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# Community-based integrated tick management programs: cost and feasibility scenarios

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## Abstract

Numerous studies have assessed the efficacy of environmentally based control methods to suppress populations of the blacklegged tick (*Ixodes scapularis* Say), but few of these estimated the cost of control. We estimated costs for a range of tick control methods (including habitat management, deer exclusion or population reduction, broadcast of acaricides, and use of host-targeted acaricides) implemented singly or in combination and applied to a model community comprising 320 residential properties and parklands. Using the high end for cost ranges, tick control based on a single method was estimated to have mean annual costs per household in the model community ranging from $132 for treating only forest ecotone with a broadcast synthetic acaricide to kill host-seeking ticks (or $404 for treating all residential forested habitat) to >$2,000 for deployment of bait boxes (SELECT TCS) across all residential tick habitat to treat rodents topically with acaricide to kill infesting ticks. Combining different sets of multiple methods in an integrated tick management program placed the annual cost between $508 and 3,192 annually per household in the model community, underscoring the disconnect between what people in Lyme disease endemic areas say they are willing to pay for tick control (not more than $100–150 annually) and the actual costs for tick control. Additional barriers to implementing community-based tick management programs within residential communities are discussed.

### Keywords

tick; control; cost; *Amblyomma*; *Ixodes*

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## Introduction

The past 3 decades have seen the development and field evaluation of an array of environmentally based methods and products to suppress vector tick populations, with a strong focus on the blacklegged tick, *Ixodes scapularis* Say (Ixodida: Ixodidae), due to its importance as a human biter and vector of causative agents of Lyme disease, anaplasmosis, and babesiosis in the eastern United States (Eisen 2022). Approaches evaluated for impact on tick populations include landscaping; vegetation management; broadcast application of synthetic, natural, and fungal acaricides against host-seeking ticks; deployment of host-targeted acaricides; and reduction of populations of white-tailed deer, *Odocoileus virginianus* Zimmermann (Artiodactyla: Cervidae), a key reproductive host for both *I. scapularis* and the lone star tick, *Amblyomma americanum* L. (Ixodida: Ixodidae)(Eisen and Dolan 2016, White and Gaff 2018, Eisen and Stafford 2021). Yet despite these efforts, the number of tick-borne disease cases have continued to rise, posing an increasing threat to public health (Eisen and Eisen 2018, Rosenberg et al. 2018). One factor potentially contributing to this rise is that, unlike mosquito control, which is most often performed by publicly funded mosquito control agencies, suppression of tick populations has remained the responsibility of individual homeowners (Piesman and Eisen 2008, Eisen et al. 2012, Eisen 2020), so that there is no coordinated effort to manage tick populations at neighborhood or community scales.

Scaling up tick control efforts beyond individual backyards to neighborhoods or communities would likely require integrated tick management (ITM) strategies that employ multiple methods to suppress ticks and have potential to impact tick populations on residential properties as well as adjacent greenspaces and other public lands (Eisen et al. 2012, Stafford et al. 2017, Eisen 2021, Eisen and Stafford 2021). However, the eventual success of any community-based tick management program will depend not only on its efficacy to control ticks and reduce human-tick bites, but also on the cost and sustainability of the program, as well as its perceived environmental and public health impacts. Cost estimates have only rarely been included in research studies on tick control (examples include Jordan et al. 2017, Jordan and Schulze 2019, Bron et al. 2020). Other recently published tick control trials failed to include details on the projected intervention cost; these included smaller scale ITM approaches (Williams et al. 2018a, 2018b, Mandli et al. 2021) as well as larger scale intervention trials based on use of a single control method on individual properties (Hinckley et al. 2016, 2021) or an ITM approach focused on the neighborhood scale (Keesing et al. 2022).

To address the lack of knowledge about cost and feasibility of implementing community-based tick management programs, our goals were to (i) develop cost range estimates for commercially available tick control interventions and (ii) select an example community comprising single-family residential properties and public lands, and develop cost estimates for implementing ITM programs using 2 and 3 intervention methods. In recognition of the increasing awareness that many areas in the eastern United States harbor sympatric species of ticks posing risk to humans, for example on school grounds in Maryland (Machtinger et al. 2021), we targeted the 2 most common human biting tick species in the study area: *I. scapularis* and *A. americanum*. Impediments or barriers to implementing ITM programs within residential communities are discussed. These include most homeowners not willing to pay more than $100–150 per year for tick control (Gould et al. 2008, Niesobecki et al. 2022), reluctance to use effective synthetic chemical control agents (Gould et al. 2008, Beck et al. 2022), and logistical challenges for the implementation of some control approaches (Stafford and Williams 2017, Connally et al. 2022).

## Materials and Methods

### Cost Range Estimates

To obtain cost estimates for individual tick control methods, we initially conducted a literature search using PubMed and Google Scholar databases to identify papers that included costs for tick control methods published in peer reviewed journals. Search terms used included “tick control”, “tick suppression”, “tick management” and iterations thereof, substituting “*Ixodes scapularis*” and “*Amblyomma americanum*” and common names of either species. Only publications for work done in the continental United States were included. It became rapidly apparent that very few published trials of tick control methods included any estimates of the cost for their implementation. Consequently, we relied heavily on published reviews of the literature (Schulze et al. 1993, Stafford 2007, Eisen and Dolan 2016, Stafford and Williams 2017, White and Gaff 2018, Eisen and Stafford 2021). We obtained local cost estimates for individual tick control interventions (materials and labor) through interviews conducted with multiple pest control and landscaping firms; the research community and government agencies; and a review of appropriate product labeling and manufacturer websites. Whenever possible, our estimates were generated using providers local to the example community in Monmouth County, New Jersey. Most of the tick control methods discussed below are suitable for use on individual properties, while some (including deer population reduction and use of 4-Poster deer treatment devices) are only appropriate for use at neighborhood or community scales. Annual tick control cost estimates for interventions appropriate for use on individual properties were scaled to 0.4 ha (1 acre) of forest habitat capable of supporting ticks and their small mammal hosts, rather than estimated on a per property basis, since the amount and configuration of “tick habitat” can vary widely among properties. Interventions for use on individual properties included installation of deer fencing and xeric barriers; landscaping/vegetation management; application of synthetic, natural product, and entomopathogenic fungal acaricides; and 2 rodent-targeted approaches: (i) Damminix Tick Tubes (Ecohealth, Inc., Brookline, MA) or Thermacell Tick Control Tubes (Thermacell Repellents, Inc., Bedford, MA) and (ii) SELECT Tick Control System (hereafter SELECT TCS, which is also marketed under the alternate brand name of TICK BOX TCS; Tick Box Technology Corporation, Norwalk, CT). Estimated costs for deer removal and deployment of 4-Poster Tick Control Deer Feeders (hereafter 4-Posters; C.R. Daniels, Inc., Ellicott City, MD) for application to deer of topical acaricide (4-Poster Tickicide, hereafter Tickicide; Y-TEX Corporation, Cody, WY) were scaled to 405 ha (1,000 acres).

### Model Community

The approximately 871 ha or 8.7 km$^2$ (2,152 acres or 3.4 mi$^2$) model community is located in western Monmouth County and composed of 320 residential properties; an adjoining section of county parkland; and an array of nonresidential agricultural land, preserved farmland, wildlife corridors, and publicly- and privately-owned green spaces (Fig. 1). Previous research involving portions of this community have documented abundant populations of ticks (both *I. scapularis* and *A. americanum*), small mammals, and deer (Schulze et al. 2007, 2008b, 2017, Dolan et al. 2017, Jordan and Schulze 2019).

## Geographic Information System Mapping

Mapping and area estimation were completed using ArcGIS Desktop 10.8.1 (Environmental Systems Research Institute, Inc., Redlands, CA). Community boundaries were drawn as lines in ArcGIS based on locations recorded in the field using hand-held GPS units (Oregon 400t, Garmin International, Inc., Olathe, KS), topographic features, and descriptions based on the Esri World Imagery Map basemap freely available in ArcGIS (ArcGIS world imagery basemap: 20190815, 0.3 m resolution, 5 m accuracy) (https://www.arcgis.com/home/item.htm l?id=10df2279f9684e4a9f6a7f08febac2a9). Once confirmed by field inspection, the boundary lines were converted to create a polygon for the community boundaries. Shapefile datasets were downloaded from the New Jersey Geographic Information Network (NJGIN) Open Data portal, including the 2015 Land Use/Land Cover classification of New Jersey (NJ Department of Environmental Protection, Edition 20190128) (https://njogis-newjersey.opendata.arcgis.com/documents/njdep::land-use-landcover-of-new-jersey-2015-download/about), a cadastral parcel survey (2022 Parcels Composite of New Jersey. NJ Office of Information Technology, Office of GIS) (https://njogis-newjersey.opendata.arcgis.com/documents/d543ddcc1e6844319ffa826fee52fccf/about), and files for parks, open spaces (2022 State, Local, and Nonprofit Open Space of New Jersey; NJ Department of Environmental Protection, Bureau of GIS) (https://njogis-newjersey.opendata.arcgis.com/datasets/njdep::state-local-and-nonprofit-openspace-of-new-jersey/about), and road centerlines (2018 Road Centerlines. Edition 20190301; Monmouth County Division of Planning, GIS Section) (https://data-monmouthnj.hub.arcgis.com/datasets/1bc60d61f55644dc9320624a8fbea521_0/about). Slight adjustments were made to the community boundaries polygon to align with cadastral parcel boundaries, and this subsequently was verified by field inspection. The downloaded datasets were clipped to the community boundaries outline to reduce their size and increase ease of usability.

The Land Use/Land Cover dataset was used to create separate layers of forests and a layer of wetlands using the “Create Layer from Selected Features” tool and selecting forests or wetlands based on the description in the 2015 Label. The created forest layer was edited to remove areas that were not forested on the aerial imagery, and to add areas that were visibly forested on aerial imagery. This composite forest layer was subdivided by the cadastral parcels layer. Calculate Geometry was used to determine the hectare coverage of forest within each parcel. To create a line representing the forest edge, the Polygon to Line tool was used to convert the edge of the composite forest polygon to a line. The Intersect tool found points where the line intersected cadastral parcel boundaries. The tool Split Line at Point was used to divide the line by polygon boundaries. Quality control was undertaken by inspection of aerial photography to assure that forest edges included edges where forests met roads, and that each length of forest edge fell within a parcel and did not overlap with itself. Calculate Geometry was used to calculate the length of forest edge within each parcel. Attribute tables were exported to Microsoft Excel (retrieved from https://office.microsoft.com/excel). Where a forest edge coincided with a parcel edge, the forest edge line segment was occasionally assigned to the neighboring parcel that did not contain forest, resulting in the neighboring parcel having substantial forest edge length but no forest area. Most of these cases were corrected in Excel by subtracting the forest edge length of the unforested parcel and adding the length to the forested parcel. One unforested parcel was left, since it contained forest edge from multiple neighboring forested parcels, and so it would have been difficult to reassign edge length accurately among the parcels without introducing errors.

### Intervention Methods Selection Criteria

We estimated the cost for community-based ITM programs combining 2 or 3 intervention methods for control of *I. scapularis* and *A. americanum* within our model community. Selection criteria included the proven ability to reduce sympatric populations of *I. scapularis* and *A. americanum* within a diverse mammal community, cost, and ease of implementation, public perception, regulatory issues, and sustainability. In addition, while we are aware of other potential tick control methods currently being evaluated that may be available for inclusion in community-wide control programs in the future, only methods that were commercially available and that had undergone significant field efficacy testing at the time of writing were considered.

## Results

### Cost Range Estimates

Cost range estimates for the various interventions in our study area are summarized in Table 1, while details are provided below. Because several interventions (installation of xeric barriers, application of acaricides, and deployment of tick tubes) can be used by homeowners, we included costs for materials in Table 1, but do-it-yourself costs were not considered in the final cost calculations.

Actual tick management/tick control plans for individual properties would require individual inspections and assessment of the extent, quality, and accessibility of habitats for ticks and tick hosts (Schulze and Jordan 1996). For the purposes of our cost model, we used estimates of primary habitats (forest, non-forest, and forest edge) from digital imagery. While these estimates were coarse, we believe that they served adequately for calculating the community-wide cost for the different interventions. Similarly, the community boundaries were selected to conform to roadways, landscape features (stream corridors), and municipal boundaries. Consequently, calculation of the area of the different habitat components was somewhat arbitrary, as was calculation of the resultant cost of the various intervention methods. Also, we made no attempt to rank the different control methods and assumed equal likelihood of acceptance and participation of all households in the community.

## Tick Control Methods for Individual Residential Properties

The following sections outline cost estimates for tick control methods that can be implemented on individual residential properties.

**Landscape and vegetation management.—**Various non-chemical tick control methods that attempt to modify the landscape or vegetation to render a residential property less hospitable to ticks and/or their hosts have been discussed in the literature (Stafford 2007, Eisen and Dolan 2016, Stafford et al. 2017, Fischhoff et al. 2019, Jordan and Schulze 2019, 2020, Eisen and Stafford 2021). We developed cost estimates for 3 such methods: erecting deer exclusion fencing, managing vegetation to reduce the extent of available habitats for ticks and/or their hosts, and creating and maintaining xeric barriers between high-use areas and adjacent habitats that may support ticks and their hosts.

Costs to employ these methods vary widely. For example, reported costs for installation of deer exclusion fencing on larger tracts of land varied widely, from an installed cost for a tensile electric deer fence (with 7 strands) at ca. \$450/ha (\$182/acre) (Stafford 1993), to a more complex 2.4–2.6 m (8.0–8.5 ft) high woven wire fence (average cost of \$600–1,483/ha or \$243–600/acre) (Ellington and McAninch 1984, Bloemer et al. 1990). More recently, VerCauteren et al. (2006) reported a range of \$10–20/m (ca. \$3–6/ft) for a 2.4 m (ca. 8 ft) high deer fence, depending on the material. Review of websites of several local contractors suggested a range of ca. \$13– 20/m (\$4–6/ft) or \$3,340–5,010 to install deer fencing around a 0.4 ha (1 acre) parcel of land (254 m or 835 ft perimeter), but with 1 source offering a cost of ca. \$66/m (\$20/ft) or a total of \$16,720.

Similarly, cost for installation of a xeric barrier varied substantially from a simple mulch barrier (ca. \$46–92/$m^3$ or \$35–70/$yd^3$, depending on the quality and amount of material used), to a barrier of decorative river stone (ca. \$111–406/$m^3$ or \$85–310/$yd^3$, depending on the quality and size of stone). The extent (and consequently cost for installation) of a xeric barrier will also vary widely depending on the length and configuration of the boundary between high-use areas and potential tick habitat. For example, a 30.5 m (100 ft) long, 0.9 m (3.0 ft) wide (as suggested by Stafford 2007), and 8 cm (3 in) deep xeric barrier would require ca. 2.12 $m^3$ (2.77 $yd^3$) of material. A range of costs for the different methods are summarized in Table 1.

**Habitat-targeted acaricide application.—**While habitat-targeted application of acaricides (including synthetics, natural products, and fungal agents) is the most widely studied method of controlling ticks, few studies have reported the costs associated with such applications (Schulze et al. 1997, 2008a, Stafford 1997, Jordan and Schulze 2020a). In the most recent of these, 66 of 189 (35%) pest management firms charged between \$100 and 150 to treat 0.4 ha (1 acre) of tick habitat, while 106 (56%) of these companies charged between \$151 and 200 (Jordan and Schulze 2020a). Although hourly rates charged to clients for a certified pesticide applicator ranged substantially by region (\$100–\$200/h), firms operating in the vicinity of our model community charged an average of \$172/h (Jeffrey White, White Mantis, Inc., Allentown, NJ, personal communication). Thus, cost for a single application to a 0.4 ha (1 acre) of tick habitat ranged between \$125 and

295, depending on environmental obstacles, such as landscaping, hardscaping, pool areas, play structures, and fencing. Jordan and Schulze (2020a) found that application of liquid formulations of synthetic acaricides applied using high pressure and backpack sprayers was the most common tick control method used. While local pest control professionals reported no differences in client cost for the use of synthetic, natural products, or fungal acaricides, product costs for natural and fungal acaricides exceed those of synthetics and require multiple applications, increasing total costs (Table 1).

Many synthetic acaricides used by pest management firms to control ticks are available to homeowners at lower concentrations and termed over-the-counter, general-use acaricides (Jordan et al. 2017, Bron et al. 2020). Jordan et al. (2017) tested liquid concentrate and granular formulations of 3 general-use acaricides and reported costs for treating a 0.4 ha (1 acre) of tick habitat ranged between $150 and 370 for liquid formulations and $50–250 for granular formulations, including costs for low-end application equipment. However, the less expensive, lower capacity sprayers and spreaders are impractical for treating larger areas of tick habitat. Bron et al. (2020) reported the cost for a single application of granular gamma-cyhalothrin was ca. $64/ha ($26/acre). A number of online sources indicated costs for commonly used natural products ranged between $69 and 1,378/ha ($28 and 558/acre), depending on the specific acaricide and application rate.

**Host-targeted acaricide application.—**Commercially available rodent-targeted tick control is currently limited to tick tubes and bait boxes. Tick tubes are cardboard tubes filled with cotton balls that have been treated with 7.4% permethrin. Theoretically, mice gather the cotton to use as nesting material and any ticks attempting to feed on mice become exposed to the permethrin and are killed. At present, there are 2 commercial products available: Damminix Tick Tubes and Thermacell Tick Control Tubes. Because purchase and distribution of either product does not require a professional pesticide applicator license, they are available for homeowner use. SELECT TCS or TICK BOX TCS rodent bait boxes (Tick Box Technology Corporation, Norwalk, CT) consist of a child-resistant, injection-molded plastic box that houses a bait attractant and a fipronil-treated felt wick placed so that small mammals entering a box are passively treated by contacting the wick while attempting to reach the bait. Purchase and distribution of these bait boxes require a pesticide applicator license.

Deployment costs for either tick tubes or bait boxes depend largely on the number of units per 0.4 ha (1.0 acre) required to meet manufacturer's guidelines, which in turn depends on the amount and configuration of small mammal habitat on individual properties. Manufacturer deployment guidelines recommend 10 m spacing between units for both tick tubes and bait boxes. However, we have found that a substantial reduction in cost is possible by increasing the spacing distance: Using SELECT TCS, substantial control of host-seeking *I. scapularis* nymphs was demonstrated for 20–25 m box deployment intervals by Dolan et al. (2017) and Jordan and Schulze (2019). Control of subadult *I. scapularis* on their small mammal hosts, using either tick tubes or bait boxes, requires 2 deployments per year to first target nymphs (spring) and then larvae (summer).

While control efficacy using tick tubes has been extensively studied (Mather et al. 1987, 1988, Daniels et al. 1991, Deblinger and Rimmer 1991, Stafford 1991b, 1992, Jordan and Schulze 2019, Brown et al. 2020), only 2 papers have reported costs for their use (Jordan and Schulze 2019, Mandli et al. 2021). The product cost to treat 0.4 ha (1.0 acre) of mouse habitat is estimated to be $300/yr for the manufacturer recommended 10 m spacing. A local pest management firm, using the manufacturer recommended 10 m spacing, provided a cost estimate of $378 per deployment, or $756 per year for the recommended 2 deployments (J. Shelton, SavATree, Hamilton, NJ, personal communication).

Four published articles on the efficacy of SELECT TCS or Maxforce TMS bait boxes provided data on size of areas treated, numbers of bait boxes deployed, deployment interval, and/or cost estimates for each deployment (Schulze et al. 2007, 2017, Williams et al. 2018a, Jordan and Schulze 2019). The current commercial manufacturer's suggested retail price is $50/bait box, which includes the bait box, protective metal cover (to prevent interference with the box by non-target mammals such as squirrels *Sciurus carolinensis* Gmelin, and raccoons, *Procyon lotor* L.), anchoring stakes, and labor (D. Whitman, Tick Box Technology Corporation, Norwalk, CT, personal communication). Based on this per unit price, we estimated the cost of 2 deployments per year, at the manufacturer recommended unit spacing interval of 10 m, to be $3,707/ha ($1,500/acre) of small mammal habitat.

## Community-Wide Tick Control Methods

The following sections outline cost estimates for tick control methods that cannot be implemented on individual residential properties but are feasible to use at neighborhood or community scales.

**Reduction of deer populations.—**The New Jersey Division of Fish and Wildlife (DFW) encourages use of sport hunting during existing deer-hunting seasons as the most appropriate and economical option for managing white-tailed deer populations. However, in suburban situations, where development patterns do not allow for effective deer control using a traditional hunting program, the DFW allows alternative methods of reducing deer populations under the Community-Based Deer Management Permit (CBDMP) program.

A permit application must be submitted 120 days prior to the implementation of the program. However, in a fairly lengthy process, the application community must first designate a Special Deer Management Area, encompassing an entire municipality or some portion of it, where deer control is deemed to be necessary. This generally requires creation of some form of local task force or other administrative body which is responsible for garnering and maintaining public support for the process. The applicant must then develop and submit a management plan for the designated area which demonstrates that deer are overabundant usually through some form of recognized deer population survey methods such as fixed-wing or helicopter FLIR (Forward Looking InfraRed) surveys of the area estimated to cost ca. $500/h for helicopter flights (B. Gosnell, Monmouth County Shade Tree Commission, personal communication) and that the overabundant deer population has caused significant environmental or property damage or presents a threat to public health. Finally, the plan must demonstrate if it proposes to use traditional sport hunting to reduce deer density, or why it is not an option. The plan is then verified by DFW personnel, and the DFW reserves the right to propose modifications of the plan or to reject it entirely. Once approved by the DFW, it must then be approved by the independent Fish and Game Council before a permit may be issued. All costs of any proposed alternative methods of deer control, including any administrative costs, are the responsibility of the permit applicant.

Many municipal governments receiving a CBDMP, when properties targeted for deer control are considered to be too small to accommodate traditional sport hunting, or public sentiment prevents adoption of traditional hunting, have opted to hire a private company to cull deer outside of the traditional deer season dates, without bag limit restrictions. Shooters typically operate from tree stands over bait stations. Permits generally require that venison be donated to a community food bank, with all processing costs borne by the permit applicant.

On its website (https://www.njfishandwildlife.com/cbdmp.htm), the New Jersey Department of Environmental Protection, Division of Fish and Wildlife, suggested that a typical CBDMP would incur costs of $200–500/deer. White Buffalo, Inc. (Moodus, CT) listed sharpshooting costs at $200–400/deer shot and an additional processing cost of $70–125/deer for a total cost of $270–525/deer harvested (https://www.whitebuffaloinc.org).

There is no current estimate of deer population density specific to the proposed model community. However, an unmanned aerial vehicle (drone) survey of deer population densities in New Jersey commissioned by the New Jersey Farm Bureau in 2018 produced an estimated density for an area of Millstone Township that encompassed part of the model community of ca. 44 deer/km$^2$ (114 deer/mi$^2$) (NJFB 2019). We assume that deer density is similar to this across the entire model community. In order to effect any observable change in tick questing density, it is thought that deer population density needs to be reduced below a target threshold of <8–10 deer/km$^2$ (see Stafford 2007, Eisen and Dolan 2016). Using the NJFB (2019) deer density estimate, between 137 and 145 deer would need to be culled from the 405 ha (1,000 acres) model community to achieve the reduction goal of <8–10 deer/km$^2$ (<21–26 deer/mi$^2$) and at the sharpshooting cost range of $270–525/deer harvested (https://www.whitebuffaloinc.org), the total cost would be $36,990–76,125 per 405 ha (1,000 acres) (Table 2).

**Deployment of 4-poster topical acaricide treatment device for deer.—**The 4-Poster device passively applies acaricide to the head, neck, and ears of deer as they rub against treated paint rollers while feeding on corn bait. A licensed pesticide applicator is required to treat the paint rollers. A review of the published literature on the efficacy of the 4-Poster topical treatment device identified 7 field studies that provided information about costs (Carroll and Kramer 2003, Solberg et al. 2003, Schulze et al. 2007, 2009, Pound et al. 2009, Harmon et al. 2011, Edwards et al. 2016). However, costs varied considerably because these studies had varying lengths of deployment. Because both *I. scapularis* and *A. americanum* are abundant in our model community, we selected a 40-wk deployment required to address the decidedly different activity periods of the 2 species.

Costs to deploy and maintain 4-Posters within a hypothetical 405 ha (1,000 acres) model community were determined using manufacturer's price list (www.crdaniels.com), corn consumption and acaricide use data from 2 studies previously conducted in portions of the model community (Schulze et al. 2007, 2008b), the Tickicide label, and estimated labor cost. Projected costs assume that 1 4-Poster will treat deer within an area of ca. 20 ha (50 acres) (Solberg et al. 2003, Schulze et al. 2007, Pound et al. 2009).

Current retail price for the bulk purchase of 4-Posters is $639/unit. Including cost for ancillaries (4 pesticide application rollers and 2 warning signs) and assembly, the initial fixed cost for each 4-Poster is $734 or $14,687 for the hypothetical model community. Tickicide retails for $60/liter ($228/gallon), while the application gun, which can be used to treat all the 4-Posters, costs $188. There is a ±5% government discount rate for these products. These costs do not include transportation to the model community or physical deployment of the 4-Posters.

Using corn consumption data from a portion of the model community (Schulze et al. 2007, 2008b) and pesticide application rates from the Tickicide label, we estimated a weekly materials cost for corn and Tickicide of ca. $700 (not including any repairs to damaged units). It is estimated that 6 h will be required to maintain 20 4-Posters each week, including travel to and from the model community and acquisition of corn. Using the average hourly rate charged by local pest control firms, labor is estimated to be ca. $900/wk and the combined costs to operate the 4-Posters in the model community to be $1,600/wk. For the model community, the total cost for the first year, including the initial start-up expenditures (nearly $15,000) and 40-wk maintenance costs for 20 4-Posters ($63,720), would be $78,720 or $194/ha ($79/acre), excluding costs for any replacement parts (Table 2).

## Model Community

The model community includes 511 ha (1,262 acres) of "residential area" (62% of the total area), 194 ha (479 acres) of publicly-owned "parkland" (23%), and 126 ha (312 acres) "other acreage" in agricultural production, preserved farmland and other undeveloped green spaces, and a high-voltage power line right-of-way (15%). These green spaces are intentionally unmanaged, geographically inaccessible, and unavailable for public use, and were not included in developing costs for the community ITM programs (Table 3).

The residential portion of the community includes 320 single-family residential properties of variable configuration, but typically with ca. 43% forested, 45% in other non-forest managed areas (lawns, landscaping, gardens, and play areas), and the remainder including building footprints and paved areas (Table 4). Parkland within the model community consists of 110 ha (272 acres) of forest and 84 ha (208 acres) of non-forest habitat (either old field or leased agriculture fields). The forested portion of the park is crossed by 3.6 km (2.2 mi) of unimproved hiking trails. Approximately 40% of the county park property included 7 agricultural fields, 5 of which were planted in cover crops. The perimeter of 5 fields supports 5.7 km (3.5 mi) of hiking trails that are mowed periodically throughout the growing season. Wetlands comprise ca. 11 ha (26 acres) of the park.

### Selection of Methods Included in ITM Programs

For the residential portion of our model community, we selected application of synthetic pyrethroid acaricide to the forested areas of the properties and deployment of 4-Posters as our 2 component ITM program. In such a hypothetical treatment regime, initial deployment of 4-Posters would occur in the fall (mid-September through December) of Year 1 and operate in succeeding years beginning in early March through December, depending on weather conditions and observed tick activity (Schulze et al. 2007, 2008b). Applications of synthetic acaricide to all forested areas of residential properties would then be made in May of Year 2 to provide residents with interim protection from host-seeking *I. scapularis* and *A. americanum* nymphs until 4-poster host-targeted control becomes effective (Schulze et al. 2007). We would expect that fall establishment of 4-Posters would prevent substantial emergence of host-seeking *I. scapularis* larvae by killing adults feeding on deer, that host-seeking nymphs of both species would be suppressed by the acaricide application, and the 4-Posters would continue to suppress both species (including any surviving *A. americanum* nymphs and larvae feeding on deer) throughout the spring and summer. The control of nymphs should blunt the subsequent populations of adults, which would impact the next generation of larvae and so on. To complete the 3 component ITM program, we added 2 deployments of SELECT TCS bait boxes each year to coincide with the spring and summer activity periods of *I. scapularis* nymphs and larvae, respectively.

Synthetic acaricides (Stafford 1991a, Curran et al. 1993, Schulze et al. 1994, 2001, 2005, 2007, Hinckley et al. 2016), 4-Posters (Schulze et al. 2007, 2008b, Carrol et al. 2009, Daniels et al. 2009, Miller et al. 2009, Stafford et al. 2009, Curtis et al. 2011, Harmon et al. 2011, Grear et al. 2014), and SELECT TCS and its predecessors (Dolan et al. 2004, 2017, Schulze et al. 2007, 2017, Williams et al. 2018a, 2018b, Jordan and Schulze 2019, Hinckley et al. 2021, Keesing et al. 2022) represent the 3 most widely studied tick control methods in residential landscapes. Synthetic acaricides (Schulze et al. 2001, Jordan et al. 2017, Schulze and Jordan 2020, 2021) and 4-Posters (Schulze et al. 2009) were effective against both tick species in New Jersey, were readily accepted by the community in earlier studies, with recruitment levels of ≥70% (Schulze et al. 2001, 2007, 2008b), and were relatively affordable (Schulze et al. 2007, 2008a, 2009, Jordan et al. 2017).

United States Environmental Protection Agency label restrictions for Tickicide prevent deployment of 4-Posters within 91 m (100 yd) of a residence or other location where unsupervised children might be present. Many properties within our model community were large enough to accommodate this restriction, which also can be overcome by placing a protective fence around the 4-Poster device. We found that although considerably more expensive than synthetic pyrethroids or 4-Posters, bait boxes were effective in reducing subadult *I. scapularis* burdens on small mammals, as well as populations of host-seeking nymphs, and have high homeowner acceptability (Schulze et al. 2007, 2017, Jordan and Schulze 2019). We chose SELECT TCS bait boxes over the less costly tick tubes because eastern chipmunks, *Tamias striatus* L., have historically been the dominant small mammals in our model community and apparently do not regularly use cotton nesting material offered in the tick tubes (Schulze et al. 2017, Jordan and Schulze 2019). Previously, the combination of a single barrier (lawn-woods ecotone) spray application of the synthetic pyrethroid deltamethrin in the spring, fall, and spring deployments of 4-Posters for 3 consecutive years, and spring and summer deployments of bait boxes for 2 consecutive years reduced nymphal and larval *I. scapularis* burdens on small mammals by 98% and 93%, respectively, and the density of host-seeking *I. scapularis* nymphs by 94% by the conclusion of the study (Schulze et al. 2007).

Because visitor activity in the county park portion of our model community is limited to hiking, dog walking, and horseback riding along maintained trails, we would envision employing 2 interventions in a hypothetical ITM program that would include public awareness education (distribution of educational materials relating to ticks and tick-borne disease) and managing tick habitat along hiking trails, both of which are already included in the Monmouth County Parks System budget. In the event that park activities are expanded that might increase risk of visitor exposure to host-seeking ticks, a 3 intervention ITM program would likely include the judicious use of acaricides in areas of high risk for human-tick encounters.

## Estimated Cost for Community-wide ITM

Using the cost range estimates (Tables 1 and 2) and the GIS mapping data, we calculated the costs for implementation of our hypothetical ITM program combining 2 intervention methods (application of synthetic acaricide and deployment of 4-Posters) or 3 methods (application of synthetic acaricide, deployment of 4-Posters, and deployment of SELECT TCS bait boxes) to control *I. scapularis* and *A. americanum* within the residential portion of the community.

**Community-wide ITM program with 2 intervention methods.—**We estimated the area of upland forested tick habitat at 262 ha (647 acres), with a total forest edge of 85,882 m (281,765 ft). At a cost range of $100–200 to treat 0.4 ha (1.0 acre), a single treatment of all the upland forest with a synthetic acaricide would cost between $64,698 and 129,396. If treatment was limited to a 10 m (33 ft) wide barrier application to the forest edge (as a cost saving measure), an area encompassing 86 ha (212 acres), the cost would range between $21,216 and 42,432.

Assuming 1 unit treating ca. 20 ha (50 acres), 25 4-Posters would be required to treat the 511 ha (1,262 acres) residential portion of the model community. For the first year of intervention, the cost of 25 4-Posters ($18,358) and 40-wk maintenance ($79,650) would be $98,008 ($192/ha or $77/acre), but then drop to roughly $79,650 ($156/ha or $63/acre) annually thereafter (maintenance and baiting only).

With 100% community participation, the combined cost of the one-time acaricide application to all identified tick habitats and deployment of 4-Posters for the residential portion of the model community would range between $162,706 and 227,404 for the initial year (a per household cost of ca. $508–710 for the start-up year). Alternatively, the cost for more limited barrier applications of acaricide and deployment of 4-Posters would range between $119,224 and 140,440 for the first year (per household cost of between $373 and 439 during the start-up year). In subsequent years, with only the maintenance required for the 4-Posters, the annual cost would drop to roughly $249 per household.

**Community-wide ITM program with 3 intervention methods.—**At the recommended density of 1 bait box/10 m (33 ft) and cost of $50 per bait box, placement along the 85,882 m (281,765 ft) of woodland edge would cost $429,409 per deployment or $858,818 annually. Depending on the configuration of the forested area, a second ring of bait boxes would increase the cost proportionally. Combined with the one-time acaricide application and deployment of 4-Posters, the total cost would range between a minimum of $1,021,524–1,086,222 for the first year ($3,192–3,394 per household) and decline to $938,468 ($2,932 per household) in subsequent years.

**Cost models for residential properties.—**The calculations presented above assume that the program costs would be evenly distributed among the 320 residential properties. However, there are substantial differences in property size (range = 0.04–5.6 ha or 0.1–14 acres), amount of forested area (range = 0–4.3 ha or 0–11 acres), and length of forest edge (0–882 m or 0–2,893 ft) within the model community. As such, homeowners with larger properties (more forest and more edge, as compared with those with very small properties with no forest/forest edge) would be provided a substantial relief in financial burden if costs are assessed equally across properties. It seems reasonable that the financial burden of any community-based ITM program, if borne solely by the residents, would need to be adjusted to reflect these differences in properties.

## Discussion

The tick control interventions discussed here have various advantages and disadvantages that should be considered in the development of community-based ITM programs. For example, some landscape management methods, such as the installation of deer fencing and xeric stone barriers may initially be prohibitively expensive, but have the advantage of requiring little maintenance thereafter, whereas mulch barriers must be replaced periodically at potentially higher cost in subsequent years. Although xeric barriers may serve to limit host-seeking activity of *I. scapularis* (by presenting a dry, inhospitable environment that also offers no opportunities to ascend vegetation to quest for a host) and reduce their potential for horizontal movement, they do not impede movement of small mammal tick hosts and may most effectively serve as a visual reminder to homeowners that tick habitat lies beyond. While some studies have suggested that deer fencing can reduce numbers of host-seeking ticks, other studies have not, and they do not provide a barrier to small mammal and avian tick hosts (Ginsberg et al. 2002). Fencing also may concentrate deer on adjacent unfenced areas.

Vegetation management, such as tree trimming and leaf removal, although less expensive, requires annual attention and mowing lawns is a weekly or biweekly event. We considered these to be routine yard maintenance activities performed by homeowners or landscapers, rather than part of a formal tick control program. In addition, there is only limited published evidence that these landscape management methods can effectively reduce the density of host-seeking ticks (Eisen and Dolan 2016, Jordan and Schulze 2020b).

The application of synthetic acaricides to tick habitat is a reliable and relatively inexpensive method to quickly reduce tick populations. Its primary disadvantage is public concern over safety and environmental contamination, especially if used over large areas. Natural product and entomopathogenic fungal acaricides may provide less toxic, and thus more acceptable, alternatives. However, unlike their synthetic counterparts, their limited residual activity requires multiple applications to achieve similar long-term efficacy, making them less reliable and considerably more expensive (Eisen and Dolan 2016, Schulze and Jordan 2021, Keesing et al. 2022). Entomopathogenic fungal acaricides are further hampered by an inherent delay in measurable efficacy (Eisen and Stafford 2021), due to their vulnerability to weather conditions that affect germination and mortality rates of live spores (Sullivan et al. 2022), and the fact that, as of this writing, products labeled for use against ticks are not currently commercially available.

The universal advantage of host-targeted technologies is that they limit the amount of acaricides introduced into the environment, but their effectiveness and cost vary. Tick tubes are the least expensive, but their efficacy seems to be tied to the dominance of white-footed mice, *Peromyscus leucopus* Rafinesque, in the small mammal community. Live-trapping in sections of our model community has previously shown that eastern chipmunks are the dominant small mammals (Schulze et al. 2005) and since chipmunks appear to ignore tick tubes, they were largely ineffective against *I. scapularis* (Jordan and Schulze 2019). In contrast, SELECT TCS bait boxes treat a wide variety of small mammals, but are considerably more expensive. Also, effectiveness of both tick tubes and SELECT TCS is limited to tick species that feed on small mammals as subadults, making them largely ineffective against *A. americanum*, which feed primarily on deer in all postembryonic stages.

Although their use is labor intensive, 4-Posters are relatively cost-effective in killing ticks because a single unit is purported to treat the majority of deer within a 20 ha (50 acres) area and once target levels of control are achieved in an ITM program, 4-Posters alone have been shown to maintain these levels (Schulze et al. 2008b). While effective against tick species where at least 1 postembryonic stage feeds on deer, 4-Posters are ideally suited for use against *A. americanum* (Williams et al. 2021). However, the use of 4-Posters faces some regulatory constraints, not least concern that the concentration of foraging deer may facilitate disease transmission, as well as habitat damage (Stafford and Williams 2017, Eisen and Stafford 2021, Connally et al. 2022). The major disadvantage of all of the host-targeted technologies is that they have an inherent delay in efficacy based on the muti-year life cycles of *I. scapularis* and *A. americanum*, but this can be addressed by initially using them in conjunction with other tick control methods having immediate impacts on the ticks (Schulze et al. 2007, 2008b).

Although a significant reduction in the deer population has led to reduced density of host-seeking *I. scapularis* in geographically isolated environments, it has yet to be shown effective in ecologically open, residential areas (Kugeler et al. 2016). With the exception of some specific ecological situations, there is currently insufficient empirical evidence to consider deer population control as a means of reducing risk of tick-borne diseases. While there may be an array of social and ecological justifications for community-wide deer control, community-based organized deer reduction programs are expensive to initiate and maintain, and in light of substantial opposition from the public and local hunters, may be too controversial to be a viable tick management strategy (Kugeler et al. 2016, Williams et al. 2018a).

We selected 3 extensively evaluated tick control technologies for our hypothetical community-based ITM program with 2 or 3 intervention methods. We relied heavily on the use of host-targeted interventions that limit the amount of acaricide introduced into the environment while sequentially attacking all postembryonic stages of *I. scapularis* and/or *A. americanum*. Given public concern over the use of synthetic acaricides, we limited their use to a single application to provide protection against human-tick encounters while the rodent- and deer-targeted technologies became effective.

The cost estimates presented in Table 5 represent the first published assessment of what community-based ITM programs are likely to cost. We found the annual costs for the ITM programs to exceed the $100–150 most homeowners say they are willing to pay for tick control on their own residential properties (Gould et al. 2008, Niesobecki et al. 2022). The discrepancy between willingness-to-pay ($100–150 per year) and estimated average annual cost per residential property in the model community was more than $100 for the program with 2 intervention methods (estimated to cost ca. $500 in the first year and $250 in subsequent years) and more than $2,700 for the program with 3 intervention methods (ca. $3,200 in the first year and $2,900 in subsequent years), driven by the very high cost of SELECT TCS (ca. 2,700 per year). Doubling the spacing between SELECT TCS units (Schulze et al. 2007, Dolan et al. 2017, Jordan and Schulze 2019) would cut the cost for deploying this control product in half but the discrepancy between willingness-to-pay and the program with 3 intervention methods would still be in the range of $1,000 per year. Our cost estimates for individual tick control methods (Tables 1 and 2) will allow future surveys of willingness-to-pay for community-based ITM programs to include realistic cost estimates for different combinations of control methods carrying variable total costs. Because evidence is still lacking that large-scale ITM can reduce either human-tick encounters or tick-borne disease incidence rates, to date assessed only in a single study, Keesing et al. (2022), with a disappointing outcome, it also is unclear that community-based ITM programs of the sort envisioned here will provide a viable means of reducing the incidence of tick-borne diseases.

Another important question is how community-based ITM programs could be organized and financed. Although it may be beneficial to include tick control in already existing community-based programs for mosquito control (Eisen 2020), there are several issues to consider (Jordan and Egizi 2020). In New Jersey, for example, neither mosquito control nor public health agencies have formal ITM programs. Although mosquito control agencies are proficient in killing mosquitoes, and include personnel with pesticide application experience, they are unlikely to be familiar with the specific strategies and methods to control the more ubiquitous tick populations. Further, the public health community does little in the way of pest control in general and its efforts relating to ticks are geared more toward surveillance and public awareness and education. The willingness and ability of local agencies to become involved in community-based tick control, with or without funding support from state or federal agencies, is still unclear. Surveys of local agencies are underway, including in New Jersey, to close this knowledge gap. As noted previously (Eisen 2020, Jordan and Egizi 2020), community-based tick control is not feasible without substantial and sustained funding, whether tick control programs are combined with mosquito control or built as stand-alone programs. Finally, it should be noted that tick-borne diseases, for example, Lyme disease, have consistently high case numbers from year to year in endemic areas. It, therefore, would be important to fund community-based tick control at a high and sustained level, avoiding scenarios common to mosquito control with fluctuating budgets across years (Moise et al. 2019).

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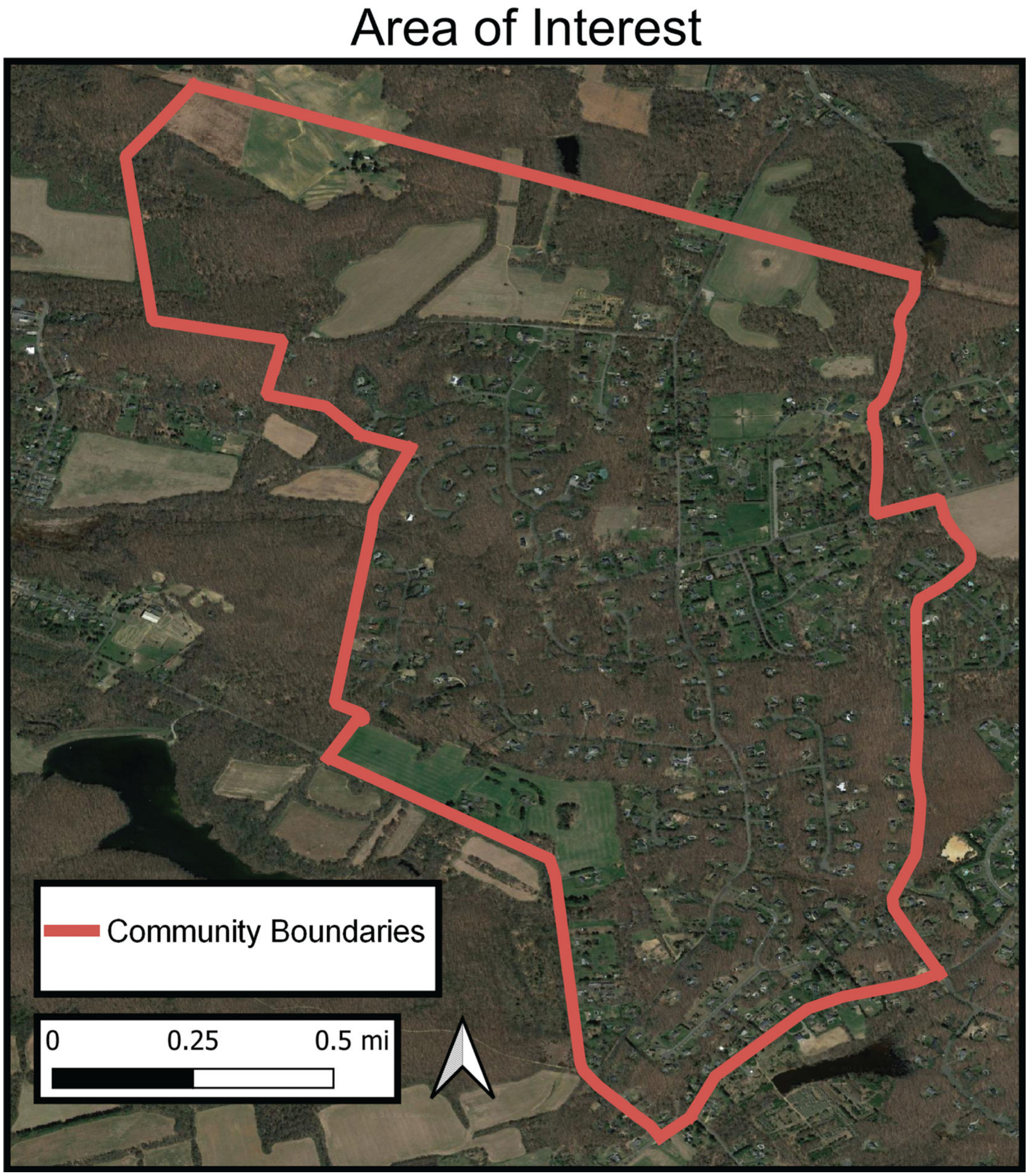


**Fig. 1.**
Model community boundaries shown on aerial photo image of Millstone Township, Monmouth County, NJ.

**Table 1.**

Estimated costs for various tick interventions scaled to 0.4 ha (1.0 acre) of tick/small mammal habitat[a]

| Intervention | Cost range Low | High | Conditions and information sources |
|---|---|---|---|
| Deer fencing | | | |
| Metal | $3,018 | $6,771 | Excluding cost of gates, grates, and maintenance https://www.fenceguides.com; https://www.homeadvisor.com; https://www.deerbusters.com |
| Plastic | $2,661 | $7,152 | |
| Professional landscaping | | | |
| Mowing | $80 | $200 | Single mowing https://www.truelawncare.com; http://www.angi.com |
| Tree trimming | $80 | $1,000 | Single tree depending on height https://www.homeguide.com/costs/tree-trimming-cost |
| Tree removal | $250 | $1,800 | Single tree depending on height https://www.homeguide.com/costs/tree-removal-cost |
| Brush removal | $1,279 | $1,755 | Excludes hauling and disposal fees https://www.homeguide.com/costs/land-clearing-cost |
| Leaf removal | $400 | $700 | Excluding bagging/curbside pickup https://www.homeguide.com/costs/leaf-removal-cost |
| Professional xeric barrier installation | | | |
| Mulch | $46 | $92 | Cost per $m^3$ depending on quality https://www.homeguide.com/costs/mulch-prices |
| River stone | $111 | $406 | Cost per $m^3$ depending on size https://www.homeadvisor.com/costs/landscaping-river-rock-prices |
| Gravel | $33 | $131 | Cost per $m^3$https://www.homeadvisor.com/costs/landscaping-river-rock-prices |
| Homeowner xeric barrier installation | | | |
| Mulch | $20 | $85 | Cost per $m^3$ excluding delivery https://www.homeserve.com |
| River stone | $72 | $229 | Cost per $m^3$ excluding delivery https://www.homeadvisor.com/costs/landscaping-river-rock-prices |
| Gravel | $20 | $98 | Cost per $m^3$ excluding delivery https://www.homeadvisor.com/costs/landscaping-river-rock-prices |
| Professional area application of acaricide | | | |
| Synthetic acaricide | $100 | $200 | Single application of liquid or granular formulations (Schulze et al. 1997, 2008a, Stafford 1997, Jordan and Schulze 2020a) |
| Natural product acaricide | $100 | $200 | Single application, excluding additional cost of product (Jordan and Schulze 2020a) |
| Fungal acaricides | NA[b] | NA | Single application, excluding additional cost of product (Jordan and Schulze 2020a) |
| Homeowner area application of acaricide | | | |
| Synthetic acaricides | | | |
| Liquid formulations | $150 | $370 | Single application, depending on cost of product and sprayer (Jordan et al. 2017) |
| Granular formulations | $50 | $250 | Single application, depending on cost of product and spreader (Jordan et al. 2017) |
| Hose end | $74 | $190 | Single application, depending on cost of product and hose https://www.amazon.com; https://www.lowes.com; https://www.homedepot.com |

| Intervention | Cost range | | Conditions and information sources |
|---|---|---|---|
| | Low | High | |
| Natural product acaricides | $28 | $558 | Single application, depending on cost of product and application equipment (Jordan et al. 2017) |
| Fungal acaricides | NA | NA | Single application, depending on cost of product and application equipment (Jordan et al. 2017) |
| Professional host-targeted tick control | | | |
| Tick tubes | $260 | $300 | Two deployments with 10-m tube spacing, excluding labor https://www.ticktubes.com; https://www.thermacell.com (Jordan and Schulze 2019) |
| | $756 | | Two deployments with 10-m tube spacing, including labor (J. Shelton, SavATree, Hamilton, NJ, personal communication) |
| SELECT TCS bait boxes | $1,500 | | Two deployments with 10-m box spacing, including labor (D. Whitman, Tick Box Technology Corporation, Norwalk, CT, personal communication) |
| Homeowner application of tick tubes | $260 | $300 | Two deployments with 10-m tube spacing, product only https://www.ticktubes.com; https://www.thermacell.com |

[a]Unless otherwise noted.

[b]NA, not available: No product commercially available at time of writing.

**Table 2.**

Estimate costs for various tick interventions scaled to 400 ha (1,000 acres) of tick/small mammal habitat

| Intervention | Cost range | | Conditions and information sources |
|---|---|---|---|
| | Low | High | |
| Deer Reduction | $36,990 | $76,125 | Based on reducing the current estimated density of 44 deer/km$^2$ (114 deer/mi$^2$; NJFB 2019) to <8–10 deer/km$^2$ (<21–26 deer/mi$^2$) and a sharpshooting cost of $270–550/deer harvested https://www.whitebuffaloinc.org |
| Deployment of 4-Posters | $78,720 | | Based on initial cost of 20 4-Posters and equipment/supplies (https://www.crdaniels.com), corn consumption, acaricide use from previous deployment in portions of the model community (Schulze et al. 2007, 2008b), and estimated labor costs for a 40-week deployment for the initial year; cost drops to $63,720 in subsequent years |

**Table 3.**

Habitat composition within different settings in the model community

| Location | Area/Length |
|---|---|
| Residential area | |
| Forest area | 262 ha (647 acres) |
| Other area | 249 ha (615 acres) |
| Total area | 511 ha (1,262 acres) |
| Forest edge | 85,882 m (28,176 ft) |
| Parkland | |
| Forest area | 110 ha (272 acres) |
| Other area | 84 ha (208 acres) |
| Total area | 194 ha (479 acres) |
| Forest edge | 10,447 m (34,274 ft) |
| Other area | |
| Forest area | 41 ha (100 acres) |
| Other area | 86 ha (212 acres) |
| Total area | 1,267 ha (312 acres) |
| Forest edge | 9,186 m (30,138 ft) |

**Table 4.**

Habitat composition of the 320 residential properties in the model community

| | Hectares for area/meters for edge | | | Acres for area/feet for edge | | |
|---|---|---|---|---|---|---|
| **Type** | **Mean ± SE** | **Sum** | **Range** | **Mean ± SE** | **Total** | **Range** |
| Forest Area | 0.8 ± 0.04 | 262 | 0–4.3 | 2.0 ± 0.1 | 647 | 0–11 |
| Other Area | 0.8 ± 3.0 | 249 | 0–3.4 | 1.9 ± 7.3 | 615 | 0–8.5 |
| Total Area | 1.6 ± 0.04 | 511 | 0.4–5.8 | 3.9 ± 0.1 | 1,262 | 0.1–14 |
| Forest Edge | 268 ± 9.6 | 85,882 | 0–882 | 881 ± 31.5 | 281,764 | 0–2,892 |

## Table 5.

Estimated annual per household costs for implementation of tick control programs in the residential portion of the model community, comprising 320 individual residential properties, based on a single method or 2–3 combined methods, calculated using total area and extent of forested habitats on the 320 individual properties

| Method | Total annual cost | Annual cost per household | Annual cost range for households[a] |
|---|---|---|---|
| Program with single tick control method | | | |
| All forested habitat treated with synthetic acaricide/Low end of cost range | $64,698 | $202 | 0–$1,064 |
| Forest ecotone treated with synthetic acaricide/Low end of cost range | $21,216 | $66 | 0–$218 |
| Forest ecotone treated with synthetic acaricide/High end of cost range | $42,432 | $132 | 0–$436 |
| Acaricide treatment of deer with 4-Posters—First year (including device purchase) | $98,008 | $306 | $8.5–1,117 |
| Acaricide treatment of deer with 4-Posters—Subsequent years | $79,650 | $248 | $6.9–907 |
| Acaricide treatment of rodents with SELECT TCS | $859,158 | $2,685 | 0–$8,818 |
| Program with multiple tick control methods (2 or 3 methods) | | | |
| Two control methods—First year[b] | $162,706 | $508 | $8.5–1,331 |
| Two control methods—Year 2 onward[c] | $79,650 | $249 | $6.9–907 |
| Three control methods—First year[d] | $1,021,524 | $3,192 | $8.5–10,008 |
| Three control methods—Year 2 onward[e] | $938,468 | $2,932 | $6.9–9,584 |

[a] Some residential properties include no forested habitat (and thus no forest edge) and would not receive either acaricide application or SELECT TCS bait boxes. On the other hand, all properties would benefit from treating deer which potentially range across all properties regardless of the presence/absence of particular habitats.

[b] Includes a single application of synthetic acaricide (low-end cost) to all forest areas and purchase and maintenance of 4-Poster devices.

[c] Includes only 4-Poster maintenance.

[d] Includes a single application of synthetic acaricide (low-end cost) to all forest areas, purchase and maintenance of 4-Poster devices, and 2 deployments in spring and summer of SELECT TCS bait boxes.

[e] Includes maintenance of 4-Poster devices and continued deployments of SELECT TCS bait boxes.