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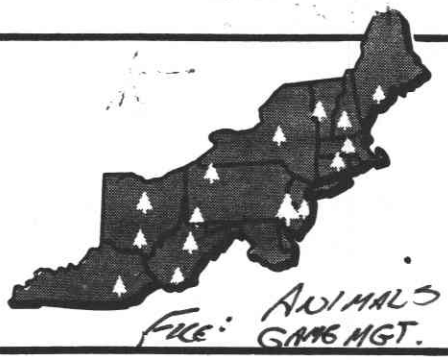

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THE EFFECT OF DEER EXCLOSURES ON THE RECOVERY OF VEGETATION IN FAILED CLEARCUTS ON THE ALLEGHENY PLATEAU

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Abstract. In 6- to 10-year-old clearcuts that had failed to regenerate naturally, fencing was erected to protect seedlings from deer browsing. The fencing allowed the gradual recovery of the forest cover. Small seedlings that otherwise would have been browsed continued to grow, and ground cover species such as *Rubus,* which reduced ferns and grasses that sometimes interfere with seedling development, were reestablished. Fencing alone is likely to promote satisfactory restoration of forest cover only in failed clearcuts that contain adequate numbers of seedlings initially—few new seedlings became established after fencing.

REGENERATION FAILURES

Regeneration sometimes fails after harvest cutting on the Allegheny Plateau of Pennsylvania as a result of excessive deer browsing, (Marquis 1975a, Jordan 1967, Shafer and others 1961, Grisez 1957, Bennett 1957, Frontz 1930). Most such failures can be avoided by limiting cutting to stands that contain abundant advance seedlings, or by using shelterwood techniques (Marquis and others 1975). But regardless of the care used in prescribing cuts, there continue to be a few regeneration failures.

Once regeneration fails, ecological changes occur that make it increasingly difficult to establish tree seedlings. Any viable seed buried in the forest floor generally germinates during the first 3 or 4 years after cutting (Marquis 1975b). Thereafter, seed sources become limiting to further seedling establishment. Herbaceous vegetation often becomes established and some kinds of herbs can interfere with the growth and development of any seedlings present (Horsley 1977a, 1977b). Deer browsing also continues to restrict seedling growth, and artificial regeneration with hardwoods is not feasible unless the seedlings are also

protected from browsing (Marquis 1977, Marquis and others 1976).

Recently clearcut areas will usually regenerate naturally if they are protected against browsing soon after cutting while there are still numerous seeds and seedlings present, and before herbaceous vegetation has become well established. To determine whether natural regeneration would develop in older failed clearcuts if protected, we studied the effect of fencing on the development of vegetation in areas that had failed to regenerate 6 to 10 years earlier.

METHODS

Four clearcuts that had failed to regenerate were selected in 1971. Two were about 6 years old; one was 8 years old, and the other 10 years old. Within each clearcut, eight pairs of 6-foot-radius (1/385-acre) plots were established, and one of each pair was fenced to exclude deer. Tree seedlings and sprouts were tallied on all plots by species and size class, and herbaceous vegetation was recorded as a percentage of the ground surface covered. Vegetation tallies were made when the study began and again in 1973, 1975, 1977. A test for paired plots was used to determine significant differences between fenced and unfenced plots. Relationships between regeneration stocking at the beginning and at the end of the study were examined with regression analysis.

RESULTS

Seedling development

There was a general decline in the number of seedlings throughout the 6-year study period. The decline in black and pin cherry was significantly greater on the unfenced than on the fenced plots. Differences were not significant for the other species, but the differences for the two cherries were large enough to result in a significantly smaller overall decrease on the fenced plots (Table 1).

Table 1.—Total number of seedlings per acre in fenced and unfenced plots in 6-year study

Species	1971	1973	1975	1977	Change, 1971 to 1977
Black cherry					
Fenced	2,000	2,350	1,750	2,025	+25
Unfenced	3,425	3,475	2,550	1,925	−1,5000*
Red maple					
Fenced	1,400	1,425	785	1,125	−275
Unfenced	1,225	3,725	2,300	1,075	−150
Birch					
Fenced	350	50	175	100	−250
Unfenced	175	250	650	125	−50
Beech					
Fenced	1,125	450	250	500	−625
Unfenced	650	375	275	450	−200
Pin cherry					
Fenced	700	175	150	375	−325
Unfenced	2,200	750	225	125	−2,075*
All desirable species[a]					
Fenced	3,400	3,775	3,125	3,175	−225
Unfenced	4,850	7,000	4,900	2,975	−1,875*
All commercial species[b]					
Fenced	5,050	4,450	3,625	3,775	−1,275
Unfenced	5,725	7,650	5,825	3,355	−2,370*
All stems					
Fenced	6,000	4,725	3,925	4,400	−1,600
Unfenced	6,650	8,750	6,625	2,782	−3,868*

[a] Black cherry, red maple, sugar maple, white ash, yellow-poplar, red oak, cucumber tree.
[b] Above species, plus beech, yellow birch, black birch, eastern hemlock.
* Statistically significant at 0.05 level.

Occasional new seedlings of several species were established each year. The most important such occurrence was the result of a bumper seed crop of red maple in 1973 in the stand adjacent to one of the four clearcuts. These red maple seedlings appeared most abundantly on the unfenced plots, apparently because the dense growth of *Rubus* spp. on the fenced plots precluded new seedlings there. But these increases were temporary and relatively unimportant compared to the overall decrease in seedlings.

Before fencing in 1971, there were comparatively few seedlings over 1 foot in height. Most were new, or slow-growing seedlings, or stems that had been repeatedly browsed. Over the 6-year period, the number of stems over 1 foot tall increased in both treatments, but the increase was considerably larger in the fenced plots (Table 2).

The proportion of plots stocked with at least one stem 1 foot tall, and the proportion stocked with at least one stem 3 feet tall were considerably higher for the fenced than the unfenced treatments by the end of the study in 1977 (Table 3).

The age of the clearcut seemed to have an impact on the regeneration. At the start of the study, 8- and 10-year-old clearcuts had fewer seedlings and fewer stems over 1 foot tall, and at the end of the study, they had fewer plots stocked with stems over 1 and 3 feet tall than the two 6-year-old clearcuts (Table 4). No statistical tests were run since there were only two clearcuts in each age group.

Fencing did not result in a dramatic recovery of tree vegetation in these failed clearcuts. With a few exceptions, the number of seedlings continued to decline in spite of the fencing, although protection from browsing reduced the rate of decline; more seedlings survived in fenced than in unfenced areas.

The major effect of fencing on seedling regeneration has been an increase in height growth of the surviving seedlings. In 6 years, 56 percent of the fenced plots contained a desirable stem over 3 feet tall, and 84 percent contained a desirable stem over 1 foot tall. Although these amounts of stocking would not be nearly adequate to develop satisfactory regeneration in unfenced areas, they may eventually permit these fenced areas to revert to forest cover. Some unfenced areas may also recover, but the process will be much slower, and the resulting stands less adequately stocked.

There was a definite relationship between the number of seedlings (or the stocking) before fenc-

Table 2.—Number of stems per acre over 1 foot tall in fenced and unfenced plots in 1971 and 1977

Species	Fenced		Unfenced	
	1971	1977	1971	1977
Black cherry	325	1,575	700	1,475
Red maple	25	450	25	75
All desirable species	400	2,150	725	1,550
All commercial species	825	2,600	975	1,725
All stems	900	3,075	1,175	1,875

Table 3.—Proportion of fenced and unfenced plots stocked with at least one stem 1 foot tall and one stem 3 feet tall in 1977 (in percent)

Treatment	Percent of plots with:			
	Black Cherry	Red Maple	All desirable species	All commercial species
	1+ FEET TALL			
Fenced	69	44	84	84
Unfenced	28	9	34	47
	3+ FEET TALL			
Fenced	50	22	56	66
Unfenced	16	0	16	25

Table 4.—Effect of age of clearcut on stocking of desirable stems in fenced and unfenced plots, by number of stems and percentage of plots

Treatment	Clearcut	
	6-year-old	8- to 10-year-old
	STEMS IN 1971	
Both	5,500	2,750
	STEMS 1+ FEET IN 1977	
Fenced	3,200	1,100
Unfenced	3,100	0
	PLOTS WITH STEM 1+ FEET IN 1977	
Fenced	88	75
Unfenced	69	0
	PLOTS WITH STEM 3+ FEET IN 1977	
Fenced	76	38
Unfenced	32	0

ing and the stocking 6 years after fencing. The more seedlings present initially, the better the chances for the reestablishment of a forest cover. Of numerous stocking criteria tested, the percentage of plots that contained at least four seedlings of desirable species per plot before fencing was more closely related than any other parameter to the percentage of plots stocked with at least one desirable stem over 3 feet tall 6 years later. An r^2 value of .82 was obtained for this regression.

Although only four stands were represented in this study, the above relationship can serve as a crude guide to the feasibility of fencing in a failed clearcut. If a regeneration survey indicates that 70 percent of the 6-foot-radius plots sampled contain at least four desirable seedlings, then one could expect the area to be at least 70 percent stocked with desirable stems over 3 feet tall 6 years later. If less than 70 percent of the plots are stocked with four stems initially, the chances of obtaining full stocking within a reasonably short time from fencing alone are less; artificial regeneration may be required in addition to fencing in such areas.

Since the number of seedlings declines over time, older clearcuts can be expected to have fewer seedlings—as did the four clearcuts studied here. An early identification of potential regeneration failure followed by the prompt erection of fences will therefore improve the chances of forest vegetation to recover.

Ground cover changes

Changes in the ground cover after fencing were far more dramatic than changes in seedling vegetation (Table 5). Before fencing, there was little *Rubus*[1] present; most plots were dominated by ferns or grasses. Within 2 years after fencing, *Rubus* seemed to dominate many plots, and continued to increase gradually. On plots where *Rubus* developed, the fern and grass declined.

Deer browsing obviously has a major impact on the ground cover in clearcut areas. Preferred species such as *Rubus* are virtually eliminated by browsing, and are soon replaced by ferns and grasses. These latter plants have been shown to reduce seedling growth and survival by release of toxic biochemicals (Horsley 1977a, 1977b). Thus, browsing has indirect effects on tree reproduction in addition to the direct damage to seedlings.

[1] Mainly blackberry (*Rubus allegheniensis*). Raspberry (*Rubus idaeus*) was also present on one area.

Table 5.—Percentage of plots with a particular dominant ground cover in 6-year study

Treatment	1971	1973	1975	1977	Change (1971-1977)
			GRASS		
Fenced	56	41	25	19	− 37
Unfenced	59	69	47	44	− 15
			FERN		
Fenced	38	6	10	13	− 25
Unfenced	38	20[a]	38	41	+ 3
			TALL HERBS		
Fenced	3	6	9	9	+ 6
Unfenced	0	3	9	13	+ 13
			RUBUS		
Fenced	0	41	50	59	+ 59
Unfenced	0	6	3	3	+ 3

[a] Some of the decline in ferns in 1973 is the result of a heavy June frost.

Fencing permits rapid recovery of *Rubus,* and, by reducing fern and grass, may eventually provide a more favorable environment for the recovery of tree species as well.

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