Human–Wildlife Interactions 4(1):56–66, Spring 2010

Effectiveness of deer repellents in Connecticut

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***Abstract*:** Browsing by overabundant herds of white-tailed deer (*Odocoileus virginianus*) can cause significant economic damage to agricultural crops and landscape plantings. In many instances, for both commercial growers and homeowners, commercially available repellents may be an appealing alternative to physical exclusion and lethal control of animals. We tested 10 different commercially-available repellents (Chew-Not®, Deer Off®, Deer-Away® Big Game Repellent, Plantskydd®, Bobbex®, Liquid Fence®, Deer Solution®, Hinder®, Repellex® systemic tablets, and coyote urine) on yews (*Taxus cuspidata* Densiformis) at 2 different locations in Connecticut. The study included both positive (fence) and negative (no treatment) controls. We planted yews in 2 blocks at each location in the spring of 2006; each block had 12 groups of 6 yews. We randomly assigned one of the 12 treatments to each group of yews within each block. We applied repellents based on manufacturers' label recommendations for the 2006 and 2007 growing seasons and recorded application costs. We derived a protection index based on plant size and dry needle weights at the end of the 2007 growing season. In general, repellents that required more frequent application performed better. Bobbex® ranked highest, but was the most expensive repellent treatment. Hinder® performed nearly as well at a fraction of the cost. Yews protected by Repellex®, Deer Solution®, coyote urine, and Plantskydd® were the same size as unprotected controls at both sites and did not have significantly more needles. No repellents prevented 100% of browse damage. The choice of repellent usage is a trade-off among effectiveness, cost, ability to follow recommended reapplication interval, and plant to be protected.

***Key words*:** conditioned aversion, Connecticut, human–wildlife conflicts, *Odocoileus virginianus*, repellent, *Taxus cuspidata* Densiformis, white-tailed deer, yew

White-tailed deer (*Odocoileus virginianus*) populations in Connecticut have steadily increased from an estimated <20 animals in 1900 to an estimated >76,000 today. With overabundant deer herds living in areas of medium to high human density, conflicts arise. In many areas of high deer density, deer are no longer considered an awe-inspiring, valuable natural resource, but rather traffic hazards, pests that damage landscape plantings and agricultural crops, and important hosts of the ticks that transmit the causal agents of Lyme disease (Stafford 2007).

Annual losses due to deer in Connecticut included $1 million in lost sales to homeowners discouraged by repeated deer damage and $1.5 to $2.0 million in direct damages to plants prior to sale at nurseries and garden centers (Williams et al. 2006). More than 20% of gardeners discontinued growing yews (*Taxus* spp.), hostas (*Hosta* spp.), and lilies (*Lilium*) because of extreme deer browse damage (Ward 2000).

A survey of Connecticut growers found that crop-damage permits for lethal control of deer and fencing were the only methods reported as generally effective ≥50% of the time (Williams et al. 2006). However, in developed areas with high housing density, use of lethal management of deer to reduce browse damage is often unfeasible because of human safety concerns and logistical and political considerations. Fencing, alternative plant selection, or repellents may be the only practical options in such environments. Fencing is very effective but can be costly, unsightly, and restricted by local zoning ordinances. Williams et al. (2006) reported that 39% of growers found that repellents were the least effective method of deterring deer. They also reported that 39% of growers found repellents generally effective, while 44% of growers found them somewhat effective (Williams et al. 2006).

Over the past few decades, use of repellents to deter deer browse damage has become increasingly popular, especially in ornamental settings. Repellent manufacturers have responded by introducing new brands and formulations. With so many products now on the market, companies have developed new formulations and application strategies, each claiming to be better than other products of competitors at reducing browse damage. Several manufacturers have attempted to overcome the problem of continued reapplication by systemic integration of the repellent into the plant via root uptake or foliar application. Some companies claim their product to be effective for up to 3 years.

Chemical repellents can typically be classified into 4 categories: fear, conditioned aversion, pain, and taste (Beauchamp 1997, Mason 1997, Wagner and Nolte 2001). 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 (DeNicola et al. 2000).

Fear repellents

Deer survival depends on constant awareness of their surroundings using visual, audio, and olfactory cues. Deer may flee an area sprayed with predator urine for fear of being ambushed (Swihart et al. 1991). Putrid egg solids with a sulfurous scent that mimic predator odors are a common ingredient in fear-based repellents, including Bobbex® (Bobbex Inc., Newtown, Conn.), Deer-Away® Big Game Repellent (Havahart®, Woodstream Corp., Lititz, Pa.), and Plantskydd® (Tree World® Plant Care Products Inc., St. Joseph, Mo.; Wagner and Nolte 2001). Liquid Fence® (Liquid Fence Company, Brodheadsville, Pa.) also contained egg solids in its formulation.

Conditioned-aversion repellents

Conditioned-aversion repellents can cause some types of illnesses such as gastrointestinal distress or nausea. Deer that consume plants treated with these repellents will eventually associate their distress with the consumption of the treated vegetation. One drawback to using such repellents is that deer need to learn to avoid treated crops, so a significant amount of damage may occur before animals become conditioned. Repellents that contain ammonium soaps of fatty acids, such as Hinder® (Matson, LLC, North Bend, Wash.), can be found in this category and are among the few repellents that have been approved for usage on edible crops. Thiram (tetramethylthiuram disulfide) is a commercial fungicide that was reported to be an effective browse deterrent (Conover 1984) and was an active ingredient in Chew-Not® (Nott Products Co. Inc., Coram, N.Y.). Deer Solution® (Natural Pest Solutions, Danbury, Conn.) is another repellent in this category as it is formulated to simulate the smell of daffodils (*Narcissus* spp.), which are unpalatable to deer (Horton and Edge 1994, Tilt et al. 1996, Kays et al. 1997). As a result, deer are reported to learn to avoid the treated area.

Pain-inducing repellents

Repellents that have active ingredients, including ammonia, capsaicin, and other naturally-occurring extracts, such as peppermint, evoke pain when they come in contact with the deer's eyes, gut, and mucous membranes of the mouth and nose (DeNicola et al. 2000). Deer learn to avoid vegetation treated with such products due to immediate discomfort after consumption. Deer-Off® (Havahart, Woodstream Corp., Lititz, Pa.) uses some of these ingredients in its formulations.

Taste repellents

Taste-based repellents usually contain a bitter or foul-tasting substance to make the treated vegetation unpalatable to deer. Many of the commercial repellents combine a taste-based formulation with the other 3 categories of repellents. 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.

Numerous repellent trials were conducted in the 1980s and 1990s (Conover 1984, 1987; Andelt et al. 1991; El Hani and Conover 1997; Nolte 1998), but few comparative studies have been published in recent years. Little objective information comparing the efficacy of recent products with those developed earlier is available to nursery operators, landscapers, and homeowners.

This study was conducted to compare

the effectiveness of old and new repellent formulations in reducing deer browse damage over a 2-year period. We used yews (*Taxus cuspidata* Densiformis) for this study because they are palatable to deer, numerous Connecticut residents have discontinued growing them due to continued browse damage (Ward 2000), and they have been used in past repellent trials (Conover 1987, Swihart and Conover 1990).

Methods

Study areas

We tested repellents at 2 sites in Connecticut during late May 2006. The Windsor study area in northern Connecticut was an agricultural field adjacent to other fields that had been repeatedly damaged by browsing. The Dawson study area in southern Connecticut was a periodically-mowed, grassy field. Soils at both Windsor (Merrimac sandy loam) and Dawson (Agawam fine sandy loam) are mesic Typic Dystrudepts. There was no hunting at Windsor because of proximity to residential housing. Dawson was a controlled access property where hunting was prohibited. The areas are in the northern temperate climate zone with 1,128 mm average annual precipitation evenly distributed over the year.

Study design

We established 2 planting blocks at each study area. We planted 12 groups of 6 yews in each block (72 yews per block). Each group was planted at 0.5-m spacing between plants, and 2-m spacing between groups within a row and between rows. The 2-m spacing between groups was greater than the <1 m aversion distance for repellents reported by Swihart and Conover (1990) and Nolte and Wagner (2000). Blocks were separated by 2 m. We periodically hand-weeded the blocks and applied a granular weed control agent plus fertilizer (Preen® Step Saver Weed Control, Preen, Lebanon, Pa.) at the time of planting and again in May 2007. The container-grown (2-L size) yews were donated by Clinton Nursery, Westbrook, Connecticut.

Repellents

We randomly assigned repellent treatments after container plants had been planted. (The use of trade names in this paper is for the purpose of identification and does not indicate endorsement of commercial products by the Connecticut Agricultural Experiment Station.) We tested 10 different repellent formulations: Chew-Not®, Deer Off®, Deer-Away Big Game Repellent®, Plantskydd®, Bobbex®, Liquid Fence®, Deer Solution®, Hinder®, Repellex® systemic tablets (Repellex USA, Niles, Mich.), and coyote urine (Leg Up Enterprises, Lovell, Me.; Table 1). Each block also had a group that was not treated (negative control) and a group that was protected by a metal fence supported by metal posts (positive control). We prepared repellents and applied them according to label instructions. We applied Deer Solution, Bobbex,

Table 1. Deer repellents examined in a Connecticut study along with actual and recommended treatment intervals (n.a. = data not available).

	Number of applications		Days between treatments		Recommended treatment intervals	
Treatment	Windsor	Dawson	Windsor	Dawson	Label directions	Days
Repellex	2	2	339	339	2 growing seasons	365
Deer Solution	5	6	107	113	Every 100 days	100
Coyote urine	24	26	17	19	After rain	n.a.
Plantskydd	3	4	168	162	Up to 6 months	180
Deer-Off	7	8	70	76	2–3 months	60–90
Chew-Not	2	3	339	226	1 growing season	365
Big Game	7	8	70	76	60–72 days	60–72
Liquid Fence	13	14	34	38	1 week, then monthly	30
Hinder	25	26	17	19	10–14 days	10–14
Bobbex	25	26	17	19	10–14 days	10–14

Table 2. Analysis of variance tables for the effects of deer repellents on yew size (cm) and needle weights (g); r^2 describes how much of the variability of the dependent variable can be explained by the model.

Source	Sum-of-Squares	df	MS[b]	*F*-ratio	*P*
Size (both plots), $r^2 = 0.85$[a]					
Study area (SA)	160.2	1	160.2	20.1	<0.001
Repellent (R)	676.5	11	61.5	7.7	<0.001
Interaction (SA × R)	301.3	11	27.4	3.4	0.006
Error	191.1	24	8.0		
Size (Dawson), $r^2 = 0.92$					
Repellent	880.9	11	80.1	14.0	<0.001
Error	68.6	12	5.7		
Size (Windsor), $r^2 = 0.44$					
Repellent	97.0	11	8.8	0.9	0.593
Error	122.5	12	10.2		
Needle weights (Dawson), $r^2 = 0.96$					
Repellent	153,147	11	13,922	30.1	<0.001
Error	5558	12	463		

[a]The r^2 of 0.856 indicates that 85% of the variability in plant size can be explained with study area, repellent, and their interaction.
[b]MS = mean square.

Hinder, and Liquid Fence with 7.6-L tank sprayers (Solo® Model LCS-2, Newport News, Va.). Plantskydd, Chew-Not, and Deer-Away Big Game Repellent using a plastic watering can. We placed Repellex tablets directly in the root ball at planting. We applied coyote urine directly to cotton darts and placed them between planted yews. We purchased Deer Off in a hand-spray bottle and used it throughout the study. To avoid potential mixing of repellents, a labeled, dedicated sprayer, watering can, or spray bottle was used for each repellent. Reapplication intervals were as close as possible to label instructions, but did vary because of weather.

Measurements and analysis

We harvested plants prior to spring growth flush in April 2008 after they had been exposed to deer browsing during 2 growing and 2 dormant seasons. We measured height and width of all surviving plants to the nearest 2.5 mm. We cut plants at ground level at the Dawson study area where browsing was more severe and air-dried them in a greenhouse. After removing debris, we hand-stripped needles from all plants to determine needle weights as a measure of plant health. We dried samples at 82° C for 1 week in a forced-air oven and weighed them to the nearest gram.

Initial experimental design for plant size was a 2-factor (study area, deer repellent) analysis of variance. There were 2 replicates at each study area. Because treatment randomization was restricted by group, each group of 6 plants was considered a replicate to avoid potential pseudo-replication. Therefore, average plant measures (height, width, weight) for each group was used in the statistical analysis, rather than individual plant measures. There was a significant interaction between study area and deer repellent for plant size ($F_{11,24} = 3.44$, $P = 0.006$). Therefore, we used a separate 1-factor (deer repellent) analysis of variance to examine plant size at each study area (Table 2). We used Tukey's HSD test (SYSTAT 1992) to test differences in plant size and needle weights among deer repellents. We considered differences significant at $P < 0.05$.

We used Chi-square statistics to determine whether mortality differed among treatments. Differences were considered significant at $P < 0.05$.

Protection Index (PI_i) values were defined as:

$$PI_i = \left(\frac{S_{Di}}{S_{DF}} + \frac{W_{Di}}{W_{DF}} + \frac{S_{Wi}}{S_{WF}} \right) / 3$$

Table 3. Final size (cm) of yews by study area, repellent treatment, and weight of needles (g) at the Dawson study area. See text for description of protection index.

	Final size (cm)				Needles (g)		Protection index (%)
	Windsor		Dawson		Dawson		
Control	29	a	25	a	14	a	49
Repellex	31	a	23	a	25	a	50
Deer Solution	33	a	23	a	23	a	52
Coyote urine	31	a	25	a	31	a	53
Plantskydd	33	a	23	a	81	ab	60
Deer-Off	35	a	28	ab	74	ab	65
Big Game	31	a	31	ab	140	bc	72
Chew-Not	33	a	29	ab	151	bcd	74
Liquid Fence	34	a	31	ab	164	cd	78
Hinder	36	a	35	bc	169	cde	83
Bobbex	35	a	36	bc	234	de	93
Physical fence	35	a	43	c	251	e	100

where S_{Di} was mean size of yews on i^{th} treatment at Dawson; S_{DF} was mean size of fenced yews at Dawson; W_{Di} was mean weight of yews on i^{th} treatment at Dawson; W_{DF} was mean weight of fenced yews at Dawson; S_{Wi} was mean size of yews on i^{th} treatment at Windsor; and S_{WF} was mean size of fenced yews at Windsor.

Results

Treatment effectiveness

Yew mortality averaged 7% and did not differ among repellents (χ^2_{11} = 10.1, P = 0.52). Size and needle weight did differ among treatments (Tables 2 and 3). Unprotected yews (negative control) were smaller than fenced yews (positive control) at Dawson. At Windsor, where browsing was minimal, plant size did not differ among deer repellent treatments. At Dawson where browsing was more severe, only yews treated with Hinder, Bobbex, and those protected by a fence were larger than unprotected controls (Table 3). Plants protected by a physical fence were 72% larger than unprotected controls.

At Dawson, yews inside a fence had nearly 18× the needle-weights of yews that were unprotected from deer browsing (Table 3). Yews treated with Deer-Away Big Game Repellent, Chew-Not, Liquid Fence, Hinder, and Bobbex also had greater needle weights than unprotected controls. Yews protected by Repellex, Deer Solution, coyote urine, Plantskydd, and Deer-Off were not larger than unprotected controls at both sites and did not have significantly more needles at Dawson. The effectiveness of the various repellents, as indicated by the Protection Index, varied widely among products (Table 3).

Discussion

Comparison of earlier studies

A search of the literature found 10 pen and 12 field studies that evaluated >1 repellent and also had untreated plots (Table 4). There was little consistency in the type of damage reported, which included plant mortality, number of bites, amount consumed, percentage of damage, and damage indices (Table 4). To standardize the damage as objectively as possible, we assumed that the level of damage for the unprotected control to be the maximum damage. Relative effectiveness (%) was defined as $1-(D_t/D_u)$, where D_t was damage for a given treatment and D_u was damage reported for the untreated plots.

No repellent was 100% effective in reducing browse damage (Table 4). In general, egg-based products, including Big Game Repellent, were most effective. Thiram and Hinder were more effective in field than in pen studies. Both repellents reduced browse damage in field studies to levels similar to those reported for

Figure 1. Applying Chew-Not deer repellent on yews. No repellent was 100% effective.

egg-based products. While urine and blood-based repellents were somewhat effective in short-term pen studies, they were less effective in field studies. Most studies reported that bitter-based repellents were only slightly better than no protections, and were actually worse in 2 studies. Only 1 report included Bobbex in a comparative study (Lemieux et al. 2000). In that report, Bobbex reduced damage relative to controls but had higher damage levels than egg-based and bitter repellents.

Based on the present study, repellents can provide protection approaching that of a physical barrier such as a fence (Table 3). The 2 repellents that provided the best protection, Bobbex and Hinder, were also the products that required the most frequent application (Table 1). Hinder was as effective as other products in several field studies (Conover 1984, 1987; Lutz and Swanson 1997), while Bobbex was less effective than other repellents in a Rhode Island study (Lemieux et al. 2000); it was only applied twice over a 5-month period rather than the biweekly interval during the growing season, as suggested on the label. Bobbex was the most expensive treatment in the study (Table 5), had a somewhat unpleasant odor, and required cleaning of the tank sprayer after each application to avoid clogging the spray nozzle. Hinder was the second least expensive treatment (Table 5), as it had a much lower dilution rate (1:20) than Bobbex did (1:8), had virtually no smell, never clogged the tank sprayer nozzle, and unused material could be stored in the sprayer for usage at a later time. Hinder is also EPA registered for use on food crops.

Yews protected by Liquid Fence, Chew-Not, and Deer-Away Big Game Repellent were nearly as large as yews protected by the above repellents, and needle weights were similar to yews protected by Hinder (Table 3; Figure 1). Deer-Away Big Game Repellent is the most field-tested repellent in the literature; it has been found to be effective in both field and pen studies (Table 4). Reapplication intervals were much longer than Bobbex and Hinder (Table 1), and more frequent applications might improve its efficacy. Once Bobbex was diluted, all of the mixture had to be applied that same day, and the tank sprayers needed to be cleaned extensively after each usage. Our study ranked Chew-Not, a thiram-based product, slightly better than Deer-Away Big Game Repellent. While a field study found both repellents offered similar protection (Conover 1984), pen studies reported thiram-based products were not as effective as Deer-Away Big Game Repellent (Palmer et al. 1983; Andelt et al. 1991, 1992; Wagner and Nolte 2001). Thiram-based products with a latex sticker, such as Chew-Not, have the advantage of very long intervals (>180 days) between applications. However, the latex sticker required extensive mixing, use of a watering can to apply it, and extensive cleanup. In addition, thiram is an EPA-registered fungicide, which may require a pesticide applicator's license for its application.

We could find no published field trials in the scientific literature that used Liquid Fence. Liquid Fence ranked high on our Protection Index, and total costs were low (Tables 3 and 5). Liquid Fence did not need to be applied as frequently as Hinder or Bobbex or after rain (1 week after initial treatment and every 30 days thereafter), and it ranked just behind both in our Protection Index. Liquid Fence did not clog tank sprayers, and excess material could be stored in sprayers for usage at a later time.

Four of the repellents (Repellex tablets, Deer

Table 4. Comparison in percentage of repellent effectiveness relative to unprotected controls. Higher values indicate greater control (0% = no difference from unprotected controls; 100% = no damage). Period = duration of study; wk. = week; mon. = month; yr. = year.

				Pen studies (% effective)							
Study	Cervida	Period	Plant	BGR-L[b]	BGR-P	Eggs	Urine	Hinder	Blood	Thiram	Bitter
Andelt et al. (1991)	MD	<1 wk.	Feed	81		82	80[c]	55		58	20
Andelt et al. (1992)	Elk	<1 wk.	Medicago	72		53	86[c]	41		38	3
Nolte et al. (2001)	BT	2 wk.	Thuja		91		10[f]				
Palmer et al. (1983)	WT	2 wk.	Cornus	73				49		18	
Kimball and Nolte (2006)	BT	3 wk.	Thuja		99				39[d]		
Kimball et al. (2005)	WT	3 wk.	Thuja		99						
Sullivan et al. (1985)	BT	3 wk.	Gaultheria			94[g]	92[c]				
Melchoirs and Leslie (1985)	BT	1 mon.	Gaultheria	12	86		18[e]				
Nolte (1998)	BT	14 wk.	Pinus and Thuja		76				76[d]	68	4
Wagner and Nolte (2001)	BT	18 wk.	Thuja	44		12[h]	16[c]	0	32[d]	12	12
$\bar{X}$—pen studies				56	90	60	51	36	49	39	10

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Table continued.

Study	Cervida	Period	Plant	BGR-L[b]	BGR-P	Eggs	Urine	Hinder	Blood	Thiram	Bitter
				Field studies (% effective)							
Lutz and Swanson (1997)	WT	2 wk.	Feed	89			41[c]	90			18
Baker et al. (1999)	Elk	5 wk.	Populus	24							
Milunas et al. (1994)	WT	6 wk.	Taxus		31						
Santilli et al. (2004)	FD	8 wk.	Olea						28[i]		23
Swihart et al. (1991)	WT	8 wk.	Taxus and Tsuga				11[c]				
Swihart and Conover (1990)	WT	5 mon.	Taxus	76							-7
Lemieux et al. (2000)	WT	6 mon.	Ilex and Taxus			90[j]					56
Conover (1984)	WT	6 mon.	Taxus	47				44		52	
Conover (1987)	WT	6 mon.	Taxus	50				48			
Witmer et al. (1997)	Deer and elk	7 mon.	Conifer	67	86						-5
Bergquist and Örlander (1996)	RD	8 mon.	Pinus and Picea								13
Conover and Kania (1988)	WT	1 yr.	Malas	25							
$\bar{x}$— field studies				54	58	90	26	61	63	52	16
$\bar{x}$—all studies				55	81	66	44	47	55	41	14

[a]Elk (*Cervus elaphus*), RD (*Capreolus capreolus*), FD (*Dama dama*), MD (*Odocoileus hemionus*), BT (*Odocoileus hemionus columbianus*), WT (*Odocoileus virginianus*).
[b]BGR-L = Big Game Repellent liquid; BGR-P = Big Game Repellent powder.
[c]Coyote urine.
[d]Plantskydd.
[e]Predator fecal extracts.
[f]Wolfin (synthetic wolf urine).
[g]unreported commercial product.
[h]Mr T's Deerblocker and Not Tonight Deer.
[i]Eutrofit.
[j]Holly Ridge.

Solution, coyote urine, and Plantskydd; Table 3) that we evaluated provided no significant reduction of browse damage relative to unprotected controls. Most studies reported that repellents using a bitter compound, such as Repellex, are ineffective (Table 4). The addition of bittering agents as repellents did not decrease feed consumption for several herbivores (Nolte et al. 1994, Wright and Milne 1996). Levels of bittering agents sufficient to deter browsing were phytotoxic and resulted in >75% seedling mortality (Bergquist and Örlander 1996). Repellex tablets were easy to plant with the shrubs and were inexpensive (Table 5), but were ineffective. In addition, the use of systemic repellents would likely be undesirable for produce and other food items.

Short-term pen studies suggested that predator urine provided short-term (<1 month) protection from browsing (Table 4). Our results found that urine offers little longer term protection; deer were observed browsing on yews treated with urine within 2 months of the initiation of the study. Another study showed that coyote urine sprayed on yews was much more effective in reducing browse damage than urine applied from tubes with cotton darts (Swihart et al. 1991). Coyote urine costs were moderate (Table 5). Coyote urine was easy to apply, but it smells bad to humans, too.

The effectiveness of blood-based repellents, including Plantskydd, has varied among studies in other regions (Table 4). Casual observation during the first growing season suggested Plantskydd was effective; however, damage was significant by the end of the experiment (Table 3). Plantskydd, which consisted of dried bovine blood, had to be mixed in a watering can, and when applied looked and smelled like blood. Costs were moderate (Table 5), and effectiveness may have been enhanced with more frequent application.

We could find no published field trials of Deer Solution in the scientific literature. Deer Solution had a pleasant odor, costs were moderate (Table 5), did not clog spray nozzles, and could be stored in sprayers over time. While we found Deer Solution was not effective in our study (Table 3), it may have been more effective with a more frequent application schedule.

While proper physical exclusion can prevent 100% of browse damage by white-tailed deer at a one-time cost and minimal long-term labor, fencing can be unsightly and expensive to install. Commercially available repellents provide an alternative to fencing, but are not as effective. The selection of which repellent to use is a trade-off between effectiveness, cost (material and time), ability or willingness to follow reapplication interval, and plant species to be protected. Our research has shown that generally, repellents that were applied more frequently ranked higher on our Protection Index.

Acknowledgments

We thank the South Central Connecticut Regional Water Authority for providing a field site; Clinton Nurseries, Clinton, Connecticut, and Sunny Border Nursery-Kensington, Connecticut, for plant donations; and J. P. Barsky, G. M. Picard, R. Vidro, D. V. Tompkins, R. A. Wilcox, and E. A. Kiesewetter for assistance with plot maintenance and data collection. This research was partly funded by Hatch Project CONH-0560.

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