment	SIA	VHF	A23	95	6.11	0.01	2.47	29.29	0.05	11.85
2009	Treatment	SIA	VHF	A27	96	2.01	0.00	0.81	14.26	0.02	5.77
2009	Treatment	SIA	VHF	A30	84	37.19	0.06	15.05	150.38	0.23	60.86
2009	Treatment	SIA	VHF	A33	95	18.93	0.03	7.66	76.20	0.12	30.84
2009	Treatment	SIB	VHF	B02	97	7.08	0.01	2.86	32.48	0.05	13.15
2009	Treatment	SIB	VHF	B03	65	45.40	0.07	18.37	234.67	0.37	94.97
2009	Treatment	SIB	VHF	B05	90	25.63	0.04	10.37	131.96	0.21	53.40
2009	Treatment	SIB	VHF	B13	101	7.13	0.01	2.89	38.31	0.06	15.50
2009	Treatment	SIB	VHF	B14	93	6.12	0.01	2.48	30.45	0.05	12.32
2009	Treatment	SIB	VHF	B17	85	5.31	0.01	2.15	30.75	0.05	12.44
2009	Treatment	SIB	VHF	B18	96	11.20	0.02	4.53	78.36	0.12	31.71
2009	Treatment	SIB	VHF	B25	99	6.94	0.01	2.81	47.75	0.07	19.32
2009	Treatment	SIB	VHF	B26	99	5.48	0.01	2.22	25.82	0.04	10.45
2008	Control	NH	VHF	001	29	7.81	0.01	3.16	42.20	0.07	17.08
2008	Treatment	SIA	VHF	A01	97	6.79	0.01	2.75	27.30	0.04	11.05
2008	Treatment	SIA	VHF	A02	98	6.64	0.01	2.69	28.58	0.04	11.57
2008	Treatment	SIA	VHF	A03	89	16.15	0.03	6.53	78.68	0.12	31.84
2008	Treatment	SIB	VHF	B02	94	4.51	0.01	1.83	25.11	0.04	10.16
2008	Treatment	SIB	VHF	B03	97	29.81	0.05	12.06	178.63	0.28	72.29
2008	Treatment	SIB	VHF	B05	71	65.10	0.10	26.35	325.33	0.51	131.65

Table 4. Changes in home range and core area sizes were examined over time (2008-2010) to evaluate behavioral responses by deer to 4-Poster devices within treatment and normal range fluctuation where no bait was present within the control area. Average home range and core area sizes were compared between years (2008, 2009, and 2010) for each area (treatment and control areas) using ANOVAs (SAS 9.2).

						ANOVA			
Area	Variable	Year	n	Mean	Std Dev	df	Adjusted (Type III) Sum of Squares	Mean Square	P-value
Treatment	Home Range	2008	7	108.53	110.23				
		2009	29	111.71	97.98	2	2172.53	1086.27	0.8771
		2010	23	98.81	74.20				
	Core Area	2008	7	20.97	21.36				
		2009	29	18.47	12.82	2	45.60	22.80	0.9007
		2010	23	18.10	14.84				
Control	Home Range	2008	3	72.87	44.21				
		2009	14	64.30	40.91	2	313.64	156.82	0.9129
		2010	12	70.15	41.45				
	Core Area	2008	3	15.88	10.51				
		2009	14	14.39	11.09	2	6.87	3.43	0.9662
		2010	12	14.21	8.40				

Table 5. The percent overlap between the geographic boundaries of core areas estimated for different study years (2008-2009, 2008-2010, and 2009-2010) for the treatment study areas (SIA and SIB) and the control area (NH). Core area estimates were derived for each study year (2008-2010) and the percent overlap between years for each collared deer was calculated as,

Percent Overlap = $[(\text{Area of Overlap}_{\alpha\beta} / \text{Core Area}_{\alpha}) * (\text{Area of Overlap}_{\alpha\beta} / \text{Core Area}_{\beta})]^{0.5} * 100$,

where core area$_{\alpha}$ was the core area size of the respective individual during one study year, core area$_{\beta}$ was the core area size of the same individual during a subsequent study year, and area of overlap $_{\alpha\beta}$ was the area common to both core areas (Atwood et al. 2009).

Collar Type	Area	Tag	Study Years Compared	Percent Overlap
GPS	NH	003	2008 - 2009	52.04330044
GPS	NH	002	2008 - 2009	78.7446873
GPS	SIA	A08	2008 - 2009	59.40381921
VHF	SIA	A02	2008 - 2009	31.8008473
VHF	SIA	A01	2008 - 2009	38.28880303
VHF	SIA	A03	2008 - 2009	36.67470551
VHF	SIB	B03	2008 - 2009	48.28866755
VHF	SIB	B02	2008 - 2009	55.29429445
VHF	SIB	B05	2008 - 2009	46.86897712
GPS	NH	003	2008 - 2010	48.15188241
GPS	SIA	A08	2008 - 2010	50.17006803
VHF	SIA	A02	2008 - 2010	38.46732398
VHF	SIA	A01	2008 - 2010	35.46593932
VHF	SIA	A03	2008 - 2010	39.78902618
VHF	SIB	B02	2008 - 2010	41.25629256
VHF	SIB	B05	2008 - 2010	45.8234283
GPS	NH	003	2009 - 2010	82.71281387
GPS	NH	021	2009 - 2010	77.75377286
GPS	NH	026	2009 - 2010	78.50014605
VHF	NH	006	2009 - 2010	51.67920322
VHF	NH	015	2009 - 2010	52.06123564
VHF	NH	017	2009 - 2010	49.03420713
VHF	NH	019	2009 - 2010	61.74002003
VHF	NH	023	2009 - 2010	27.22314556
VHF	NH	027	2009 - 2010	67.69045386
GPS	SIA	A08	2009 - 2010	98.16222609
GPS	SIA	A13	2009 - 2010	81.11776953
GPS	SIA	A11	2009 - 2010	68.62843612
GPS	SIA	A12	2009 - 2010	79.47372566
GPS	SIA	A16	2009 - 2010	78.91464776
GPS	SIA	A19	2009 - 2010	81.74673125
VHF	SIA	A02	2009 - 2010	58.79893342
VHF	SIA	A01	2009 - 2010	52.06096749
VHF	SIA	A03	2009 - 2010	46.01833448
VHF	SIA	A23	2009 - 2010	58.52369033
VHF	SIA	A27	2009 - 2010	64.23107255
VHF	SIA	A30	2009 - 2010	66.99496346
VHF	SIA	A33	2009 - 2010	34.40019081
GPS	SIB	B23	2009 - 2010	46.17251062
VHF	SIB	B02	2009 - 2010	58.47852149
VHF	SIB	B05	2009 - 2010	58.85137494
VHF	SIB	B13	2009 - 2010	56.49990641
VHF	SIB	B14	2009 - 2010	55.26335957
VHF	SIB	B18	2009 - 2010	44.83368233
VHF	SIB	B25	2009 - 2010	74.44025319
VHF	SIB	B26	2009 - 2010	58.05059376

Table 6a. Summary statistics for the average relative number of each animal observed visiting 4-Poster devices during monthly trail camera surveys conducted on the treatment area during 2008-2010.

Year	Variable	N	Mean	Std Dev	Minimum	Maximum
2008	Deer	150	35.45	28.52	0.00	122.51
	Raccoon	150	45.83	97.40	0.00	593.10
	Squirrel	150	9.78	19.03	0.00	101.47
	Birds	150	7.14	18.16	0.00	152.77
2009	Deer	186	39.79	26.92	0.00	133.57
	Raccoon	186	41.38	69.40	0.00	429.00
	Squirrel	186	11.21	22.31	0.00	132.47
	Birds	186	10.03	23.42	0.00	236.33
2010	Deer	186	43.94	29.29	0.67	129.67
	Raccoon	186	24.18	49.50	0.00	353.67
	Squirrel	186	3.92	8.86	0.00	83.00
	Birds	186	4.12	7.13	0.00	62.33

Table 6b. ANOVA and Kruskal-Wallis estimates used to evaluate differences between the monthly average relative number of each animal using 4-Poster devices throughout the study (2008-2010).

	ANOVA				Kruskal-Wallis		
Variable	df	Adjusted (Type III) Sum of Squares	Mean Square	P-value	df	Chi-Square	P-value
Deer	2	5990.510224	2995.255112	0.024			
Raccoon					2	15.29	0.0005
Squirrel					2	4.85	0.0886
Birds					2	3.06	0.2169

Table 7. ANOVA and Kruskal-Wallis estimates used to evaluate differences between the seasonal (spring, summer, and fall) monthly average relative number of each animal using 4-Poster devices throughout the study (2008-2010).

	ANOVA												Kruskal-Wallis								
	Spring				Summer				Fall				Spring			Summer			Fall		
Variable	df	Adjusted (Type III) Sum of Squares	Mean Square	P-value	df	Adjusted (Type III) Sum of Squares	Mean Square	P-value	df	Adjusted (Type III) Sum of Squares	Mean Square	P-value	df	Chi-Square	P-value	df	Chi-Square	P-value	df	Chi-Square	P-value
Deer	2	1297.195	648.597613	0.1507	2	5722.043	2861.02132	0.0249	2	4874.121	2437.060287	0.0925									
Raccoon													2	1.9032	0.3861	2	19.0524	<0.0001	2	10.572	0.0051
Squirrel													2	30.6363	<0.0001	2	3.1213	0.21	2	26.8357	<0.0001
Birds													2	9.1057	0.0105	2	0.5076	0.7759	2	2.3561	0.3079

Table 8. Summary statistics for the average relative number of each animal observed visiting 4-Poster devices during monthly trail camera surveys throughout the seasons (spring, summer, and fall) of each study year (2008-2010).

Season	Year	Variable	N	Mean	Std Dev	Minimum	Maximum
Fall	2008	Deer	61	39.40	32.90	0.00	122.51
		Raccoon	61	82.72	136.82	0.00	593.10
		Squirrel	61	8.30	18.86	0.00	101.47
		Birds	61	5.18	19.57	0.00	152.77
	2009	Deer	70	41.63	30.19	1.33	133.57
		Raccoon	70	42.28	73.95	0.00	348.00
		Squirrel	70	0.66	1.59	0.00	8.57
		Birds	70	6.45	17.87	0.00	131.00
	2010	Deer	67	50.90	32.43	0.67	128.00
		Raccoon	67	23.21	48.02	0.00	256.00
		Squirrel	67	2.99	7.39	0.00	48.00
		Birds	67	2.76	6.53	0.00	37.67
Spring	2008	Deer	19	24.50	12.33	7.14	48.57
		Raccoon	19	15.62	26.14	1.00	116.00
		Squirrel	19	7.75	13.91	0.00	52.57
		Birds	19	6.41	10.39	0.14	42.29
	2009	Deer	45	33.75	21.28	0.00	83.39
		Raccoon	45	40.82	65.81	0.30	292.25
		Squirrel	45	25.97	32.25	0.00	132.47
		Birds	45	14.02	18.14	0.00	74.17
	2010	Deer	48	28.62	17.29	0.67	82.13
		Raccoon	48	25.02	46.37	0.00	290.33
		Squirrel	48	2.48	3.72	0.00	19.67
		Birds	48	4.66	5.05	0.00	19.38
Summer	2008	Deer	70	34.99	27.00	0.37	113.65
		Raccoon	70	21.88	44.64	0.00	302.58
		Squirrel	70	11.62	20.39	0.00	97.42
		Birds	70	9.05	18.53	0.00	101.48
	2009	Deer	71	41.82	26.47	2.67	111.67
		Raccoon	71	40.85	67.93	0.00	429.00
		Squirrel	71	12.27	20.15	0.00	97.33
		Birds	71	11.04	30.05	0.00	236.33
	2010	Deer	71	47.72	29.21	2.00	129.67
		Raccoon	71	24.51	53.44	0.00	353.67
		Squirrel	71	5.78	11.88	0.00	83.00
		Birds	71	5.02	8.62	0.00	62.33

Table 9. ANOVA and Kruskal-Wallis estimates used to evaluate differences between the monthly average relative number of each animal using 4-Poster devices each season (spring, summer, and fall) throughout each study year (2008, 2009, and 2010).

	ANOVA												Kruskal-Wallis								
	2008				2009				2010				2008			2009			2010		
Variable	df	Adjusted (Type III) Sum of Squares	Mean Square	P-value	df	Adjusted (Type III) Sum of Squares	Mean Square	P-value	df	Adjusted (Type III) Sum of Squares	Mean Square	P-value	df	Chi-Square	P-value	df	Chi-Square	P-value	df	Chi-Square	P-value
Deer	2	3245.13	1622.6	0.1361	2	2171.55	1085.8	0.2243	2	15525.29	7762.7	<0.0001									
Raccoon													2	8.4739	0.0145	2	2.9076	0.2337	2	4.0438	0.1324
Squirrel													2	4.9262	0.0852	2	75.8338	<0.0001	2	11.3453	0.0034
Birds													2	5.2529	0.0723	2	25.825	<0.0001	2	16.3233	0.0003

Table 10. Estimates of the number of deer and deer density (deer/mi^2) derived using a capture-resight (Bowden's Model Estimation, NoRemark; White et al., 1982, White 1996) method and branch-antlered buck (BAB) method (Jacobson et al. 1997). Estimates were for study areas (4.24 to 5.67 mi^2) used during 2008-2010 on Shelter Island (treatment area) and North Haven (control area).

		Shelter Island					North Haven				
		Bowden			BAB		Bowden			BAB	
Season	Study Year	Estimated No. of Deer	Confidence Interval	Deer/mi^2	Estimated No. of Deer	Deer/mi^2	Estimated No. of Deer	Confidence Interval	Deer/mi^2	Estimated No. of Deer	Deer/mi^2
Spring	2008	301	156 - 584	53.1	--	--	--	--	--	--	--
Fall	2008	541	361 - 812	95.4	286	50.4	--	--	--	150	26.9
Spring	2009	692	483 - 992	149.8	--	--	249	184 - 339	91.9	--	--
Fall	2009	615	489 - 775	133.1	440	95.2	311	232 - 418	114.8	229	36.2
Spring	2010	726	543 - 972	171.2	--	--	274	201 - 373	101.1	--	--
Fall	2010	1299	903 - 1869	306.4	672	158.5	446	314 - 635	164.6	257	38.4

Table 11. Summary statistics and 2-sample t-test results comparing the mean dressed weights of adults, yearlings, and fawns harvested on Mashomack Nature Preserve (TNC), Shelter Island during January 2008 and 2010.

	2007-2008					**2009-2010**					
Age Class and Sex	Weight (lbs)	n	sd	min	max	Weight (lbs)	n	sd	min	max	**p-value**
Adult Male	107.25	20	14.06	86	135	119.50	18	12.16	90	138	0.0071
Adult Female	89.48	46	9.84	62	110	94.76	54	8.55	76	116	0.0050
Yearling Male	88.97	37	12.25	62	118	99.12	41	13.47	66	135	0.0009
Yearling Female	77.65	17	9.69	63	95	84.06	32	9.89	71	106	0.0347
Fawn Male	47.67	30	9.12	33	66	54.10	59	9.56	32	78	0.0030
Fawn Female	40.60	42	8.35	24	56	47.80	46	9.07	32	68	0.0002

Table 12. Contact types that occurred between deer at each 4-Poster device deployed within the treatment area, Shelter Island, New York, throughout 2008-2010.

Device	Contact Type[a] None %	None n	Direct %	Direct n	Indirect %	Indirect n	Total
1	67.24	39	0.00	0	32.76	19	58
2	40.34	263	3.53	23	56.13	366	652
3	24.33	397	2.45	40	73.22	1195	1632
4	51.85	42	4.94	4	43.21	35	81
5	17.71	125	2.27	16	80.03	565	706
6	28.76	86	2.34	7	68.90	206	299
7	56.22	217	1.55	6	42.23	163	386
8	83.11	187	0.00	0	16.89	38	225
9	32.47	189	1.20	7	66.32	386	582
10	32.11	105	3.67	12	64.22	210	327
11	74.06	237	0.31	1	25.63	82	320
12	35.93	120	0.00	0	64.07	214	334
13	36.50	469	1.17	15	62.33	801	1285
14	51.51	545	2.74	29	45.75	484	1058
15	39.87	183	1.31	6	58.82	270	459
16	56.25	81	0.69	1	43.06	62	144
17	38.92	230	1.18	7	59.90	354	591
18	61.80	144	1.72	4	36.48	85	233
19	46.15	36	3.85	3	50.00	39	78
20	76.92	10	0.00	0	23.08	3	13
21	50.00	67	2.99	4	47.01	63	134
22	60.68	196	2.17	7	37.15	120	323
23	73.15	79	0.00	0	26.85	29	108
24	19.57	99	3.36	17	77.08	390	506
25	39.44	56	0.70	1	59.86	85	142
26	40.54	45	4.50	5	54.95	61	111
27	60.84	87	1.40	2	37.76	54	143
28	68.35	54	1.27	1	30.38	24	79
29	68.25	43	3.17	2	28.57	28	63
30	97.14	34	0.00	0	2.86	1	35
31	55.56	75	2.96	4	41.48	56	135
32	90.91	10	9.09	1	0.00	0	11
33	92.31	24	0.00	0	7.69	2	26
34	55.56	25	0.00	0	44.44	20	45
35	69.57	32	0.00	0	30.43	14	46
36	60.26	47	0.00	0	39.74	31	78
37	51.81	43	4.82	4	43.37	36	83
38	75.00	21	0.00	0	25.00	7	28
39	26.34	118	4.24	19	69.42	311	448
40	53.66	22	0.00	0	46.34	19	41
41	88.89	72	0.00	0	11.11	9	81
42	65.96	31	2.13	1	31.91	15	47
43	55.17	32	0.00	0	44.83	26	58
44	75.00	30	0.00	0	25.00	10	40
45	80.00	8	0.00	0	20.00	2	10
46	47.54	29	1.64	1	50.82	31	61
47	45.31	29	3.13	2	51.56	33	64
48	88.89	16	5.56	1	5.56	1	18
49	61.90	13	4.76	1	33.33	7	21
50	50.00	57	1.75	2	48.25	55	114
51	46.40	200	2.55	11	51.04	220	431
52	53.59	112	0.00	0	46.41	97	209
53	67.31	35	0.00	0	32.69	17	52
54	36.44	125	2.62	9	60.93	209	343
55	27.90	89	1.88	6	70.22	224	319
56	36.36	264	3.31	24	60.33	438	726
57	28.91	148	3.32	17	67.77	347	512
58	32.67	295	3.65	33	63.68	575	903
59	40.50	130	1.25	4	58.26	187	321
60	50.21	243	1.65	8	48.14	233	484

[a]Overall $\chi 2 = 1725.33$; $P < 0.001$

Table 13a. Continuous and categorical explanatory variables evaluated using linear mixed model regression (SAS 9.2) to discern variables that significantly impacted the distances deer-vehicle collisions (DVCs) occurred to 4-Poster devices within the treatment area (Shelter Island) or control area (North Haven, New York) between the pre-treatment (2005-2007) and during treatment (2008-2010) periods. The continuous variables included, road speed limit (mph), traffic volume (AADT or average vehicles/day), and density of roads (roads/m^2). Categorical variables included treatment type (treatment area or control area), period (pre-treatment period, 2005-2007 and treatment period, 2008-2010), and the interaction between treatment type and period.

	Fixed Effects				
Effects	**Estimate**	**Std Error**	**df**	**F-value**	**Pr > F**
Road Speed Limit	13.49	11.29	1, 303	1.43	0.2330
Traffic Volume	0.25	0.13	1, 303	3.66	0.0567
Density of Roads	23416.00	8683.89	1, 312	7.27	0.0074
Road Speed Limit*Traffic Volume	0.00	0.00	1, 324	0.30	0.5858
Treatment Type*	-451.89	88.89	1, 76	30.15	<0.0001
Period*	61.55	29.67	1, 306	1.15	0.2846
Treatment Type*Period*	-58.96	59.40	1, 302	0.99	0.3216

* Categorical variables. Least Square Means and Differences of Least Square Means provided in Table 1b for categorical variable of concern.

Table 13b. Linear mixed model regression was followed by pairwise comparisons for the interaction between treatment type and period using the LSMEANS statements of SAS 9.2; these comparisons specifically identified how the distance DVCs occurred to devices differed between periods (pre-treatment and during treatment) on the control site as well as on the treatment site. The interaction between treatment type and period was a variable of importance when assessing 4-Poster impact and was evaluated for each pair combination.

			Least Square Means					Differences of Least Square Means				
Effects	**Treatment Type**	**Period**	**Estimate**	**Std Error**	**df**	**t-value**	**Pr > t**	**Estimate**	**Std Error**	**df**	**t-value**	**Pr > t**
Treatment Type*Period	Control	During	52.37	78.15	93	0.67	0.5044	2.59	51.71	303	0.05	0.9601
		Pre	49.79	70.72	72	0.70	0.4837					
	Treatment	During	563.23	37.70	67	14.94	<0.0001	61.55	29.67	308	2.07	0.0388
		Pre	501.68	36.98	57	13.56	<0.0001					

Table 14. The percentages of natural plants sampled as unbrowsed (NB), lightly (L), moderately (M), or heavily browsed (H), across plots (distance classes) for the control area and treatment study areas (SIA and SIB) throughout 2009-2010. Small sample sizes for many browse intensity categories within plots for each site hindered thorough statistical evaluation. One plot was established within each distance class of 0-33 ft (0-10 m; plot 1), 36-328 ft (11-100 m; plot 2), 331-656 ft (101-200 m; plot 3), and 659-984 ft (201-300 m; plot 4).

		Plot								
		1		2		3		4		
Area	Browse Intensity Category	%	n	%	n	%	n	%	n	Total (N)
Control	NB	21.26	27	9.45	12	9.45	12	59.84	76	127
	L	41.38	12	6.90	2	10.34	3	41.38	12	
	M	20.00	4	20.00	4	15.00	3	45.00	9	
	H	48.30	71	19.73	29	4.76	7	27.21	40	
SIA	NB	28.90	89	17.21	53	14.29	44	39.61	122	308
	L	26.27	31	20.34	24	14.41	17	38.98	46	
	M	22.22	8	58.33	21	11.11	4	8.33	3	
	H	56.14	32	38.60	22	0.00	0	5.26	3	
SIB	NB	15.01	77	28.85	148	30.41	156	25.73	132	513
	L	13.68	61	22.87	102	25.56	114	37.89	169	
	M	50.39	65	6.20	8	3.10	4	40.31	52	
	H	62.86	22	2.86	1	0.00	0	34.29	12	

Table 15a. The amounts of permethrin detected on deer samples collected from Shelter Island, New York (treatment area) accompanied by harvest and 4-Poster use information for each deer sampled. The amount of permethrin detected within neck muscles, hind quarter muscles, and livers are provided in ppb while coat swab results are in µg. The laboratory used detection limits of 10 ppb and 0.01 µg and any results below these limits were reported as non-detects (ND).

Deer ID	Neck Muscle	Hindquarter Muscle	Liver	Coat Swab	Harvest and Sample Collection Date	Hunting Method	Sex	Approximate Age	Approximate Weight	Observations of 4-Poster Use	Date Last Observed at a 4-Poster During a Camera Survey
SI1	ND	—	ND	ND *	9/13/2008	Not Applicable	F	2.5	110	—	—
SI2	ND	—	ND	ND *	9/17/2008	Shotgun	F	8.5	130	—	—
SI3	ND	—	ND	ND *	9/17/2008	Shotgun	M	4 months	40	—	—
SI5	11.2	—	ND	16.28	10/3/2008	Regular Bow	M	5 months	60	Corn present in rumen	—
SI6	ND	—	ND	0.06	10/6/2008	Regular Bow	F	5 months	45		—
SI7	ND	—	ND	0.02	10/6/2008	Not Applicable	F	5 months	40	Corn present in rumen	—
SI8	ND	—	ND	0.02	10/10/2008	Not Applicable	F	5 months	45	—	—
SI9	ND	—	ND	0.02	10/10/2008	Regular Bow	F	3.5	120	—	—
SI11	ND	—	ND	2.6	10/10/2008	Regular Bow	M	1.5	120	Verified 4-Poster use	9/19/2008
SI14	ND	—	ND	68.4	10/17/2008	Nuisance Shotgun	M	1.5	125	Verified 4-Poster use	9/19/2008
SI15	55.9	—	ND	704	10/18/2008	Regular Bow	M	2.5	150	Verified 4-Poster use	9/16/2008
SI20	ND	—	ND	71.3	11/3/2008	Regular Bow	F	2.5	120	Tagged (B12) Verified 4-Poster use	9/18/2008
SI21	270.3	—	ND	5110.3	11/5/2008	Regular Bow	M	1.7	125	Verified 4-Poster use	9/19/2008
SI22	ND	—	ND	107.2	11/8/2008	Regular Bow	M	2.7	140	Tagged (B052) Verified 4-Poster use	10/21/2008
SI23	ND	—	ND	610.7	11/11/2008	Regular Bow	M	2.7	135	Tagged (A55) Corn in rumen. Verified 4-Poster use	10/23/2008
SI24	ND	—	ND	258.8	11/11/2008	Nuisance Shotgun	M	1.7	125	Tagged (A57) Verified 4-Poster use	6/19/2008
M1	ND	ND	ND	7.2	7/28/2009	Shotgun	M	1.2	120	Verified 4-Poster use	7/24/2009
M2	ND	ND	ND	108.1	7/30/2009	Shotgun	M	2.2	155	Verified 4-Poster use	7/23/2009
L3	ND	ND	ND	24.93	8/4/2009	Shotgun	M	Unknown Adult	90	Verified 4-Poster use	7/23/2009
SI7-09	ND	ND	ND	131.74	10/2/2009	Nuisance	M	1.5	125	Corn present in rumen. Verified 4-Poster use.	9/15/2009
SI-A20	ND	ND	ND	173.71	12/7/2009	Not Applicable	F	1.7	130	Corn present in rumen. Verified 4-Poster use.	9/15/2009
SI13-09	ND	ND	ND	1089.55	10/15/2009	Nuisance Shotgun	M	1.5	130	Corn present in rumen. Verified 4-Poster use.	9/15/2009
SI-B03	ND	ND	ND	297.26	10/11/2009	Not Applicable	F	2+	140	Corn present in rumen. Verified 4-Poster use.	8/20/2009
SI17-09	ND	ND	ND	1030.89	11/19/2009	Nuisance Shotgun	M	1.5	140	Corn present in rumen. Verified 4-Poster use.	11/18/2009
SI18-09	ND	ND	ND	34.98	11/23/2009	Regular Bow	M	3.5	165	Verified 4-Poster use	10/14/2009
SI21-09	ND	ND	ND	435.43	12/1/2009	Nuisance Shotgun	M	1.5	125	Corn present in rumen. Verified 4-Poster use.	11/19/2009
SI6-09	ND	ND	ND	5296.49	10/2/2009	Regular Bow	M	1.5	115	Tagged (A75) Corn in rumen. Verified 4-Poster use	9/15/2009
SI24-09	ND	ND	ND	578.25	12/8/2009	Nuisance Shotgun	M	1.5	130	Corn present in rumen. Verified 4-Poster use.	11/19/2009
SI25-09	ND	ND	ND	402.06	12/13/2009	Nuisance Shotgun	M	1.5	130	Verified 4-Poster use	11/17/2009
SI01-2010	ND	ND	—	176.15	10/22/2010	Nuisance Bow	M	1.7	115	Corn present in rumen. Verified 4-Poster use.	10/21/2010
SI02-2010	ND	ND	—	39.72	10/26/2010	Nuisance Shotgun	F	5 months	60	Corn present in rumen	—
SI04-2010	ND	ND	—	34.7	10/26/2010	Nuisance Shotgun	F	2.5	120	Corn present in rumen	—
SI05-2010	27.8	ND	—	1.02	11/1/2010	Regular Bow	F	3.5	115	Corn present in rumen	—
SI07-2010	ND	ND	—	9.01	11/2/2010	Nuisance Shotgun	M	2.5	125	Corn present in rumen. Verified 4-Poster use.	10/31/2010
SI08-2010	ND	ND	—	6.64	11/3/2010	Nuisance Shotgun	F	4.5	120	Tagged (A22). Verified 4-Poster use.	10/28/2010
SI09-2010	ND	ND	—	8.51	11/4/2010	Nuisance Shotgun	M	1.5	130	Corn present in rumen. Verified 4-Poster use.	10/29/2010
SI10-2010	17.33	ND	—	68.7	11/10/2010	Nuisance Shotgun	M	1.5	125	Corn present in rumen. Verified 4-Poster use.	11/9/2010
SI11-2010	ND	ND	—	281.88	11/10/2010	Nuisance Shotgun	M	1.7	80	Corn present in rumen. Verified 4-Poster use.	10/8/2010
SI13-2010	27.57	ND	—	42.86	11/11/2010	Nuisance Shotgun	M	1.5	120	Corn present in rumen. Verified 4-Poster use.	11/10/2010

Table 15b. The amounts of permethrin detected on deer samples collected from North Haven, New York accompanied by harvest information for each deer sampled. North Haven was the control site where no 4-Poster devices were used. The amount of permethrin detected within neck muscles, hind quarter muscles, and livers are provided in ppb while coat swab results are in µg. The laboratory used detection limits of 10 ppb and 0.01 µg and any results below these limits were reported as non-detects (ND).

Deer ID	Muscle	Hindquarter Muscle	Liver	Coat Swab	Harvest and Sample Collection Date	Hunting Method	Sex	Approximate Age	Approximate Weight	Observations of 4-Poster Use	Last Observation at a 4-Poster During a Camera Survey
NH1	ND	—	ND	0.02	10/4/2008	Nuisance	F	4.5	115	Not Applicable	Not Applicable
NH2	ND	—	ND	0.04	10/4/2008	Nuisance	F	5 months	50	Not Applicable	Not Applicable
NH3	ND	—	ND	0.05	10/4/2008	Nuisance	M	5 months	50	Not Applicable	Not Applicable
NH4	ND	—	ND	ND	10/27/2008	Nuisance	M	1.5	125	Not Applicable	Not Applicable
NH1-09	ND	ND	ND	0.2426	10/14/2009	Nuisance	M	6 months	50	Not Applicable	Not Applicable
NH2-09	ND	ND	ND	0.2277	10/27/2009	Nuisance	M	2.5	145	Not Applicable	Not Applicable
NH3-09	ND	ND	ND	0.0635	11/12/2009	Not Applicable	F	4.5	130	Not Applicable	Not Applicable
NH4-09	ND	ND	ND	0.0712	12/1/2009	Nuisance	M	1.6	135	Not Applicable	Not Applicable
NH5-09	ND	ND	ND	0.0613	12/9/2009	Nuisance	M	1.6	120	Not Applicable	Not Applicable
NH6-09	ND	ND	ND	ND	12/9/2009	Not Applicable	F	6 months	50	Not Applicable	Not Applicable
NH01-2010	ND	ND	—	ND	11/9/2010	Nuisance	M	5 months	45	Not Applicable	Not Applicable
NH02-2010	ND	ND	—	ND	11/11/2010	Nuisance	F	4.5	125	Not Applicable	Not Applicable
NH03-2010	ND	ND	—	0.27	12/3/2010	Nuisance	M	1.5	110	Not Applicable	Not Applicable
NH04-2010	ND	ND	—	ND	12/4/2010	Nuisance	M	5 months	55	Not Applicable	Not Applicable
NH05-2010	ND	ND	—	0.19	12/4/2010	Nuisance	M	5 months	55	Not Applicable	Not Applicable

Table 16. The maximum and minimum amounts of permethrin (µg) detected on coat swabs of deer collected from the treatment area during 2008-2010.

	Maximum		Minimum	
Year	Deer ID	Coat Swab	Deer ID	Coat Swab
2008	SI21	5110.3	SI1*	0
2009	SI6-09	5296.49	M1	7.2
2010	SI11-2010	281.88	SI05-2010	1.02

* Multiple deer ids with 0 µg coat swab results.

Table 17. The amounts of permethrin detected on or within deer samples collected on Shelter Island (treatment area) accompanied by device use history information for each deer sampled during 2008-2010. Device use history information was based on either the last device a deer was observed using if trail camera data was available or the device of probable use based on closest proximity to where the deer was harvested.

						Based on Device Location Where Last Observed					Based on Device Closest to Harvest Location		
Year	Deer ID	Date Harvested	Neck Muscle	Hindquarter Muscle	Coat Swab	Date Last Observed at a 4-Poster	Number of Days Between Last Observed and Harvest	Date of Last Application	Application Amount Per Post (ml)	Number of Days Between Last Application and Harvest	Date of Last Application	Application Amount Per Post (ml)	Number of Days Between Last Application and Harvest
2008	SI1	9/13/2008	ND	—	ND *	—	—	—	—	—	9/10/2008	7.5	3
2008	SI2	9/17/2008	ND	—	ND *	—	—	—	—	—	—	—	—
2008	SI3	9/17/2008	ND	—	ND *	—	—	—	—	—	—	—	—
2008	SI5	10/3/2008	11.2	—	16.28	—	—	—	—	—	10/2/2008	15	1
2008	SI6	10/6/2008	ND	—	0.06	—	—	—	—	—	10/2/2008	22.5	4
2008	SI7	10/6/2008	ND	—	0.02	—	—	—	—	—	10/2/2008	15	4
2008	SI8	10/10/2008	ND	—	0.02	—	—	—	—	—	10/8/2008	15	2
2008	SI9	10/10/2008	ND	—	0.02	—	—	—	—	—	9/17/2008	15	
2008	SI11	10/10/2008	ND	—	2.6	9/19/2008	21	10/8/2008	30	2	10/8/2008	30	2
2008	SI14	10/17/2008	ND	—	68.4	9/19/2008	28	10/15/2008	20	2	10/15/2008	20	2
2008	SI15	10/18/2008	55.9	—	704	9/16/2008	32	10/15/2008	30	3	10/15/2008	22.5	3
2008	SI20	11/3/2008	ND	—	71.3	9/18/2008	46	10/29/2008	22.5	5	10/29/2008	22.5	5
2008	SI21	11/5/2008	270.3	—	5110.3	9/19/2008	53	10/29/2008	7.5	7	10/29/2008	27.5	7
2008	SI22	11/8/2008	ND	—	107.2	10/21/2008	18	11/6/2008	22.5	2	11/6/2008	22.5	2
2008	SI23	11/11/2008	ND	—	610.7	10/23/2008	19	10/22/2008	25	20	11/7/2008	27.5	4
2008	SI24	11/11/2008	ND	—	258.8	6/19/2008	164	11/7/2008	5	4	11/7/2008	5	4
2009	M1	7/28/2009	ND	ND	7.2	7/23/2009	5	7/25/2009	28	3	7/25/2009	28	3
2009	M2	7/30/2009	ND	ND	108.1	7/24/2009	6	7/25/2009	28	5	7/25/2009	28	5
2009	L3	8/4/2009	ND	ND	24.93	7/23/2009	12	8/3/2009	40	1	8/3/2009	40	1
2009	SI7-09	10/2/2009	ND	ND	131.74	9/15/2009	17	10/1/2009	14	1	10/1/2009	14	1
2009	SI-A20	12/7/2009	ND	ND	173.71	9/15/2009	83	12/6/2009	25	1	12/6/2009	25	1
2009	SI13-09	10/15/2009	ND	ND	1089.55	9/15/2009	30	10/8/2010	2	7	10/8/2010	2	7
2009	SI-B03	10/11/2009	ND	ND	297.26	8/20/2009	52	10/8/2009	18	3	10/8/2009	18	2
2009	SI17-09	11/19/2009	ND	ND	1030.89	11/18/2009	1	11/19/2009	3	0	11/19/2009	3	0
2009	SI18-09	11/23/2009	ND	ND	34.98	10/14/2009	40	11/23/2009	17	0	11/23/2009	17	0
2009	SI21-09	12/1/2009	ND	ND	435.43	11/19/2009	12	11/30/2009	16	1	11/30/2009	18	1
2009	SI6-09	10/2/2009	ND	ND	5296.49	9/15/2009	17	10/1/2009	13	1	10/1/2009	8	1
2009	SI24-09	12/8/2009	ND	ND	578.25	11/19/2009	19	11/30/2009	18	8	11/30/2009	18	8
2009	SI25-09	12/13/2009	ND	ND	402.06	11/17/2009	26	12/9/2009	13	4	12/9/2009	13	4
2010	SI01-2010	10/22/2010	ND	ND	176.15	10/21/2010	1	10/18/2010	13	4	10/21/2010	2	1
2010	SI02-2010	10/26/2010	ND	ND	39.72	—	—	—	—	—	10/25/2010	17	1
2010	SI04-2010	10/26/2010	ND	ND	34.7	—	—	—	—	—	10/25/2010	17	1
2010	SI05-2010	11/1/2010	27.8	ND	1.02	—	—	—	—	—	11/1/2010	21	0
2010	SI07-2010	11/2/2010	ND	ND	9.01	10/31/2010	2	10/28/2009	8	5	11/1/2010	1	1
2010	SI08-2010	11/3/2010	ND	ND	6.64	10/28/2010	6	10/21/2009	3	13	10/28/2010	6	6
2010	SI09-2010	11/4/2010	ND	ND	8.51	10/29/2010	6	10/28/2009	1	7	11/1/2010	4	3
2010	SI10-2010	11/10/2010	17.33	ND	68.7	11/9/2010	1	11/4/2010	14	6	11/10/2010	18	0
2010	SI11-2010	11/10/2010	ND	ND	281.88	10/8/2010	33	9/28/2010	5	12	11/10/2010	6	0
2010	SI13-2010	11/11/2010	27.57	ND	42.86	11/10/2010	1	11/4/2010	8	7	11/10/2010	6	1

Table 18. 4-Poster locations, deployment periods, Tickicide and corn use – 2008.

Shelter Island Units		**UTM Location (Zone 18)**		**Deployment**	**Relocations**			**Last**	**Device**	**Corn**	**Tickicide**		
Device	**Location**	**Easting**	**Northing**	**Date**	**Easting**	**Northing**	**Date**	**service**	**-days[1]**	**(lb)**	**(ml)**	**(gal)**	**Comments**
1	South Ferry	725189	4547474	5/8/08				12/3/08	216	3300	2150	0.57	
2[A]	Cackle Hill two	721130	4549679	5/8/08	722033	4549998	9/29/08	12/3/08	192	2980	2150	0.57	Hunting; moved to Stegner site, activated after move on 10/16/2008
3[A]	Silver Beach	722303	4547118	5/1/08				9/17/08	146	2650	1730	0.46	
4[A]	Turtle hole (Westmoreland)	721754	4547980	5/1/08				9/17/08	146	2350	1440	0.38	
5[A]	Airstrip-S (Westmoreland)	721854	4548078	5/1/08	721628	4548199	9/30/08	12/3/08	223	4700	3010	0.80	
6[A]	Nursery-N (Westmoreland)	721654	4548116	5/1/08	721546	4548167	9/30/08	12/3/08	223	4150	2710	0.72	
7[B]	Nursery/Cemetery (east)	723588	4551995	5/1/08	723504	4552100	9/9/08	12/3/08	223	2750	2050	0.54	
8[B]	Catholic Cemetery (west)	723403	4551952	5/1/08	723504	4552100	9/9/08	12/3/08	223	2650	1710	0.45	
9	21 Thomson La	725521	4548149	5/1/08				12/3/08	223	1750	1360	0.36	
10[B]	Nicklin (via Geo. Fox)	724505	4550680	5/1/08				12/3/08	223	3200	2090	0.55	
11[B]	DH-Golf Course (west of shed)	724143	4552340	5/1/08	724600	4552519	9/9/08	12/3/08	223	2600	1800	0.48	
12[B]	DH-Golf Course 2 (hollow)	724518	4552713	5/1/08				12/3/08	223	1650	1310	0.35	
13[A]	Brandenstein Crab Creek	721217	4548137	5/1/08	721174	4548218	9/30/08	12/3/08	200	2900	2100	0.55	Hunting; activated after move on 10/16/2008
14[A]	Becker-Fallert two	720364	4549570	5/1/08				12/3/08	223	2900	2030	0.54	
15[A]	Becker-Fallert one	720530	4549327	5/1/08				12/3/08	223	2650	1800	0.48	Moved slightly north from original spot due to proximity to public road
16	Sachem's Woods	723083	4550207	3/22/08				12/3/08	263	5235	3299	0.87	
17	Locust/airstrip (Klenawicas)	724682	4550186	3/18/08				12/3/08	267	5100	3080	0.81	
18[B]	Ice pond (removed 4/10)	722245	4550660	3/6/08	723765	4550720	5/8/08	12/3/08	244	2950	1970	0.52	Complaints at Ice Pond site (visible, near water), moved to Fiske Windmill[B]
19	Big Ram Island 1	727767	4550820	3/22/08	726241	4550856	9/29/08	12/3/08	239	2100	1530	0.40	Hunting; to Birch site, activated after move on 10/16/2008
20	Big Ram Island 2	727934	4550792	3/22/08	728220	4550805	9/29/08	12/3/08	263	3700	2440	0.64	Hunting
21	Mowing shed/blazes	723848	4550268	3/18/08	723981	4550195	9/9/08	12/3/08	267	4250	2400	0.63	Hunting
22	Locust/airstrip (Klenawicas)	724678	4550183	5/8/08				12/3/08	216	3750	2430	0.64	2nd unit - doubled
23	Nelson White N	722646	4548303	3/22/08	722577	4548122	9/9/08	12/3/08	263	3350	2370	0.63	Hunting
24	Nelson White S	722564	4548213	3/22/08				12/3/08	263	3900	2530	0.67	
25	RHF-N (Ryan horse farm)	722917	4549238	3/22/08				12/3/08	263	3450	2410	0.64	
26	RHF-S (Ryan horse farm)	722899	4549369	3/22/08				12/3/08	263	4285	2760	0.73	
27	Murrin/Murdock	724757	4549532	3/24/08	724765	4549560	9/16/08	12/3/08	261	4100	2730	0.72	Hunting
28	Tuttle-Dickerson Creek	723849	4548022	3/22/08				12/3/08	263	3950	2570	0.68	Slight move to less visible adjacent site 4/10/2008
29	Mashomack1 Cowpens	725147	4549253	4/3/08				12/3/08	251	4150	2660	0.70	
30	Mashomack2 Boy Scout Camp	725627	4549054	4/3/08				12/3/08	251	2000	1210	0.32	
31	Mashomack3 Buckey's Rd	726215	4549393	4/3/08				12/3/08	251	2500	1620	0.43	
32	Mashomack4 Beehives	726241	4548402	4/3/08				12/3/08	251	1850	1290	0.34	
33	Mashomack5 North field	726287	4548822	4/3/08				12/3/08	251	1350	860	0.23	
34	Mashomack6 Chukar lot	726775	4548451	4/3/08				12/3/08	251	2150	1400	0.37	

35	Mashomack7 Skeet range	727653	4548890	4/3/08				12/3/08	251	2940	1880	0.50	
36	Mashomack8 Tennis courts	727594	4548138	4/3/08				12/3/08	251	1700	1190	0.31	
37	Mashomack9 Manor house	727176	4547341	4/3/08				12/3/08	251	1100	830	0.22	
38	Mashomack10 Water tower	725577	4548640	4/24/08				12/3/08	230	1950	1240	0.33	
39	Golf Course (Town)	722061	4550714	4/2/08	722032	4550535	9/9/08	12/3/08	252	4150	2570	0.68	Relocation from hill to near 7 tee, better access and deer use
40	Mashomack11 Across from Cowpens	725180	4549174	4/3/08				12/3/08	251	2500	1710	0.45	
41	Mashomack12 Gibson cherries	728470	4546963	4/3/08				12/3/08	251	1000	650	0.17	
42	Mashomack13 Gibson south	727866	4547017	4/3/08				12/3/08	251	1150	810	0.21	
43	Mashomack14 Gibson KT	728057	4547295	4/3/08				12/3/08	251	1600	1110	0.29	
44	Mashomack15 Maritime 2	728621	4548054	4/3/08				12/3/08	251	1500	1120	0.30	
45	Mashomack16 Road to Buckey's	727707	4549020	4/3/08				12/3/08	251	1600	1030	0.27	
46	Mashomack17 Maritime 1	727737	4549260	4/3/08				12/3/08	251	2250	1530	0.40	
47	Mashomack18	728588	4546847	6/5/08				12/3/08	188	1050	830	0.22	
48	Mashomack19	725904	4548714	6/4/08				12/3/08	189	1150	820	0.22	
49	Mashomack20 Triangle	728287	4548331	4/3/08				12/3/08	251	1450	960	0.25	
50	Landfill	722687	4549448	4/17/08				12/3/08	237	2400	1680	0.44	
51[B]	Fiske-Quaker cemetery	723228	4550683	5/1/08	723183	4550808	9/9/08	12/3/08	223	3800	2490	0.66	Hunting
52[B]	Fiske-North field	723434	4551475	5/1/08	723476	4551124	9/9/08	12/3/08	223	4400	2820	0.74	Hunting
53[B]	Fiske-Hidden field	723751	4551068	5/1/08				12/3/08	223	2750	1840	0.49	
54	Sachem's Woods 2	723083	4550207	7/17/08				12/3/08	146	2600	1830	0.48	2nd unit - doubled
55	Mowing shed/blazes 2	723848	4550268	7/11/08	723981	4550195	9/9/08	12/3/08	152	2350	1440	0.38	2nd unit - doubled
56	RHF- (Ryan horse farm) 2	722899	4549369	7/16/08				12/3/08	147	3050	2150	0.57	2nd unit - doubled
57	Golf Course (Town) 2	722061	4550714	7/16/08	722032	4550535	9/9/08	12/3/08	147	2450	1640	0.43	2nd unit - doubled
58[B]	Fiske-Quaker cemetery	723228	4550683	7/17/08	723183	4550808	9/9/08	12/3/08	146	2700	1860	0.49	2nd unit - doubled
								Total	**13235**	**160890**	**107029**	**28.27**	
Fire Island Units													
RM1	Golf course	644686	4498233	3/17/08				12/3/08	268	4520	2955	0.78	
RM2	Tiger Shop	646863	4498552	3/17/08				12/3/08	268	4295	2813	0.74	
RM3	Field 4 (parking lot 4)	648049	4498614	3/17/08				12/3/08	268	3915	2523	0.67	
RM4	Field 5 (parking lot 5)	649817	4499050	3/17/08				12/3/08	268	5245	3370	0.89	
RM4A	Field 5 II	649817	4499050	9/18/08				12/3/08	83	1375	880	0.23	2nd unit - doubled
FI1	Saltaire incinerator	652860	4499956	4/3/08	652788	4499990	7/21/08	12/3/08	251	4995	3153	0.83	Better access location
FI1A	Saltaire incinerator II	652788	4499990	8/20/08				12/3/08	112	3205	2095	0.55	2nd unit - doubled
FI5	Atlantique	654415	4500548	4/3/08				12/3/08	251	5110	3350	0.88	
								Total	**1769**	**32660**	**21138**	**5.58**	

[A]Unit located in Shelter Island Study Area A (South)
[B]Unit located in Shelter Island Study Area B (North). Unit 18 was originally located outside a study area (Ice Pond), reassigned to a new site in Study Area B on 5/8/08
Some units were relocated in early fall to allow access for hunting season, for better access or due to community issues (see Comments)
Shelter Island and Fire Island units were serviced weekly
[1]Device-days, the number of days a 4-Poster device was active in the field, was calculated by adding 7 days to the period from deployment date to last servicing date.

Table 18 (continued). 4-Poster locations, deployment periods, Tickicide and corn use – 2009.

Shelter Island Units		**UTM Location (Zone 18)**		**Deployment**	**Relocations**			**Last**	**Device**	**Corn**	**Tickicide**		
Device	**Location**	**Easting**	**Northing**	**Date**	**Easting**	**Northing**	**Date**	**service**	**-days**	**(lb)**	**(ml)**	**(gal)**	**Comments**
1	South Ferry	725188	4547471	3/30/09				12/9/09	261	5200	4183	1.11	
2[A]	Cackle Hill two	721127	4549678	3/30/09				12/9/09	261	4300	3675	0.97	
3[A]	Silver Beach	722308	4547119	3/30/09				12/9/09	261	4550	3501	0.92	
4[A]	Turtle hole (Westmoreland)	721752	4547990	3/30/09	721570	4548162	8/28/09	12/9/09	261	5100	4011	1.06	Moved - proximity to water
5[A]	Airstrip-S (Westmoreland)	721847	4548051	3/30/09	721904	4548162	9/28/09	12/9/09	261	7200	5149	1.36	Hunting
6[A]	Nursery-N (Westmoreland)	721650	4548112	3/30/09	721628	4548199	9/28/09	12/9/09	261	7200	5191	1.37	Hunting
7[B]	Nursery/Cemetery (east)	723589	4552000	3/30/09	723504	4552100	9/28/09	12/9/09	261	3750	3077	0.81	Hunting
8[B]	Catholic Cemetery (west)	723388	4551952	3/30/09	723504	4552100	9/28/09	12/9/09	261	4300	3344	0.88	Hunting
9[A]	Stegner	722033	4549998	3/30/09				12/9/09	261	6150	4700	1.24	
10[B]	Nicklin (via Geo. Fox)	724521	4550684	3/30/09				12/9/09	261	5950	4475	1.18	
11[B]	DH-Golf Course (west of shed)	724128	4552376	3/30/09	724600	4552519	9/28/09	12/9/09	261	3000	2556	0.68	Hunting
12[B]	DH-Golf Course 2 (hollow)/Menhaden	724838	4552778	3/30/09	724518	4552686	7/6/09	12/9/09	261	2720	2359	0.62	Low use at Menhaden, moved to GBCC (DH golf course) hollow
13[A]	Brandenstein Crab Creek	721210	4548126	3/30/09	721174	4548218	9/30/09	12/9/09	261	7800	5623	1.49	Hunting
14[A]	Becker-Fallert two	720383	4549582	3/30/09				12/9/09	261	5540	4347	1.15	
15[A]	Becker-Fallert one	720530	4549326	3/30/09				12/9/09	261	5800	4573	1.21	
16	Sachem's Woods	723073	4550209	3/30/09				12/9/09	261	6550	4787	1.26	
17[A]	Floyd	721021	4548802	3/30/09				12/9/09	261	9250	6555	1.73	
18[B]	Fiske - Windmill	723757	4550760	3/30/09				12/9/09	261	5200	4011	1.06	
19	Big Ram Island 1	727767	4550824	3/30/09	728220	4550805	9/28/09	12/9/09	261	6100	4431	1.17	Hunting
20	Little Ram Island	726240	4550854	4/23/09				12/9/09	237	1250	1432	0.38	
21	Mowing shed/blazes	723846	4550267	3/30/09	723981	4550195	9/28/09	12/9/09	261	6170	4677	1.24	Hunting
22[B]	Locust woods	724069	4551633	3/30/09	724054	4551670	4/15/09	12/9/09	261	3800	3069	0.81	Complaints; new location less apparent
23	Nelson White N	722630	4548302	3/30/09				12/9/09	261	8330	5953	1.57	
24[A]	Kelt	721802	4547441	3/30/09				12/9/09	261	8050	5825	1.54	
25	RHF-N (Ryan horse farm)	722899	4549396	3/30/09				12/9/09	261	8650	6068	1.60	
26	RHF-S (Ryan horse farm)	722929	4549227	3/30/09				12/9/09	261	7850	5573	1.47	
27	Murrin/Murdock	724757	4549532	3/30/09	724765	4549560	9/28/09	12/9/09	261	6450	4847	1.28	Hunting
28	Tuttle-Dickerson Creek	723850	4548018	3/30/09				12/9/09	261	5125	3923	1.04	
29	Mashomack1 Cowpens	725147	4549253	3/31/09				12/10/09	261	5530	3952	1.04	
30	Mashomack2 Boy Scout Camp	725627	4549054	3/31/09				12/10/09	261	4100	3048	0.81	
31	Mashomack3 Buckey's Rd	726215	4549393	3/31/09				12/10/09	261	5180	3924	1.04	
32	Mashomack4 Beehives	726241	4548402	3/31/09				12/10/09	261	3650	2896	0.77	
33	Mashomack5 Locusts	726579	4548224	3/31/09				12/10/09	261	3550	2804	0.74	
34	Mashomack6 Chukar lot	726775	4548451	3/31/09				12/10/09	261	4325	3200	0.85	
35	Mashomack7 Skeet range	727653	4548890	3/31/09				12/10/09	261	4660	3348	0.88	
36	Mashomack8 Tennis courts	727594	4548138	3/31/09				12/10/09	261	4420	3168	0.84	

37	Mashomack9 Manor house	727176	4547341	3/31/09				12/10/09	261	2800	2360	0.62	
38	Mashomack10 Water tower	725577	4548640	3/31/09				12/10/09	261	5400	4000	1.06	
39	Golf Course (Town)	722032	4550708	3/30/09				12/9/09	261	5900	4595	1.21	
40	Mashomack11 Tupelos	725407	4549018	3/31/09				12/10/09	261	4000	3128	0.83	
41	Mashomack12 Gibson cherries	728470	4546963	3/31/09				12/10/09	261	4200	3244	0.86	
42	Mashomack13 Gibson south	727866	4547017	3/31/09				12/10/09	261	3550	2848	0.75	
43	Mashomack14 Plum Pond Rd South	728174	4547365	3/31/09				12/10/09	261	3850	2928	0.77	
44	Mashomack15 Maritime 2 (M2)	728756	4548100	3/31/09				12/10/09	261	4060	3052	0.81	
45	Mashomack16 Road to Buckey's	720787	4562666	3/31/09				12/10/09	261	4225	3140	0.83	
46	Mashomack17 Maritime 1 (M1)	727821	4549333	3/31/09				12/10/09	261	5750	4108	1.09	
47	Mashomack18 Beech Block	727341	4548080	3/31/09				12/10/09	261	3605	2808	0.74	
48	Mashomack19	725904	4548714	3/31/09				12/10/09	261	3325	2628	0.69	
49	Mashomack20 Triangle	728287	4548331	3/31/09				12/10/09	261	3830	2992	0.79	
50	Landfill	722688	4549446	3/30/09				12/9/09	261	5250	3998	1.06	
51[B]	Fiske-Quaker cemetery	723214	4550685	3/30/09	723183	4550808	8/10/09	12/9/09	261	8800	6157	1.63	Hunting
52[B]	Fiske-North field	723429	4551485	3/30/09	723532	4551046	9/28/09	12/9/09	261	6400	4633	1.22	Hunting
53[B]	Fiske-Hidden field	723751	4551061	3/30/09				12/9/09	261	6000	4464	1.18	
54[B]	Firehouse	724512	4552110	3/30/09				12/9/09	261	4130	3267	0.86	
55[B]	Island Way	723913	4552208	3/30/09				12/9/09	261	4250	3416	0.90	
56[A]	Seymour	721352	4549832	3/30/09				12/9/09	261	4700	3736	0.99	
57	Serpentine	721552	4550464	4/15/09				12/9/09	245	4050	3392	0.90	
58[B]	Brush	724742	4551181	3/30/09				12/9/09	261	4950	3804	1.00	
59[B]	Olsen	725022	4550599	3/30/09				12/9/09	261	7100	5108	1.35	
60[B]	Parcells	723357	4552554	4/13/09				12/9/09	247	2700	2508	0.66	
								Total	**15606**	**309575**	**234566**	**61.97**	
Fire Island Units													
RM1	Golf course	644686	4498233	3/18/09				12/10/09	274	6510	4660	1.23	
RM1A	Golf course 2	644686	4498233	8/11/09				12/10/09	128	2964	1990	0.53	2nd unit - doubled
RM2	Tiger Shop	646863	4498552	3/18/09				12/10/09	274	5425	3960	1.05	
RM3	Field 4 (parking lot 4)	648049	4498614	3/18/09				12/10/09	274	6679	4610	1.22	
RM4	Field 5 (parking lot 5)	649817	4499050	3/18/09				12/10/09	274	5540	3930	1.04	
FI1	Frank Markus (Saltaire)	651773	4499661	3/25/09				12/10/09	267	9899	6630	1.75	
FI2	Saltaire incinerator	652788	4499990	3/25/09				12/10/09	267	9447	6370	1.68	
FI3	Sara Price (Fair Harbor)	653240	4500243	4/1/09				12/10/09	260	6675	4560	1.20	
FI4	Jeff Christensen/Elm Walk (Fair Harbor)	653734	4500331	4/8/09				12/10/09	253	8099	5630	1.49	
								Total	**2271**	**61238**	**42340**	**11.19**	

[A]Unit located in Shelter Island Study Area A (South)
[B]Unit located in Shelter Island Study Area B (North)
Some units were relocated in early fall to allow access for hunting season (see Comments)
20 Mashomack units were serviced weekly; other Shelter Island units were serviced twice each week
Fire Island units were serviced weekly; additional servicing each week of Saltaire (July 31 - Oct 19) and Fair Harbor (Sep 23 - Oct 19) 4-Posters provided later in deployment period

Table 18 (continued). 4-Poster locations, deployment periods, Tickicide and corn use – 2010.

Shelter Island Units		**UTM Location (Zone 18)**			**Relocations**								
Device	**Location**	**Easting**	**Northing**	**Deployment Date**	**Easting**	**Northing**	**Date**	**Last service**	**Device -days**	**Corn (lb)**	**Tickicide (ml)**	**Tickicide (gal)**	**Comments**
1	South Ferry	725188	4547471	3/22/10				11/23/10	253	4100	3360	0.89	
2[A]	Cackle Hill two	721127	4549678	3/22/10				11/23/10	253	6400	4784	1.26	
3[A]	Silver Beach	722308	4547119	3/22/10				11/23/10	253	6060	4348	1.15	
4[A]	Turtle hole (Westmoreland)	721570	4548162	3/22/10				11/23/10	253	5720	4312	1.14	
5[A]	Airstrip-S (Westmoreland)	721847	4548051	3/22/10	721904	4548162	9/27/10	11/23/10	253	6450	4808	1.27	Hunting
6[A]	Nursery-N (Westmoreland)	721650	4548112	3/22/10	721628	4548199	9/27/10	11/23/10	253	4700	3696	0.98	Hunting
7[B]	Nursery/Cemetery (east)	723589	4552000	3/22/10	723538	4552116	9/27/10	11/23/10	253	4100	3256	0.86	Hunting
8[B]	Catholic Cemetery (west)	723388	4551952	3/22/10	723538	4552116	9/27/10	11/23/10	253	4850	3656	0.97	Hunting
9[A]	Stegner	722033	4549998	3/22/10				11/23/10	253	8110	5832	1.54	
10[B]	Nicklin (via Geo. Fox)	724521	4550684	3/22/10				11/23/10	253	4950	3960	1.05	
11[B]	DH-Golf Course (west of shed)	724128	4552376	3/22/10	724600	4552519	9/27/10	11/23/10	253	2800	2524	0.67	Hunting
12[B]	DH-Golf Hollow Adjusted	724384	4552806	3/22/10				11/23/10	253	2455	2260	0.60	
13[A]	Brandenstein Crab Creek	721210	4548126	3/22/10	721174	4548218	9/27/10	11/23/10	253	6600	4880	1.29	Hunting
14[A]	Becker-Fallert two	720383	4549582	3/22/10				11/23/10	253	5300	4036	1.07	
15[A]	Becker-Fallert one	720530	4549326	3/22/10				11/23/10	253	7100	5216	1.38	
16	Sachem's Woods	723073	4550209	3/22/10				11/23/10	253	6050	4612	1.22	
17[A]	Floyd	721021	4548802	3/22/10				11/23/10	253	8510	6108	1.61	
18[B]	Fiske - Windmill	723757	4550760	3/22/10				11/23/10	253	3950	3372	0.89	
19	Big Ram Island 1	727767	4550824	3/22/10	728220	4550805	9/27/10	11/23/10	253	3600	2996	0.79	Hunting
20	Little Ram Island	726240	4550854	3/22/10				11/23/10	253	2300	2260	0.60	
21	Mowing shed/blazes	723846	4550267	3/22/10	723981	4550195	9/27/10	11/23/10	253	4200	3380	0.89	Hunting
22[B]	Locust woods	724069	4551633	3/22/10				11/23/10	253	3800	3212	0.85	
23	Nelson White N	722630	4548302	3/22/10				11/23/10	253	6800	4964	1.31	
24[A]	Kelt	721802	4547441	3/22/10				11/23/10	253	7460	5408	1.43	
25	RHF-N (Ryan horse farm)	722899	4549396	3/22/10				11/23/10	253	7700	5528	1.46	
26	RHF-S (Ryan horse farm)	722929	4549227	3/22/10				11/23/10	253	7650	5504	1.45	
27	Murrin/Murdock	724757	4549532	3/22/10	724765	4549560	9/27/10	11/23/10	253	4650	3688	0.97	Hunting
28	Tuttle-Dickerson Creek	723850	4548018	3/22/10				11/23/10	253	5800	4396	1.16	
29	Mashomack1 Cowpens	725147	4549253	3/25/10				11/24/10	251	6350	4388	1.16	
30	Mashomack2 Boy Scout Camp	725627	4549054	3/25/10				11/24/10	251	3200	2699	0.71	
31	Mashomack3 Buckey's Rd	726215	4549393	3/25/10				11/24/10	251	4750	3433	0.91	
32	Mashomack4 Beehives	726241	4548402	3/25/10				11/24/10	251	3850	3042	0.80	
33	Mashomack5 Locusts	726579	4548224	3/25/10				11/24/10	251	3150	2523	0.67	
34	Mashomack6 Chukar lot	726762	4548470	3/25/10				11/24/10	251	3150	2622	0.69	
35	Mashomack7 Skeet range	727653	4548890	3/25/10				11/24/10	251	3650	2904	0.77	
36	Mashomack8 Tennis courts	727594	4548138	3/25/10				11/24/10	251	3600	2683	0.71	

37	Mashomack9 Manor house	727176	4547341	3/25/10				11/24/10	251	3250	2699	0.71	
38	Mashomack10 Water tower	725608	4548827	3/25/10				11/24/10	251	4050	3170	0.84	
39	Golf Course (Town)	722032	4550708	3/22/10				11/23/10	253	7555	5480	1.45	
40	Mashomack11 Tupelos	725407	4549018	3/25/10				11/24/10	251	4100	3265	0.86	
41	Mashomack12 Gibson cherries	728470	4546963	3/25/10				11/24/10	251	5250	3900	1.03	
42	Mashomack13 Gibson south	727866	4547017	3/25/10				11/24/10	251	3200	2556	0.68	
43	Mashomack14 Plum Pond Rd South	728174	4547365	3/25/10				11/24/10	251	4250	3333	0.88	
44	Mashomack15 Maritime 2 (M2)	728756	4548100	3/25/10				11/24/10	251	4850	3505	0.93	
45	Mashomack16 Road to Buckey's	726548	4548707	3/25/10				11/24/10	251	4150	3229	0.85	
46	Mashomack17 Maritime 1 (M1)	727821	4549333	3/25/10				11/24/10	251	4300	3241	0.86	
47	Mashomack Cedar Island Cove	727287	4549005	3/25/10				11/24/10	251	4550	3463	0.91	
48	Mashomack19	725904	4548714	3/25/10				11/24/10	251	2450	2247	0.59	
49	Mashomack20 Triangle	728287	4548331	3/25/10				11/24/10	251	4100	3092	0.82	
50	Landfill	722688	4549446	3/22/10				11/23/10	253	5600	4228	1.12	
51[B]	Fiske-Quaker cemetery	723214	4550685	3/22/10	723183	4550808	9/27/10	11/23/10	253	7250	5268	1.39	Hunting
52[B]	Fiske-North field	723429	4551485	3/22/10	723532	4551046	9/27/10	11/23/10	253	5950	4548	1.20	Hunting
53[B]	Fiske-Hidden field	723751	4551061	3/22/10				11/23/10	253	5750	4376	1.16	
54[B]	Firehouse	724512	4552110	3/22/10				11/23/10	253	4900	3784	1.00	
55[B]	Island Way	723913	4552208	3/22/10				11/23/10	253	6260	3776	1.00	
56[A]	Seymour	721352	4549832	3/22/10				11/23/10	253	6100	4526	1.20	
57	Serpentine	721552	4550464	3/22/10				11/23/10	253	4255	3496	0.92	
58[B]	Brush	724742	4551181	3/22/10				11/23/10	253	6655	4788	1.26	
59[B]	Olsen	725022	4550599	3/22/10				11/23/10	253	6300	4668	1.23	
60[B]	Parcells	723357	4552554	3/22/10				11/23/10	253	4550	3580	0.95	
								Total	**15140**	**303490**	**230868**	**60.99**	
Fire Island Units													
RM1	Golf course	644686	4498233	4/8/10				12/3/10	246	6825	4588	1.21	
RM1A	Golf course 2	644686	4498233	7/22/10				12/3/10	141	3855	2564	0.68	2nd unit - doubled
RM2	Tiger Shop	646863	4498552	4/8/10				12/3/10	246	6135	4147	1.10	
RM3	Field 4 (parking lot 4)	648049	4498614	4/8/10				12/3/10	246	6045	4068	1.07	
RM4	Field 5 (parking lot 5)	649817	4499050	4/8/10				12/3/10	246	5400	3586	0.95	
FI1	Frank Markus (Saltaire)	651773	4499661	4/1/10				12/2/10	252	10225	5285	1.40	
FI2	Saltaire incinerator	652788	4499990	4/1/10				12/2/10	252	9420	5230	1.38	
FI3	Sara Price (Fair Harbor)	653240	4500243	4/1/10				12/2/10	252	4910	3600	0.95	
FI4	Jeff Christensen/Elm Walk (Fair Harbor)	653734	4500331	4/8/10				12/2/10	245	7110	4860	1.28	
								Total	**2126**	**59925**	**37928**	**10.02**	

[A]Unit located in Shelter Island Study Area A (South)
[B]Unit located in Shelter Island Study Area B (North)
Some units were relocated in early fall to allow access for hunting season (see Comments)
Shelter Island units outside Mashomack were serviced twice weekly; Mashomack units were serviced weekly
Fire Island units were serviced weekly; additional servicing each week of Saltaire units provided later (July 22 - Nov 26) in deployment period

Table 19. Numbers of adult (A) and immature (N/L) blacklegged and lone star ticks found on individual ears from deer collected from sampling, hunting, roadkill or other sources on Shelter Island (SI) and North Haven (NH), 2008 – 2010. The majority of samples were taken in October – November in all years.

2008 Collections	Blacklegged		Lone star	
Sample ID	**A**	**N/L**	**A**	**N/L**
NH 1	0	0	0	0
NH 2	0	0	0	0
NH 3	0	0	0	0
NH 4 L	4	0	0	1
SI 1 L	0	0	0	31
SI 1 R	0	0	0	250
SI 2 L	0	0	0	11
SI 2 R	2	0	0	0
SI 21	0	0	0	0
SI 22	0	0	0	0
SI 3 L	0	0	0	0
SI 3 R	0	11	0	0
SI 4	0	0	0	0
SI 5	0	0	0	1
SI 6	0	0	0	134
SI 7	0	0	0	180
SI 8	0	0	0	0
SI 9 L	7	0	0	0
SI 10	0	0	0	150
SI 11	0	0	0	42
SI A12 R	0	0	0	0
SI 13	0	0	0	0
SI 15	0	0	1	124
SI 16	0	0	0	4
SI 17 R	0	0	0	12
SI 18 R	2	0	1	25
SI 19 R	0	0	0	0

2009 Collections	Blacklegged		Lone star	
Sample ID	**A**	**N/L**	**A**	**N/L**
A66 L	1	0	0	0
B 03 L 10/11/09	0	0	0	0
B 03 R 10/11/09	0	0	0	0
B 22 L 11-9-09	2	0	0	0
B 22 R 11-9-09	2	0	0	0
NH 1 R 09	0	0	0	16
NH 2 L 09	2	0	2	0
NH 3 R 09	0	0	0	0
NH 6 R 09	2	0	0	0
SI 2 L B 21 09	0	0	0	15
SI 3 R 09	0	0	0	0
SI 4 L 09	0	0	0	0
SI 5 R 09	1	0	0	0
SI 6 L 09	0	0	0	1
SI 7 R 09	0	0	0	0
SI 8 L 09	0	0	0	3
SI 9 R 09	0	0	0	0
SI 10 L 09	0	0	1	7
SI 11 R 09	0	0	0	0
SI 12 R 09	0	0	0	0
SI 13 R 09	0	0	0	0
SI 14 L 09	0	0	0	0
SI 16 L 09	0	0	0	0
SI 17 L 09	0	0	0	0
SI 18 R 09	0	0	0	0
SI 19 R 09	6	0	0	0
SI 24 R 09	0	0	0	0
SI 25 R 09	0	0	0	3
SI L3 R 09	0	0	1	61
SI M1 L 09	0	0	2	2

2010 Collections	Blacklegged		Lone star	
Sample ID	**A**	**N/L**	**A**	**N/L**
B 051 L	0	0	0	0
Kelly SI L 6/3/10	0	0	2	0
Kelly SI R 6/3/10	0	0	1	9
NH 01 L 11/9/10	1	0	0	0
NH 01 R 11/9/10	0	0	0	0
NH 02 L 11/11/10	2	0	0	0
NH 02 R 11/11/10	0	0	0	0
Roadkill L 6/25/10	0	0	4	4
Roadkill R 6/25/10	0	0	21	4
SI 01 L 10/22/10	0	0	0	0
SI 01 R 10/22/10	0	0	0	0
SI 02 L 10/26/10	0	0	0	0
SI 02 R 10/26/10	0	0	0	0
SI 03 L 10/26/10	0	0	0	0
SI 03 R 10/26/10	0	0	0	0
SI 04 L 10/26/10	0	0	0	0
SI 04 R 10/26/10	0	0	0	0
SI 05 L 11/1/10	0	0	0	0
SI 05 R 11/1/10	0	0	0	0
SI 06 L 11/1/10	0	0	0	0
SI 06 R 11/1/10	0	0	0	0
SI 07 L 2010	0	0	0	0
SI 07 R 2010	0	0	0	0
SI 08 L 2010	0	0	0	0
SI 08 R 2010	0	0	0	0
SI 09 L 11/4/10	0	0	0	0
SI 09 R 11/4/10	0	0	1	0
SI 10 L 11/10/10	1	0	0	0
SI 10 R 11/10/10	0	0	0	0
SI 11 L 11/10/10	0	0	0	0
SI 11/R 11/10/10	0	0	0	0
SI 12 L 11/11/10	1	0	1	0
SI 12 R 11/11/10	2	0	0	0
SI 13 11/11/10	0	0	0	0
SI 13 11/11/10	0	0	0	0