# Control of Deer Damage with Chemical Repellents in Regenerating Hardwood Stands

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**ABSTRACT**—Wildlife damage can be a major problem in natural tree regeneration or tree plantings. In the North Central Hardwoods region, white-tailed deer (*Odocoileus virginianus*) are a significant cause of damage to hardwood seedlings. We evaluated the use of a combination of chemical repellents (Hinder®, Tree Guard®, chicken eggs, and Plantskydd®) in restoring a poor hardwood stand to higher-valued, native trees in Hixon Forest, La Crosse, Wisconsin. Chemically treated oak (*Quercus spp.*) and black cherry (*Prunus serotina*) seedlings had less terminal browse damage ($P < 0.005$) during the growing season than untreated seedlings. Results during the winter will also be presented. Preliminary results support further study of an integrated use of chemical repellents in regenerating hardwood stands.

In the Central Hardwoods Region, white-tailed deer are arguably the most important species causing damage to forest resources (Conover and Decker 1991). Their social and economic importance as a game species (USFWS 2001), reproductive capacity (McCullough 1997), and wide distribution (Fig. 1) are all contributing factors.

Deer can impact natural tree regeneration (Tilghman 1989, Trumbull and others 1989, Jones and others 1993, Cornett and others 2000), tree plantings (Beringer and others 1994), nurseries (Conover and Kania 1995), or orchards (Mower and others 1997, Lemieux and others 2000b). Repeated browsing of terminal shoots distorts growth and suppresses tree seedling height and longer rotations and mortality can result (Nolte and Dykzeul 2002). Conover and others (1995) estimated total losses from wildlife damage to the timber industry in the U.S. to be $3.4 million annually. Annual economic losses due to wildlife damage to all forest resources in Oregon were estimated at $333 million (Nolte and Dykzeul 2002). With no animal damage management, the total predicted reduction in value for Oregon forests alone was estimated at $8.3 billion. These figures underscore the importance for understanding the types and amounts of damage caused by wildlife, the factors that influence the severity of damage, and scientifically-based methods to reduce wildlife damage.

Chemical repellents have been evaluated in deterring deer damage in pen (Andelt and others 1992, Lutz and Swanson 1997, Witmer and others 1997, Wagner and Nolte 2000) and field (Conover 1984, Swihart and Conover 1990, Fargione and Richmond 1995, Witmer and others 1997, Lemieux and others 2000b) trials. However, few studies tested the efficacy of repellents in an integrated approach to minimizing deer damage. Switching among repellents has the potential to maximize the strengths of each repellent. Also, strategies using multiple techniques have a better chance of success than those that incorporate a single technique (Conover 2002:375). Jordon and Richmond (1992) found that the use of repellents increased the effectiveness of fencing alone. In our study, we evaluated the combined use of Hinder®, Tree Guard®, chicken eggs, and Plantskydd® to minimize deer damage to tree seedlings in a natural stand and present preliminary results in this paper. We also summarize and discuss research on available options to control deer damage in commercial tree plantings and natural hardwood regeneration.

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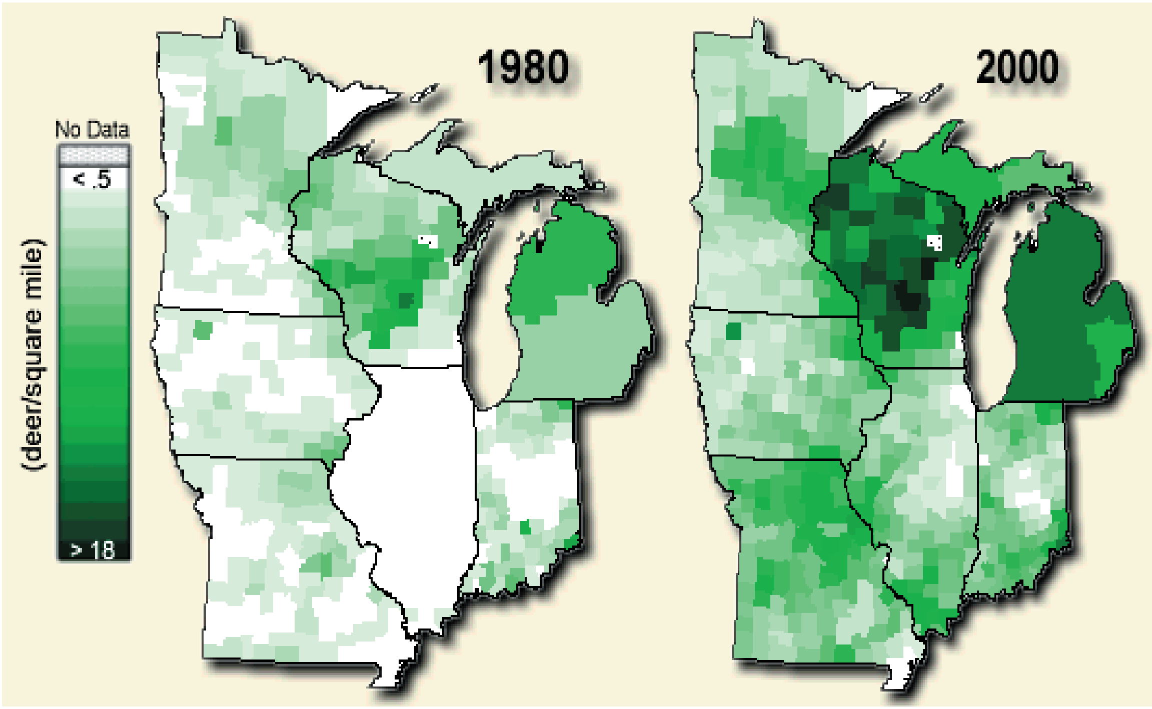


**Figure 1.—Total deer harvested per square mile (region for Michigan) in the Midwest in 1980 and 2000. The total number of whitetail deer harvested increased by nearly 250 percent during this time period. (USDA Forest Service, North Central Region)**

## METHODS

The Hixon Forest is a 291 ha woodland located within the city of La Crosse, Wisconsin. The forest has been uncut for the past 90 years and is dominated by a mixture of timber oaks (*Quercus* spp.), hickory (*Carya* spp.), bigtooth aspen (*Populus grandidentata*), black walnut (*Juglans nigra*), black cherry (*Prunus serotina*), and basswood (*Tilia americana*). Because of it is located within the city limits of La Crosse, deer densities and browse pressure are presumably high, although we did not measure this.

We were interested in regenerating shade intolerant species that would be available for education and research. We chose an area accessible to the public that was dominated by black locust (*Robinia pseudoacacia*), an invasive tree not native to the region. In winter of 2002, a 0.6 ha opening was cleared in an initial attempt to evaluate the feasibility of regenerating more economically valuable tree species using a combination of chemical repellents and herbicide treatment. All trees and shrubs were cut except a few trees which were left for aesthetics at the request of the park. Dominate species removed included black locust, bigtooth aspen, birch (*Betula* spp.), box elder (*Acer negundo*), and buckthorn (*Rhamnus* spp.). The opening was bordered on the west by a maintained mowed area (approx. 1 acre).

The clearing was divided into one treatment plot (approx 0.5 ha) and two control plots (each approx. 0.05 ha). We maintained several access trails within the treatment block. Control plot A was planted with tree seedlings, and both controls had no weed control or repellent applications.

During the spring of 2003 in the treatment block, control plot A, and the perimeter of control plot B we planted 1,157 2-year-old seedlings of white oak (*Quercus alba*), swamp white oak (*Quercus bicolor*), red oak (*Quercus rubra*), shagbark hickory (*Carya ovata*), black cherry, white ash (*Fraxinus americana*), black walnut, butternut (*Juglans cinerea*), and white pine (*Pinus strobus*) in a 6 ft by 7 ft spacing. Each seedling was mulched with woodchips and marked with a wood stake. Seedlings were planted in clusters of 7-9 seedlings of the same species. In the treatment plot, we sprayed a glyphosate herbicide (Round-Up®) at the labeled rate in an approximately 50 cm radius band around each seedling. Thirty-four oaks, walnuts, and butternut were replanted in the fall of 2003 to replace early seedling mortality.

Prior to planting the treatment plot, we brushed Tree Guard® (a Bitrex formulation, [0.2% denatonium benzoate]) onto each terminal bud. When the seedlings began to break bud post planting, we sprayed the terminals with a premixed formulation of Plantskydd® (87% edible animal protein), a taste and smell deterrent. Beginning in May, using a hand-held sprayer we applied a mixture of 200 ml Hinder® (0.66% ammonium soaps of higher fatty acids), six blenderized chicken eggs, and 3.78 L water at approximately monthly (4-6 weeks) intervals until the seedlings went dormant in October. Each application took approximately 1.5 man-hours. After all seedlings were dormant, we reapplied Tree Guard® with a paint brush on each terminal bud. A second application was applied in February 2004.

In the treatment plot, competing vegetation was controlled once it began to shade planted seedlings. Vegetation was removed by hand-pulling or with the use of brush cutters. A glyphosate herbicide (Round-Up®) at the labeled rate was applied with a wick applicator or hand-held sprayer onto all buckthorn and honeysuckle bushes, and stump sprouts of any species.

In all plots, we tallied tree survival during the first year of growth. In the fall of 2003 and spring of 2004, we inspected the terminal of each tree for browse damage. Any sign of damage was counted as being browsed and recorded for each species or species group. We present data from the treatment and control plot A.

## RESULTS

Until November 2003, 9.4% of the seedlings died (n = 112). Seedling survival was similar in both groups. The hickory seedlings had the lowest survival rate (68%) and accounted for most of the seedlings that failed the first growing season. Only black walnut seedlings (86%) had a survival rate below 90%.

Summer browse damage was confined mainly to black cherry and white ash, and occasionally oaks (Table 1). Percent browsed was much higher in the control plot for oaks ($x^2$ = 13.1, df = 1, P = 0.0003) and black cherry ($x^2$ = 8.2, df = 1, P = 0.004). Percent browsed for shagbark hickory and white ash in the treatment plots were 1.7% and 11.9%, respectively. Neither of these species showed browse damage in the control plot.

Preliminary inspection this winter indicates that most of the white pine seedlings have browse damage while other species had an increased damage rate during this period. This data has yet to be collected and will be presented during our oral presentation.

## DISCUSSION

Our data suggest that a combination of chemical repellents and herbicide treatments has the potential to provide satisfactory results in controlling deer browsing of tree seedlings in the first year post harvest. However, conclusions should be drawn with caution since our results are preliminary and sufficient replication was lacking. The ultimate measure of success will be the number of tree seedlings that survive to a height beyond the reach of a deer.

Repellents are more appropriate for short-term problems (Conover 2002) and are typically reserved for smaller areas because it is cost-prohibitive. For

**Table 1.—Percent of tree seedlings with terminal bud browsed by white-tailed deer during 2003 growing season.**

| | Control Plot A | | | Treatment | | |
|---|---|---|---|---|---|---|
| Species | Total Trees | Number of Trees Browsed | Percent Browsed | Total Trees | Number of Trees Browsed | Percent Browsed |
| Oak spp. | 29 | 7 | 24.1 | 253 | 14 | 5.5 |
| White pine | 18 | 0 | 0.0 | 115 | 0 | 0.0 |
| White ash | 13 | 0 | 0.0 | 67 | 8 | 11.9 |
| Butternut | 15 | 0 | 0.0 | 98 | 0 | 0.0 |
| Black walnut | 16 | 0 | 0.0 | 137 | 0 | 0.0 |
| Black cherry | 16 | 7 | 43.8 | 166 | 40 | 24.1 |
| Shagbark hickory | 15 | 0 | 0.0 | 58 | 1 | 1.7 |
| Total | 122 | 14 | 11.5 | 894 | 63 | 7.0 |

our study, an annual cycle of repeated applications of chemical repellents on the treatment plot (0.6 ha) was approximately $71.00. Many studies site cost as a downside to using chemical repellents. However, our costs were relatively inexpensive, although cost of labor would significantly increase our costs. Costs would also be higher for remote sites.

In a review of the current literature, El Hani and Conover (1997) did not find a repellent that consistently reduced deer damage > 50% in field trials. Despite the wide variance in study design, location, deer and plant species, trial duration, criteria of success, and time of year, they found BGR® was the most effective repellent. Predator urine, although not yet labeled by the EPA for use as repellents, showed promise. We used a combination of repellents that had mixed to favorable results in previous studies. In studies reviewed by El Hani and Conover (1997), Hinder® was ranked as effective (n = 3), intermediate (n = 2), or slightly effective (n = 1); chicken eggs was effective (n = 2). In a test of 20 repellents and 2 delivery systems, Wagner and Nolte (2001) found only BGR® and Plantskydd® reduced browse damage to western red cedar by penned black-tailed deer. In their study, Hinder® protected seedlings up to only 4 weeks and Tree Guard® up to 12 weeks. In a trial of Hinder®, Tree Guard®, Miller Hot Sauce®, Deer Away®, chicken eggs, and predator urine, Lutz and Swanson (1997) found Tree Guard® to be the most ineffective while the others had mixed results. Our study involved the use of several repellents with repeated applications (7) per year.

We cannot differentiate if one, two, or all three repellents were effective. Our study site was located in an area with presumably high deer populations typical of urban areas not open to hunting. Deer browse pressure is at its highest during the winter when alternative forage is limited. Chemical repellents have been found to loose efficacy when presented to hungry cervids (Andelt and others 1991, 1992). Efficacy of our methods may be reduced during the winter and may approach results of other studies (i.e., < 50%).

Methods other than chemical repellents have been used to minimize deer damage in natural stands and commercial nurseries. Combining one or more of these methods in conjunction with chemical repellents may reduce deer browsing than any method used alone. A summary of common techniques and their results is presented below.

## Cultural Methods

Tree seedlings are vulnerable to deer browsing up to about 1.8 m (Craven and Hyngstrom 1994). One strategy to minimize deer damage in regenerating stands is to decrease the length of time terminal shoots are available to deer or physical prevent access to tree seedlings. Cultural methods to reduce deer damage to tree seedlings in harvested stands include leaving slash piles (Bergquist and Örlander 1998) or management of the surrounding vegetation. Gourley and others (1990) found that vegetation control helped minimize the effects of deer browsing by reducing competition for the tree seedlings, allowing for increased growth rates. However, surrounding vegetation may also protect seedlings by concealing them or by providing an alternate food source (Campbell and Evans 1978). Diversionary foods may deter small herbivore damage to tree seedlings (Sullivan and others 2001).

The size of forest opening may influence the amount of deer damage. Akins and Michael (1997) found that percent browsed for all tree species groups was generally lower in 0.8 ha clearcuts compared to 0.2 ha clearcuts. Our openings approached the lower end of their study. Further research needs to done to test the effectiveness of our methods or the amount of repellents and treatments on larger openings. If larger openings have lower browse pressure, chemical repellents can potentially be more cost efficient on a per acre basis, although total costs may still be prohibitive.

## Fencing

Electric fences can reduce deer damage (Craven and Hyngstrom 1988, Jordan and Richmond 1992). Fencing has the advantage of being a long-term solution. Cost varies by fence type, but all are relatively expensive compared to other techniques (Table 2). Fences require regular maintenance, are effective on areas 16 ha or less, and success is maximized if installed prior to planting (Craven and Hyngstrom 1994). A temporary electric fence provides inexpensive protection when the goal is to minimize browse damage to terminal buds of trees until they have outgrown the reach of deer.

## Lethal Control

Have been used successfully in urban areas and lands previously protected from deer harvest. A shotgun-archery hunt reduced a residential deer herd by 92% in 6 days (Kilpatrick and others 2002). Success would likely be lower in more rural areas with more abundant habitat and would depend in part on surrounding hunting pressure and hunter skill. Lethal control is often sited as the most cost-effective method of controlling wildlife populations (Conover 2002). Most states have a program where

**Table 2.—Cost comparison of different fencing types (from Craven and Hyngstrom 1994, Bender 1998).**

| Fence Type | Cost Per Linear Foot | Cost Per Acre | Items Included in Cost | Year |
|---|---|---|---|---|
| 8-ft. mesh / woven wire fence | $1.05<br>$2-$4 | $1222 | Materials | 1990<br>1994 |
| | $4-$6 | | Materials & installation | |
| High tensile electric fence (5-ft.) | $0.89-$2.03 | | Materials & installation | 1998 |
| | | $30/year | Maintenance | 1998 |
| High tensile electric fence (6.5-ft.) | $2.15-$2.70 | $368 | Materials & installation | 1992 |
| High-tensile fence (8-ft.) | $0.75-$1.50 | | Materials | 1994 |
| Polytape electric fence | $0.50-$1.20 | | Materials | 1997 |
| | $0.11 | | Materials | 1994 |
| Slanted seven-wire fence | $0.75-$2.00 | | Materials | 1994 |

deer can be taken out of season with a permit when damage exceeds a set economic threshold.

Methods used to control deer damage in natural stands are commonly utilized in tree plantations and nurseries (Lemieux and others 2000a). Damage caused by deer is difficult to control in nurseries because their home range likely will include the nursery and the surrounding area. Because of their small home ranges, damage caused by smaller herbivores are less influenced more by physical characteristics of a plantation rather than surrounding habitat (Pietrzykowski and others 2003). Annual variation of deer browsing in Connecticut nurseries was not associated with local deer densities, the availability of native browse, or winter weather conditions (Conover and Kania 1995). Physical size of nurseries, the degree bordered by woodlots, or level of remoteness has not been found to influence observed levels of deer browsing, but the size of adjacent woodlots and the combined area of woodlots within 2 km has (Conover 1989).

In conclusion, our preliminary results support further study of an integrated use of herbicides and chemical repellents in regenerating natural hardwood stands. Their success will likely depend on use of other methods, local deer browse pressure, surrounding habitat, and weather and other stochastic variation. Further research is needed to identify influencing factors that explain the level of deer browsing in different landscapes at different temporal scales. As development pressure increases and forestland ownership continues to become increasingly fragmented, economic pressures to regenerate nature stands of high-valued timber may necessitate more intensive and costly control of deer damage and other limitations to regeneration.

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