Integrated Tick Management

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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.

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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.

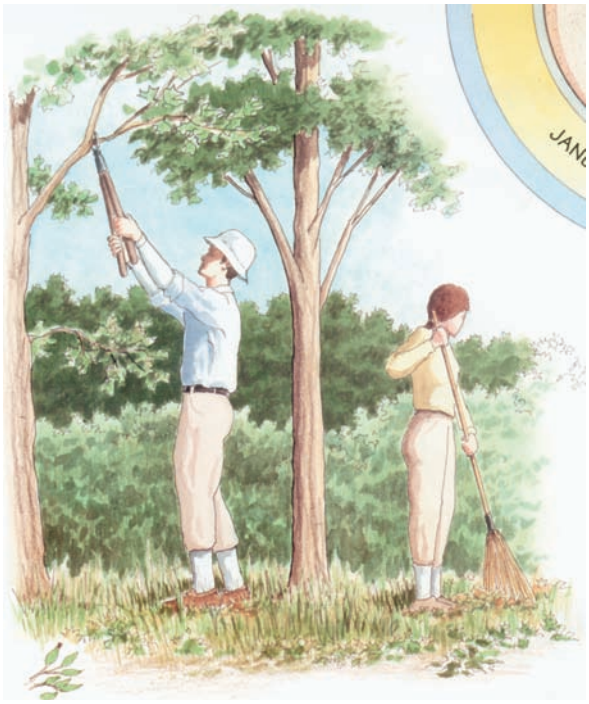
Table 3. Tick management strategies for the control of *Ixodes scapularis*.

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, host reduction, and host reduction by management of the host 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 & Natural Control	Use of fungal pathogens and plant extracts as biopesticides to control ticks.

Some actions to consider in an integrated management approach include:

- 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 a least-toxic 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. Deer-browse resistant exotic-invasive understory vegetation is associated with greater tick abundance. 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 94 Lyme disease cases in comparison to 156 with the application of acaricides or 121-272 with the 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!

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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 the land to direct solar exposure, and include that 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. See the section on Environmentally Friendly Lawns and Backyard Wildlife Programs. 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.
- Avoid invasive plant species and plantings that are inappropriate for where they will be growing. Several guides and listings of invasive plants and native alternatives are available. Some nurseries are helping to assess invasiveness and introducing alternative cultivars.

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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.

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B. Yard after landscape intervention.

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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. Composting or removal by appropriate bagging is an acceptable method of disposing 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.

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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.

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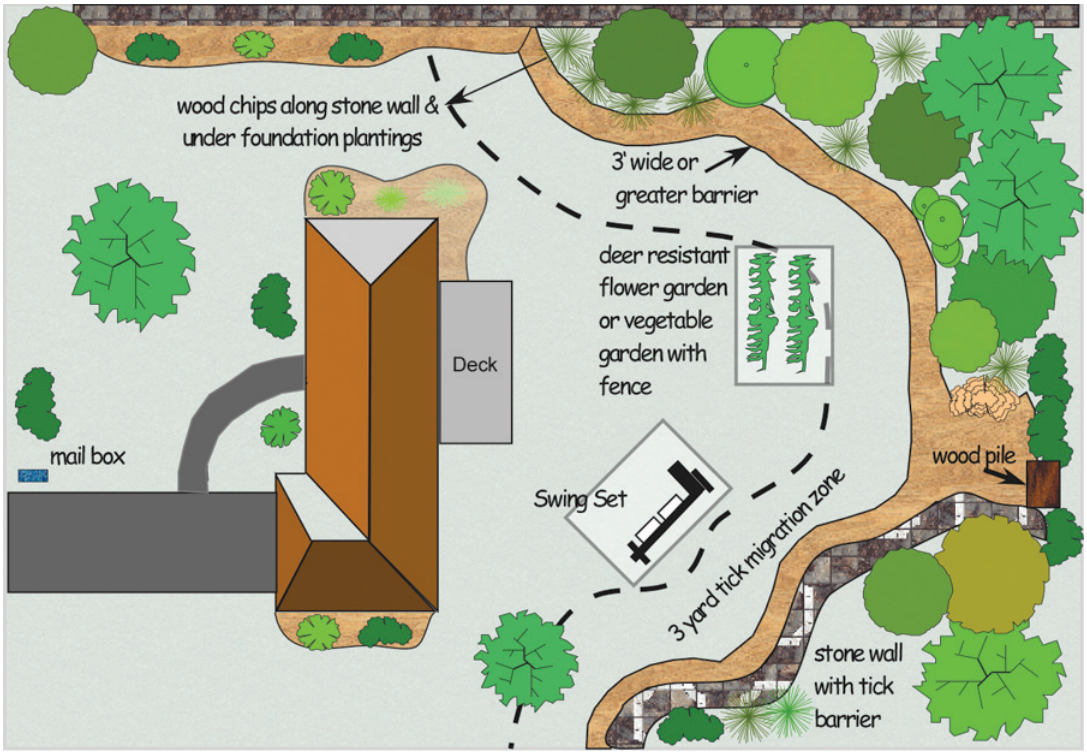

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The use of hardscapes, mulches, and xericape landscaping techniques can help reduce tick habitat and isolate parts of the yard from tick hot spots. Hardscapes refer to nonliving features of the landscape like patios, decks, and paths. Mulches are used to suppress weeds and help retain soil moisture, but also can help reduce tick movement. In the laboratory, landscape materials 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 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 become 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.

Organic Land Care Practices

Standards for organic land care practices for design and maintenance of ecological landscapes have been developed and published by the Connecticut and Massachusetts chapters of the Northeast Organic Farming Association (NOFA). Tick IPM practices are covered under pest and wildlife management guidelines (*NOFA Standards for Organic Care*). Practices that are preferred to manage ticks would include personal protection measures, making the environment unsuitable for the pest (i.e., landscape modifications as reviewed in this section), deer resistant plantings (the use of native plants is generally encouraged), fencing against deer, and herbal-based deer repellents (reviewed in the next section on host management). Ammonia or hot sauce based deer repellents are allowed. The use of arthropod pathogens like entomopathogenic fungi (fungi that kill insects), diatomaceous earth, insecticidal soaps and botanical insecticides are allowed under the standards. However, botanicals cannot be formulated with EPA List 1 inert ingredients (i.e., inert ingredients of toxicological concern). Prohibited under the organic standards are all synthetic insecticides and piperonyl butoxide as an insecticide synergist, rodenticides containing warfarin, predator urine (due to collection practices), and products containing sewage sludge (e.g., Milorganite). Two other NOFA resource publications are the *NOFA Guide to Organic Land Care: Directory of Accredited Organic Land Care Professionals* (2007 Edition) and *The NOFA Lawn and Turf Handbook* (www.organiclandcare.net).

Environmentally Friendly Lawns and Backyard Wildlife Programs

A residential lawn of pure, carefully manicured grass has been the standard American suburban landscape for many decades. Lawns provide valuable areas for play and recreation and are esthetically pleasing to many communities. With increased environmental awareness, the focus for many backyards has been to provide a more natural or organic landscape (sometimes retaining the manicured front lawn for community relations), with reduced inputs of energy, water, pesticides, fertilizer and labor, and increased wildlife habitat. An alternative landscape may involve a lawn of mixed grasses and low-lying plants like clover, reducing the amount of lawn, or replacing the lawn entirely. 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 can result in the presence of ticks. This is an area that has not been adequately explored and little information is available on how to best integrate the two different objectives. Open lawns harbor fewer ticks and wildlife that carry potentially infected ticks. There is limited evidence that increased animal diversity may reduce the rate of transmission of tick-associated disease, resulting in fewer infected ticks. However, the fragmented woodland and ecotone environment of suburbia favors the deer and mice most involved in the maintenance and transmission of tick-associated diseases.

What kind of organic landscape, alternative habitat, or wildlife program could be set up within or adjacent to the tick safe zone? While deer-browse resistant exotic-invasive understory vegetation is associated with greater tick abundance, 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 much difference. Some plants used in butterfly gardens are more attractive to deer, while most herbs are highly resistant to deer browsing. If a property is large enough, a separate wildlife and tick-managed zone could be maintained. Fencing against deer will allow greater landscape flexibility. Certain activities such as xeriscaping, mulching, removing invasive exotics, and planting native deer resistant plants can conserve resources and fit into a tick reduction program. Use a grass variety that requires little additional water, pesticide, and fertilizer and allow the lawn to go dormant in the hot summer. The proper selection of plants may help support a diversity of butterflies and other insects, bats, hummingbirds, salamanders, toads, and turtles, but not encourage deer or key small mammals. Possible alternatives to increasing lawn area might include mulched or gravel paths, a meadow or prairie patch, vegetable, herb or butterfly garden, or hard landscaping as previously discussed. Choosing plantings can get complicated when native versus non-native or invasive species, deer susceptible versus deer resistant plants, aesthetic, and wildlife values are considered.

Reducing ticks in a “naturalscape” will require higher level of management of the landscape and visiting wildlife. Consider consulting a specialist on natural landscapes and ask them to incorporate tick management concepts into your design. The objective of a tick management program is to discourage activity of several key tick hosts and create a barrier between woodland habitat and areas the family uses most frequently.

Possible Landscape Options

- Butterfly gardens in large open sunlit areas may make an attractive alternative to an open expanse of manicured lawn. Nectar plants are placed in sunny areas protected from wind by shrub nectar sources and trees and selected to provide continuous bloom for the adult butterflies. Clumping nectar sources is more attractive to butterflies. Clumps of nectar flowers can be separated from tick habitat by gravel or mulch paths or strips of lawn to reduce its potential for harboring ticks. A much larger separation also would minimize any impact from targeted use of pesticides for tick control. Butterfly gardens also can be placed in sunny flower borders, along walkways, in containers on patios, or in a small wildflower meadow, which attracts the most butterflies. Some nectar plants are deer browse resistant.
- Colonial style gardens are formal layouts of herbs, vegetables, and flowers surrounded by fieldstone, gravel or lawn walks. The sunny, warmer landscape, separated from woodland habitat, should harbor few ticks.
- Native wildflower and grass meadows require no fertilizer, little or no supplemental water, and only annual mowing, once established. A small wildflower meadow is very attractive to butterflies. While data are limited, meadows appear to harbor few blacklegged ticks except along narrow edges with woodlands, dense vegetation and stonewall. Native grasses, which usually grow in small clumps, provide cover for meadow birds and certain butterflies (particularly skippers) and are deer resistant.
- Ferns may be an option in more shady portions of the landscape. In some cases, fewer ticks have been recovered in stands of fern, except adjacent to stonewalls or woodland. However, another study found nymphal ticks to be more abundant in moist fern habitat than open understory, deciduous litter habitat. Ferns are deer browse resisant.

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 and chipmunks, 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, *Odocoileus virginianus* (Zimmerman)

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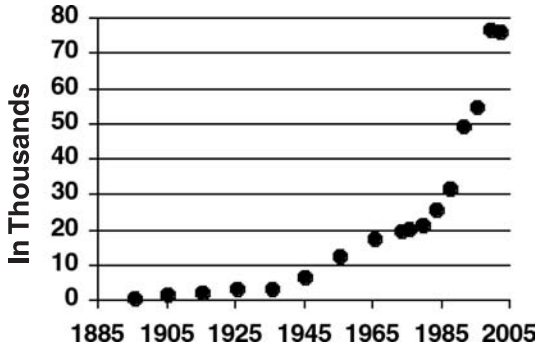
In the northeast from New Jersey and New York to Maine, the deer population is estimated at 1,918,000 animals. In Connecticut, the number of deer has increased from about 12 in 1896 to over 76,000 today. Overabundance of deer is associated with problems such as deer/vehicle collisions, agricultural damage, lack of forest regeneration, detrimental impacts on other wildlife (especially birds), damage to residential landscapes, spread of seeds of invasive plants, 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.



Historical estimates for white-tailed deer abundance in Connecticut (Data: CT DEP).

The abundance and distribution of *I. scapularis* has been related to the size of the deer population. It has been estimated that over 90% of adult ticks feed on deer, each laying ~3,000 eggs. Therefore, deer are the 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 (ca. > 100/mi^2) 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 as fencing would need to enclose an area large enough to exceed the range of smaller animal hosts. A deer fence does not inhibit small animal movement and tick movement. 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. Barrier fencing can be used to protect individual trees, shrubs or other plantings from deer.

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 for a fence is a plastic or wire mesh vertical structure. 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.

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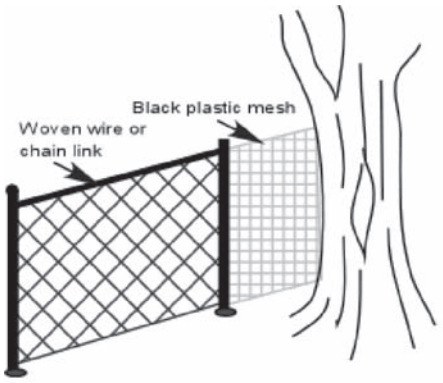
Non-electric fence: The fence may be vertical or three-dimensional. A vertical fence requires the least space and a wide variety of fence materials and designs are available. Increasingly, a black polypropylene plastic fence-like mesh or steel mesh is being used instead of a chain-link for vertical fences 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.



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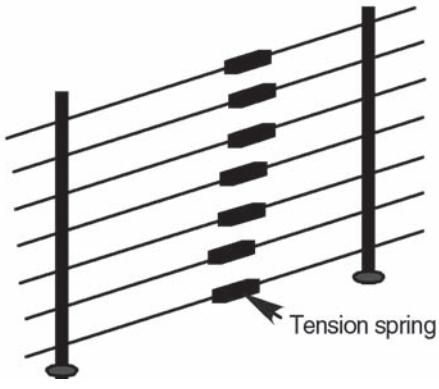

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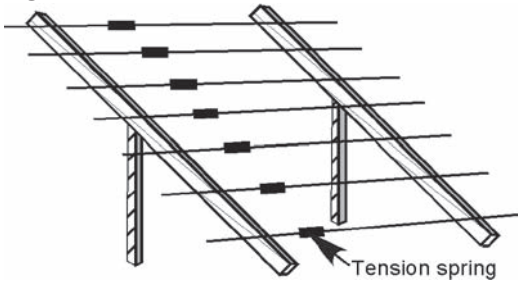
Electric fence: An electric fence requires maintenance, proper grounding, and may not be appropriate in many residential settings. A vertical or slant seven-strand, high-tensile electric fence is very effective for larger areas where deer densities are high.



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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.

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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. Many states prohibit or restrict the selling, movement or planting of certain invasive plants or noxious weeds. For example, Connecticut prohibits importing, selling, buying, cultivating, distributing or transplanting of 81 listed invasive plant species (some are aquatic). Massachusetts bans the importation and sale of more than 140 plants identified as either noxious and/or invasive. Lists of banned and 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.ct.gov/caes). 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

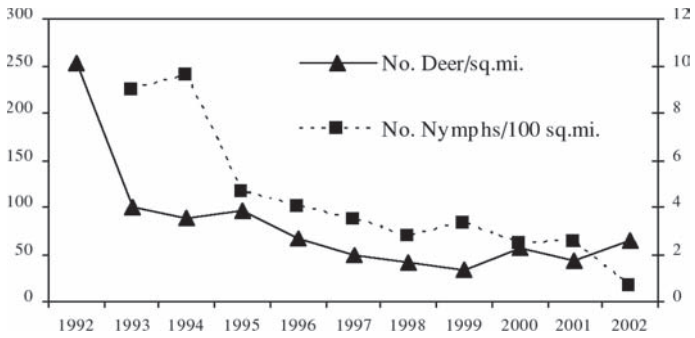
herbs, and butterfly garden plants are resistant to deer browse. The most browse resistant plantings can be placed at the edges and entrances of the property and the most browse susceptible plants closer to the house or areas frequented by people and pets. Susceptible plants can be surrounded by less 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 rodent host.

Deer Reduction and Management

Some communities have explored the reduction of white-tailed deer through regulated hunting or controlled hunts to reduce problems associated with deer overabundance, particularly related to Lyme disease. A major question has been how far deer densities must be lowered to reduce tick exposure and human disease. The incremental removal, reduction or elimination of deer has clearly been shown to substantially reduce tick abundance in many studies. Observational studies and computer models suggest that a reduction of deer densities to less than twenty deer per square mile may significantly reduce tick bite risk, while lower levels (~8 deer/mi^2) would interrupt the enzootic cycle of Lyme disease and transmission of *B. burgdorferi* to wildlife and humans. Fewer ticks have been reported at deer densities less than 18 animals/mi^2 in one study. Because of issues related to locations where most deer reduction studies have been conducted and limited human case reports, data on the impact on human disease are more limited. However, reductions in human tick-associated disease with the lowering of deer densities have been reported.

Select Deer Reduction Studies on the Blacklegged Tick and Lyme Disease

- The reduction of deer on Great Island (a peninsula on Cape Cod, MA) by 97% from an estimated 32 deer to 1 animal from 1982 to 1984 (52 deer in all) resulted in ~80 and ~55% average reductions in larvae and nymphs on mice in the 3 years following the intervention. Continued maintenance of a density >6 deer/mi^2 has reduced tick-borne disease incidence from 16% of a community of 220 people to only 3 cases since 1986 (Telford 2002; Wilson et. al. 1988).
- In the coastal community of Ipswich, MA, removal of deer over a 7-year deer period from 160 deer/mi^2 to 27 deer/mi^2 (~83%) reduced the average number of larval and nymphal *I. scapularis* on mice by 50 and 41%, respectively (Deblinger et. al. 1993).
- In Connecticut, deer were reduced from over 200/mi^2 to ~30/mi^2 (~84%) at the Bluff Point Coastal Preserve and a geographically isolated tract in Bridgeport (see figure below) producing a substantial (>90%) decline in tick abundance from 9-12 nymphal *I. scapularis* per 100 m^2 to ~1.0/100m^2 (Stafford et. al. 2003).



- In Mumford Cove, a residential community in Groton, Connecticut, the deer population was reduced 92% from ~100/mi^2 to ~12/mi^2 and the number of Lyme disease cases was reported to have dropped from 30 to less than 5 within three years. Although part of this reduction was due to a regional decrease in tick activity and in reported Lyme disease cases during the same period, tick abundance was reduced and a regional increase in tick numbers and reported Lyme disease cases in 2005 was not reflected in the Mumford Cove community (Kilpatrick & LaBonte 2003; Stafford, unpublished data).
- Deer were completely eliminated from Monhegan Island, Maine over a 28-month period resulting in the steady disappearance of *I. scapularis* from the island (Rand et. al. 2004).
- Computer simulations with a program called LYMESIM suggest that a 70% reduction in deer density and maintenance level of 19 deer per square mile (7.5/km^2) would achieve ~40% reduction in infected nymphs within 4 years. The virtual elimination of deer would result in a 99% reduction in infected nymphs (Mount et. al. 1997).

While adult ticks also feed on opossums, raccoons, coyotes, and skunks, it doubtful that *I. scapularis* can be maintained in significant numbers just from feeding on these medium-sized alternate animal hosts. They are less abundant than deer and, in the case of raccoons, ticks are frequently removed while grooming. Some ticks still may continue to be introduced into an area on migrating birds, even with the complete removal of deer. A few adult ticks have been recovered from deer-free islands. Interestingly, the number of adult ticks on remaining deer and the 'apparent' adult tick host-questing abundance will increase for several years following deer reductions as questing adult ticks, many of which would have fed on deer, become available to other hosts. The prevalence of *B. burgdorferi* in the ticks will initially rise as a greater proportion of immature ticks feed on reservoir competent hosts before dropping in subsequent years. The time that is required for reductions in the questing tick population is due, in part, to the 2 year life cycle of the tick.

Although deer and tick reductions have been successfully carried out on some islands, peninsulas or some other defined geographical tracts, it is not clear if a deer population can be reduced sufficiently to achieve a satisfactory level of tick control in more densely populated areas on the mainland. Conversely, unregulated deer populations may potentially lead to an increasing tick population. Lethal management options for deer are effective, though controversial, while the use of anti-fertility agents remains 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

The U.S. Department of Agriculture, Agricultural Research Service (ARS), developed passive self-treatment methods for white-tailed deer through both systemic (i.e. ivermectin-treated corn) and topical application technologies to kill ticks feeding on deer. A device termed a '4-Poster' was designed for the application of topical acaricides to white-tailed deer to prevent the successful feeding of adult ticks. It consists of a feeding station with four paint rollers that hold the pesticide. Deer self treat themselves when, because of the design, they are forced to brush against the rollers as they feed on whole kernel corn. Computer simulations of various intervention scenarios

suggested that acaricide applied to white-tailed deer (assuming 90% of deer are treated and 90% tick mortality on these deer) would prevent more cases of human Lyme disease except perhaps for the best use scenario of a Lyme disease vaccine.

Because white-tailed deer are the keystone species for adult blacklegged ticks and lone star ticks, the '4-Poster' was evaluated on free-ranging deer in a multi-year (5 years treatment plus 2 additional years tick sampling) project in the northeastern United States for the control of both tick species at seven 2-mi^2 sites in 5 states (MD, NJ, NY, CT, RI). Approximately one device was placed per 51 acres, although some minimally used 4-posters were redeployed near heavily used devices to increase host access. Treatments utilized a 2% oily formulation of amitraz and reduced blacklegged tick abundance by up to 81% and lone star ticks up to 99.5% in the treated communities in comparison with untreated areas after 3 or more years of use. Similarly, the application of 10% permethrin to a 600-acre fenced population of deer resulted in a 91-100% reduction of larval, nymphal, and adult questing blacklegged ticks at the Goddard Space Flight Center, MD. While usage of the devices by deer was generally high (> 90 to 100%), utilization of the devices by deer can be low or sporadic when alternative food sources were available such as heavy acorn mast. Maintenance of the feed and topical insecticide through the tick season is labor intensive. Nevertheless, 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) and may be an alternative to the application of area-wide acaricides and the maintenance of drastically reduced deer populations.

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The '4-Poster' Deer Treatment Bait Station is licensed to the American Lyme Disease Foundation of Lyme, CT (www.aldf.com) and manufactured by C. R. Daniels, Inc. of Ellicott City, MD (www.crdaniels.com). The U.S. Environmental Protection Agency (EPA) has registered an oily 10% permethrin formulation of ready to use tickicide (Y-TEX '4-Poster' Tickicide®, Y-TEX Corporation, Cody, WY) especially for application to deer via the '4-Poster Deer Treatment Stations to control *I. scapularis* and *A. americanum*. Permethrin is the chemical used as a tick repellent on clothing and as an acaricide in some louse and scabies mite treatment products for human use. According to the 'Tickicide' label, the acaricide is not to be used less than 100 yards from any home, apartment, playground, or other place children might be present without adult supervision. States may impose more restrictive requirements than the federal label. State pesticide registrations have been obtained in 47 of the 48 contiguous states except for New York, which has strict regulations against feeding deer. Approval requirements or regulations for use by state wildlife officials vary from state to state and use of the device raises some concerns among some state wildlife agencies. Although no cases have been observed in New England and only a single isolated occurrence in New York, Chronic Wasting Disease (CDW) has been shown to be transmitted via blood and saliva of infected deer, primarily in Michigan and other north central states. The use of the 4-poster will probably be most practical as part of a neighborhood or community coordinated program to reduce ticks and the risk of Lyme disease, managed under state use regulations, and combined with some form of a deer management program.

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Small Mammals and Birds

Rodents and birds can infect ticks with *B. burgdorferi* and transport these ectoparasites 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 these hosts may not be able to infect their ticks with spirochetes.

Rodents

While different rodent and bird species may predominate in certain years and locations, white-footed mouse, *Peromyscus leucopus*, is generally the most abundant and efficient animal reservoir for the Lyme disease bacteria. They contribute more infected ticks than eastern chipmunks or meadow voles do. White-footed mice also are reservoirs for the causal agents of anaplasmosis 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*, which are most abundant in fields, pastures, orchards, 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. Although not quantified, this author has noticed mouse populations drop dramatically (based on trapping success) with resultant declines in the tick population at a sample site 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.

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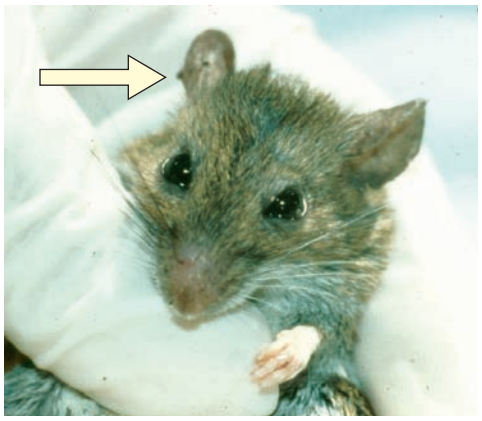

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White-footed mice (top, middle) and Eastern chipmunk (bottom). Note the engorged larval ticks(arrow) feeding on the ears and around the eyes of the white-footed mouse in the middle picture. Larval ticks become infected with B. burgdorferi and other pathogens while feeding on an infected mouse or chipmunk.

White-footed Mouse
Peromyscus leucopus (Rafinesque)

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 of 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 stacked firewood. Mice may readily enter and nest in buildings, especially during the winter months and 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 exposure to hantavirus.

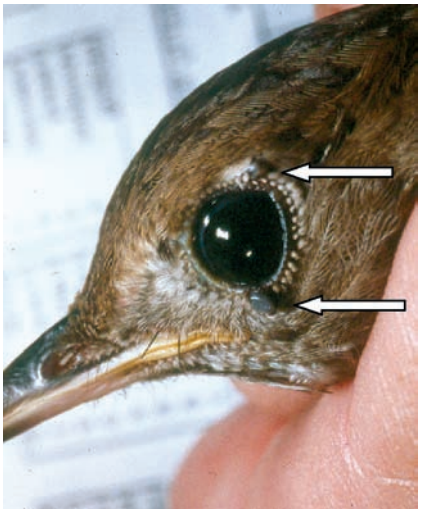
Eastern Chipmunk *Tamias striatus* L.

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 may even 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.

Birds

Birds are frequent hosts for immature stages of the blacklegged tick. In a Connecticut woodland study, 26% of 5,297 individual birds were infested with ticks, 41.4% of 87 bird species were infested, and 94% of 4,065 specimens collected from the birds were *I. scapularis*. In a Maine study, a similar proportion of bird species were infested (39% of 64) with blacklegged ticks and immature *I. scapularis* were recovered from 86.9% of the 1,972 birds examined. At times, the number of individual ticks on birds exceeded that found on white-footed mice.

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, and reservoir



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

competence, it is uncertain how many ticks birds actually contribute to an individual residential landscape. One study found that American robins, a reservoir competent bird, were likely contributors to the nymphal tick population found in some suburban residential landscapes. However, based on another study, most birds probably contribute few infected ticks and may actually dilute pathogen transmission, at least in comparison to mice. Bird feeders were not found to be a risk factor for Lyme disease in a recent study, possibly because birds that frequent feeders in the summer have less exposure to ticks on the ground. 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 have on the prevalence of ticks as related to mouse and chipmunk activity. 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 from deer and are good bird plants. Japanese barberry (*Berberis thunbergii*) is considered invasive. Both nymphs and adults of the blacklegged tick have been reported to be around twice as abundant in areas dominated by deer-browse resistant exotic invasive plants, particularly Japanese barberry, than areas dominated by native shrubs. Lower small mammal species diversity, increased densities of white-footed mice, and therefore increased tick abundance and Lyme disease risk have been linked to habitat with higher density woody understory with more leaf litter and good soil moisture. The Connecticut Agricultural Experiment Station publication *Alternative for Invasive Ornamental Plant Species* is available on the CAES website (www.ct.gov/caes).

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. However, 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 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.
- Select or replace exotic-invasive shrubs with native shrubs.

A fitted stonewall (right) is unlikely to harbor rodents and ticks, compared to the old stonewall with leaf litter and other vegetative cover (left)

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Host-Targeted Chemical Tick Control for Rodents

The first rodent-targeted product was a cardboard tube of cottonballs treated with the insecticide permethrin (Damminix® Tick Tubes). 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. Although reductions in tick numbers were reported in a couple of Massachusetts studies, evaluations in Connecticut and New York 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 an 18-acre tract study conducted in Massachusetts.

Another approach, using bait boxes for the topical treatment of rodents with fipronil, was first successfully evaluated for the control of *I. scapularis* on wild white-footed mice on Mason's Island, Connecticut, where 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. 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 4-6 weeks. A commercial version called the Maxforce® Tick Management System that was available through licensed pesticide applicators consisted of a sealed, ready to use, child resistant box containing nontoxic food blocks and an applicator wick impregrated with 0.70% fipronil. Due to added costs from a metal shroud required to prevent squirrels from chewing into the boxes, the Maxforce® Tick Management System is no longer being manufactured by Bayer Environmental Science.

Prevention of Tick-Associated Disease in Companion Animals

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Engorged female *I. scapularis* on a domestic cat (Pfizer).

The prevention of Lyme disease and other tick-associated diseases 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 bacterins or recombinants based on outer surface protein A - OspA - of *B. burgdorferi*). Vaccination early, prior to tick exposure, will provide better protection, but vaccination after treatment can help reduce future infection. 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.

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), while others require the assistance of veterinarians. 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, permethrin and imidacloprid, amitraz, or fipronil (see section on chemical control). Fipronil is the only option for cats. 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.

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Although the risk of clinical disease is low, the canine Lyme disease vaccines can provide high levels of protection for dogs living in or traveling to 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 by the manufacturer.

Area-Wide Chemical Control of Ticks

Insecticides, or as termed for ticks, acaricides, are the most effective way to reduce ticks, particularly when combined with the landscaping changes to decrease tick habitat reviewed earlier in this handbook. These measures provide consistent control, are relatively easy to apply, and are relatively inexpensive. Only small amounts of an acaricide applied at the right time of year are necessary. Chemical intervention should focus on early control of nymphal *I. scapularis* ticks, the stage most likely to transmit Lyme disease, by spraying once in May or early June. A fall application in October may be used to control adult blacklegged ticks (or in the spring if no fall application was made). Targeting lawn and woodland edges and perimeter areas near tick "hot-spots" or along the "tick zone" can minimize exposure. Some general points to consider if you spray for ticks:

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- Applications can be made by the homeowner or by a commercial applicator.
- Spray once in the late spring or early summer for control of *I. scapularis* nymphs. For American dog ticks, an application can be made anytime after the adults emerge in the spring.
- A single application of most ornamental-turf insecticides will provide 85-90% or better control with some residual activity so multiple applications are rarely necessary. Some organic pesticide products are less effective, breakdown rapidly, and multiple applications may be required.
- Focus treatment on tick habitat. Spray areas where the lawn meets the woods, stonewalls, or ornamental plantings. Spray several yards into bordering woodlands, area of greatest tick density. Spray groundcover vegetation like *Pachysandra* near the home or walkways. Spray perimeter of areas of the yard often used by people (play areas, gardens, outside storage areas, walkways or paths to neighbors or mailboxes). Avoid herb, vegetable, and butterfly gardens.
- In parks and school athletic fields, restrict any applications to high-risk tick habitat. Spraying of open fields and lawns is not necessary.

- Use a product specifically labeled for controlling ticks. Some products are packaged as fertilizer-pesticide mixtures or mixtures of different pesticides (e.g., herbicide and insecticide) or target just garden insects.

Acaricides Used for Tick Control

There are several factors that will influence the selection or use of a specific chemical product. All pesticides sold must be registered with the U.S. Environmental Protection Agency (EPA) and the appropriate state pesticide agency for use within that state.

- The product must be labeled for area-wide tick control (see Table 4). Some products are General Use Pesticides and others are classified as Restricted Use Pesticides for commercial use only, available only to licensed applicators. Some products are labeled for brown dog ticks only or for ticks on surfaces, indoors, as a building foundation or perimeter treatment and are not labeled for use on ornamentals or turf. Check the label and ask for assistance. A licensed commercial applicator often will have a preferred acaricide that is used most frequently.
- The toxicity and environmental impact of the chemical. Chemicals differ in their toxicity to humans, wildlife, aquatic organisms and beneficial insects. While some general information is provided in this handbook, more detailed information can be obtained from sources listed at the end of chemical control section.
- The type of formulation and method of application. Both liquid and granular formulations have been reported effective against *I. scapularis* with somewhat better control usually obtained with liquid formulations. Sufficient spray volume and pressure should be used for thorough coverage and penetration of the vegetation and leaf litter. A small hand pump sprayer is unlikely to provide the coverage needed for good tick control and, at a minimum, some type of garden hose sprayer is indicated for an adequate application. A homeowner who wishes to apply a granular material with a fertilizer spreader for tick control may not be able to treat woodland margins effectively and the product may be labeled for lawn use only.
- Effectiveness in controlling ticks. Blacklegged ticks and American dog ticks are readily killed by almost all ornamental and turf insecticides labeled for tick control. With the withdrawal of the organophosphate insecticides chlorpyrifos and diazinon from residential use (the U.S. Environmental Protection Agency cancelled registration of these compounds for residential area-wide use), the synthetic pyrethroid insecticides are the most commonly used tick control agents. Pyrethroids are particularly effective at rates 6-45 times less than the now cancelled organophosphate insecticides and the carbamate insecticide carbaryl. In the laboratory, nymphal *I. scapularis* crawling on landscape stones treated with pyrethrin-based desiccants and insecticidal soaps suffered high (> 88%) mortality. However, natural pyrethrin with the synergist piperonyl butoxide provided limited tick control in the residential landscape in several trials. By contrast, synergized pyrethrin was more effective when combined with insecticidal soap or as part of a silicon dioxide (from diatomaceous earth) product. Silicon dioxide acts as a desiccant. Thorough coverage appears particularly important with pyrethrin and insecticidal soap products. With the exception of a desiccant, there is little residual activity. At least two applications may be required.

- Site use restrictions. Many states, including Connecticut, regulate, restrict, or ban the use of pesticides in school buildings or on school grounds. In some cases, applications may be permitted under an approved integrated pest management (IPM) plan or for a health emergency. As these laws or regulations change, the state pesticide regulatory agency can be consulted to determine current requirements and restrictions.

Table 4. Acaricides with products labeled for the control of ticks in the residential landscape.

Chemical	Some brand or common names*	Chemical type and usage
Bifenthrin	Talstar® Ortho® product	Pyrethroid insecticide. Available as liquid and granular formulations. Products available for homeowner use and commercial applicators.
Carbaryl	Sevin®	Carbamate insecticide. A common garden insecticide for homeowner use, some products are for commercial use only.
Cyfluthrin	Tempo® Powerforce™	Pyrethroid insecticide. Available for commercial and homeowner use with concentrates and ready to spray (RTS) products.
Deltramethrin	Suspend® DeltaGard® G	A pyrethroid insecticide for commercial applicators.
lambda-cyhalothrin	Scimitar® Demand®	A pyrethroid insecticide for commercial applicators.
Permethrin	Astro® Ortho® products Bonide® products Tengard® SFR Others	Pyrethroid insecticide. There are concentrates and ready to spray (RTS) products. Most are for homeowner use, a few are for commercial use.
Pyrethrin	Pyrenone® Kicker® Organic Solutions All Crop Commercial & Agricultural Multipurpose Insecticide®	Natural pyrethrins with the synergist piperonyl butoxide (PBO) or insecticidal soap provide limited tick control. A combination of pyrethrin and PBO with either insecticidal soap or silicon dioxide (from diatomaceous earth) was found effective against ticks in one trial.

*Active ingredients and brand names frequently change as new products are registered and others discontinued. New formulations for homeowner use may become available. Mention of a product is for information purposes only and does not constitute an endorsement by the Connecticut Agricultural Experiment Station.

Homeowner Application of Acaricides for Tick Control

One option is for the homeowner to make the pesticide application. Anyone applying pesticides to their own property should be familiar with how to read a pesticide label, how to correctly mix the pesticide, and follow the listed precautions in handling and applying the material. The pesticide label provides information on the active chemical ingredients, formulation, pests and sites for which it can be legally used, directions for use, precautions, hazards to humans, wildlife and the environment, and first aid instructions. Always read and follow pesticide label directions and precautions. It is a violation of federal law to use a pesticide in a manner inconsistent with the label. The label will provide an indication of how hazardous a pesticide is by the signal word on the label. Signal words are based on the EPA toxicity class and must be included on pesticide labels.

- Danger-Poison means highly toxic or poisonous through oral or dermal exposure

- Danger means highly toxic, but may include severe skin or eye irritants
- Warning means moderately toxic or hazardous
- Caution means slightly toxic or hazardous
- No signal word means practically nontoxic

Not all brands of a particular pesticide chemical will be labeled for area tick control. Some products may be for application in or on building and their immediate surroundings. Check the label. Homeowner products come in three forms.

- Ready-to-use (RTU) is premixed and applied directly from the existing container. They are used for spot treatments, treatments of individual plants, or treatment of small areas. Some RTU products, for example, are used to control dog ticks indoors or around a dog's bedding. Ready-to-spray (RTS) products are used for treating larger areas. The container attaches directly to a garden hose for automatic mixing of the water with the concentrate. For example, a ready spray of 2.5% permethrin or 0.75% cyfluthrin is available as a hose end sprayer for the control of *I. scapularis* and will cover about 5,000 square feet.
- Concentrates require mixing the product with water and using your own sprayer (pump-up style, hose-end style, or other type sprayer). Homeowner products may contain carbaryl, cyfluthrin, or permethrin.
- Granules are designed for lawn applications with a hand held or broadcast spreader. The chemical is usually released with addition of water, so granules generally must be watered in. Granules for tick control on the lawn may contain bifenthrin or carbaryl.

Appropriate protective gear as directed on the label should be used when applying pesticides. Surveys have shown many individuals fail to take precautions while applying pesticides. Pesticides should be stored in a cool, dry, secure place. Keep them out of the reach of children. An EPA survey found 85% of households had at least one pesticide on the property and 47% with young children (under age 6) stored them within reach of the child. Keep a pesticide in its original container; do not store diluted spray. Either use up the product or properly depose of leftover product through a community household hazardous waste program. Pesticides should never be poured down the sink or toilet. Empty containers should be triple rinsed and placed in the trash. For more information on handling, applying, storing and deposing of pesticides, readers may refer to the EPA's Citizen's Guide to Pest Control and Pesticide Safety (available at www.epa.gov).

Commercial Application of Acaricides

Another option is to have a licensed commercial pesticide applicator apply the acaricide. Most companies offering tick control services are lawn care, landscape, or tree care companies, but may include some pest control operators (PCOs) in some states, depending upon what licenses the operator has obtained. A survey of commercial applicators in Connecticut in the mid-1990s found that about 16% offered tick control services. The application of pesticides for tick control comprised less than 5% of their business for most companies. Nevertheless, most companies reported that tick control business had increased and a few companies have specialized solely in providing tick control. A follow-up survey by the author in 1999 indicated that 53% were now offering tick control services. A number of companies provide organically oriented pest management services.

A company offering commercial application of pesticides must be registered with the state or states in which they conduct business. A pesticide license is required for the commercial application

of pesticides or the application of restricted use materials in the area. There must be at least one commercial supervisory pesticide applicator certified in the type of application being made. In Connecticut, for example, a license for ornamental and turf application from the Department of Environmental Protection is required for applying pesticides for tick control in the landscape. Some tree service companies (arborists) also treat for ticks. Although arborists are tested and licensed by the state specifically for arboriculture services, they must also possess an ornamental and turf license to spray for ticks. Consumers should employ individuals who are licensed to spray for ticks and may request to see the license or license number or check with the agency responsible for the state pesticide program to see if the firms are properly registered and licensed. A commercial company should provide a consumer the name of the pesticide product to be used, the active ingredient in the product, the reentry period (the time before family members can safely reenter the treated area), and the form of the pesticide and type of equipment to be used. In most states, companies are required to provide copies of the label and material safety data sheets (MSDS). With this information, additional information can be obtained over the Internet, from local Cooperative Extension offices, state agencies and pesticide alternative groups. Tips on hiring an applicator are available from EPA's Citizen's Guide to Pest Control and Pesticide Safety (available at www.epa.gov). Some general guidelines about a pesticide application that homeowners and commercial applicators should be aware of include:

- Many states (including all New England states, New York, New Jersey, Pennsylvania) have notification laws that require customers or adjacent residents receive written notice prior to an urban pesticide application. Usually this notification is provided only to those who request it through a registry.
- Pesticides should not be applied on windy days (greater than 10 mph) to avoid drift to non-target areas.
- Before the spraying, the windows and doors of the home should be closed.
- Pesticides should be kept away from plants and play areas that you do not want treated. Most tick control pesticides are for ornamental and turf use only and are not labeled for use on plants meant for human consumption. Most of these chemicals are toxic to bees and should not be applied to areas with foraging bees.
- Pesticides should not be applied near (within 25 feet) wetlands (i.e. lakes, reservoirs, rivers, streams, marshes, ponds, estuaries, and commercial fish farm ponds) or near (within 100 feet) coastal marshes or streams. Even organic pesticides are toxic to fish and aquatic invertebrates.
- Family members and pets, especially cats, should be kept off the treated area for 12-24 hours or other specified reentry interval following the treatment (generally until a spray thoroughly dries).
- Do not water the lawn after the application of a pesticide to avoid run off (there are a few exceptions with some granular products which must be watered in). Do not apply within 24 hours of rain to avoid run-off. Pesticides typically reach streams via run-off when rains hit a recently applied area or flush treated soil or other matter into the water body. Once the pesticide has dried, however, some materials bind tightly to the soil or vegetation and do not readily move or wash off. They will breakdown with exposure to sunlight and soil microbes.
- Avoid pesticide applications near a wellhead. The shaft of the well should be tightly sealed and the well water source should be isolated from surface water source. Most acaricides used for tick control are water insoluble and pose little risk to wells by leaching through the soil, but direct exposure should be avoided.

- Many states (including all New England states, New York, New Jersey, Pennsylvania) have laws that require signs to be posted after an urban treatment is made.

An Acaricide Primer

The purpose of this section is to serve as a reference for some basic, general material on the major classes of chemicals used in tick control. More detailed information is available from the EPA, the Cooperative Extension Service, state pesticide agencies, and independent groups, particularly over the Internet. Some sources of information are listed at the end of this section. Acaricides belong to a variety of chemical classes, which differ in their chemistry, mode of action, toxicology, and environmental impacts. They also contain "inert ingredients," chemicals that carry or enhance the application or effectiveness of the active ingredient (i.e., the actual acaricide). A variety of pesticides are also used in products to control ectoparasites on pets. Some pet care products are available over the counter and others through a veterinarian.

- **Organophosphates.** There were two organophosphate insecticides commonly used for area-wide tick control, chlorpyrifos (i.e., Dursban) and diazinon. The EPA cancelled the residential use and some agricultural uses of chlorpyrifos and cancelled the registration of diazinon for lawn, garden, and other residential outdoor use. Residential applications accounted for nearly 75% of the use of diazinon. Products with these chemicals are no longer used for tick control.
- **Carbamates.** Carbaryl (Sevin®) is the carbamate used in the control of ticks. Carbaryl is a broad-spectrum compound used for a wide variety of pests on the lawn, on pets, and in the home. Carbaryl in animals is readily broken down and excreted. It does not appear to cause reproductive, birth, mutagenic, or carcinogenic effects under normal circumstances, but it is a suspected endocrine disrupter. Carbaryl is extremely toxic to bees and beneficial insects, is moderately toxic to fish, but is relatively nontoxic to birds.
- **Pyrethrins.** Pyrethrum is a natural insecticide extracted from certain chrysanthemum plants. Natural pyrethrins are a group of six compounds that form the insecticidal constituents of the natural pyrethrum, which is highly unstable in light and air. Natural pyrethrins are considered knockdown agents because they rapidly paralyze insects, but many insects can detoxify the compound and recover. Therefore, pyrethrins are sometimes combined with a synergist. A synergist is a compound that enhances the toxicity of an insecticide, but is not an insecticide itself. The most common synergist used with pyrethrin is piperonyl butoxide, which inhibits the enzymes that break down pyrethrin. Pyrethrins also may be combined with insecticidal soaps, spreader sticker agents, silicon dioxide (desiccant) and other agents to enhance the effectiveness of the product. Pyrethrins have little residual effect, being quickly broken down by exposure to light, moisture, and air.
- **Pyrethroids.** Synthetic pyrethroids are derivatives of the natural compounds, chemically modified to increase toxicity and stability. Most of the chemicals used for area-wide tick control are pyrethroids. The pyrethroids are less volatile than the natural compounds and photostable, which provides some residual activity and greater insecticidal activity. Both pyrethrins and pyrethroids are highly toxic to fish and other aquatic organisms, but generally are much less toxic to mammals, birds and other wildlife. Pyrethroids can be skin and eye irritants. Many concentrated pyrethroid formulations are restricted to commercial use by licensed applicators because of their potential impact on aquatic organisms. However, low concentration, ready-to-use products are available for homeowner use.
- **Inert ingredients**. They may be solvents, propellants, spreaders, stickers, wetting agents, or carriers for the active pesticide chemical. Because these compounds are not the active chemical, they are labeled "inert ingredients" or sometimes "other ingredients". These

compounds often make up the major part of a pesticide formulation. In some cases, the inert ingredients may be more toxic than the active ingredient. A few examples of inerts include napththalene, petroleum distillates, and the organic solvents xylene and toluene.

- **Acaricides for control of ticks on pets**. Carbaryl, the pyrethroid permethrin and imidacloprid are used in several flea and tick control products for dogs. Studies have indicated that use of permethrin and permethrin/imidacloprid products (i.e., K9 Advantix™, Kiltix®) can prevent the transmission of *B. burgdorferi*. Both are topical products applied to spots along or on the back of the animal. They are not for use on cats, as cats are particularly susceptible to pyrethrin poisoning. Fipronil, a phenypyrazole, is the only commercial insecticide of this chemical type and may be used on cats. Formulated pet products are available as a spray or topical spot application (Frontline®, Frontline® Top Spot™, Frontline® Plus) for long-term control of fleas and ticks on dogs and cats. Fipronil dissolves in the oils on the skin, spreads over the body, and collects in sebaceous glands and hair follicles for long-term reapplication. It is not affected by bathing or water immersion. Skin irritation may occur. Fleas are killed from 1-3 months, while ticks are killed for about a month. Trizapentadiene or formanidene compounds include one currently used material, amitraz. In livestock, it is used to control ticks, mites, and lice. It is not a skin irritant, is not readily absorbed into tissue, and degrades rapidly in the environment. Amitraz is used in a tick prevention collar for dogs (Preventic®), and one study indicated it could prevent transmission of *B. burgdorferi*. An amitraz product was one of the compounds initially evaluated for the topical treatment of deer to control *I. scapularis*.

Additional sources of information about pesticides

Environmental Protection Agency (EPA) Public Information Center (telephone 202-260-2080), National Center for Environmental Publications and Information (telephone 513-489-8190), EPA booklets or the EPA web site (www.epa.gov).

National Pesticide Information Center (NPIC) (formerly the National Pesticide Telecommunications Network) is a cooperative effort of Oregon State University and the U.S. Environmental Protection Agency (EPA). The toll-free service is staffed 6:30 am – 4:30 pm Pacific time (9:30 a.m. – 7:30 p.m. Eastern time) 7 days week, except holidays (telephone 1-800-858-7378). Information provided by the NPIC includes pesticide information, information of recognizing and managing pesticide poisonings, safety information, health and environmental effects, referrals for investigation of pesticide incidents and emergency treatment information, and cleanup and disposal procedures. Pesticide related fact sheets and other information are available at the web site, a source of factual chemical, health, and environmental information about more than 600 pesticide active ingredients incorporated into over 50,000 different products registered for use in the United States since 1947 (http://npic.orst.edu/). Their address is NPIC, Oregon State University, 33 Weniger Hall, Corvallis, Oregon 97331-6502.

Extension Toxicology Network (EXTOXNET) is a cooperative effort of University of California-Davis, Oregon State University, Michigan State University, Cornell University, and the University of Idaho. Primary files are maintained and archived at Oregon State University. Pesticide Information Profiles (PIPs) and Toxicology Information Briefs (TIBs) provide information on pesticide trade names, regulatory status, acute and chronic toxicological effects, signs and symptoms of poisoning, ecological effects and environmental fate, physical properties, manufacturer, and references (http://ace.orst.edu/info/extoxnet/).

State pesticide regulatory agencies can provide information on the laws and regulations governing the application of insecticides, certification of pesticide applicators, and which products