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Development of Red Oak Seedlings Using Plastic Shelters on Hardwood Sites in West Virginia

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Abstract

Plastic shelters were used to grow red oak seedlings on good-to-excellent Appalachian hardwood growing sites in north central West Virginia. Preliminary results indicate that shelters have the potential to stimulate development of red oak seedling height growth, especially if height growth continues once the seedling tops are above the 5-foot-tall shelters.

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Introduction

During the 1980's, plastic shelters were used in Europe to protect forest seedlings (Morrow 1988; Potter 1988; Tuley 1983, 1985). Shelters protect seedlings from deer and small mammal damage and provide seedlings with a greenhouse-like environment by increasing temperature and humidity inside the shelter. There is also a higher level of carbon dioxide within the shelter; thus, seedlings should produce more food for growth (Mayhead and Jones 1991). In recent years, the use of shelters has increased drastically in the Eastern United States.

Information discussed in this paper is based on preliminary results from research designed to understand how the shelters might work with northern red oak (*Quercus rubra* L.) growing on good-to-excellent Appalachian hardwood sites (red oak site index 70 and above). A major forest management objective on these sites is the establishment and development of a specific species such as northern red oak.

Study Area

The studies reported in this paper were done on the Fernow Experimental Forest located near Parsons, West Virginia. The Fernow is a 4,700-acre forest, outdoor laboratory, that was established for forest research purposes in 1934. It is located on the Monongahela National Forest and maintained by staff from the Timber and Watershed Laboratory of the Northeastern Forest Experiment Station. Appalachian hardwoods dominate the species composition including a mixture of oaks, yellow-poplar, black cherry, sweet birch, beech, maples, and birch. Current stands are primarily second growth resulting from logging during 1905 to 1911. Average annual precipitation on the Fernow is approximately 55 inches with 120 to 140 frost-free days during the growing season. Site productivity ranges from red oak site index 60 to 80. During 1991, the growing season was uncharacteristically dry on the Fernow. The average annual precipitation for April to September is 35.7 inches, but for 1991, it was 23.3 inches.

Methods

From 1988 to 1991, red oak seedlings and acorns were planted on five different sites. Shelters were used to protect the seedlings. All shelters were 5-foot-tall circular plastic tubes manufactured by Tubex. Some shelters were white but most were brown. Shelters were installed on both natural and planted red oak seedlings. Two kinds of planted bare-root red oak seedlings were used: the typical 2-0 seedlings purchased directly from a commercial nursery and special 2-0 seedlings that were root-pruned during early August of the first year in the seedbed (Fig. 1). Roots were pruned at this early age to minimize the characteristic taproot and develop a more fibrous root system (Johnson, et al. 1986). Also, in addition to the seedlings, stratified red oak acorns were planted in the spring and protected with shelters. At this time, acorn information is available for only one growing season.

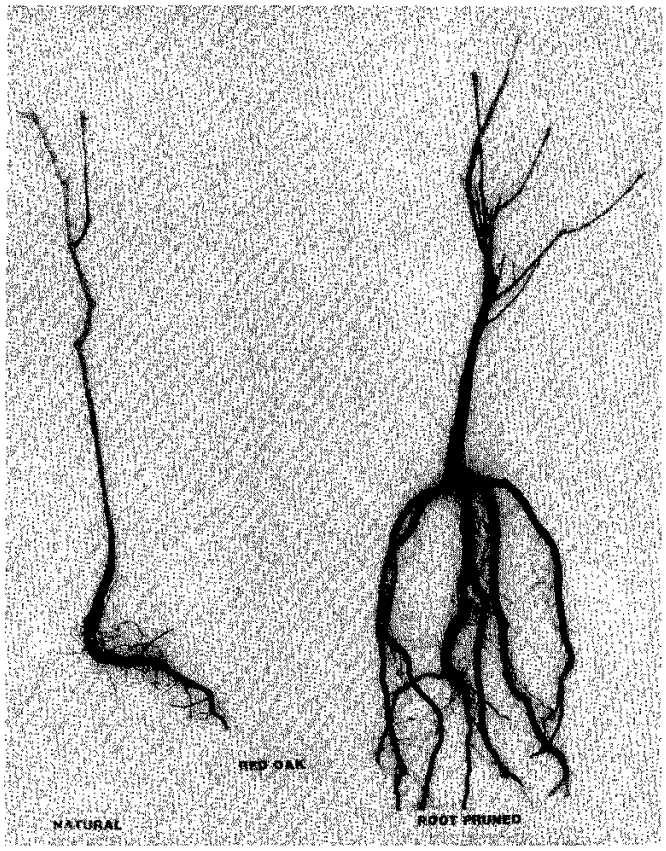

Figure 1.—Special 2-0 red oak seedlings where roots were pruned in early August during first year in the seedbed.

During study installation, seedlings were planted and shelters installed as a separate operation. Normally shelters were installed at ground line and pushed slightly into the soil by hand. Soil was then placed around the base of the shelter to minimize the risk of an air draft that could result in seedling mortality. Most of the shelters were attached to a wooden 5-foot white oak pointed stake that was driven into the ground about 1 foot. The top of the wooden stake was near the top of the plastic tie on the shelter.

Most seedlings were planted or selected (naturals) at least 25 feet apart to allow for the future application of herbicides to control competing vegetation if necessary. In all situations, comparison seedlings of the same age were used for control purposes (no shelters installed). For the planted, stratified acorns, one or two acorns were buried at a soil depth of about 1.5 to 2.0 inches. Shelters were then installed as previously discussed. Also shelters were installed with the bottom of the shelter 8 inches under the soil. This was done for the purpose of protecting the acorns from rodent predation and so on. Finally, stratified acorns were planted but shelters were not installed.

Testing for significance was done at the 0.01-percent level using Chi-square and analysis of variance techniques and Tukey's test for multiple comparison purposes.

Results and Discussion

Because five small-scale studies were done, for the purpose of clarity, it was decided to include specific methodology within the results and discussion section. Likewise, sites that had better results are discussed first.

Site 1

Seedlings planted on a new clearcut area. During March 1991, all trees 1.0 inch d.b.h. and larger were removed from a clearcut area. Special 2-0 root-pruned red oak seedlings were planted. Initially the seedlings averaged about 1.5 feet tall before planting and all were at least 0.5 inch in diameter at the root collar (Table 1). All seedlings were top pruned before being lifted from the seedbed. Brown 5-foot-tall shelters were installed on 80 seedlings, and white shelters were installed on another 80 seedlings. A total of 40 seedlings were used as controls where no shelters were installed. For the brown shelters, 37 percent of the terminal shoot tips were even or above the top of a 5-foot-tall shelter after one growing season. Similarly, this was 45 percent for seedlings in the white shelters (Fig. 2). For the 160 seedlings in plastic shelters, survival was nearly 100 percent after 1 year (one seedling died). For the 40 control seedlings with no shelters, seven died (Table 1).

At the end of the first growing season, average height growth for seedlings with brown or white shelters was about 2.5 feet (Table 1). Seedlings without shelters had no additional height growth. All seedlings without shelters were severely browsed by deer. It is important that the oak seedlings get a quick start on the competing vegetation. In most situations, it is desirable for all seedlings to be as tall or taller than the 5-foot-tall shelter at the end of the first growing season.

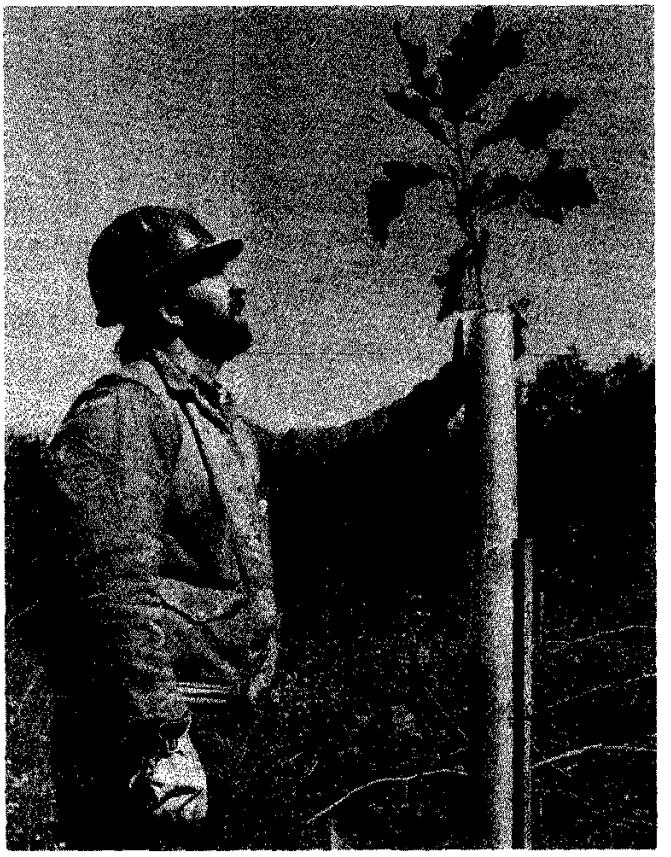

Figure 2.—Special 2-0 root-pruned red oak seedling above the top of 5-foot-tall shelter after the first growing season. Seedling was 1.5 feet tall when planted.

Table 1.—Survival and height growth of red oak seedlings with and without shelters planted in new clearcut area after one growing season.

Treatment	Initial number	Survival first year		Initial height	Height first year, feet		
		Number	Percent[a]		Height	Growth	Range
Control	40	33	82a	1.5	1.4	-0.1a	0.4-1.9
Brown Shelters	80	79	99b	1.5	3.9	2.4b	1.8-6.4
White Shelters	80	80	100b	1.4	4.1	2.7b	1.8-6.7

[a]Treatment means with similar column letters were not significantly different at the 0.01-percent level of testing.

Table 2.—Survival and height growth of special 2-0 red oak seedlings planted in a 1-year-old clearcut after one growing season.

Treatment	Initial number	Survival first year		Initial height	Height first year, feet		
		Number	Percent[a]		Height	Growth	Range
Control	40	40	100a[a]	1.4	2.0	0.6a[a]	1.2-3.2
Control/Cut-off [b]	40	39	98a	1.4	1.4	0.0a	0.7-2.4
Shelter	40	40	100b	1.4	3.4	2.0b	1.3-6.2
Shelter/Cut-off [b]	40	40	100b	1.4	3.0	1.6b	1.0-5.2

[a]Treatment means with similar column letters were not significantly different at the 0.01-percent level of testing.
[b]Seedlings top cut off to a height of 4.0 inches above the ground.

Site 2

Seedlings planted on a 1-year-old clearcut area. For another study area, special 2-0 red oak seedlings were planted during the spring of 1991, *1 year after clearcutting.* A total of 40 seedlings were used for each treatment. The four seedling treatments were as follow: seedling with no shelter; seedling with brown shelter; seedling top cut off with no shelter; and seedling top cut off with brown shelter installed. For the cut-off treatments, after planting, each seedling top was cut off leaving a stem 4 inches above the ground.

After one growing season with shelters (2 years after clearcutting), only five shelter seedlings (12.5 percent) were as tall or taller than the 5-foot-tall shelter, and, similarly, only four (10 percent) of the shelter/top cut-off seedlings were as tall or taller than the 5-foot shelter (Table 2). Although the shelters protected the seedlings and undoubtedly had a positive effect on height growth, there was a major increase in competition from vegetation during the second growing season after clearcutting. The portion of seedlings at the top or above the 5-foot-tall shelters is low compared to results of planting immediately after clearcutting. It should be noted that all planted seedlings in this instance were from the same nursery seedbed. The only difference between planting areas is a slightly lower site index (however, all sites were red oak site index (SI) 80) and the flush of competing vegetation the second year after clearcutting. By the end of the second growing season, many of the first-year shelters were partially shaded by vegetation.

Site 3

Acorns and seedlings planted on a 1.5-year-old clearcut. During the 1991 spring season, stratified red oak acorns were planted in a clearcut area that was 1.5 years old. These acorns were planted during late April, and brown shelters installed within 2 days after planting. A total of 30 samples were used for each of six treatments. The treatments were as follow:

1. Control (no shelter) with 1 acorn;
2. Control (no shelter) with 2 acorns;
3. Shelter (normal installation with 1 acorn);
4. Shelter (normal installation with 2 acorns);
5. Shelter (deep installation with 1 acorn);
6. Shelter (deep installation with 2 acorns).

All acorns were planted at a soil depth of between 1.5 to 2.0 inches. Acorns for the control treatments were not protected from predation. Shelters were installed two ways: normal with the base of the shelter at groundline, and deep where the base of the shelter was placed at a soil depth of 8 inches in an effort to control the rodents. Data after the first growing season are summarized in Table 3.

About 3 weeks after planting the acorns, many of the control acorns were gone. However, there was quick acorn germination and seedling development response inside the shelters. All shelters had at least one germinated oak seedling. Many of the seedlings were at least 6 inches tall and results at that point were very encouraging. However, as the 1991 summer became drier and the competing vegetation shaded the sides of the shelters, the germinated acorn seedlings, though alive, were not responding. As indicated in Table 3, survival at the end of the first growing season was 92 percent for all the acorns with shelters (110/120). Height growth after the first growing season was not satisfactory (less than 1 foot) and many of the seedlings had dead tops. However, germination of the acorns and early seedling height growth were impressive.

Also, with the spring 1991 acorn planting in the 1.5-year-old clearcut, 30 special 2-0 root-pruned, bare-root red oak seedlings were planted. Within 2 days after the late April planting, a shelter was installed on each seedling. We wanted to compare the acorn seedling development to the 2-0 bare-root seedling development in this 1.5-year-old clearcut. The average initial height of these planted 2-0 seedlings was 1.4 feet and at the end of the first growing season, the 30 seedlings averaged 2.8 feet tall with heights ranging from 1.2 to 4.9 feet. Only one planted seedling was at the top of the 5-foot-tall shelter. On this same area, shelters were also installed on 10 natural red oak seedlings (age

Table 3.—Survival and height growth of red oak acorns planted in a 1.5-year-old clearcut, after one growing season.

Treatment	Initial number	Survival first year		Height first year, feet	
		Number	Percent	Growth	Range
Control (1)[a]	30	0	0	0	—
Control (2)	30	1	3	0.2	—
Shelter (N-1)[b]	30	30	100	0.6	0.3-1.0
Shelter (N-2)	30	26[c]	87	0.6	0.3-1.0
Shelter (D-1)[d]	30	26	87	0.7	0.3-1.4
Shelter (D-2)	30	28[c]	93	0.8	0.2-1.6

[a]Numbers in parentheses refer to the number of acorns planted initially.
[b]Normal shelter installation with one acorn.
[c]At least one seedling established in the shelter.
[d]Deep shelter where base is 8 inches underground.

Table 4.—Survival and height growth of special 2-0 red oak seedlings planted on an excellent hardwood site that was clearcut in July-early August of the previous year, by the first and second year.

Treatment	Survival				Height feet			
	Initial number	First year	Second year		Initial	First year	Second year	Two-year growth
		Number	Number	Percent				
Control	41	41	39	95a[a]	0.9	1.2	1.8a[a]	0.9
Control/cut-off[b]	33	35	33	85ab	0.9	0.7	1.8a	0.9
Shelter	39	39	39	100a	1.0	1.8	3.9b	2.9
Shelter/cut-off[b]	41	34	32	78b	1.0	1.2	3.0b	2.0

[a]Treatment means with similar column letters were not significantly different at the 0.01-percent level of testing.
[b]Seedlings top cut off at groundline immediately before installing plastic shelters.

unknown). Initial heights of the natural seedlings were 1.1 feet. At the end of the first growing season, the 10 seedlings averaged 2.4 feet tall, ranging from 1.6 to 3.9 feet. None of these natural seedlings were out the top of the 5-foot-tall shelters. As indicated, the competing vegetation and the drought were the main reasons for lack of height growth.

Site 4

Seedlings planted on a 1.5-year-old clearcut. Some shelters have been installed on the "special" planted red oak seedlings for 2 years. These seedlings were planted in spring 1990 on excellent hardwood growing sites that were clearcut during July to early August before the spring planting. There were four treatments with approximately 40 seedlings per treatment. Treatments included seedlings with and without shelters and seedlings cut off at groundline with and without shelters. Data results are summarized in Table 4.

Some of the planted seedlings with shelters did reasonably well (approximately 1 foot in height growth) after the first year. In fact, from our past experience (Wendel 1980), we did not anticipate much of a height-growth response. However, at the end of the first growing season, no seedlings were above or near the top of the 5-foot-tall shelter.

After the second year, about 38 percent (15/39) of these planted seedlings were as tall or taller than the shelter. A couple of the seedlings were 6 feet or taller. For cut-off seedlings with shelters, only 12 percent (5/41) were as tall or above the shelters. At the end of the first growing season, the seedlings with shelters averaged 1.2 feet tall. The cut-off seedlings without shelters were 0.7 feet tall, no practical difference. However, after the second growing season, the cut-off seedlings with plastic shelters averaged 3 feet tall and the unprotected seedlings were 1.8 feet tall.

Site 5

Planted and natural seedlings on a new clearcut area. During the 1988-89 dormant season, a stand was clearcut on an excellent growing site (limestone soil). The following spring (1989), large 2-0 red oak seedlings from a commercial nursery were planted. These planted "carrot root" seedlings were at least 0.5 inch in diameter at the root collar (Fig. 1). At the same time, a good acorn crop occurred during the fall of 1988. This resulted in the establishment of natural seedlings on all sites throughout the local area. Thus, both planted and newly germinating natural red oak seedlings were treated. Planted seedlings were treated immediately, whereas most of the natural seedlings were at least 6 inches tall before the early May treatment.

Initial seedling treatments, singly and in combinations, included a control, black plastic mulch (4 mil) placed in a 5-foot radius around the seedling, Velpar-L applied in an 8-foot radius around each seedling including a 2-foot radius buffer, and installing plastic shelters. However, the shelters were not installed until late March before the start of the *second* growing season after planting. Likewise, Velpar-L was applied during late April of the second growing season too. Three-year treatment results for the planted seedlings are summarized in Table 5.

There was an obvious seedling response after shelters (only) were installed on both the planted and natural seedlings (Tables 5 and 6). For the planted seedlings, height growth increased about a foot annually during the 2-year measurement period after the shelters were installed (Table 5). For the natural seedlings (Table 6), height-growth increased 1.5 feet per year. The three remaining shelter treatments (plastic, Velpar, and Velpar-plastic) initially had only five seedlings per treatment. With so few samples, no statistical analyses were done. However, even with few samples, after 3 years, all treatment combinations that included a shelter averaged approximately 1.5 feet taller than the shelter-only treatment.

Table 5.—Survival and height growth of planted commercial red oak seedlings, by first, second, and third year.

	Survival, number				Height, feet		
Treatment	Initial number	First year	Second year	Third year	Initial	First year	Second year	Third year
Control	31	31	29	26	2.4	2.4	2.4	3.2b[a]
Plastic (P)	10	10	7	7	2.1	2.0	1.6	2.0a
Velpar (V)	15	15	14	12	2.4	2.5	2.2[b]	2.8b
P-V	14	14	12	12	2.5	2.5	2.0	1.7a
Shelter (S)	15	15	13	13	2.6	2.6	3.4[b]	4.6c
S-P	5	5	5	5	2.5	2.4	3.8	5.9
S-V	5	5	4	4	2.5	2.4	3.8	5.9
S-V-P	5	5	4	4	2.4	2.1	3.7	6.0

[a]Treatment means with similar column letters were not significantly different at the 0.01-percent level of testing.
[b]Plastic shelters and Velpar treatments applied in late March and April, respectively, at the start of the second growing season.

Table 6.—Survival and height growth of natural seedlings, by first, second, and third year.

	Survival, number				Height, feet		
Treatment	Initial number	First year	Second year	Third year	Initial	First year	Second year	Third year
Control	47	46	35	33	0.5	0.8	1.7	2.7a[a]
Plastic (P)	16	16	12	11	0.5	0.9	1.6	2.5a
Velpar (V)	17	17	17	17	0.5	0.8	1.3[b]	1.9b
P-V	15	14	10	10	0.5	0.8	1.1	1.7b
Shelter (S)	16	16	15	12	0.5	0.9	2.5[b]	4.3c
S-P	5	5	4	3	0.5	0.6	3.3	5.8
S-V	5	5	5	5	0.5	1.2	4.8	6.4
S-V-P	5	5	5	5	0.5	0.9	2.7	5.5

[a]Treatment means with similar column letters were not significantly different at the 0.01-percent level of testing.
[b]Plastic shelters and Velpar herbicide treatments applied in late March and April, respectively, before the start of the second growing season.

Recommendations

Overall results indicate that using shelters has potential for stimulating red oak seedling development, but we are cautious about future recommendations, because all seedling stems are not above the top of a 5-foot-tall shelter in one growing season. Also, once above the shelter, these seedlings must continue to develop height growth to compete successfully with associate vegetation.

Total conversion of Appalachian cove hardwood stands to oak is not the objective of the Fernow research. Instead, the primary objective is to retain red oak in the next stand. Establishing 15 to 20 oaks in a codominant crown class position in a 20-year-old even-aged stand would be a major accomplishment. Likewise, a similar comment could be made for perhaps other oaks, white ash, and black walnut.

For oaks, artificial regeneration in forested sites should be considered because of the uncertainty of good-to-excellent (bumper) oak seed crops. Most natural seedlings present in a mature oak stand on the better growing sites are less than 2 feet tall. A noncommercial shelterwood cut using herbicides has potential as a means of stimulating existing oak seedlings to develop without stimulating adverse competition from other vegetation such as yellow-poplar (Loftis 1990).

This early research experience indicates that installing 5-foot-tall plastic shelters increases early height growth of planted and natural red oak seedlings. Shelters have the potential for retaining red oak seedlings on the good-to-excellent Appalachian hardwood growing sites immediately following clearcutting, if these guidelines are followed:

- Use special root-pruned, 2-0 seedlings that are a minimum of 0.4 inch diameter at the root collar.

- When planting large seedlings, take care to dig a large planting hole. Roots should not be crammed into the hole because j-shaped root development can easily occur causing the seedling to grow slowly or die.

- Plant seedlings in the early spring immediately after clearcutting and install shelters immediately (within a day or two) after planting.

- Do not cut off seedling tops to less than 1.5 feet tall. Cutting off tops of seedlings at 4 and 6 inches from groundline has potential too. However, to date, the better Fernow results occurred using taller top-pruned seedlings or seedlings not top-pruned.

- Use existing advanced natural seedlings and install shelters before leafout during the spring immediately following a dormant season clearcutting. If red oak acorns germinate during the early spring after clearcutting, install a shelter on the small seedling. Although these germinating seedlings will have leaves, installing shelters early (until early-May on recently leafed out seedlings) will not kill the seedlings. However, the manufacturer of the shelters does not recommended installing shelters on seedlings that have leafed out.

- Use properly installed, 5-foot-tall shelters. This includes at least one annual maintenance check or more as necessary depending on vandalism, bear, groundhogs, deer, high wind, poor stakes, or installation procedures.

- Plant seedlings or acorns in the spring immediately following a dormant season cut and install a 5-foot-tall plastic shelter immediately on each seedling or acorn(s). This approach should help the planted seedlings-acorns get an early start on height-growth development. Also, it is not a good practice to clearcut cove hardwood stands during the early part of the growing season when a good acorn seed crop is evident. Delay cutting until the seed-bearing oaks can produce mature acorns. Good-to-excellent red oak acorn seed crops are a rare occurrence in this locale.

An herbicide treatment may be necessary to control competing vegetation. Although, at this point, it is uncertain if this treatment will always be necessary. Once above the tops of the shelters, some seedlings may continue accelerated height-growth response and compete successfully with the associate vegetation.

Although seedling height growth was increased by using plastic mulch or herbicides to control the competing vegetation, the major response occurred when using plastic shelters. Hexazinone (Velpar-L) was used with a 2-foot-radius, nontreated buffer around each seedling; however, Velpar-L moves in the soil. A safer herbicide would be trichlopyr (Garlon 3A) or, in late summer, perhaps a glyphosate (Roundup) application. Seedlings in or above the shelters should be covered with a plastic bag/rubber band until after the mistblowing spray job is complete. For the better Appalachian hardwood sites, an herbicide application may be desirable the third growing season after clearcutting. Competing vegetation is not too tall and often is not that difficult to work in at this stage. The competing vegetation would be reduced allowing the oak seedlings more time for development. Installing plastic shelters and then applying herbicide is expensive. Total cost for planting, installing shelters, and perhaps a necessary herbicide treatment will determine how many trees the landowner can afford to establish.

Although there is much concern for the flush of competing vegetation during the second and third year after clearcutting, in areas where deer are numerous, this vegetation concern may be minimal to nonexistent. For this situation, installing shelters may have even greater potential.

Our experience indicates that planting stratified acorns in the spring and immediately installing a shelter after the dormant-season clearcut has much potential in protecting acorns from predators. At this point, mammals have not been a problem in eating or pilfering the seed. However, if gypsy moths are present, larvae will rapidly defoliate young seedlings.

There has been some discussion about removing the shelters once the seedlings are above the top of the shelter. We have not done this but understand the seedlings remain rigid. Some researchers indicate they can use the same shelter two or three times. No doubt a major cost savings. Currently to plant 30 seedlings per acre and install a 5-foot-tall shelter on each seedling, the cost is about $170.00 per acre (Smith 1993). This cost is based on the following rates: $4.50 for shelter and stake, two people installing 200 shelters per day each at $7.00 per hour, and one person planting 200 seedlings per day at $7.00 per hour. Seedling cost is $0.60 each.

We believe it is possible to get an acceptable number of red oak seedlings above the 5-foot-tall shelters 1 year after clearcutting good-to-excellent hardwood growing sites. However, we are uncertain how long this rapid height growth will continue or if the seedlings will continue to compete for dominance with the associate vegetation on better Appalachian hardwood growing sites.

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