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Deer Damage Management Options

BY SCOTT C. WILLIAMS, JEFFREY S. WARD, AND UMA RAMAKRISHNAN

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INTRODUCTION

White-tailed deer (*Odocoileus virginianus*) populations in Connecticut have steadily increased from fewer than twenty animals in 1900 to an estimated 76,000 or more today (Ward 2000). In many areas, deer are no longer considered an awe-inspiring, valuable natural resource (Figure 1), but rather tick carriers, agricultural pests, and traffic hazards (Figure 2).

Figure 1. A Connecticut white-tailed buck with antlers in velvet.

Figure 2. Increasing deer numbers have become significant road hazards to Connecticut motorists.

With overabundant deer herds living in areas of medium to high human density, comes conflict. Nationwide, it has been estimated that 1.5 million deer/vehicle collisions occur annually, resulting in 1.3 million deer deaths, $1.1 billion in vehicle damage, 29,000 human injuries, and over 200 human fatalities (Conover et al. 1995). An estimated 18,000 deer are killed annually on Connecticut roadways, but only about 3,000 are reported (Kilpatrick 2004). In addition, fencing, signs, and carcass removal cost Connecticut taxpayers money.

Deer are also hosts for black-legged ticks (*Ixodes scapularis*), sometimes referred to as "deer ticks", which transmit the spirochete *Borrelia burgdorferi*, the causal agent of Lyme disease in humans and some pets (Stafford 1993). Black-legged ticks can transmit another disease-causing bacterium (*Anaplasma phagocytophilum*) which causes human granulocytic anaplasmosis (Belongia et al. 1997, Little et al. 1998, Magnarelli et al. 2004) and a protozoan parasite (*Babesia microti*) which causes human babesiosis (Anderson et al. 1987).

Deer damage both landscape plants and agricultural crops. The Connecticut Nursery and Landscape Association (CNLA) estimates that deer cause $1.5 – $2.0 million in direct damages to plants at nurseries and garden centers prior to sale. The CNLA also estimates indirect damages of $1 million in lost sales to homeowners so discouraged by deer damage they cease buying more plants. Lastly, CNLA estimates Connecticut nurseries and garden centers spend approximately $500,000 annually to protect nursery stock from deer, e.g., fencing, repellents (R. Heffernan, Executive Secretary CNLA, personal communication).

This Bulletin is designed to assist gardeners, growers, landscapers, tree farmers, and others in effectively reducing deer damage to plants, trees, and crops. The first section, DEER ECOLOGY, includes information on some life history, behavioral habits, and feeding patterns of white-tailed deer, details on how the population has been changing over the past hundred years in Connecticut, and thoughts on the impact of increasing deer herds on natural landscapes.

The next section, SURVEY OF DEER DAMAGE in Connecticut, presents the results of a survey of browse damage on farms, orchards, and nurseries in Connecticut. The following four sections describe strategies homeowners and growers alike can use to alleviate browse damage: HERD CONTROL, PHYSICAL BARRIERS, REPELLENTS, and PSYCHOLOGICAL DETERRENTS. The last section, BROWSE RESISTANT GARDENING, provides an updated listing of browse resistant plants and gives hints for gardening in areas where browse damage can be expected.

DEER ECOLOGY

To effectively deter deer from damaging vegetables, cut flowers, shrubs, and crops, it is necessary to understand deer behavior and feeding habits. White-tailed deer inhabit most of the contiguous United States, Mexico, and southern Canada. Body size can range from 50 to nearly 400 pounds. Larger deer are found in northern climates, while Florida has the smallest subspecies in North America. In Connecticut, adult white-tailed deer typically weigh between 100 and 250 pounds, depending on density and/or nutrition. A typical home range of female deer (does) in Connecticut is a few hundred acres, while male deer (bucks) can range over territories of several thousand acres. In early spring, bucks grow antlers, which are often incorrectly called horns by many people. Antlers are made of bone and are shed annually in late fall/early winter. Horns are made of keratin (similar to human fingernails) and are retained for the life of the animal.

The Connecticut deer population has drastically increased over the past century. This is due in large part to the abandonment of agricultural fields and the resulting reforestation of the state. In some areas, overabundant deer have nearly halted natural ecological succession and altered forest species composition. Very little understory vegetation is present and few oak (*Quercus*) saplings have grown tall enough to escape browsing in these areas of

high deer density. Thus, our valuable hardwood forests are being replaced by less economically desirable and less palatable (to deer) tree species such as striped maple (*Acer pensylvanicum*), hophornbeam (*Ostrya virginiana*), and black birch (*Betula lenta*) as older trees are harvested or die. In effect, the state deer herd is slowly altering the character of the natural landscape, and because trees live for a century or more, these changes will be long-term.

White-tailed deer in the wild are usually shy, reclusive, and alert, as an exposed deer is susceptible to predators. However, herds in areas of higher human population density become habituated (i.e., accustomed) to traffic, lawnmowers, and the "quiet life" of suburbia. They are crepuscular by nature; meaning, they are most active during the twilight hours of dusk and dawn. The majority of this time is spent feeding. Deer are browsers that seemingly wander throughout their range, selectively feeding on the most nutritious portions of various species of tree saplings, shrubs, grasses, sedges, as well as fruits, nuts, mushrooms, and forbs (Verme and Ullery 1984). A deer in the garden may feed in a haphazard manner, until it finds a row of lettuce days from harvest, a bed of tulips (*Tulipa*) just hours from flowering, or a rhododendron (*Rhododendron*) in late winter (Figure 3).

Figure 3. Severe browse damage often occurs in late winter or early spring, when deer are most desperate for available food.

Deer are ruminants as are cattle, sheep, and goats. They have a four-chambered stomach and rely on microorganisms to process materials that monogastric animals (e.g., humans) cannot. Deer typically feed in haste, storing material in the largest of the four chambers, the rumen. Then during daylight hours, deer generally remain bedded regurgitating, remasticating, and reswallowing previously ingested material, much in the same way a cow chews its cud. This material flows virtually unrestricted between the rumen and secondary chamber, the reticulum, then eventually to the omasum that absorbs water and minerals, and finally to the abomasum which secretes acids (Verme and Ullery 1984). Material is then passed through the small and large intestines where nutrients and water are absorbed and unprocessed material is eventually excreted. This feeding strategy limits the time the animal is susceptible to predators and maximizes the time the deer is safely bedded, remasticating browsed items. It is this feeding strategy that also explains why gardeners often find entire crops or flower beds wiped out by deer in a few short days.

Figure 4. Comparison of rabbit (left) and deer (right) browse damage.

Before implementing a deer deterrent program on your own property, it is essential to determine that the damage to your garden is, in fact, from deer. Deer do not have upper incisors (front teeth). Instead, they have a bony plate. Branches browsed by deer will usually have a frayed, trailing edge remaining on the stalk where the deer pulled the vegetation away from the main stem (Figure 4). Damage can occur anywhere from approximately six feet high down to ground level. Stems browsed by rabbits (*Sylvilagus* spp.) and rodents can be easily distinguished from deer browse damage because the stems are usually cleanly sheared at a 45 degree angle no more than a foot from the ground. Hoof prints in your garden are also a sure sign of deer visitation.

SURVEY OF DEER DAMAGE IN CONNECTICUT

Anecdotal reports of extensive deer damage to agricultural crops in Connecticut are common, but not well documented. In 2003-2004, surveys were distributed to members of the Connecticut Farm Bureau, Connecticut Nursery and Landscape Association, and the Connecticut Pomological Society. Growers were requested to report on actual crop damage from different wildlife species (including deer), percent of that crop lost, percent of that crop damaged by each species of animal, monetary loss due to each damaged crop, and measures taken to avert animal damage.

Table 1. Effectiveness of deer damage control methods tried by growers in Connecticut.

Deer damage control method	Generally effective	Somewhat effective	Not effective	Sample size
Crop damage permit	57%	36%	7%	42
Deer fence	56%	32%	12%	25
Electric fence	52%	33%	15%	27
Deer netting	41%	47%	12%	17
Recreational hunting	39%	49%	12%	82
Dogs	39%	47%	14%	36
Repellents	28%	44%	28%	61

Table 2. Relationship between deer damage and hunting as reported by growers in Connecticut.

	Allow hunting		Sample
Deer damage on property	No	Yes	size[1]
Negligible	43%	57%	54
Tolerable	33%	67%	39
Unreasonable	13%	87%	38
Combined	31%	69%	131

1/ Only growers who answered both questions are included.

A total of 137 surveys were returned from growers in 83 towns. On average, respondents had owned or managed their land for 31 years. These farms, orchards, and nurseries included over 6,000 acres of the nearly 100,000 acres of working landscape in Connecticut. The surveys indicated wildlife damage on nearly 40% of the acreage. A wide variety of crops was reported to be damaged by deer including Christmas and fruit trees, pumpkins, berries, nursery plants, vegetables, grapes, and hay fields.

As part of the survey, growers reported the monetary losses related to wildlife damage. Respondents indicated a total of $70,000 in wildlife damage to Christmas tree crops, $42,000 in damages to fruit trees, $15,000 to vegetable crops, and $8,000 in other crops. These totals would undoubtedly be larger if all farms in Connecticut were surveyed. Economic losses were not limited to direct damage of crops, but also to indirect damages from profitable crops that could not be grown. Forty growers had stopped using at least one field, or had stopped growing a crop, because of damage. Christmas trees and pumpkins were the crops most commonly discontinued.

Thirty-four percent of growers reported increased wildlife damage in the past five years. Growers with increased damage spent an average of $710 to reduce damage during 2002. Growers have employed a variety of methods to reduce browse damage (Table 1). Crop damage permits and fencing were the only methods that were reported to be generally effective at least half of the time. Repellents were reported to be the least effective method.

Nearly 70% of growers indicated that deer were hunted on their land, mostly by family members and friends. An average of 4.3 deer were harvested on each property with approximately equal number of bucks and does. Not surprisingly, hunting increased as the degree of perceived damage increased (Table 2). Growers who reported unreasonable deer damage were much more supportive of hunting than growers with negligible damage.

The reasons for not allowing hunting were varied (Table 3). The most common reason given for not allowing hunting is concern of potential liability. However, Connecticut Department of Environmental Protection Hunting Laws and Regulations states “Landowners who allow, without fee, the recreational use of their property are protected from liability by Connecticut law (C.G.S. 52-557g)”. Interestingly, the second most common reason, parcel size, was not one of the choices but was penciled in by ten respondents. Only a quarter of growers did not allow hunting because of ethical considerations.

An earlier study found that deer browse damage can shift the composition of landscape species that are grown by Connecticut gardeners (Ward 2000). Over half of the 269 gardeners had stopped growing at least one species because of deer browse damage. Tulips were the most common species that was no longer grown. Other herbaceous species abandoned by gardeners included: hosta (*Hosta*), sunflower (*Helianthus*), lilies (*Lilium*), daylily (*Hemerocallis*), garden phlox (*Phlox*), and impatiens (*Impatiens*). The most common shrub species that were severely damaged by browsing deer included: yew (*Taxus*), arborvitae (*Thuja*), rhododendron, azalea (*Rhododendron*), and yucca (*Yucca*).

Table 3. Reasons why hunting was not allowed on some properties in Connecticut.

Reason	Percent
The potential liability is too great to allow hunting	36%
Other	26%
Parcel too small or too close to buildings[1]	24%
I don’t believe in hunting	24%
Hunters cause me too many problems	17%

1/ Not an original answer option, penciled in by the respondents.

STRATEGIES FOR REDUCING DEER BROWSE DAMAGE

There are five approaches for reducing deer browse damage to your plants. These include herd control, physical exclusion, repellents, psychological control, and plant selection. Each one of these strategies will be discussed below. Though each strategy may work by themselves, combining different strategies can be even more effective at reducing damage. Hopefully, by reading this Bulletin, professionals in agriculture, landscaping, and gardening will become better informed about deer. Growers can then use this knowledge to create a deer damage control strategy that works best for them on their property.

HERD CONTROL

Lethal

Lethal removal of animals remains the most efficient and cost-effective means of reducing browse damage by curbing deer population growth. In the absence of any significant natural predation in Connecticut, hunting is used as a management tool to reduce overabundant populations. Lethal removal of animals with firearms has limitations in some areas due to discharge regulations. Also, some state residents are morally opposed to the killing of deer. Lethal removal of deer regulated by the state includes recreational hunting, controlled hunting, and crop damage permits. As with all wildlife species, deer are owned by the public. The State of Connecticut is the legal custodian of wildlife species and has a separate law enforcement agency to enforce game and non-game regulations. The Department of Environmental Protection regulates season dates, season limits, license sales, and other provisions regarding hunting and wildlife control. For updated information on hunting regulations and crop damage permits, contact the Connecticut Department of Environmental Protection's Wildlife Division (http://dep.state.ct.us/burnatr/index.htm)

Recreational hunting: After proof of the completion of a hunter safety course, all new resident firearm deer hunters must purchase a small game hunting license ($14) and a private land ($14) and/or state land ($14) deer hunting permit. Archery hunters must show proof of completion of the Connecticut Conservation Education/Firearms Bowhunting Safety Course before purchasing a small game/archery license ($30). All license revenue goes into the State of Connecticut General Fund, a portion of which is used for game and non-game species habitat creation and restoration. Connecticut deer hunters pay for the privilege of hunting deer and simultaneously provide a public service.

Crop damage permits: The State of Connecticut also issues crop damage permits. Commercial agriculturalists can apply for such permits if they can prove deer have the potential to cause more than $2,500 in economic damage to crops. Crop damage permits allow the taking of deer outside the regulated hunting season on permitted property.

Sharpshooting: A third means of lethal removal is sharpshooting. Homeowner associations, local governments, and non-profit organizations with excessive deer damage may seek assistance from qualifying sharpshooters. The Department of Environmental Protection also regulates this activity. Sharpshooters are experienced and proficient with firearms and have advanced knowledge of projectile trajectories, ballistics, distance estimation, and usage of appropriate backdrops. Sharpshooters can efficiently and humanely remove a large number of deer in a short period of time, keeping public safety as their primary concern. Efforts are expensive, but deer numbers can be drastically reduced in a matter of days. In most cases, all venison is donated to a local food bank.

Non-Lethal

Capture and relocation: One of the earlier techniques for controlling deer was to capture nuisance animals and relocate them to areas with few deer. Capturing deer is labor intensive and expensive, ranging from $500 to $1,000 per animal depending on deer density and other factors. In addition, mortality rates of relocated animals can be exceptionally high. In one study in California, 85% of relocated animals died within the year (O'Bryan and McCullough 1985). In addition, relocating live deer outside of their natural home range increases the potential to introduce or spread disease to other animals in other locations. Because of these serious limitations, capture and relocation has been largely abandoned by wildlife professionals.

Immunocontraception: A more publicly accepted method of reducing deer populations is through immunocontraception. Immunocontraception manipulates the animal's immune system or hormone levels to prevent conception. The most common immunocontraceptives are Porcine Zona Pellucida (PZP) and Gonadotropin-Releasing Hormone (GnRH). PZP induces an immune response to make the protein layer surrounding the egg (the zona pellucida) impenetrable to sperm. GnRH is a naturally occurring hormone that controls the release of follicle stimulating hormone and luteinizing hormone. A disruption in these hormone levels prevents eggs from being released from the ovaries.

Research studies using immunocontraception have had some limited success in controlling white-tailed deer populations (Turner et al. 1992, Miller et al. 1998, Rudolph et al. 2000, Miller et al. 2001, Fraker et al. 2002, Walter et al. 2002). A successful program is dependent on continual funding for annual capture and treatment of fertile females.

Sterilization: Sterilization procedures exist for both male and female deer. Boone and Wiegert (1994) suggest that sterilization is a viable option to keep deer herds under control. Most sterilization procedures are invasive and require a surgical tubal ligation to be done in the field on sedated females. Our research resulted in the development of a non-invasive male sterilization technique that does not affect hormone levels, antler growth, or breeding behaviors (Ramakrishnan and Williams 2003). One possible strategy, as yet untried, would be to sterilize male deer in conjunction with female immunocontraception efforts.

Contragestation: Contragestation has been shown to be an effective means of reducing fecundity rates in local deer populations (DeNicola et al. 1997). In this technique, a prostaglandin F2α injection causes regression of the corpus luteum during pregnancy. The corpus luteum is essential to maintain the pregnancy, and without it, the female will abort the fetus. Because this is somewhat controversial, it receives little public support. This technique has been essentially abandoned by wildlife professionals.

Oral contraception: Oral contraception (feed laced with a drug to prevent pregnancies) has been suggested as a possible method of controlling large deer populations. Currently, there are no safe, non-steroidal compounds that could be used for oral contraception in white-tailed deer and are safe for non-target species (e.g., raccoons (*Procyon lotor*), turkeys (*Meleagris gallopauo.*), squirrels (*Sciurus spp.*)) and secondary consumers of deer meat (e.g., humans, coyotes (*Canis latrans*), birds of prey). There is also no way to determine which deer have received the drug at the proper effective dosage. Although this method may become an effective tool to control deer populations on a large scale, more research is required to derive a safe and effective contraceptive formulation.

PHYSICAL BARRIERS

The only mechanism that can work in preventing 100% of deer damage is physical exclusion. Numerous types of fencing are available depending on deer density, cost, and aesthetics. An 8-foot high fence should be sufficient in most situations. Although deer can jump this high, they are unlikely to take the risk, especially when other food sources are available. It is imperative that the fence goes close to ground level as deer are far more likely to crawl under a fence than endangering themselves by jumping over it.

Cost is not limited to installation. Fences are effective only as long as they remain intact. Therefore, there are the additional costs of periodic inspection, especially after strong storms, and repair. Choosing to fence an entire property requires installation of a gate. Deer can, and do, walk on roads to reach feeding areas. Cattle guards may be used to allow vehicles to cross but not deer. However, be sure to extend the guards as deer are much more agile than cows.

We will discuss some of the advantages, limitations, and potential uses of the various fencing options in the following section. More detailed descriptions for installing and maintaining fencing can be found in Craven and Hygnstrom (1994). You may wish to consult with a local fence contractor unless you have experience in fence installation. Be sure to check with local officials for zoning restrictions and town ordinances before installing your fence.

Plastic fencing

Plastic mesh fencing made of polypropylene is available in various heights, lengths, and gauges. It has been used by both homeowners and farmers because it is relatively inexpensive, easy to install and maintain, and does not stand out as much as metal fencing (Figure 5). Because it is hard for deer to see the fence, three foot lengths of high visibility flagging or tape should be tied on every ten feet at about four feet off the ground. Flagging can be removed after a few weeks or months, when the deer have become accustomed to the presence of the fence. Ground staples used every twelve feet will pin the fence to the ground.

Figure 5. Black plastic fencing is relatively inexpensive and blends well into the landscape. Note attached flagging for increased visibility.

End and corner posts need to be sturdy to prevent the fence from sagging. Trees, cedar posts, or metal posts sunk into the ground work well. Smaller metal or fiberglass support poles should be placed every 20–30 feet. Fencing can be supported by trees if they are no more than 35 feet apart. Fencing can be wrapped around, or tied to, trees to limit damage to the trunks. A strand wire running along the top of the fence poles will protect the fence from falling branches and provide an attachment to keep the fence from sagging. Nylon coated wire works well for this application. A plastic mesh fence can be expected to cost between $0.75 and $1.50 per linear foot.

Another advantage to using this type of fencing, is that plastic is not a conductor of electricity. As a result, electrified wire can be attached or woven through for added crop protection. Be sure that insulators are used on support and corner posts and a proper ground is established.

High tensile

High tensile fences are frequently used to contain cattle and other livestock. As cattle are not as swift on their hooves as are deer, fences for livestock need not be very high, typically four to six feet. This same fencing strategy works very well for excluding deer, though the fence needs to be taller (eight to ten feet). This type of exclusion works for protecting large gardens, orchards, and agricultural fields where there is moderate to severe deer damage (Craven and Hygnstrom 1994). Craven and Hygnstrom (1994) estimated the cost of the fence to be approximately $0.75–$2.00 per linear foot. It can be electrified to allow for maximum crop protection. A properly constructed high tensile fence should last 20–30 years.

Slanted 7-wire fence

A slanted 7-wire fence is a good choice for large fields (10–50 acres) of nursery stock, orchards, row crops, and other high value crops that receive moderate to severe levels of deer damage. This high tensile fence is constructed at a 45 degree angle from the ground on the crop-side outward, giving it a three dimensional shape which interferes with the deer's depth perception. This provides a significant psychological and physical barrier. Costs and installation are similar to that

of vertical high tensile fencing. A slanted 7-wire fence can be electrified. Again, regular inspection and maintenance of the fence is needed. Because of its three dimensional nature, vegetation growing around and through the fence may be difficult to control and will require periodic mowing or herbicide applications (DeNicola et al. 2000).

Woven wire

A woven wire fence is the ultimate in year-round protection of high value crops grown in large areas (30+ acres) experiencing severe levels of deer damage (Figure 6). This type of fence is expensive and difficult to install, but relatively easy to maintain. Woven wire fences were most often used to protect orchards and nurseries until electrified high tensile wire became a popular, less expensive alternative. Falling branches rarely damage this type of fencing. Falling trees and vandalism are the most frequent causes of failure. At $2.00–$4.00 per linear foot to install, careful consideration of acreage, crop value, expected crop damage, and life expectancy of the fence (20 years) should all be taken into account to justify the initial expense of materials and installation (Craven and Hygnstrom 1994).

Figure 6. Woven wire fencing is an excellent physical barrier.

Electric fence

An electric fence is probably the most economical and effective deer deterrent for owners of field crops up to 40 acres that have moderate deer damage and for large vegetable and flower gardens (Craven and Hygnstrom 1994). Electric fencing is relatively inexpensive and effective, blends well into the landscape, and provides deer with a negative stimulus. Some limitations include continued maintenance, the cost of electricity, and the potential for pets, small children, and deer to become entangled, limiting their capacity to escape. For human safety, electric fences should be well marked with warning signs. Town ordinances and local regulations may restrict use of electric fences in some areas. Because electric fences are not a complete physical barrier, they should not be used alone to completely fence orchards and nursery stock, unless they are of sufficient height and strength (i.e., electrified high tensile). Anecdotal research in New York State found that vertical electric fences alone seldom provide reliable protection for areas larger than five acres under intense deer foraging pressure (DeNicola et al. 2000). Some professionals suggest hanging 4" x 4" pieces of aluminum flags with peanut butter at 10–15 feet intervals along the electric fence to bait the deer into touching the fence (Kinsey 1976, Porter 1983). The resulting shock provides a negative stimulus that deer remember and in turn, learn to avoid the area. There is debate as to whether or not it is wise to alert deer to the presence of your field, orchard, or garden. It is likely the crop or flowers are attractive enough and inquisitive animals will encounter the fence on their own.

There are several other types of fencing options that can be utilized to protect crops and gardens from deer. The above mentioned are a few of the more popular and effective types used for this purpose. Detailed explanations of each type of fencing and installation guidelines are described by Craven and Hygnstrom (1994).

REPELLENTS

There are numerous deer repellents on the market. The effectiveness of all repellents varies with the study and the plant species they were tested on (El Hani and Conover 1995, Lutz and Swanson 1995, Anon. 1998). Repellents are best suited for orchards, nurseries, gardens, and high-value plants. Because of high product costs, the need for repeated applications, and some label restrictions, repellents are not well suited for row crops, pastures, or other low value crops (DeNicola et al. 2000). Repellents can only reduce browse damage from deer, not prevent it (Craven and Hygnstrom 1994).

Reapplication is often required for many of the repellents after they are washed off by heavy rains or wet snows. Some repellents adhere to plant surfaces better than others, requiring fewer applications. Another problem with some repellents is that new growth, which is most tender and nutritious, emerges unprotected from treated plants (Allan et al. 1984), requiring reapplication every four to five weeks during the growing season, or as long as feeding pressure remains high (Sayre and Richmond 1992). A potential solution is the recent advent of systemically integrated repellents that protect new growth and do not need to be reapplied.

Repellents fall into four categories: fear, conditioned aversion, pain, and taste (Beauchamp 1997, Mason 1997). Fear repellents emit an odor that mimics predator scents. Conditioned aversion repellents work by creating gastrointestinal discomfort. Pain inducing repellents affect the mucous membranes of the eyes, nose, mouth, and throat. Taste-based repellents usually include a bitter or hot tasting ingredient that makes the plant unpalatable to deer.

As deer can become habituated to certain scents and tastes easily, it is suggested that multiple repellents be used in an alternating schedule. Labels on repellents should be read carefully to determine if they can be used on produce to be consumed by humans at a later date. In addition, each repellent brand has their own "secret ingredient" that they do not necessarily advertise. However, given ingredients written on the item itself, the educated consumer can determine how they work.

Fear
In a simplified food chain, plants are the producers, found at the bottom of the chain. Herbivores (plant eaters), deer in this case, are the primary consumers of plant matter and carnivores (meat eaters) such as coyotes, wolves (*Canis lupus*), bears (*Ursus spp.*), mountain lions (*Felis concolor*), and humans are secondary consumers. Deer are prey. Their survival depends on constant awareness of their surroundings using visual, audio, and olfactory cues. Deer may be temporarily deterred from an area by introducing one of these cues. By using predator urine, or other repellents containing sulfurous compounds in your garden, deer may flee from the area in fear of being ambushed. Typical predator urines that can be purchased include bobcat (*Lynx rufus*), mountain lion, and coyote. In choosing predator urine, it is advisable to use one from an animal that inhabits Connecticut such as coyote, bobcat, or domestic dog (*Canis familiaris*). Human urine can act in the same manner and has been used by gardeners to protect their flower beds. Putrid egg solids are a common ingredient in fear-based repellents with a sulfurous scent that mimics predator odors.

Plantskydd® is a repellent that contains odors that indicates predator activity. Deer Away® uses an egg-based formulation that also contains predator mimicking odors. Deer-Off® relies on taste and odor to deter browsing deer, including egg solids. Deer Stopper® is a certified organic repellent that also relies on taste and odor (also egg-based) to deter deer both with fear and taste. A home-brew repellent can be made by mixing three fresh eggs per gallon water and spraying liberally. The eggs rot on the plants and the smell repels the deer. The mixture should be strained through cheesecloth before putting it into the sprayer to prevent clogging spray nozzles.

Conditioned aversion
Conditioned aversion repellents cause some type of illness such as gastrointestinal distress or nausea. Deer that consume plants treated with these repellents will associate their distress with the consumption of the treated vegetation. One drawback to the usage of such repellents is that deer need to learn to avoid treated crops, so a significant amount of damage can occur before animals become conditioned. Repellents that contain ammonium soaps of fatty acids such as Hinder® can be found in this category. Hinder® is one of the few repellents that has been approved for usage on edible crops. Thiram (tetramethylthiuram disulfide) is a commercial fungicide that was found to be an effective browse deterrent. It is an active ingredient in Chew-Not® and Shot Gun®. A check of the ingredient label will indicate whether the repellents contain such ingredients.

Pain
Repellents that have active ingredients such as ammonia, capsaicin (the active ingredient in hot peppers), and other naturally occurring extracts such as peppermint evoke pain when they come in contact with the eyes, gut, and mucous membranes of the mouth and nose. Deer learn to avoid vegetation treated with such products due to immediate discomfort after consumption. Miller's Hot Sauce® and Deer-Off® use some of these ingredients in their formulations.

Taste
Taste-based repellents usually contain a bitter tasting substance to make the treated vegetation unpalatable to deer. Deer learn to avoid vegetation that has been treated with bitter tasting substances. Many of the commercial repellents combine a taste-based formulation with the other three categories. It is safe to say that nearly all repellents can be classified as taste-based, using a variety of different ingredients to decrease palatability. As a result, there are numerous individual repellent brands that fall into this category.

More recently, there are now commercially available systemic repellents that treat the entire plant through uptake of danatonium benzote, including new emerging growth. Such repellents can be applied with direct foliar application and are also available in pelletized form that are planted with the root ball to be absorbed over time (DeerBusters®). Such repellents claim to be effective for up to three years, but there are no long-term data to verify such claims. Systemic repellents should not be used on edible crops.

PSYCHOLOGICAL DETERRENTS
Psychological deterrents play on the nervousness of white-tailed deer. Though deer are naturally skittish, they can quickly become habituated if behaviors are not associated with a negative stimulus. For instance, a dog barking at a deer in the garden from inside the house may scare the deer off on its first, second, third, or perhaps tenth visit to the garden. But as this stimulus (the barking dog) becomes more and more familiar, the deer is likely to continue pilfering the vegetable garden despite the presence of the noisy dog behind the front door.

Pyrotechnic scaring devices
As deer are easily startled, loud sounds can deter deer from damaging gardens and crops. Pyrotechnic devices are commercially available for this purpose. Such devices fire a shell that travels up to several hundred feet before exploding with a loud bang. Other shells make a loud whistling sound as they travel. A gunshot will serve the same purpose. These devices require the presence of a human and routine patrol of the area.

Figure 7. A propane cannon in a Connecticut cornfield.

Propane cannons (Figure 7) do not require human presence to function. These devices ignite a propane burst that mimics a gunfire blast at 100–125 decibels. Propane cannons cost between $250–$350 including a 20-pound

propane tank. Depending on the model, cannons can be set to go off at intervals from 30 seconds to 40 minutes. A limitation of this technique is that neighbors in residential areas will probably not tolerate such noises. Frightening devices are better suited for agricultural areas with larger acreage, fewer neighbors, and moderate to light deer densities and damage. They can be effective for eliminating damage on up to five acres.

Deer may flee at the first scaring devices they encounter. However, after encountering several devices, they may be disturbed at the sound initially, but then continue feeding. Propane cannons set at 15 minute intervals throughout the night were ineffective at reducing deer damage to corn (*Zea mays*) fields in Nebraska (Gilsdorf et al. 2004a). Belant et al. (1996) suggested that a motion sensor be included on the device to trigger firing only when deer were present to create a negative association with feeding behavior. Propane cannons should be moved every few days to prevent deer from becoming habituated to their presence. Frightening devices are not permanent solutions to alleviating deer damage. They can be used as a temporary solution until a more permanent solution has been implemented.

Monofilament
A cheap trick that has been used by local gardeners is to use several lengths of monofilament (fishing line) to "fence" a garden. Using three or four strands of 30-50 pound test line around your garden creates a "psychological fence". When browsing deer approach the garden, the feel of the fishing line pushing against them is foreign and may cause retreat. The benefit of this technique is that it may cost only $20 and is nearly invisible from a distance. Though inexpensive, it is not very reliable. It may work for smaller gardens and foundation plantings in close proximity to houses that receive low levels of damage. Routine inspection is essential.

Water scaring devices
Water scaring devices are attached to a garden hose and utilize a motion-sensitive trigger. When a deer (or other animal) passes in front of the device, it receives a blast of water, startling the animal. Such devices have not been tested scientifically as their range of effectiveness is limited (DeNicola et al. 2000). This device may work if you have a small garden with low damage levels. Over time, deer will most likely learn the location of the device and avoid the area. If such a device is to be used, it should be moved every few days to keep deer from getting habituated.

Dogs
Large, aggressive dogs can be used as an effective deer deterrent (DeNicola et al. 2000), but family pets are generally ineffective. Most family dogs are brought inside during night hours, allowing deer access to shrubs and gardens. Deer have also been known to use their sharp hooves to kill smaller dogs. Two dogs confined within an invisible fence were effective in protecting five acres of white pine seedlings (Beringer et al. 1994). The dogs were reported to be more effective at preventing damage than a commercial deer repellent. Dogs should serve as a deterrent only, as dogs pursuing or harassing deer is illegal.

Sound emitting devices
Ultrasonic devices emit a sound that is not detected by humans. Manufacturers claim that the sound falls within the "stress" range of many animals. Although deer can hear at these frequencies, they are not repelled by it as they do not associate the sound with danger (Curtis 1995, DeNicola et al. 2000). Gilsdorf et al. (2004b) experimented with a motion activated bio-acoustic frightening device for avoiding deer damage in Nebraska cornfields. Passing deer triggered the device to play distress and alarm calls of deer. They concluded the device was not effective in protecting cornfields from damage.

Home remedies
Many home owners have experimented with novel deer deterrents that may work for them. Some include hanging bars of soap on trees and shrubs that are often browsed by deer. The bars need to be hung at three foot intervals to be effective. Irish Spring® brand soap is often used, but different brands may work better in different gardens. Whichever you chose, be sure it has a strong perfume odor to it.

On this same principle, many homeowners have tried spraying perfume around their garden or directly on plants. This may have the desired effect, but also could impart off flavors in produce. It may have the undesired effect of killing plants if sprayed directly on them.

Another inexpensive home remedy is human hair. Gardeners have reported mixed results with this remedy. Human hair is gathered, placed in mesh bags, and hung on stakes about three feet off the ground throughout the area that is being damaged. The smell of the hair cues the deer that a human has recently been in the area and they may retreat in fear of potential danger. A visit to your local barber or salon will probably produce more human hair than you will need.

BROWSE RESISTANT GARDENING

For many Connecticut gardens that are repeatedly visited by deer, the only practical solution is to grow plants that are resistant to browse damage. The effectiveness of this strategy will depend on your tolerance of deer browse damage, local deer density, their feeding habits, and available forage in the neighborhood and surrounding woods. Which species are browsed and the amount of browse damage will vary year to year, and neighborhood to neighborhood. It is important to select plants that are appropriate for the level of browse damage in your area. Where possible, scout for browse damage in your neighborhood, especially on plants that you are considering adding to your landscape. Discovering

which species have light browse damage will allow you to determine the browse pressure in your location.

This section updates Connecticut Agricultural Experiment Station Bulletin 968 "Limiting deer browse damage to landscape plants" (Ward 2000). It incorporates both the original and new surveys of browse damage by gardeners in Connecticut and the surrounding states. An analysis of the 303 surveys shows that 96% of respondents had gardens and landscape plants that had been damaged by deer. Eighty-three percent of gardeners noted browse damage to both their shrubs and herbaceous plants. Fully 94% of respondents have observed one or more deer on their property.

As a part of the survey, gardeners noted which species had, and had not, been browsed in their gardens to provide an estimate of the frequency of browse damage. Gardeners also noted the severity of browse damage for plants that had been browsed. Severity was noted on a scale from 0-no damage to 5-extreme (cannot grow species). An index of browse damage susceptibility was calculated for each species using both the frequency and severity of browsing. A more detailed description of methodology can be found in Ward (2000). The index was used to sort landscape plants in four categories of browse damage susceptibility: highly resistant, moderately resistant, susceptible, and highly susceptible.

Highly resistant plants (Table 4) include species that were infrequently browsed, and when browsed, damage was light to moderate. These species are appropriate for areas where browse damage may be expected.

Moderately resistant plants (Table 5) include species that were browsed in less than half the gardens, and the observed browse damage was rated as generally moderate (noticeable but tolerable). These species are appropriate for areas where occasional browsing can be expected.

Susceptible plants (Table 6) include species that were browsed in less than half of gardens, but observed browse damage was generally rated as heavy (growth and floral display affected). These plants are not likely to thrive in areas where moderate browse damage may be expected.

Highly susceptible plants (Table 7) include species that were browsed in more than half of the gardens and damage was rated as heavy, severe (some plant have to be replaced), or extreme (cannot grow species). These plants are not likely to survive in areas where moderate browse damage may be expected.

There are other steps you can take to reduce deer browse damage. Plant the most browse resistant plants along the edge of your property, or where deer access your property (Table 4). This will help deter deer from including your landscape as part of their feeding territory. Plants that are susceptible or highly susceptible to deer browse (Tables 6 and 7) should be planted close to the most commonly used door, intermingled with browse resistant plants, or grown within a small fenced area (Miller et al. 1992, Lee 1998).

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Mention of a product is not necessarily an endorsement by the Connecticut Agricultural Experiment Station.

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Table 4. Plants that were found to be highly resistant to deer browse damage by a survey of Connecticut gardeners. These plants are appropriate for areas where moderate browse damage may be expected. Plants are listed by common name with genus in parentheses.

Annuals	Vinca (*Catharanthus*)	Spiderflower (*Cleome*)	Alyssum (*Lobularia*)
	Dusty miller (*Senecio*)	Marigold (*Tagetes*)	
Bulbs	Winter aconite (*Eranthis*)	Snowdrop (*Galanthus*)	Daffodil (*Narcissus*)
	Star of Bethlehem (*Ornithogalum*)		
Garden herbs	Ornamental chives (*Allium*)	Wild ginger (*Asarum*)	Lavender (*Lavandula*)
	Lemon balm (*Melissia*)	Mint (*Mentha*)	Catmint (*Nepeta*)
	Oregano (*Origanum*)	Rubarb (*Rheum*)	Comfrey (*Symphytum*)
	Thyme (*Thymus*)	Costmary (*Tanacetum*)	
Groundcovers	Grass (*various*)*	Bugleweed (*Ajuga*)	Sweet woodruff (*Galium*)
	Dead nettle (*Lamium*)	Pachysandra (*Pachysandra*)	Myrtle (*Vinca*)
Herbaceous	Yarrow (*Achillea*)	Monkshood (*Aconitum*)	Lady's mantle (*Alchemilla*)
perennials	Silvermound (*Artemisia*)	Basket of gold (*Aurinia*)	Snow-in-summer (*Cerastium*)
	Lily of the valley (*Convallaria*)	Tickseed (*Coreopsis*)	Foxglove (*Digitalis*)
	Globe thistle (*Echinops*)	Spruge (*Euphorbia*)*	Lenten rose (*Helleborus*)
	Red-hot poker (*Kniphofia*)	Sweetpea (*Lathyrus*)	Poppy (*Papaver*)
	Russian sage (*Perovskia*)	Mayapple (*Podophyllum*)	Rue (*Ruta*)
	Goldenrod (*Solidago*)	Lamb's ears (*Stachys*)	Trillium (*Trillium*)
Shrubs	Maple (*Acer*)*	Shadbush (*Amelanchier*)	Barberry (*Berberis*)*
	Birch (*Betula*)	Boxwood (*Buxus*)	Heather (*Calluna*)
	Trumpet creeper (*Campsis*)	Bluebeard (*Caryopteris*)	Broom (*Cytisus*)
	Deutzia (*Deutzia*)	Goldenbells (*Forsythia*)	Kerria (*Kerria*)
	Beautybush (*Kolkwitzia*)	Honeysuckle (*Lonicera*)*	Spruce (*Picea*)
	Andromeda (*Pieris*)	Cinquefoil (*Potentilla*)	Poison ivy (*Rhus radicans*)
	Spirea (*Spiraea*)	Wisteria (*Wisteria*)	

*Some species are listed as invasive species in Connecticut and can not be legally imported, moved, sold, purchased, transplanted, cultivated or distributed (C.G.S. Sec. 22a-381d).

Table 5. Plants that were found to be moderately resistant to deer browse damage by a survey of Connecticut gardeners. These plants are appropriate for areas where light browse damage may be expected. Plants are listed by common name with genus in parentheses.

Annuals	Blue floss flower (*Ageratum*)	Cockscomb (*Celosia*)	Globe amaranth (*Gomphrena*)
	Verbena (*Verbena*)		
Bulbs	Glory-of-the-snow (*Chionodoxa*)	Autumn crocus (*Colchicum*)	Siberian squil (*Scilla*)
Herbaceous	Columbine (*Aquilegia*)	Goatsbeard (*Aruncus*)	False spirea (*Astilbe*)
perennials	Yellow bleeding heart (*Corydalis*)	Bachelor buttons (*Centaurea*)*	Bleeding heart (*Dicentra*)
	Cranesbill (*Geranium*)	Baby's breath (*Gypsophila*)	Virginia Bluebell (*Mertensia*)
	Beebalm (*Monarda*)	Peony (*Paeonia*)	Evening primrose (*Oenothera*)
	Jacob's ladder (*Polemonium*)	Lungwort (*Pulmonaria*)	Pincushion flower (*Scabiosa*)
	Sage (*Salvia*)	Bloodroot (*Sanguinaria*)	Hen & chicks (*Sempervivum*)
	False Solomon's seal (*Smilacina*)	Foamflower (*Tiarella*)	Spiderwort (*Tradescantia*)
Shrubs	Flowering quince (*Chaenomeles*)	Butterfly bush (*Buddleia*)	Cotoneaster (*Cotoneaster*)
	Witch hazel (*Hamamelis*)	Leucothoe (*Leucothoe*)	Almond (*Prunus glandulosa*)
	Contoneaster (*Pyracantha*)	Lilac (*Syringa*)	Weigela (*Weigela*)

*Some species are listed as invasive species in Connecticut. (see footnote in Table 4)

Table 6. Plants that were found to be susceptible to deer browse damage by a survey of Connecticut gardeners. These plants are not likely to thrive in areas where moderate browse damage may be expected. Plants are listed by common name with genus in parentheses.

Annuals	Snapdragons (*Antirrhinum*)	Canna (*Canna*)	Larkspur (*Consolida*)
	Cosmos (*Cosmos*)	Morning glory (*Ipomoea*)	Moss rose (*Portulaca*)
	Nasturtium (*Tropaeolum*)		
Bulbs	Wood hyacinth (*Endymion*)	Trout lily (*Erythronium*)	Fritillaria (*Fritillaria*)
	Hyacinth (*Hyacinthus*)	Grape hyacinth (*Muscari*)	
Herbaceous	Snowdrops (*Anemone*)	Butterfly weed (*Asclepias*)	False indigo (*Baptisia*)
perennials	Marsh marigold (*Caltha*)	Fairy candles (*Cimicifuga*)	Carnation (*Dianthus*)
	Coralbells (*Heuchera*)	Iris (*Iris*)*	Blazing star (*Liatris*)
	Flax (*Linum*)	Obedient plant (*Physostegia*)	Primrose (*Primula*)
	Meadow rue (*Thalictrum*)	Speedwell (*Veronica*)	Violet (*Viola*)
Shrubs	Clematis (*Clematis*)	Dogwood (*Cornus*)	Daphne (*Daphne*)
	Mockorange (*Philadelphus*)	Pine (*Pinus*)	Blueberry (*Vaccinium*)
	Viburnum (*Viburnum*)		

*Some species are listed as invasive species in Connecticut. (see footnote in Table 4)

Table 7. Plants that were found to be very susceptible to deer browse damage by a survey of Connecticut gardeners. These plants are not likely to survive in areas where moderate browse damage may be expected. Plants are listed by common name with genus in parentheses.

Annuals	Begonia (*Begonia*)	English daisy (*Bellis*)	Flowering kale (*Brassica*)
	Caladium (*Caladium*)	Aster (*Callistephus*)	Coleus (*Coleus*)
	Dahlia (*Dahlia*)	Gladiolus (*Galdiolus*)	Impatiens (*Impatiens*)
	Geranium (*Pelargonium*)	Petunia (*Petunia*)	Zinnias (*Zinnias*)
Bulbs	Crocus (*Crocus*)	Daylily (*Hemerocallis*)	Lilies (*Lilium*)
	Tulip (*Tulipa*)		
Groundcovers	Ground ivy (*Hedera*)		
Herbaceous	Stonecrop (*Aethionema*)	Hollyhock (*Alcea*)	Aster (*Aster*)
perennials	Bolton's aster (*Boltonia*)	Bellflower (*Campanula*)	Turtlehead (*Chelone*)
	Daisy (*Chrysanthenum*)	Phlox (creeping) (*Phlox*)	Larkspur (*Delphinium*)
	Coneflower (*Echinacea*)	Joe Pye weed (*Eupatorium*)	Blanketflower (*Gaillardia*)
	Sunflower (*Helianthus*)	Ox-eye (*Heliopsis*)	Hosta (*Hosta*)
	Shasta daisy (*Leucanthemum*)	Cardinal flower (*Lobelia*)	Lupine (*Lupinus*)
	Garden phlox (*Phlox paniculata*)	Rose mallow (*Malva*)	Balloonflower (*Platycodon*)
	Solomon's seal (*Polygonatum*)	Coneflower (*Rudbeckia*)	Stonecrop (*Sedum)*
	Stokes' aster (Stokesia)		
Shrubs	Summersweet (*Clethra*)	Euonymus (*Euonymus*)*	Rose of sharon (*Hibiscus*)
	Hydrangea (*Hydrangea*)	Candytuft (*Iberis*)	Holly (*Ilex*)
	Juniper (*Juniperus*)	Mountain laurel (*Kalmia*)	Crabapple, apple (*Malus*)
	Rhododendron (*Rhododendron*)	Azalea (*Rhododendron*)	Rose (*Roses*)*
	Willow (*Salix*)	Yew (*Taxus*)	Arborvitae (*Thuja*)
	Hemlock (*Tsuga*)	Yucca (*Yucca*)	

*Some species are listed as invasive species in Connecticut. (see footnote in Table 4)

I was seven years old at the time, trout fishing with my dad in southern New Hampshire. It was a late spring morning and the rising sun had not yet burned the fog off the glass surface we referred to as the "Big Lake". I can remember sitting in the bow of the canoe about 100 yards off shore with my spinning rod in hand, watching the suspended droplets of water moving across the lake in waves, soaking my hands and coalescing on the inner walls of the canoe. I spotted something on the water out in the fog and just stared at it. Actually, it was four "somethings". My seven-year-old brain could not comprehend what I was seeing this morning through the fog. "Look Dad, ducks", I remember saying as I pointed the objects out to him. The objects had grabbed his attention too and I now realize that he could not comprehend what they were either. We both remained silent and watched these figures gliding over the surface of the water, slicing through the fog in an unwavering trajectory toward the wooded refuge of Governor's Island. As the objects neared shore, they rose off the water. It was only after the two classic, large-bodied northern white-tailed bucks shook the water out of their remnant winter coats on Sweeney's Beach did we realize what we had been seeing, two pairs of velveted antlers perched atop two swimming bucks cutting through the fog.

That is the most memorable mental image of white-tailed deer from my childhood. I had seen a few before that experience, but the mystery and majesty of that morning in 1983 will be forever engrained in my brain and likely contributed to my fascination with deer.

Mr. Scott C. Williams is a Wildlife Research Technician in the Department of Forestry and Horticulture studying the impacts of overabundant white-tailed deer on natural and managed ecosystems. He is also a Ph. D. candidate in wildlife management at the University of Connecticut.

Dr. Jeffrey S. Ward is the Chief Scientist of the Department of Forestry and Horticulture. His research has focused on long-term population dynamics of woody plants in natural areas, growth response of individual trees following stand disturbance, and methods of reducing deer browse damage in forest plantations.

Dr. Uma Ramakrishnan is an Assistant Professor of Environmental Science & Studies at Juanita College in Pennsylvania. She was an Assistant Scientist at The Connecticut Agricultural Experiment Station from 2000-2005. Her research projects have included non-lethal deer reproductive control, deer behavior, and predator avoidance behavior in bonnet macaques.

NOTES