# EFFECTIVENESS OF ELECTRIC DEER FENCES TO PROTECT PLANTED SEEDLINGS IN PENNSYLVANIA

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Abstract: Electric fences are used in Pennsylvania following a timber harvest to reduce deer browse on natural regeneration. In 1984, five-strand electric deer fences were constructed around two central Pennsylvania clearcuts. Northern red oak, white ash, white pine, and yellow-poplar seedlings were planted inside each fenced clearcut area in 1984 and 1985. One-half of the 1280 seedlings for each species were maintained free from herbaceous and woody vegetation competition with annual applications of glyphosate. Seedling survival, height and deer browsing in the growing season were recorded annually for four years. These data were analyzed to evaluate the effectiveness of electric deer fences to reduce deer browsing on planted seedlings with emphasis on (a) years from construction, (b) species, and (c) species specific height growth. The fences were effective in reducing deer browsing on the planted seedlings for the first two years after construction. After this time, browsing during growing season increased. Frequency of browsing was dependent on species and seedling height. White pine was the least frequently browsed and northern red oak was the most frequently browsed. Practices to enable the seedlings to grow >1.2 m in height in two or three years after fence construction will produced the most successful tree planting programs in Pennsylvania.

## INTRODUCTION

Post-harvest artificial regeneration in mixed oak stands may be used when regeneration stocking is inadequate or the species composition of the regeneration is not desirable. When stands have abundant herbaceous vegetation and high deer populations, artificial regeneration programs should include steps to control competing vegetation and deer browsing. Effects of competing vegetation on species desirable in mixed oak stands have be reported for planted seedlings (Von Althen 1972, Farmer 1981, Johnson 1984, and Bowersox and McCormick 1987) and planted seeds (Kolb et al. 1990). The use of deer exclosures to reduce the incidence of deer browsing on natural regeneration is well documented (Jordan 1967, Marquis and Brenneman 1981 and Trumbull et al. 1989). Electric fences similar to those described by Brenneman (1982) are currently used to minimize deer browsing to seedlings from natural sources in Pennsylvania. However, the incidence of deer browse to planted seedlings inside

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an electric deer fence has not been well documented. Electric fence designs can vary but principle components are high tensile strength wire and energizers capable of charging the fence with at least 5500 volts. Effectiveness of the various designs may depend on local conditions. In Pennsylvania, properly constructed and maintained five-to-seven strand vertical fences have performed satisfactory.

This study reports on the effectiveness of electric fences to protect planted seedlings of four species (white pine (*Pinus strobus* L.), white ash (*Fraxinus americana* L.), northern red oak (*Quercus rubra* L.), and yellow-poplar (*Liriodendron tulipifera* L.)) from deer browsing in two central Pennsylvania clearcuts.

## METHODS

Two mixed oak stands in the Ridge and Valley Provenience of central Pennsylvania were used as study sites. The two sites were located 14 km south of State College and within 1 km of each other. The sites were similar, except one had a southeastern aspect and the other had a northwestern aspect. Additional site information and soil chemical properties have been reported by Kolb et al. (1990). The stands had received shelterwood cuts to increase the quantity of desirable seedlings. Neither stand had acceptable stocking of seedlings 10 to 15 years after treatment. Red maple (*Acer rubrum* L.) dominated the average of 2050 to 5250 commercially important seedling per hectare for the two sites. Ground vegetation was dominated by hay-scented fern (*Dennstaedtia punctilobula* L.) and poverty oat grass (*Danthonia spicata* (L) Beauv.).

In the winter of 1983-84, approximately 6 ha of each stand were clearcut. A vertical five-strand, high tensile steel electric fence was constructed around 4 ha. Vertical arrangement of the wires were 20 cm above ground for the lowest wire, then spacings of 25, 30, 30 and 30 for a total fence height of 135 cm. Wires were attached to insulators installed on low value trees. Horizontal distance between insulators ranged 4 and 25 m, depending on topography and tree spacing. Electrical ground was established by four 1.22 m sections of copper coated rod. Deep cycle marine batteries were used to power Gallagher E-12 energizers. The batteries were changed once per month throughout the study.

In August 1983, four replications of four 80 $m^2$ plots were established in fern or grass dominated locations at each site. At this time, two plots per replication was treated with an application of 1.7 kg/ha of glyphosate to kill existing fern or grass vegetation. The remaining plots were maintained in the fern or grass condition. In May 1984, twenty bare root seedlings of each species were planted with a pointed planting bar at a 1.0 x 1.0 m spacing in each plot. Hardwood seedlings were 1-0 stock which were top-clipped at the time of planting to a height of 10 cm. The white pine seedlings were 2-0 stock and averaged 10 cm at planting time. Data for the fern and grass (Weedy) plots, and fern- and grass-free (Weed-free) plots were combined for this study. At each site, there was a total of 320 seedlings per species with 160 planted in Weedy plots and 160 planted in Weed-free plots. The 1984 planting methods and treatments were duplicated in 1985. Annual shielded applications of glyphosate

(1.7 kg/ha) were used to control competing vegetation on the weed-free plots. Seedling survival, height and deer browse on the terminal shoot during the growing season were recorded annually for four growing seasons (1984-1988). Deer densities for the area surrounding the study sites were estimated to be about 1 deer per 13 hectares.

## RESULTS

Annual seedling survival values for both planting years and both sites were combined and are presented in Table 1. Survival one year after planting was generally above 80% and not strongly affected by herbaceous condition. As years after planting increased survival decreased, more on the Weedy plots than on the Weed-free plots. Survival of the hardwood species averaged 23 to 40% lower on the Weedy plots than on the Weed-free plots.

Table 1.--Average[1] survival for the four species by herbaceous condition and years after planting.

| Species | Years After Planting | | | |
|---|---|---|---|---|
| Herbaceous Condition | 1 | 2 | 3 | 4 |
| | ----------%---------- | | | |
| White Pine | | | | |
| Weedy | 84 | 78 | 73 | 68 |
| Weed-free | 89 | 82 | 79 | 75 |
| Northern Red Oak | | | | |
| Weedy | 94 | 74 | 61 | 58 |
| Weed-free | 94 | 89 | 82 | 81 |
| White Ash | | | | |
| Weedy | 92 | 85 | 78 | 71 |
| Weed-free | 98 | 98 | 95 | 95 |
| Yellow-poplar | | | | |
| Weedy | 76 | 53 | 41 | 38 |
| Weed-free | 87 | 82 | 80 | 78 |

[1]Values were averaged over planting years and sites, n= 640.

Differences in seedling height between the Weedy and Weed-free plots was species and time dependent (Table 2). The effect of herbaceous competition on height was moderate for white pine and northern red oak, and substantial for white ash and yellow-poplar. Average four years after planting height advantage of the Weed-free plots as compared to the Weedy plots was 1.2x for white pine, 1.3x for northern red oak, 2.2x for white ash and 1.7x for yellow-poplar.

Table 2.--Average[1] height of seedlings that were not browsed by deer for the four species by herbaceous condition and years after planting.

| Species | Years After Planting | | | |
|---|---|---|---|---|
| Herbaceous Condition | 1 | 2 | 3 | 4 |
| | cm | | | |
| White Pine | | | | |
| Weedy | 22 | 44 | 66 | 97 |
| Weed-free | 22 | 42 | 77 | 115 |
| Northern Red Oak | | | | |
| Weedy | 22 | 42 | 66 | 101 |
| Weed-free | 24 | 55 | 94 | 132 |
| White Ash | | | | |
| Weedy | 29 | 55 | 87 | 121 |
| Weed-free | 39 | 99 | 178 | 265 |
| Yellow-poplar | | | | |
| Weedy | 34 | 65 | 126 | 189 |
| Weed-free | 40 | 128 | 230 | 321 |

[1]Values were averaged over planting years and sites.

Deer tracks and feces inside the fence were rare during the first and second years after construction. Signs of deer inside the fence increased in the third and following years after construction. This observed pattern of deer penetration was also reflected in the frequency of browsing (Figure 1). The frequency of growing season browsing increased with increasing years after construction and varied among the four species. Northern red oak and yellow-poplar suffered the highest level of browsing. White pine and white ash were browsed less frequently. This browsing had a major impact on seedling height (Table 3). Over all treatments and conditions, browsed white pine, northern red oak, white ash and yellow-poplar seedlings averaged 51, 67, 76 and 74 cm four years after planting, respectively. These average species specific height values were considerably lower than the unbrowsed values.

## DISCUSSION

Five strand vertical electric deer fences can be an effective tool in reducing the incidence of deer browse to planted seedlings. To maximize the effectiveness in protection, seedlings should be planted as soon after fence construction as possible and competing herbaceous vegetation should be controlled. In our study, deer penetrations of the fence were low in the first two years after fence construction. Initially, there were low frequencies of growing season browsing to the planted seedlings. Once the deer were frequently penetrating the

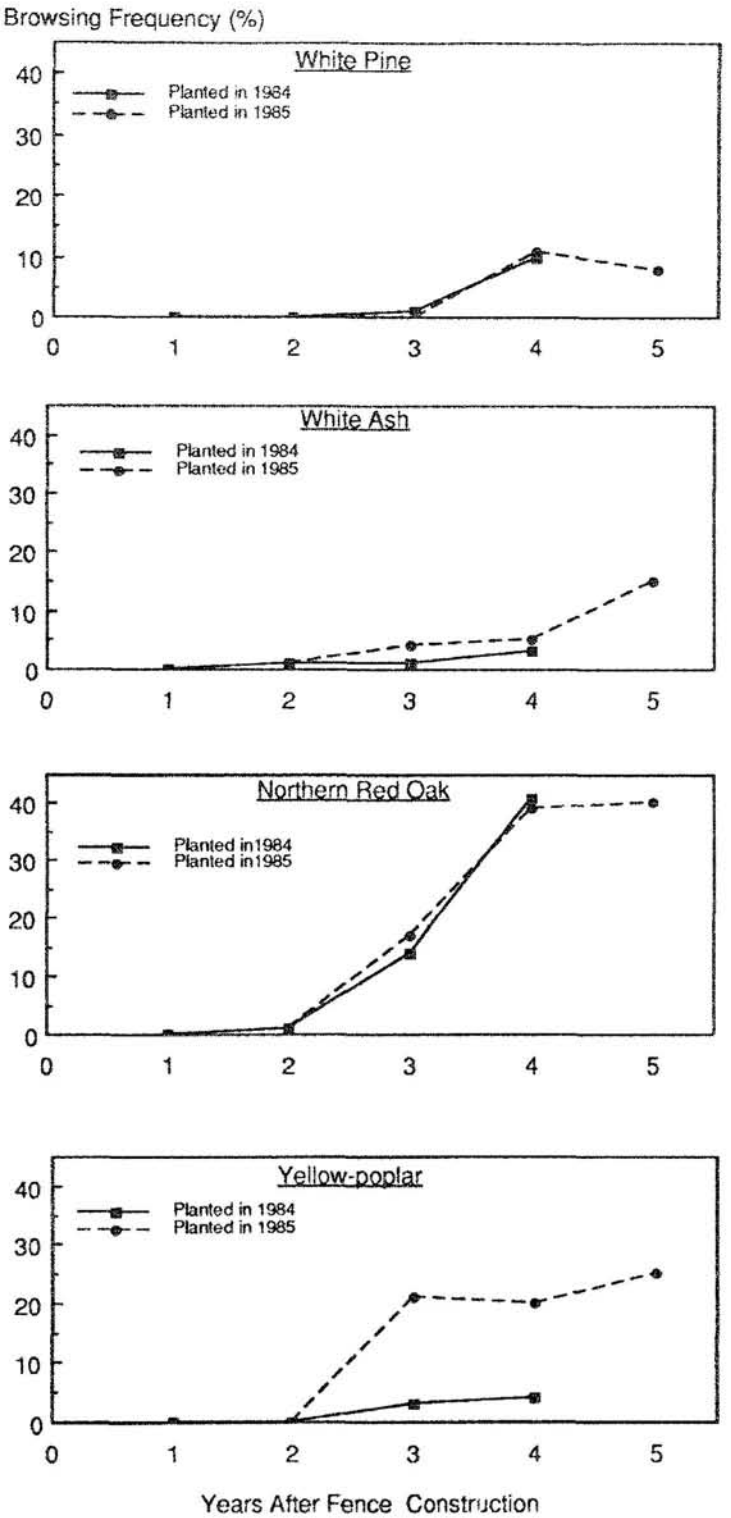


Figure 1. Frequency of deer browsing in the growing season for the four study species as a function of years after fence construction in 1984. Deer browsing activity was measured for four years after the 1984 and 1985 plantings.

Table 3.--Average[1] height of seedlings that were browsed by deer, by species.

| Species | Years After Planting | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| | cm | | | |
| White Pine | -- | 15 | 39 | 51 |
| Northern Red Oak | 24 | 51 | 58 | 67 |
| White Ash | 30 | 81 | 71 | 76 |
| Yellow-poplar | 28 | 71 | 70 | 74 |

[1]Values were averaged over herbaceous condition, planting years and sites. N ranged from 0 for 1 year after planting to 72, 370, 94 and 81 for fours years after planting for white pine, northern red oak, white ash and yellow-poplar, respectively.

fence, browsing increased and most browsing was to seedling that were <1.2 m in height. Controlling the fern and grass vegetation enabled yellow-poplar and white ash to obtain an average height of >1.2 m in two and three growing seasons, respectively. White pine did not achieve an average height beyond the 1.2 m in four years for either herbaceous condition but it also was not frequently browsed. Northern red oak was frequently browsed by the deer, and its height growth was moderately responsive to reductions in herbaceous vegetation. Additional treatments should be explored to enable northern red oak seedlings to rapidly achieve heights that are beyond the terminal browsing height of deer. These treatments can be the use of larger stock, avoid top-clipping, and selecting seed sources or nursery practices which maximize juvenile growth.

We have maintained these and other fences in Pennsylvania. We have observed deer challenges to the fences and we will use this knowledge plus the experiences of others (PA Bureau of Forestry 1987 and deCalesta et al. 1989) to modify our future installations. Our observations have been that the deer first try to go under the fence. If this fails, they jump through the strands of wire before jumping over the fence. The increase in deer penetrations with time may be attributed to an acquired "knowledge" by deer, desire for favorable habitat inside the fence, and periods of low voltage or conductivity to ground. There were occasions when there was low or no voltage to the fence. These occasions usually followed high wind and electrical storms when downed trees or branches caused shorts in the fence or lighting caused overloads to the energizer. During dry soil conditions or periods of snow pack, resistance to ground was high and differential wire to ground voltage would drop below 3500 volts. An adjustment to minimize deer penetrations was to alternate the electrical charge to each successive strand of the fence. When all the strands are positively charged an airborne deer will not sense an electrical shock, since there is no ground to carry the electricity to the deer. At times we alternated positive and negative strands of the fence to try and negate this access route by deer. Other potential adjustments could include constructing a six or seven strand fence to minimize the distance between strands, frequent maintenance inspections, and using standard electrical service instead of batteries as the power source. However, once deer

penetrated the fence there was little incentive to leave the area due to the greater abundance of food and cover within the fenced area.

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