AN EVALUATION OF POLYPROPYLENE MESH TUBING AS A DEER BROWSE DETERRENT FOR SOUTHERN HARDWOOD SEEDLINGS[a]

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Abstract: Cumulative monthly browsing by white-tailed deer (*Odocoileus virginianus*) on unprotected apical leaders of oak (*Quercus* spp.) and sweetgum (*Liquidambar styraciflua*) seedlings in plantations in Southwest Alabama exceeded 100% per year. Growth of unprotected seedlings of all species was significantly less ($P < .01$) than mean growth attained in seedlings subjected to 6 protective treatments with polypropylene mesh tubing. Mortality in unprotected sweegum seedlings was greated than in protected seedlings ($P < .05$). Mortality of oak was unaffected by protection. All treatments protected seedlings from browsing deer but some interfered with normal growth due to shading or physical restriction. Sweetgum seedlings attained the greatest growth when protected by ultraviolet green polypropylene mesh tubing 7.3 cm dia. Oaks grew best when protected by 12.7 cm dia. black polypropylene tubes. Total cost in 3 x 3 m plantations for protecting sweetgum seedlings with ultraviolet green tubes was $202 per ha, whereas the black polypropylene tubes installed on oaks costs $741 per ha.

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Hardwoods constitute over 60 percent of the southern commercial forests (Sternitzke 1975) and use of them by the forest products industry is presently increasing. Of particular interest to the industry are the highly productive bottomland hardwood sites that support mature, high-quality hardwoods along most of the major southern rivers. Past cutting operations in these areas have typically left less desirable trees to form subsequent stands.

Many companies have sought to plant improved growing stock of various hardwoods to counter the problems of slow regeneration, lack of control over species composition, and frequent failure of pine (*Pinus* spp.) in these occasionaly flooded bottomland areas. However, the intensive site preparation, planting and competition control necessary to establish such stands have greatly increased initial investment costs. To make hardwood regeneraion economically feasible in these areas, factors that contribute to a reduction in the final tree crop must be minimized.

Conflict between white-tailed deer and the southern forest products industry occurs when deer browse newly planted seedlings or natural regeneration (Maisenhelder 1957, Denton et al. 1969, Harlow and Downing 1970, Johnson 1973). As intensive management of bottomland hardwoods increases, herds that approach or exceed the carrying capacity can be expected to have a detrimental influence on hardwood regeneration. Additionally, damage to some commercial species such as cottonwood (*Populus deltoides*) that are preferred browse can be expected even in areas of low deer density.

Polypropylene tubes and mesh (Vexar)[b] produced by E. I. DuPont DeNemours and Company were evaluated in the present study as a deer browse deterrent for southern hardwoods. This biodegradable plastic is preferred over polyethylene because of its greater durability and self-supporting characteristics. In addition, the rate of deterioration of the tubes varies with color and fiber thickness, permitting a predetermined protection period.

Vexar was first evaluated in 1968 (Anon. 1972) as a deer browse deterrent in the Pacific Northwest, where it afforded nearly complete protection from deer damage to

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[b]Registered trade mark: use of the name does not constitute an endorsement.

seedlings of Douglas-fir (*Tseudotsuga mensiesii*) (Campbell 1969, Campbell and Evans 1975). It has not been evaluated for hardwoods nor in areas other than the Northwest. The present study was therefore designed to evaluate Vexar sheathing as a browsing deterrent in southeastern hardwoods.

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STUDY AREAS

Three study areas were selected where the establishment of hardwood plantations was planned in areas with dense deer populations. Inadequate harvest of deer on all 3 areas has resulted in high population densities that exceed carrying capacities, (Allen 1975). The first area, on the floodplain of the Tombigbee River west of Putnam (Marengo County) Alabama, was planted in spring of 1975 with water oak (*Q. nigra*), Nuttall oak (*Q. nuttallii*), and cherrybark oak (*Q. falcata* var. *pagodaefolia*). The area was an old-field situation that had been formerly used for cotton production. Repeated deposition of alluvial material has helped to maintain its fertility. This plantation was scheduled for a long rotation to produce saw and veneer logs. The second area was a sweetgum plantation on the Alabama River, 16 km south of Carlton (Clarke County) Alabama. Established in August of 1976, the area was recently cleared of standing timber and is managed for a 15 yr pulpwood rotation. The third area, a sweetgum plantation on the Tombigbee River east of Mount Sterling (Choctaw County) Alabama, was utilized to determine installation costs of treatments used in the study.

METHODS

Vexar is available in preformed tubes of various diameters and meshes as well as in flat sheets. Largely on the basis of product availability from the manufacturer, we selected 6 treatments (Fig. 1, Table 1) for evaluation on young seedlings in recently established plantations. The control, "treatment 7" consisted of equivalent numbers of untreated seedlings. A block design previously used in testing chemical repellents (Dodge et al. 1967) was modified to suit special conditions of this study.

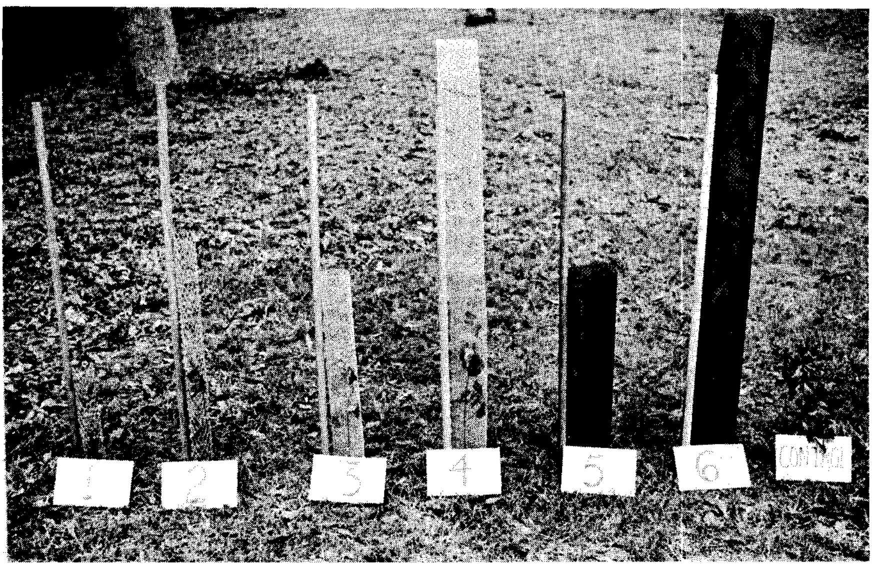

Fig. 1. Six treatments of polypropylene mesh tubing evaluated as deer browse deterrents on oak and sweetgum in southwest Alabama in 1976 and 1977.

Table 1. Dimensions, design, and expected durability of 6 treatments of polypropylene tubes tested as deer browse deterrents on southern hardwoods in southwestern Alabama in 1976-77.

Treatment Number[a]	*Length (cm)*	*Diameter (cm)*	*Mesh (cm)*	*Mesh Design*	*Expected Durability (years)*
1	38.1	5.1	1.3	Diamond	3
2	76.2	5.1	1.3	Diamond	3
3	61.0	7.3	0.6	Twill	1
4	122.0	7.3	0.6	Twill	1
5	61.0	12.7	0.6	Diamond	10
6	122.0	12.7	0.6	Diamond	10

[a]Treatments 1-4 were preformed ultraviolet green propylene and treatments 5 and 6 were black polypropylene formed into cylinders secured with twist ties.

Apical leaders of control trees were examined monthly to determine damage attributable to deer and mortality of seedlings was noted. Seedling height was measured following test installation on the Clarke County plantation and after spring green-up in Marengo County, and again at the conclusion of the study. General growth form and the extent to which apical leaders escaped laterally from tubes were also noted during final seedling measurement.

All steps in a commercial installation of the treatments were timed at the third study area in Choctaw County. This informaion was converted to man-hrs per hundred seedlings and cost per ha. Deer population density estimates based on track counts (Tyson 1952) were made during each of nine 24 hr periods on 0.4- and 0.8-km sketches of dirt road adjacent to the Marengo County study area.

RESULTS

Oaks, Marengo County: Deer browsing did not increase mortality of unprotected oak seedlings. Browsed seedlings, however, were bushy and had a hedged appearance (Fig. 2) whereas protected seedlings had apical leaders that clearly showed a dominance

Fig. 2. Hedged appearance of an unprotected oak seedling in a plantation in Marengo County, Alabama, 1977.

over other branches. Cumulative browse damage (percentage of seedlings) on unprotected oak reached 83.5 percent in 1976 and 123.5 percent by late August 1977. Most of the damage occurred from January through July in 1976, and after May in 1977 (Table 2).

Table 2. Monthly chronology and annual cumulative browsing on non-treated oak seedlings on a Marengo County, Alabama plantation during 1976-77.

Year and month[a]	*No. seedlings checked*	*Percentage of seedlings with browsed apical stems*	
		On date examined	*Cumulative*
1976			
Jan.	47	19.1	19.1
Feb.	97	16.5	35.6
Mar.	97	12.4	48.0
June	86	19.8	67.8
July	89	12.4	80.2
Sept.	89	2.2	82.4
Oct.	92	0.0	82.4
Nov.	92	1.1	83.5
1977			
Jan.	91	2.2	
Feb.	90	1.1	3.3
May	82	62.2	65.5
June	90	38.8	104.3
Aug.	83	19.2	123.5

[a]The plantation was inundated in April and May 1976 and March and April 1977.

The difference between mean growth of protected (13.4 cm) and unprotected (6.5 cm) oak seedlings was highly significant ($P < .01$). Seedlings protected by treatments 5 and 6 grew a significantly greater amount ($P < .01$) than those protected by other treatments (Table 3).

Lateral escapement in oak seedlings was related to tube diameter. Seedlings with 5.1 cm diameter tubes (treatments 1 and 2) had 57 and 58 percent lateral escapement, whereas those with 12.7 cm diameter tubes (treatments 5 and 6) had only 4 and 10 percent respectively (Table 3). Data on lateral escapement from treatments 3 and 4 were not applicable because the tubes decomposed prior to spring green-up. Tube loss during the study period on the oak plantation was less than 4 percent and evenly distributed among the treatments (Table 3).

Table 3. Growth, percent apical leader escapement and tube losses in an oak plantation in Marengo County, Alabama between 27 June 1976 and 19 June 1977.

Treatment Number	*Growth*[a] *(cm)*	*Percentage*	
		Lateral Escapes	*Tube Loss*
1	8.1	57	4
2	11.6	58	3
3	11.4	—	—
4	14.0	—	—
5	18.0	4	4
6	18.5	10	4
7 (control)	6.5	—	—

[a]Average growth for treatments 1-6 was 13.6 cm.

Sweetgum, Clarke County: Unprotected control seedlings were browsed heavily during November and December of 1976 (58.6 and 80.5%), 3 months following planting (Table 4). No new damage was discernible when seedlings were checked in January and February 1977. Following spring flooding and green-up, 4 percent of the seedlings were found browsed in June. Unprotected sweetgum seedlings average significantly less growth ($P < .01$) than protected seedlings, 18.4 versus 21.5 cm. Seedlings in treatment 3 exhibited significantly greater growth ($P < .05$) than in other treatments and those in treatment 6 significantly less growth ($P < .05$) than those in other treatments (Table 5).

Table 4. Monthly chronology and cumulative annual browsing on non-treated sweetgum seedlings on a Clarke County, Alabama plantation during 1976-77.

Year and month[a]	*No. seedlings checked*	*Percentage of seedlings with browsed apical stems*	
		On date examined	*Cumulative*
1976			
Sept.	67	3.0	3.0
Oct.	75	2.7	5.7
Nov.	75	58.6	64.3
Dec.	72	80.5	144.8
1977			
Jan.	72	0.0	0.0
Feb.	72	0.0	0.0
June	50	4.0	4.0

[a]Plantation inundated March through May 1977.

Survival of protected sweetgums at the conclusion of the study was 73.4 percent compared to 50 percent in the unprotected controls. Between September 1976 and June 1977 mortality of control seedlings (28%) was significantly higher than that of treated trees which averaged only 6 percent during the same period ($P < .05$). Unprotected seedlings were beginning to have a hedged appearance but not to the degree of the oaks in the Marengo County plantation.

Lateral escapement of apical leaders of sweetgum seedlings from tubes was inversely related to tube diameter. Escapement was 40 percent in the 5.1 cm tubes compared to only 0.5 percent in the 12.7 cm tubes (Table 5). The loss of tubes in treatment 6 during flooding was 35 percent compared to only 6 percent or less for all other treatments (Table 5).

Table 5. Growth, percent apical leader escapement and tube losses in a sweetgum plantation in Clarke County, Alabama, 18 September 1976 to 12 June 1977.

Treatment Number	*Growth*[a] *(cm)*	*Percentage*	
		Lateral escapement	*Tube Loss*
1	22.0	44	3
2	23.1	36	3
3	28.4	14	3
4	17.3	16	6
5	22.7	1	6
6	10.3	0	35
7 (control)	18.4	—	—

[a]Average growth for treatments 1-6 was 20.6 cm.

Costs, Choctaw County: The cost of treatment materials per seedling ranged from $0.055 for treatment 1 to $1.34 for treatment 6. Treatments 5 and 6 were economically prohibitive because costs exceeded $500.00 per ha. However, a 7.6 cm version of treatment 5 cost $331.71 per ha and may be economically feasible for protecting oak (Table 6).

Deer-track counts on dirt roads (Tyson 1952) averaged 37.6 per km. Assuming that the average linear distance traveled by a deer in a 24 hr period is 1.06 km (Marchinton 1968, Byford 1970), these counts would indicate a deer population of 42.7 per km^2 or 1 per 2.3 ha.

Table 6. Material and labor costs for the installation of polypropylene mesh tubes on sweetgum seedlings.

Treatment Number	*Cost[a] per tube*	*Man-hours per 100 tubes*	*Installation[b] cost per 100*	*Total cost[c] per hectare*
1	$0.06	1.5	$4.50	$ 148.26
2	0.11	1.5	4.50	202.62
3	0.09	2.1	6.21	201.73
4	0.18	2.1	6.21	292.67
5	0.67[d]	—	—	741.89
6	1.34[d]	—	—	1,404.12
5-7.6 cm. dia.	0.25[d]	1.0	3.06	331.71
6-7. cm. dia.	0.51[d]	1.0	3.06	583.75

[a]Rodger Keller, Vexar Sales, E. I. DuPont De Nemours and Company, personal communication, 1977.

[b]Hourly cost of field labor times installation time.

[c]Total cost per hectare for 988 seedlings spaced at 3 x 3 m intervals.

[d]Tubes can be formed at a rate of about 100 per hour or $0.03 each for 12.2 cm tubes.

DISCUSSION

When mature hardwood stands are cut, coppice and naturally seeded regeneration may be heavily browsed by deer in many areas of the Southeast. Although regeneration is usually sufficient for adequate stocking, particularly when large tracts are involved, growth and species composition may nevertheless be affected where the species in the stand are highly palatable. Seedlings in cultivated plantations may also sustain browsing damage that can adversely affect growth rate, survival, tree form, and stand density.

The major effect of browsing on oak seedlings was the suppression of their growth. If the present herd densities are maintained and no protection is provided the seedlings, repeated browsing will continue to retard growth. Such retardation combined with the hedged appearance observed in 1977 could be long-lasting (McNeil 1964).

The most important influence of browsing on sweetgum seedlings was a significant increase in seedling mortality ($P < .05$). Heavy browsing in November and December resulted in 28 percent mortality in the unprotected trees by the following spring as opposed to 6.1 percent in the protected trees. The extent of browsing at this time and its resulant mortality may be attributable to persistent leaves and soft stems that remained succulent longer than usual because of late planting.

The 5.1 cm dia. tubes of treatments 1 and 2 were highly susceptible in both sweetgum and oak seedlings, to lateral penetration by apical leaders, which exposed them to browsing. This was probably due to the restrictive diameter of the tubes which combined with the large mesh, may have been conducive to escapement. Oak seedlings treated with these tubes exhibited below average growth.

Sweetgum seedlings attained greatest growth in treatment 3 tubes; however, growth in oak seedlings was less than the average of all other treatments. Additionally, due to the rapid biodegradation rate of treatment 3, slow growing species such as cherrybark oak (51 cm in 3 years, McKnight 1968) were not provided adequate protection. Sweetgum, however, with a possible growth rate of 1 m per year (McKnight 1968) may receive adequate protection from these tubes to grow above browsing deer prior to biodegradation.

Treatment 4 appeared to suppress sweetgum growth possibly because of a tendency of the tube to fold over at the highest point of attachment to the support, creating a physical barrier to the seedling. Its rapid biodegradation limits its effectiveness in protecting slow-growing oak seedlings.

Data from field performance indicate that the black polypropylene used in treatments 5 and 6 is superior to ultraviolet green for oaks. Growth of sweetgum seedlings may be adversely affected by shading from the taller (treatment 6) tubes (Tables 4 and 6). Oaks were apparently not suppressed by the shading effect of the black tubes, and their greater durability (10 yrs) makes them better suited for species with slow initial growth.

Although oaks in treatments 5 and 6 attained the best growth, costs were prohibitive. The smaller 7.6 cm dia. tubes in treatment 3 and 4 caused no growth retardation attributed to restriction or lateral escapement. Therefore it may be possible to obtain adequate protection at a cost of $5.50 per ha per year during a 60 year rotation through use of a smaller (17.6 cm dia.) version of the tubes used in treatment 5. If preformed, 7.6 cm dia. tubes were available in black polypropylene that could be reused for establishment of as many as 3 oak stands, costs could be reduced to $134.36 per ha. This would amount to $2.24 per ha per year over a 60 year rotation period.

The obvious solution to typical browsing damage problems in oak and sweetgum regeneration is herd reduction, and landowners that fail to heed harvest recommendations can expect browsing damage problems to persist. For those that wish to maintain herd densities above carrying capacities, hardwood regeneration can be accomplished with the added expense of protective polypropylene sheathing until seedlings grow beyond the reach of browsing deer. Experience with the long-range effects of retarded growth will probably be necessary to reach a conclusion as to when application of this protection technique is warranted. At the point which increased rotation length reduces the annual profit margin by more than the prorated annual cost of protection, these protective treatments become economically feasible.

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