Integrated Tick Management

Integrated pest management (IPM) basically involves the selection and use of several methods to reduce, rather than eliminate, a pest population with expected ecological, economic, and sociological costs and benefits. For ticks, this may involve the use of landscape practices to reduce tick and host animal habitat adjacent to the home, management or treatment of host animals, targeted applications of least-toxic pesticides to high-risk tick habitat – all in conjunction with tick checks and other personal protective measures to either reduce the number of infected ticks and number of tick bites. The ultimate goal, of course, is to reduce the number of human cases of disease as much as possible with the resources available. A decision has to be made on how much one is willing to spend and what ecological impact one is willing to tolerate to reduce the risk of a tick-borne illness. An integrated management approach does not necessarily preclude the use of pesticides, for example, but seeks to use chemicals effectively and responsibly in order to minimize and reduce exposure and use. Research and computer models have shown that pesticides are the most effective way to reduce ticks, particularly when combined with landscaping changes that decrease tick habitat in often-used areas of your yard.

Tick Distribution and Creating a Tick Safe Zone in the Residential Landscape

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Tick abundance is related to landscape features of the suburban residential environment that provide a suitable environment for the tick and its animal hosts, particularly white-tailed deer and white-footed mice. While there is a lot of variation in tick numbers between homes, larger properties are more likely to harbor ticks because they are more likely to have woodlots. The blacklegged tick is found mainly in densely wooded areas (67% of total sampled) and ecotone (22%), which is unmaintained transitional edge habitat between woodlands and open areas. Fewer ticks are found in ornamental vegetation (9%) and lawn (2%). Within the lawn, most of the ticks (82%) are located within 3 yards of the lawn perimeter particularly along woodlands, stonewalls, or ornamental plantings. Tick abundance in manicured lawns is also influenced by the amount of canopy vegetation and shade. Groundcover vegetation can harbor ticks. Woodland paths also may have a high number of ticks, especially adults, along the adjacent grass and bushes.

The lawn perimeter, brushy areas and groundcover vegetation, and most importantly, the woods, form the high-risk tick zone. The idea for residential tick management is to create a tick managed area around your home that encompasses the portions of the yard that your family uses most frequently. This includes walkways, areas used for recreation, play, eating or entertainment, the mailbox, storage areas and gardens. Tick management strategies are summarized in Table 3 and some actions to consider in an integrated management approach are listed under Table 3.

Table 3. Tick management strategies for the control of *Ixodes scapularis*.

Personal protection	Tick-bite prevention, tick checks and tick removal.
Landscape management	Vegetative modifications to render the environment less suitable for tick survival and for tick hosts.
Management of host abundance	Exclusion of hosts by fencing and host reduction by management of the habitat.
Host-targeted acaricides	Treatment of white-footed mice, chipmunks or deer through passive topical application devices.
Area application acaricides	Spraying chemical insecticides to control ticks.
Biological control	Use of fungal pathogens as biopesticides to control ticks (not yet available at the time this was written, see section on biological control).

- Keep grass mowed.
- Remove leaf litter, brush and weeds at the edge of the lawn.
- Restrict the use of groundcover, such as pachysandra in areas frequented by family and roaming pets.
- Remove brush and leaves around stonewalls and wood piles.
- Discourage rodent activity. Cleanup and seal stonewalls and small openings around the home.
- Move firewood piles and bird feeders away from the house (see section on small mammals and birds).
- Manage pet activity, keep dogs and cats out of the woods to reduce ticks brought back into the home.
- Use plantings that do not attract deer or exclude deer through various types of fencing.
- Move children's swing sets and sand boxes away from the woodland edge and place them on a wood chip or mulch type foundation.
- Trim tree branches and shrubs around the lawn edge to let in more sunlight.
- Adopt hardscape and xeriscape (dryer or less water demanding) landscaping techniques with gravel pathways and mulches. Create a 3-foot or wider wood chip, mulch, or gravel border between lawn and woods or stonewalls.
- Consider areas with decking, tile, gravel and border or container plantings in areas by the house or frequently traveled.
- Widen woodland trails.
- Consider host products to kill ticks on deer or rodent hosts.
- Consider a pesticide application as a targeted barrier treatment.

Landscape management

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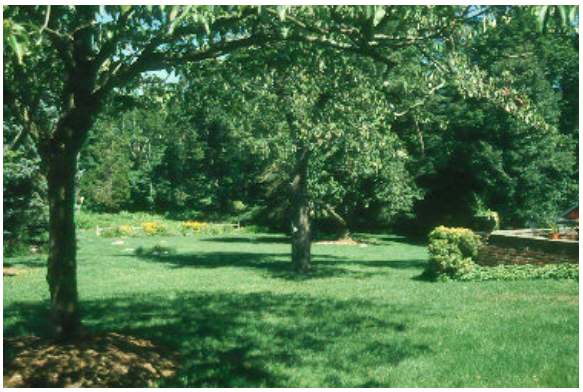
Residential landscapes are designed for a variety of aesthetic or environmental reasons and "tickscape" practices can be a part of the landscape in Lyme disease endemic areas. Landscape modifications can create an environment unattractive to primary tick hosts and may decrease the abundance of ticks that are present in parts of the yard. Fewer ticks have been found on well-maintained lawns, except on areas adjacent to woodlands, stonewalls, or heavy groundcover and ornamental vegetation. This section provides some ideas on how to incorporate tick management into the landscape. Clearing leaf litter and woodchip barriers have been documented to help reduce ticks on the lawn. However, landscape practices to create a lower risk tick zone will not directly eliminate many ticks and you may need to consider integrating other tick control practices into the overall program. Landscape work may also be expensive, not acceptable to some residents, and must be done by residents on their own property. In computer simulations of a hypothetical community of 10,000 individuals, a 90% habitat reduction on lawns, 80% habitat reduction in ecotone, and 10% reduction in forested areas by nearly half the residents resulted in the prevention of only a moderate number of Lyme disease cases in comparison to the application of acaricides or treatment or removal of deer. Landscape management alone may not reduce disease incidence, as the undetected bite of only one infected tick is required for transmission of *B. burgdorferi*.

Woodland edge and leaf litter are high-risk areas for nymphal blacklegged ticks!

In most cases, alterations will be made to an existing landscape, although landscape architects and designers should also incorporate tick safe landscaping concepts into major renovations or new construction. There are several basic interrelated concepts in modifying the landscape to create an area with fewer ticks and environmentally acceptable management practices.

- Open up to direct solar exposure the part of the landscape used or traveled frequently by family members to reduce tick and small mammal habitat and cover. Bright, sunny areas are less likely to harbor ticks.
- Isolate areas used by the family or public (i.e., lawns, play areas, recreational or ball fields) from tick habitat or tick hot spots (i.e., woods, dense vegetation, groundcover, stonewalls).
- Use hardscape and xeriscape landscaping (i.e., brick, paving, decking, gravel, container plantings, low water requirement plantings) in areas immediately around the house that are frequently used.
- In cases where environmentally acceptable alternatives to large tracts of open lawn or only small lawn areas are desired, consider butterfly gardens, vegetable gardens, formal herb gardens, colonial style gardens, wildflower meadows and hardscapes. Elimination of woodland and all wildlife habitats is not necessary or environmentally desirable. Some evidence suggests a lack of biodiversity and a landscape that specifically favors deer and mice increases tick abundance and transmission of *B. burgdorferi*. The key factor appears to be the presence and abundance of deer.



Reducing tick habitat

Altering the landscape to increase sunlight and lower humidity may render an area less hospitable to ticks. Management of the habitat should focus on the areas frequently used by the family, not necessarily the entire property. To reduce ticks adjacent to homes, prune trees, mow the lawn, remove leaf litter accumulations around the house and lawn perimeter, and cut grass, weeds, and brush along edges of the lawn, stonewalls, and driveways. Plants can be pruned to provide open space between the ground and base of the plant. Individual shade trees, with the exception of fruit trees like crab apple that are attractive to deer, and small ornamental stands in the open lawn will probably not contribute to the tick numbers unless surrounded by groundcover.

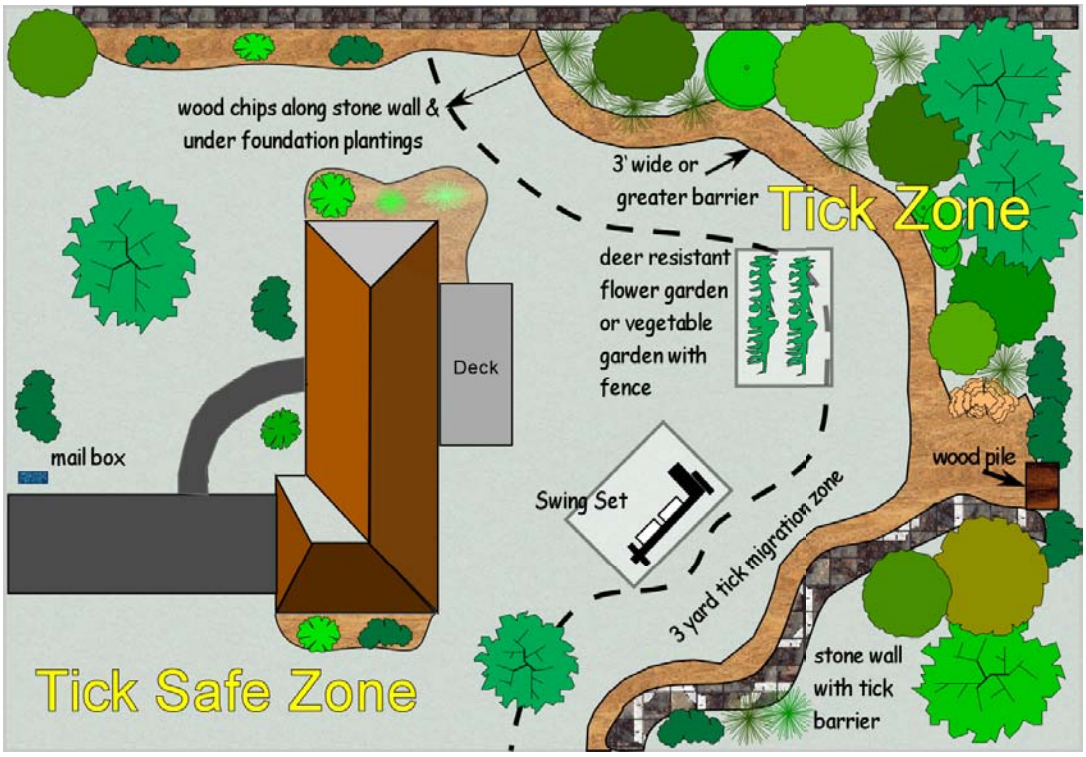
A. Yard before landscape intervention.

B. Yard after landscape intervention.

Ticks also may be found in groundcover such as *Pachysandra*. Restrict the use of groundcovers to less frequently used areas of the yard. Clean up the vegetation around or even seal stonewalls near the house. The removal of leaf litter has been shown to reduce the number of *I. scapularis* nymphs on some properties. Mowing and removing cover vegetation around the house also will discourage rodent hosts. Leaf litter and other plant debris can be raked or blown out from under shrubs and bushes (use tick protection measures while handling leaf litter). Composting or removal by appropriate bagging is acceptable method of disposing of leaf litter. Leaves should not be simply moved to another part of the property. Some communities will compost collected leaves and provide the compost to residents for free or a nominal charge.

Move swing sets and playground areas out or away from the woodland edge!

Play activity can be a high-risk activity for tick exposure and children have some of the highest rates of Lyme disease.



The use of hardscapes, mulches, and xericape landscaping techniques can help reduce tick habitat and isolate parts of the yard from tick hot spots. Hardscapes refer to nonliving features of the landscape like patios, decks, and paths. Mulches are used to suppress weeds and help retain soil moisture, but can also help reduce tick movement. In the laboratory, untreated landscape landscape stones and pinebark woodchips have been shown to deter tick movement and around homes, a three-foot wide or broader woodchip barrier may help reduce tick abundance on the lawn, although results have been found to vary widely from home to home and from year to year depending upon other factors (i.e. density of woods, amount of shade, initial tick densities). Mulches are often organic materials like bark chunks or shredded bark, but can also be small stones or gravel. Wood chip and tree bark, gravel, or similar landscaping materials between woods or stonewalls and lawn as a buffer or barrier can help reduce the number of ticks on the lawn and delineate the tick zone. Quality of the landscape material may also influence results as wood chips from chipped trees, especially if it contains leaves, quickly degrade and may soon be no different than leaf litter. Properly maintained each year, the barrier may allow fewer ticks to migrate from the woodlands into the lawn. It also serves as a reminder that people who cross the barrier may be at higher risk of getting ticks. The application of a barrier or buffer will be easiest where there is a sharp delineation between the woods and lawn. A pesticide application can be focused on the landscape barrier or buffer zone to increase the effectiveness of the barrier. Move swing sets and sandboxes away from the woodland edges and place on a covering of smooth bark, mulch or other suitable material.

Xeriscaping is the application of water conserving landscape practices. This approach reduces habitat cover; helps isolate frequently used areas, can provide an attractive focal area in the yard

or garden and reduce maintenance and water, fertilizer, and chemical use. Many drought resistant plants are also deer resistant. Landscapes can incorporate formal or informal designs around play, eating, or pool areas. Landscape materials such as laid brick, wood decking, stone paving, raked gravel or pea gravel (set down slightly from bordering bricks, stone, or paved areas), and concrete (exposed aggregate can provide varying attractive colors and textures and edged with brick or tile) can be used to create a patio and paths. Gravel can be laid over a layer of crushed stone covered with black plastic to discourage weed growth. Some plantings can be in raised beds or containers.

Management of Host Animals

Food and shelter are essential requisites for wildlife. The residential landscape can be particularly attractive to white-tailed deer and conducive to mice, both important hosts in the prevalence of ticks and Lyme disease. One component of a tick management strategy is managing deer and small rodent activity in your yard. Some landscaping practices discussed in the previous section can also help manage key animals in the landscape. Stonewalls, woodpiles, and dense vegetation can harbor rodents.

White-tailed Deer, *Odocoilius virginianus* (Zimmerman)

In the northeast from New Jersey to Maine, the deer population is estimated at 1,918,000 animals. In Connecticut, the number of deer has increased from about 12 in 1896 to over 76,000 today. Overabundance of deer is associated with problems such as deer/vehicle collisions, agricultural damage, lack of forest regeneration, detrimental impacts on other wildlife (especially birds), damage to residential landscapes, and the rising incidence of Lyme disease. The fault is not in the animal. Who has not appreciated the thrill of a glimpse of these animals in the meadow or grazing in our landscapes? The problem is in their numbers. There only need be fewer of them. Mature, shaded forests with poor forage and browse support low densities of deer and fewer ticks. A mosaic of light fragmented woodland and woodland edges, clearings and abundant shrubs, berries, grass, and forbs and a lack of predators are ideal for deer. Fencing out deer can allow greater landscape options favorable to other wildlife.

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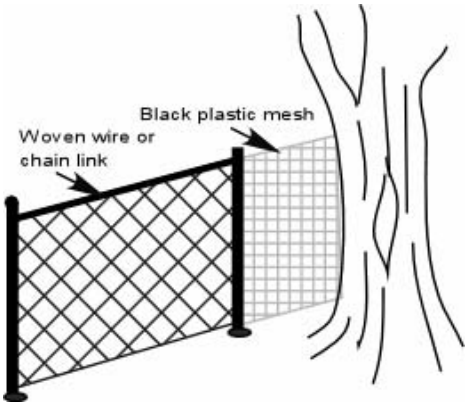
The abundance and distribution of *I. scapularis* has been directly related to the size of the deer population. It has been estimated that over 90% of adult ticks feed on deer. Therefore, deer are key to the reproductive success of the tick. Deer transport blood-engorged female ticks into the property where they can lay thousands of eggs, increasing the number of larval ticks available to feed on small animals. Reservoir incompetent, deer do not infect feeding ticks with Lyme disease bacteria. Larvae of *I. scapularis* pick up the spirochetes when they feed on small animals, especially mice, which are reservoir competent hosts. Island or peninsular communities with extremely high deer densities have superabundant tick populations. Conversely, islands without deer do not appear to support *I. scapularis* or *B. burgdorferi*. Deer management options include deer fencing, repellents, and deer resistant landscape plantings. Dogs also may help deter deer,

but to be effective the animal may have to be active both day and night, something a family pet may not do.



Deer Fencing: Fencing is the most effective method to control access by deer to a property. Fences can keep deer from large garden beds or small to moderate sized home lots. The exclusion of deer from areas of 15 to 18 acres with a slant high-tensile electric fence was shown to reduce the abundance of *I. scapularis* nymphs by as much as 84% and larval ticks by 100% approximately 70 yards or greater inside the fence. Fencing of smaller areas also may be beneficial, but tick management practices within the enclosure and the use of an insecticide at the fence perimeter may also be needed. A deer fence does not stop small animal movement and tick movement. Barrier fencing can be used to protect individual trees, shrubs or other plantings from deer.

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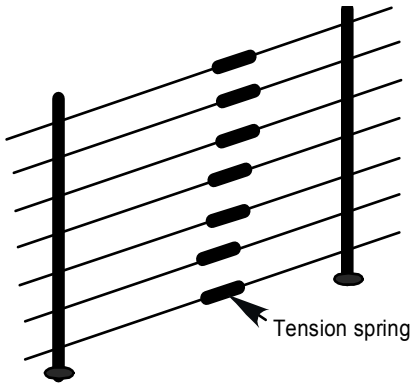
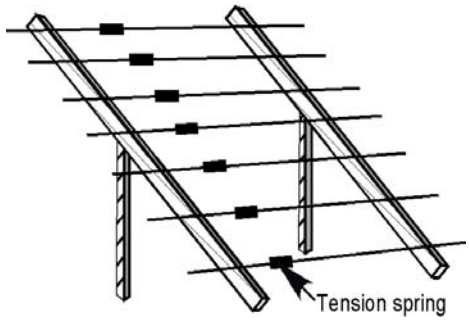
There are many types of deer fences and selection will depend upon deer pressure, area to be protected, and site characteristics. The most common choice in a fence is a plastic or wire mesh vertical fence. An electric fence is another option. A number of companies specialize in providing deer fencing and can provide the fencing materials or install the fence. However, many communities have local restrictions or ordinances on the type and height of fencing allowed – check with your local authorities.



Non-electric fence – The fence may be vertical or three-dimensional. A vertical fence requires the least space and a wide variety of fence materials and designs are available. Increasingly, a black polypropylene plastic fence-like mesh or steel mesh is being used instead of a chain-link for vertical fences because of reduced cost, low maintenance, long life, and near invisibility, an attractive feature in the residential landscape. The plastic material comes in rolls of various lengths and 7.5 feet wide and can be fastened to existing trees or several different types of posts. White flags should be attached at around 4 feet to signal the presence of the fence. While deer can jump a vertical fence of eight feet from a standing position, they rarely do so and are more likely to try and push under fencing. Proper anchoring or staking of the fence along the ground is important. Single or multiple electric strands also can be placed along the top of a vertical wire or mesh fence. Another option is a slant deer fence set at an angle of 45 degrees for use in areas with moderate to high deer densities, but it requires more space (about 6 feet of horizontal space). Deer cannot clear both the height and width of the fence and often find themselves under the top outer wire. Solid 5- to 6-foot fences are also effective. Access gates, driveway gates (can be remotely controlled in more expensive systems), or in ground driveway deer grates (similar to cattle guards) will be needed to completely enclose the area and still allow owner and vehicle access.



Electric fence – An electric fence requires maintenance, proper grounding, and may not be appropriate in many residential settings. A vertical or slant seven-strand, high-tensile electric fence is very effective for larger areas where deer densities are high.

Deer Repellents: The use of deer repellents may reduce damage to plants and help defer the animals elsewhere, but by itself will not impact tick abundance unless deer consistently avoid the property entirely. Repellent performance is highly variable depending upon the product (most are either odor or taste-based), rain, frequency of application, and the availability of other food sources for deer. Nevertheless, some repellents are fairly effective with low to moderate deer densities.

Deer Resistant Plantings: Substituting less palatable landscape plants may discourage browsing around the home, reduce damage to ornamental plants and may help make the yard less attractive to deer, though deer will also readily graze on lawns. The use of deer resistant plantings may have no impact on ticks unless deer consistently avoid the property and the use of these plants specifically as part of tick management has not been examined. It simply seems to make sense to make your yard and plantings less attractive to deer.

No plant is completely browse resistant and susceptibility depends upon deer density, food availability, and food preferences, which can vary regionally. Plant selection will depend partly upon the type of terrain you have: a sunny, moist yard, a dry, sunny garden, a dry shady garden, or a wet, shady yard, proximity to streams or ponds and effect desired (e.g., fragrance, foliage color, seasonal color, showy borders, etc.). Use of native shrubs and trees is encouraged and the use of invasive plantings is discouraged. Non-native invasive plants, some of which are very resistant to deer browse damage, can crowd out natives. Examples include Japanese barberry, multiflora rose, Asiatic bittersweet, and several non-native honeysuckles. Lists of invasive species and alternative plantings are usually available from state agencies, universities, or environmental groups in each state.

A rating of deer browse damage to many plants was compiled at the Connecticut Agricultural Experiment Station (CAES) from a survey of Connecticut gardeners. A comprehensive list of the survey results with plants ranging from very susceptible to highly resistant to browse damage is available in CAES Station Bulletin 968 (online at www.caes.state.ct.us). Information is also available on deer resistant plantings and deer proofing from a variety of books and handouts. Many nurseries and garden centers can provide a suggested list of deer resistant plantings.

Groundcovers like pachysandra and myrtle, while browse resistant, have been found to harbor ticks and may not be the most appropriate choice near heavily used areas around the house, porch, or mailbox. In general, ornamental grasses and ferns are browse resistant and may be good choices in sunny and moist shady areas, respectively. A number of medicinal herb varieties, ornamental herbs, and butterfly garden plants are resistant to deer browse. The most browse resistant plantings should be placed at the edges and entrances of the property and the most browse susceptible plants closer to the house or areas frequented by people and pets. Susceptible plants can be surrounded by less palatable species. Clean up fruits and other produce from under trees or crop plants. While eliminating cover like mixed tall grass and brush may help discourage deer from bedding near the home, deer will bed wherever they consider it safe – even open lawn. In a study of tick egg-laying, female ticks from deer were found to survive in field bedding areas and lay eggs from which larvae successfully hatched. However, larval survival in the field was shorter than in the woods and they are less likely to be picked up by a mouse host.

Deer Reduction and Management

Some communities have explored the reduction of deer through regulated hunting or controlled hunts to reduce problems associated with deer overabundance. The incremental removal and virtual elimination of deer has been shown to substantially reduce tick abundance, but observational studies and computer models suggest deer densities must be reduced to very low levels (possibly as low as 8 deer per square mile or less) to interrupt the transmission of Lyme disease. In comparison, typical suburban deer densities along coastal Connecticut have been around 30-60 deer per square mile. With the exception of some islands or peninsulas, the need for such a drastic reduction in deer population to achieve satisfactory control levels may render this strategy unrealistic in many areas. Conversely, unregulated deer populations may lead to steadily increasing tick populations. It is not clear if *I. scapularis* can be maintained on medium-sized animal hosts in the absence of deer. Adult ticks also feed on opossums, raccoons, skunks, foxes, dogs and other animals. However, tick densities may be low enough to interrupt the enzootic cycle and transmission of *B. burgdorferi* to humans.

Lethal management options for deer are effective, though controversial, while the use of anti-fertility agents is experimental and labor intensive. A community that wishes to implement a deer management program, especially in densely populated urban and suburban areas must deal with hunting restrictions, real or perceived safety or liability concerns, and conflicting attitudes on managing wildlife. Since most land in the northeast is privately held, homeowner views and hunter access are important to deer management. Any deer population control program would require an initial reduction phase to lower high densities of deer and a maintenance phase to keep the deer population at the desired targeted level. Deer capacity for reproduction is high and deer herds can potentially double in size in one year. Management would be an ongoing process.

Host-Targeted Chemical Tick Control for White-tailed deer

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The U.S. Department of Agriculture has developed a new experimental approach for the application of topical acaricides to white-tailed deer to kill ticks feeding on the deer. It consists of a feeding station with four paint rollers that hold the pesticide. Deer self treat as they brush against the rollers when they feed. These 4-posters were evaluated in the northeastern United States for the control of the blacklegged tick, having performed well in a trial against lone star ticks on deer in Texas. Computer models indicated that 95% control of *I. scapularis* on 90% of a local deer population could dramatically reduce the tick population in a treated area over a period of several years. While usage of the devices is generally high (> 90%), utilization of the devices by deer was extremely low when alternative food sources were available (i.e., acorns). The treatment of deer with 2% amitraz reduced tick abundance in the treated communities by around 64-69% by the fifth and sixth year in comparison with untreated areas. The use of 10% permethrin resulted in a 91-100% reduction of larval, nymphal, and adult questing ticks in sampled plots. According to computer simulations, this approach, in principal, could provide the

greatest reduction in Lyme disease with the least direct community involvement (i.e. number of direct participating households).

The American Lyme Disease Foundation (Somers, NY) holds the license to the product's patent and works with Dandux Outdoors (Ellicott City, MD) for manufacturing the device. The U.S. Environmental Protection Agency has registered 10% permethrin as a restricted use, ready to use tickicide (Y-TEX® 4-Poster™ Tickicide, Y-TEX Corporation, Cody, WY) for application to deer via the 4-poster device to control *I. scapularis* and *A. americanum*. The 4-posters are to be placed as far as possible, but in no case less than 100 yards from any home, apartment, playground, or other place children might be present without adult supervision. States may have more restrictive requirements than the federal label. At the time of this writing, state pesticide registrations have been obtained in 33 states including Connecticut, Massachusetts, Rhode Island, New Jersey, Maine, New Hampshire, Vermont, Maryland, Delaware, Michigan, and Minnesota. Approvals or regulations for use by state wildlife officials are pending or under review. The use of the 4-poster will probably make the most sense as part of a neighborhood or community coordinated program to reduce ticks and the risk of Lyme disease, managed under state use regulations, combined with some form of a deer management program.

Small Mammals and Birds

Rodents and birds can infect ticks with *B. burgdorferi* and transport ticks onto your property. The importance of these animals in the dynamics of Lyme disease depends on the abundance of the animal host, number of ticks feeding on the host, and the host's ability to infect feeding ticks with the Lyme disease spirochete (i.e., the reservoir potential). In other words, what animals are contributing infected ticks to your property? Some animals may have a lot of ticks, but not be able to infect them with spirochetes.

Rodents

While different rodent and bird species may predominate in certain years and locations, white-footed mice, *Peromyscus leucopus*, are generally the most abundant and efficient animal reservoir for the Lyme disease bacteria. They contribute more infected ticks than eastern chipmunks or meadow voles. White-footed mice also are a reservoir for the causal agents of ehrlichiosis and babesisois. Over 90% of white-footed mice will be infected with *B. burgdorferi* in many areas and up to half have been found to carry all three pathogens in some areas. In one study, a single mouse was estimated to infect as many ticks as 12 chipmunks or 221 voles. Meadow voles, *Microtus pennsylvanicus*, are most abundant in fields, pastures, orchards, which harbor few *I. scapularis*. Although they harbor fewer ticks, short-tailed shrews, *Blarina brevicauda*, with their high reservoir potential, may contribute to the maintenance of both *B. burgdorferi* and *B. microti* in some areas, especially when mouse numbers are low. By contrast, squirrels have a lower Lyme disease reservoir potential. One study indicated that squirrels might reduce or dilute the number of infected ticks in the landscape.

Note in the second picture of the white-footed mouse the engorged larval ticks feeding on the ears and around the eyes of the animal. Larval ticks become infected with B. burgdorferi and other pathogens while feeding on an infected mouse or chipmunk.

White-footed Mouse
Peromyscus leucopus (Rafinesque)

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The white-footed mouse is the principal animal carrying the pathogens that cause Lyme disease, human anaplasmosis (i.e., ehrlichiosis) and human babesisois. White-footed mice are found throughout most eastern and Midwestern United States, except in Florida and northern Maine. This mouse is difficult to distinguish from the deer mouse, *P. maniculatus*.

White-footed mice have a home range of generally 0.1 to 0.5 acre, sometimes larger. This woodland and brushy area dwelling animal nests in stonewalls, tree cavities, abandoned bird or squirrel nests, under stumps, logs, and may readily enter and nest in buildings, especially during the winter months. Mice may line the nest with fur, feathers or shredded cloth. These nocturnal animals are omnivorous and feed on acorns, seeds (including newly planted gardens), fruits, insects, snails, tender young plants, and carrion.

Mouse densities usually are around 1-10 per acre but can be higher (15 per acre) and may go relatively unnoticed until they enter homes that are not rodent proof. Breeding spring through fall, a female mouse typically has 3-4 young after a gestation period of 22-25 days. The mice reach sexual maturity in 6-7 weeks. There are no ticks on the mice during the winter and, inside buildings, they do not pose a risk for the transmission of Lyme disease. Folded hardware cloth (1/4-inch mesh) may be used to exclude mice from buildings, flowerbeds, and garden plots. Cleaning up small black droppings and urine-contaminated areas in confined areas can pose a risk for hantavirus disease.

Reduction of small mammal abundance should focus mainly on reducing mouse habitat near homes and encouraging predators like foxes, snakes, hawks, and owls, and weasels, to name a few. However, predators require large territories of several square miles. Although not quantified, this author has noticed mouse populations drop dramatically (based on trapping success) with resultant drops in the tick population at sample sites where a fox family or snakes have taken up residence in or near the stone walls. Mice have relatively small home ranges. Dense vegetation and ground cover plants like pachysandra adjacent to homes provide cover for rodents as they forage for food. Shaded stonewalls overgrown with grass and brush can harbor many mice and chipmunks.

Eastern Chipmunk
Tamias striatus L.

Eastern chipmunks are found in most states east of the Mississippi River, except along the southeastern coastal region. They are often the second most important rodent in the maintenance of Lyme disease and can be the principal reservoir in some areas. Solitary by habit and active during the day, chipmunks feed on seeds, grains, fruits, nuts, bulbs, mushrooms, insects, carrion and may prey on young birds and eggs. They can climb trees to gather seeds, fruit and nuts and store food throughout the year. They hibernate during the winter, but may become active for brief periods on sunny warm days. Requiring ample vegetative cover, chipmunks are found in deciduous woodlands with undergrowth, old logs, stonewalls, and in brushlands. Their home range is small, typically less than 100 yards in diameter and females defend a 50-yard radius around the home. A small (2 inch), inconspicuous entrance leads to a complex burrow system. There are typically 2 to 4 chipmunks per acre, but densities may be higher with adequate food and cover. There are 1 or 2 litters each year. Hardware cloth (1/4-inch mesh) may be used to exclude chipmunks from buildings and flowerbeds.

A fitted stonewall is unlikely to harbor rodents and ticks like the old stonewall with leaf litter and other vegetative cover.

Birds

Birds are frequent hosts for immature stages of the blacklegged tick. At a woodland residence, 26% of birds were infested with ticks and 94% were *I. scapularis*. While some bird species can infect feeding ticks with *B. burgdorferi* (i.e., American robin, veery, grackle, common yellowthroat, Carolina wren, house wren), other species (i.e., gray catbird, woodthrush) do not. Due to variability in bird species composition, population, habitat preferences, reservoir competence and feeder activity, it is unclear how many ticks (much less those infected with spirochetes) most birds actually contribute to a typical residential landscape. One early study found that American robins, a reservoir competent bird, were likely contributors to the nymphal tick population found in some suburban residential landscapes. Unlike mice, however, reservoir competency in robins declines after 2 months. A recent study suggested most birds probably contribute few infected ticks and may actually dilute pathogen transmission, at least in comparison to mice. Bird feeders in landscaped areas like mowed lawns were not found to be a risk factor for Lyme disease, probably because the habitat does not favor tick survival and seed feeding birds that frequent feeders in the summer do not deposit many ticks. However, higher tick abundance has been noted where feeders were installed at or beyond the lawn edge in wooded habitat suitable for tick survival and rodent activity (Gary Maupin, CDC retired, personal observation). Adult ticks, which are active in the fall, winter and spring months, do not feed on birds.

It is unknown what impact summer or winter fruit bearing trees and shrubs for birds has on the prevalence of ticks as related to mouse and chipmunk activity, as seeds and fruits can also serve as a food source for these animals.

Many berry plants, however, are important to fall migrants and the berries are quickly consumed. Deer resistant bird favorites include bayberry (*Myrica pensylvanica*) and Virginia creeper (*Parthenocissus*) and highbush blueberry (*Vaccinium corymbosum* – produces summer berries); cedars and certain holly cultivars, however, are subject to heavy deer browsing. Common winterberry (*Ilex verticillata*) is also fairly susceptible to heavy deer browse damage. It requires both female and male plants to produce winterberries for birds. Native viburnums will suffer only occasional to minimal damage

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Note the ticks feeding around the eyes of this veery (J. Occi).

from deer and are good bird plants. Japanese barberry (*Berberis thunbergii*) is considered invasive.

Possible small animal and bird management strategies include:

- Keep potential mouse nesting sites in stonewalls and woodpiles near the residence free of brush, high grass, weeds, and leaf litter.
- Seal or rework stonewalls near or under the home to reduce harborage.
- Move firewood away from the house.
- Place the birdhouses and feeders away from the house, but it is unknown if this will decrease risk of exposure to ticks. Clean up spilled feed (spilled bird feed can also attract mice).
- Set up bird feeders in late fall and winter when natural foods are scarce (and the immature stages of *I. scapularis* are not present on birds).
- Seal foundations. For example a garden shed on cement blocks can harbor raccoons, skunks, or woodchucks. This can be avoided through a proper foundation or use of hardware cloth buried at least two feet beneath the ground. A poorly sealed building or old garden shed can harbor mice.

Host-Targeted Chemical Tick Control for Rodents

The first rodent-targeted product was a cardboard tube of cottonballs treated with the insecticide permethrin (Damminix®). The product is aimed at larvae and nymphs of *I. scapularis* feeding on white-footed mice. The effectiveness of this product is dependent upon the mice collecting the cotton as nesting material from cardboard tubes distributed throughout the mouse habitat. Studies in Connecticut and New York state failed to show any reduction in the number of infected, host-seeking *I. scapularis* nymphs when this product was used for a three year period in woodland and residential areas of about 4 acres or less. Lack of control may be due to failure by the mice in some areas to collect the cotton or the presence of alternative tick hosts, such as chipmunks, an important secondary tick host and spirochete reservoir. Reductions in tick numbers were reported in a Massachusetts study with the treatment of one 18-acre tract.

Another approach, using bait boxes for the topical treatment of rodents with fipronil, was first evaluated for the control of *I. scapularis* on wild white-footed mice on an island community in Connecticut and then subsequently at residential locations in Connecticut, New Jersey, New York and Massachusetts. Fipronil is the active ingredient in topical or spray flea and tick control products (Frontline®). In the laboratory, a single topical application to a mouse can kill all ticks on the animal for up to 7 weeks. In the island community trial, the prevalence of infection of *B. burgdorferi* in the mice dropped dramatically after one year and nymphal tick populations were substantially reduced after only two years of use. A commercial version called the Maxforce® Tick Management System (Bayer Environmental Science, Montvale, NJ) received EPA registration July 2003 and is available through licensed pesticide applicators. The rodent bait box is one alternative to area applied sprays or efforts to reduce the small mammal population. The device consists of a sealed, ready to use, child resistant box containing nontoxic food blocks and an applicator wick impregrated with 0.70% fipronil. This device treats both white-footed mice and Eastern chipmunks as they pass through the box to forage on the food attractant. While high levels of immature tick control may be obtained by treating single, isolated properties, a number of adjacent homeowners may have to use this approach for optimum impact. The impact of the boxes on the tick population accumulates over time. There is no affect on the existing host-seeking tick population the first year the boxes are placed, so a pesticide application may be a consideration in the initial year if the Maxforce Tick Management System is used.

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A. **B.**

The pictures show an open rodent box used in the initial experimental trials in Connecticut with two non-toxic bait blocks and a yarn wick treated with fipronil (A) and the Maxforce® TMS rodent bait box (B).

Prevention of Tick-Associated Disease in Companion Animals

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Engorged female *I. scapularis* on a domestic cat.

The prevention of Lyme disease and other tick-associated disease in dogs relies on avoiding tick habitat, reducing ticks on the animal, daily tick checks, and use of one of the canine Lyme disease vaccines available (whole-cell killed bacterin or recombinant outer surface protein A of *B. burgdorferi* - OspA). Electronic fencing systems can help confine a pet in an area where the animal is less likely to pick up ticks or where other tick control measures have been implemented. If the pet is not allowed to freely roam into the wooded areas, it is less likely to pick up ticks. Animals can carry ticks into the home. However, studies to determine whether pet owners may be at increased risk of Lyme disease have been inconclusive. Ticks, once attached or fed, will not seek another host. Dogs and cats should be checked daily for ticks, but the immature stages may be virtually impossible to detect on longhair or dark-hair animals. Outdoor activities with animals also may increase the exposure of pet owners to ticks and their habitat.

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A veterinarian should be consulted about the prevention and treatment of Lyme disease in your animals. A variety of products can repel and/or kill ticks on the animal. Some are available over the counter (OTC) and others only through your veterinarian. Chemical products to protect dogs from ticks are available as spot-ons, sprays, collars, powders, and dips. Ingredients include several insecticides such as pyrethrin, permethrin, amitraz, or fipronil (see section on chemical control). Some products are combined with an insect growth regulator to help control flea eggs. Follow label directions to minimize the chances for an adverse reaction to the product in your pet and do not combine products without the advice of your veterinarian. Different products can contain the same or similar ingredients, which could result in an overdose of the animal.

Although the risk of clinical disease is low, the canine Lyme vaccines can provide high levels of protection for dogs living in or traveling to Lyme disease endemic areas with a likely exposure to ticks. Depending upon the vaccine, an initial dose can be given as early as 9 or 12 weeks of age with a second required dose several weeks later. An annual booster is recommended.

Backyard Wildlife Programs and Environmentally Friendly Lawns

With increased environmental awareness, the focus for some residents has been to provide a more natural or organic landscape, with reduced inputs of energy, water, pesticides, fertilizer and labor, and provide increased wildlife habitat. Some shrubs and other plants are selected for their wildlife value due to the berries, fruit and cover they provide for birds and small mammals. Many resources are available to help create backyard wildlife habitats. How can the desire to have a more natural, environmentally friendly habitat be balanced with the need to reduce contact with animals carrying ticks and the creation of a tick safe zone? The presence of deer and rodents will result in the presence of ticks. Little information is available on how to integrate these two different objectives. Open lawns harbor fewer ticks and wildlife that carry potentially infected ticks. There is some evidence that increased animal diversity can actually reduce the rate of transmission of tick-associated disease, resulting in fewer infected ticks, although ticks are still present. The fragmented woodland and ecotone environment of suburbia favors the deer, mice, and chipmunks most involved in the maintenance and transmission of ticks and tick-associated diseases. Mixed ecotone with uncut grass, wildflower and shrubby vegetation, especially adjacent to woodlands is good deer, mouse and tick habitat.

Little is known about relative tick densities in various alternative landscapes to turf like wildflower meadows, gardens, and butterfly gardens. It is not known what specific plants or plant groupings may be associated with more or fewer ticks or if it makes that much of a difference. Some plants used in butterfly gardens are attractive to deer, while most herbs are highly resistant to deer browsing. Fencing against deer will allow greater landscape flexibility. While data is limited, meadows appear to harbor few blacklegged ticks except along the edge with woodlands, dense vegetation and stonewall. If a property is large enough, a separate wildlife and tick-managed zone could possibly be maintained. The objective of a tick management program is to discourage activity of several key tick hosts and create a physical and/or chemical barrier between woodland habitat and areas the family uses most frequently.