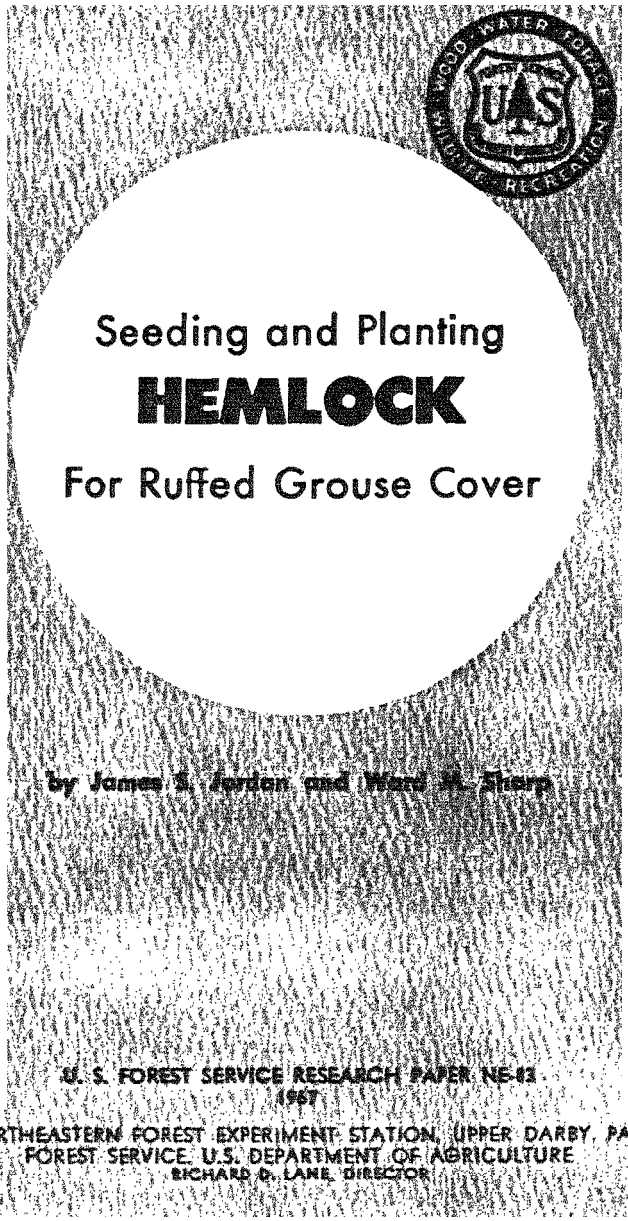

Seeding and Planting
HEMLOCK
For Ruffed Grouse Cover

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NEEDED: MORE REGENERATION

EASTERN HEMLOCK is an important cover species for ruffed grouse, turkeys, deer, snowshoe hares, and rabbits. The extensive range of hemlock in the Northeast and its silvical characteristics of shade tolerance, relatively slow growth, and feathery full foliage *(Hough 1960)* make it unequaled in value among our native conifers as a shelter species for game. Mixed woods of young hardwood-hemlock are reported to be the best all-purpose grouse cover, and all-age groups of hemlock comprising 20 to 70 percent of the crown cover provide food and shelter for all seasons — although the use of this cover type by grouse is slight in summer *(Edminster 1947)*.

The history of hemlock for the past several decades includes widespread cutting without replacement in the stand, mortality of young trees from wildfire, and elimination from stands where it competes for space with commercially more valuable hardwood species. One of the most effective deterrents to the natural regeneration of hemlock in recent times is the mortality of seedlings from deer browsing in areas of high deer populations.

These factors, when added to that of the rather rigid moisture requirements of hemlock for germination and early growth *(Olson et al. 1959)*, have reduced its abundance and effective density for forest game in many areas of the Northeast.

The reduction in hemlock density is most striking in the northern hardwood type of Pennsylvania. For example, on the Allegheny National Forest the deficiency of hemlock and other conifers is an important obstacle to habitat management for

Figure 1. — A savanna-type stand in the study area in the foreground. Tree and shrub reproduction in this type is heavily browsed by deer.

grouse and other small game species *(U. S. Forest Service 1963)*. In areas like this there has been very little natural re-establishment of hemlock — nor is re-establishment very likely to happen as long as deer populations remain at their present high level.

But artificial seeding or planting to re-establish hemlock for grouse cover may be a justifiable alternative to natural regeneration if it is done in selected areas — even if the seedlings must be protected from heavy deer browsing. Should such a program be considered, important prerequisites in planning should include not only the selection of areas that have a good potential as grouse habitat, but also the selection of sites within these areas that are favorable for the growth of hemlock.

This is a report on the results of seeding and planting tests with hemlock under different aspects, stand types, and site preparation to determine what conditions are most favorable for artificial regeneration.

THE STUDY

Location

The tests were made in a 400-acre study area in the northern hardwood type on the Allegheny National Forest in northwestern Pennsylvania. Much of the study area is in hardwood poletimber stands, except for a grading-off from these stands to orchard-type poletimber stands and an open savanna type of vegetation.

The poletimber stands are mostly 20 to 60 years old. Approximately 68 percent of the total forest acreage is in these stands. There is no formal definition for the orchard type; it is understocked with trees that are generally of poor form, and the understory is primarily a mixture of grasses and forbs that persist for many years. The ground vegetation receives shade from the overstory for some part of each day. The savanna type of stand has scattered distribution of trees and shrubs on the lower slopes and up through several of the side drainage areas (figs. 1 to 3).

Figure 2. — An orchard-type stand showing young, poorly formed black cherry trees. Many orchard stands are more thinly stocked than this one.

Figure 3. — A hardwood poletimber stand in the 20-40-year-old age class. Such stands provide little shelter for grouse.

Approximately 45,000 acres on the Allegheny National Forest and 95,000 acres in both state and federally administered forests in the Allegheny Plateau of northwestern Pennsylvania are in the savanna and orchard types. The savanna type and the more thinly stocked stands in the orchard type are choice fawning areas for deer as well as preferred brood range for ruffed grouse and turkeys. Cottontails and snowshoe hares also frequent such areas as a source of food in preference to closed-canopy forests. These areas, when occurring in blocks of more than a few acres, have been generally regarded as problems in growing timber. But the value of many of these areas for wildlife may outweigh the loss in potential production of wood fiber.

Source of Seeds and Seedlings

The seed source for the tests was the Nepaug State Forest in northwestern Connecticut. The viability of the seed was estimated by the supplier to be 65 percent. The seeds were moistened and stratified for 35 days after delivery in polyethylene bags at

temperatures of 36° to 40° F. This brief period of stratification probably resulted in some improvement in the rate of early germination. Olson *et al. (1959)* recommended stratification for 2 to 3 months.

The hemlock seedlings, 5 to 9 inches high, were 3-0 commercial stock from a western Pennsylvania nursery. Seedlings were transferred upon delivery to cold storage, from which the daily planting supply was withdrawn.

Experimental Design and Methods

Three aspects (north slope, south slope, and bottom) were selected for seeding and planting tests. There were three blocks for each aspect, and each block contained three stand types (savanna, orchard, and poletimber). Each stand type was randomly selected from those available at each block location.

In each savanna and orchard stand, one planting-site treatment was assigned at random to one of two plots. One plot was rototilled to a depth of 12 to 16 inches in a circle about 2 feet in diameter at the planting spot to break up the soil and eliminate the deep sod, and thus reduce the competition of other species with the seedling. The other plot was left undisturbed. No ground treatment was applied in the poletimber stands. Instead a single plot was left untreated in each stand.

The seedlings were planted in five rows of six seedlings each at a spacing of 6 X 6 feet. A mattock was used to form the planting hole.

Single seed spots, about 6 feet square, were also rototilled in the open and orchard types. The seed spot in the poletimber was lightly raked clear of undecayed leaves. A total of 500 seeds was broadcast on the seed spot.

Seeding and transplanting were done during the first week of May 1963. The number of germinates and the number of seedlings surviving were determined in mid-July, and both seedling survival and height growth were measured in mid-November 1963. Observations in selected blocks were continued through 1966.

Objectives

The study was designed to test the following null hypotheses:

- That there would be no significant difference in the effect of aspect and stand type on the number of first-year germinates on the treated seed spots in the open and orchard types.
- That there would be no worthwhile differences in the number of first-year germinates on the raked seed spots in the pole-timber type and the number on the rototilled spots in the open and orchard types.
- That there would be no significant differences in the effect of ground treatment on the survival and height growth of seedlings planted in the open type and seedlings planted on the orchard type within each combination of aspect and stand type.
- That there would be no significant difference in the effect of aspect and stand type on the survival and height growth of seedlings in the untreated spots in all of the stand types and aspects.
- That there would be no significant difference in the effect of aspect and stand type on the survival and height growth of seedlings in the rototilled spots in the open type and seedlings in the rototilled spots on the orchard types in all of the aspects.

Analysis

The analysis planned for comparing the results of the seeding experiment was found to be unnecessary, and only inspection of the data was required for drawing conclusions.

The design of the experiment for comparing the effects of ground preparation on the survival and height growth of seedlings provided for a separate analysis of variance for a randomized-block design for each of the six combinations of aspect and stand type (open and orchard):

Source of variation	*d.f.*
Total	5
Block	2
Ground treatment	1
Error	2

For comparing the effect of aspects and stand types on the survival and height growth of seedlings the design provided for the analysis of variance using the three untreated plot observations within the nine aspect-stand type combinations:

Source of variation	*d.f.*
Total	26
Aspect	2
Error (a)	6
Stand type	2
Error (b)	16

Aspects and stand types (open and orchard) were again compared by analysis of variance, using the two rototilled plot observations within the six aspect-stand type combinations:

Source of variation	*d.f.*
Total	17
Aspect	2
Error (a)	6
Stand type	1
Error (b)	8

The 5-percent level of significance was specified in testing the hypotheses about statistical differences in the yield of germinates and in seedling survival and height growth.

Statistical inferences from the study were limited to the experimental area and, in a more strict sense, to the particular aspects and stand types where seeding and planting were done. The conditions of the study appeared to be representative not only of those on the study area, but also of those in the northern hardwood type on the Allegheny National Forest. Thus general inferences drawn from the results of the study can be applied to the Forest. And they should also find application in other areas of the Northeast where there are similar stand types or conditions.

RESULTS AND DISCUSSION

Seeding

The rate of germination and the yield of germinates in each of the three stand types in all aspects were low (table 1). Seeding in savanna areas after rototilling was a complete failure. Rototilling may even have had an adverse effect on germination by exposing the seeds to earlier drying. Success was only slightly better in the orchard type, where the overstory provided shade for a part of the day. However, by late summer it was too difficult to locate germinates in the open and orchard seed spots to have confidence in the results. By the second growing season after seeding, a rank growth of sedges had invaded each spot and apparently had completely captured these spots.

It is doubtful that success would have been better had no ground treatment been applied, because the density of the undisturbed vegetation and the thick sod present a rigorous environment for a species so demanding in its moisture requirements.

The hypothesis that there would be no worthwhile differences in the number of first-year germinates on the raked seed spots

Table 1. — *Yield of germinates per acre and rate of germination in hemlock 2 months after seeding in spots at the rate of 4½ pounds per acre*

Aspect	Stand type			Average	Rate
	Open[1]	Orchard[1]	Pole[2]		
	No.	*No.*	*No.*	*No.*	*Percent*
North	0	4,400	34,100	12,900	2.1
South	0	8,900	12,500	7,100	1.1
Bottom	0	1,200	15,800	5,700	.9
Average	0	4,800	20,900	8,600	—
Rate (percent)	0	0.8	3.3	—	1.4

[1] Seed spots rototilled.
[2] Seed spots raked.

Table 2. — *Percent of survival in hemlock seedlings 6 months after transplanting in different stand types and aspects without ground preparation*

Aspect	Stand type			Average
	Open	Orchard	Pole	
North	93	100	96	97
South	92	96	98	95
Bottom	92	91	92	92
Average	92	96	95	—

in the poletimber and the number on the rototilled spots in the pen and orchard types was partially disproved.

Relative success was encountered in seeding in the pole stand ype where the spots were lightly raked to expose the humus. The roduction of about 34,000 germinates per acre on the north lope in this type was more than twice that on the south slope nd bottom, although the germination rate was only 5.6 percent. ut general observations of these seed spots in the pole stands luring the second year showed that most of the small hemlocks ad disappeared.

Seeding immediately after the disappearance of snow cover, ossibly in early April, and with a longer period of seed strati- ication, would be preferred over the methods used here, in which stratification was limited to 35 days and seeding was delayed until May.

eedling Survival

The overall survival rate of seedlings when measured 2 months fter planting was 98 percent. By mid-November the overall sur- al rate was 95 percent. The ground treatment had no significant ffect on the rate of survival of seedlings planted in the open type nd in seedlings planted in the orchard type within each of the hree aspects.

The aspect and stand type did not affect the survival rate ppreciably. The rate of survival on the untreated plots was 94

percent. Among these plots, the greatest difference in survival rates between aspects and between stand types was 5 percent and 4 percent, respectively. None of these was found to be significant. The highest survival rate (100 percent) was found in the orchard type on the north aspect.

On the treated plots, the overall survival rate was 96 percent. Again, survival was only 4 percent higher in the orchard type than in the open type. There was virtually no difference in the survival rates between aspects.

Seedling Height Growth

The pattern of height growth of the seedlings in general followed that of the survival rate. When measured in mid-November, there was no significant difference between the height growth of seedlings on the rototilled plots and those on the check plots within any of the six combinations of a single stand type and aspect. But inspection of the height-growth data for these six comparisons showed that although the difference in each case was small and unimportant, there was an opposing consistency in the difference within stand types:

Stand type	*Average height growth*	
	Check (feet)	*Rototilled (feet)*
Open	0.72	0.69
	.65	.60
	.67	.69
Orchard	.65	.89
	.75	.79
	.72	.73

As shown above, in two out of three instances in the open type, the removal of the competing vegetation by rototilling resulted in less growth than that of seedlings on the check plots. Probably any benefit from the elimination of competing vegetation was offset by the harmful effects of full exposure of the seedlings to sunlight and subsequent drying. But in all instances of rototilling in the orchard type, the growth of seedlings was greater than the growth of those on the check plots. The com-

Table 3. — *First-year height growth for hemlock seedlings transplanted without ground preparation in 3 stand types within each of 3 aspects*

Aspect	Stand type			Average
	Open	Orchard	Pole	
	Inches	*Inches*	*Inches*	*Inches*
North	8.7	10.2	8.4	9.1
South	8.0	8.7	8.8	8.5
Bottom	7.8	9.0	8.4	8.4
Average	8.2	9.3	8.5	8.7

peting vegetation was removed as in the open stand, but the orchard stand provided enough cover foliage to prevent the sunlight from drying the seedlings.

Although the differences between the height-growth data for ground treatments were not statistically significant, the data were not combined because of the apparent interaction of the effects of eliminating the competing vegetation and the effects of increasing light intensity and high temperatures. Of the two effects, light intensity seems to have the greater influence on the growth of hemlock seedlings.

When compared among aspects, the average height growth of seedlings on the untreated plots was greater on the north slope than on either the south slope or on the bottom (table 3) but the difference was not significant. The difference in growth of seedlings between the south slope and the bottom was negligible.

Among the stand types, the growth of seedlings was significantly better in the orchard type (table 3). There was no worthwhile difference in height growth between the open and pole-stand types. The highest growth rate (10.2 inches) occurred in seedlings in the orchard type on the north slope. Apparently this combination of stand type and aspect provided the most favorable conditions of partial shade from the overstory and a reduced daily period of direct sunlight, both resulting in optimal light and temperature conditions.

The height growth of seedlings on the rototilled plots in the open and orchard types for all aspects followed approximately the same pattern as that on the untreated plots. Growth was significantly better in the orchard type (9.6 inches) and highest in the seedlings on the north slope in this type (10.7 inches), although the latter difference was not significant.

Supplementary Observations

The depth of color of the foliage of seedlings was strikingly different among the three stand types. It varied from dark green in the pole stands to a lighter green in the orchard type to a pale green or a chlorotic yellow-green in the open.

These differences in color indicate that the similarity in average height growth between seedlings in the open and pole stands (table 3) was the result of a coincidence in the effects of opposing factors. In the pole stand, the relatively slow growth probably was due to environmental conditions of a good moisture supply but heavy shade, while in the open type slow growth was probably the result of full exposure to light, but accompanied by higher temperatures and excessive drying. The best balance between moisture, temperature, and light for the seedlings apparently occurred in the orchard type.

The seed spots were re-examined 3 years after seeding, before the annual regrowth of sedges and grasses reduced the accuracy of seedling counts. The examination confirmed the earlier finding that seeding failed completely in the open type. And, as expected, there was a high rate of loss (90 percent) in seedlings in the poletimber type in all aspects.

But contrary to expectations, the number of seedlings in the orchard type had increased from the initial average rate of 4,800 germinates per acre to 6,400 per acre. All of this increase occurred within the north and south aspects. The yield in these two aspects was 6,000 and 12,100 seedlings per acre, respectively — a high rate of density after 3 years and possibly enough to justify consideration of seeding as a management procedure in restocking hemlock.

Although the increase that occurred in the number of seedlings

may have been due to some natural seeding into the seed spots, it is more likely that germination from the initial seeding was delayed until the second and third growing seasons.

Hazards

One hazard in planting hemlock in open areas—except on north-facing slopes—occurred in the first year after a late heavy frost. The frost came after the first surge of spring growth, with the result that the new foliage on the twig tips thawed rapidly in the full sunlight and browned-off in varying amounts in 52 percent of the seedlings located on the south slopes and bottoms. Only 7 percent of the seedlings on the north slope were so affected.

By the fall season after planting, it was apparent that the seedlings would have to be protected from deer browsing; the incidence of browsing for all locations by November averaged nearly 14

Figure 4. — Protection against heavy deer browsing by fencing is necessary to establish hemlock cover for grouse on the Allegheny National Forest. This fence protects an experimental planting of hemlock in an orchard-type stand.

percent. Galvanized 21-wire poultry fence, 58 inches high, was erected at this time around all plots within four of the nine blocks in the study (fig. 4). Trees were used instead of metal posts whenever convenient. In November 1964, one year later, the incidence of deer browsing on seedlings in the unprotected plots had risen to 42 percent.

The height growth of hemlock protected from browsing on the untreated plots followed a pattern like that found in the first year after planting. The average growth for all of these seedlings was 8.2 inches. The best growth (11.5 inches) was again attained in the orchard stand on the north slope. The poorest average height growth (6.6 inches) occurred in the open plots for all aspects.

Survival rates for the fenced and unfenced seedlings, regardless of ground preparation, were determined in June 1965, approximately 2 years after planting (table 4). The survival rate for all seedlings protected from deer browsing was highest in the orchard type and lowest in the open type. The differences in rates of survival between protected and unprotected seedlings were

Table 4. — ***Percent of survival in hemlock seedlings protected and unprotected from deer browsings during the second year after planting in different stand types and aspects***

Item	Protected[1]	Unprotected[1]	Loss from deer browsing
	Percent	*Percent*	*Percent*
Aspect:			
North	77	66	11
South	79	77	2
Bottom	87	62	25
Stand type:			
Open	64	50	14
Orchard	94	88	6
Pole	88	86	2
All	81	72	9

[1] Averages from 4 blocks.

attributed to mortality from deer browsing. The loss of seedlings from this cause appeared to be highest in open areas in the bottom.

In late 1964, two management-size plantings of 3-0 hemlock seedlings were made in the orchard type on the study area. A spacing of 10 x 10 feet was used. The dimensions of the areas were 100 x 330 feet and 100 x 470 feet. The following year both areas were fenced with the same material that was used to protect the experimental plantings. Erected by management personnel, the direct cost per foot of fence, including labor and materials, was 28 cents. The total cost of fencing the smaller planting was $241.00; the cost for the larger one was $319.00.

Costs

The cost of seed used in the study was $45.00 per acre. This is derived from a cost of $10.00 per pound for seed collection, and seeding in the study at a rate of 4½ pounds per acre.

Planting costs may be competitive with the cost of seeding; the results of planting may be more predictable, and planting may impose fewer restrictions on the choice of sites. In a recent machine-planting of seedlings of mixed species on the Allegheny National Forest, the cost per acre of planting 125 acres was $44.25. This included all direct costs. Hand-planting costs are not known, but it is expected that they would be higher. Hand-planting of hemlock for grouse cover would be required in poletimber stands and in most orchard-type stands because of the difficulty of maneuvering machine equipment.

CONCLUSIONS

The high survival and growth rates of hemlock seedlings planted in the orchard type — and the report by Edminster *(1947)* that a mixture of hardwoods and hemlock is the best all-purpose type of grouse cover—indicate that the orchard type is the first choice among the three stand types for the re-establishment of hemlock cover. The higher growth rate in this type is clearly an advantage in establishing effective cover in the shortest time. The rates of annual growth found in this study indicate that useful cover for grouse would be available about 5 years after planting,

or when the trees are about 5 feet high. Roosting cover would be available about 3 years later when the trees reach a height of 7 to 8 feet.

The minimum spacing suggested in planting seedlings in the orchard type is about 10 x 10 feet (435 stems per acre) to allow the retention of foliage on the lower branches. The size of planting area need not be large; it is suggested that the form be rectangular, about 100 feet wide and not less than 300 feet long. Grouse tend to utilize the exterior margins of coniferous cover but probably require the security of at least 300 feet in which to move when disturbed.

The number of such blocks that would be required, as well as their distribution in a unit of grouse range, will depend upon the size and arrangement of other essential habitat components, a subject outside the scope of this report. It should be emphasized that a planting program for hemlock permits considerable flexibility in the choice of sites within the stand type, and hand-planting of hemlock is required to preserve this flexibility, and indeed to increase it.

The survival, growth rates, and appearance of hemlock seedlings planted in the poletimber stand make this type the second choice for cover establishment. The advantage of having a higher proportion of hardwoods in the future hemlock-hardwood stand might well make it a first choice, although some degree of thinning of the hardwoods several years after planting would be necessary to release the hemlock and preserve the full growth of foliage to the ground level. A suggested spacing of seedlings in this type is about 12 x 12 feet (300 stems per acre) to accommodate the inclusion of a large number of hardwood stems. The minimum width should be about 100 feet — the same width suggested for the orchard type.

The selection of either the orchard or poletimber type — or both — for planting will depend upon their availability, size, and distribution in relation to other essential habitat components in the area selected for cover establishment.

There seems to be little necessity to utilize openings for planting hemlock cover. The tests in this study gave marginal to poor

results. Also, the advantage of having a mixture of hemlock and hardwoods would be lost by solid plantings of hemlock in this type.

It is expected that other game species would also benefit from the establishment of hemlock cover. Therefore the cost of establishment may be justifiably distributed in proportion to the increase in benefits to other species if these benefits are desired. Equally important, the cost of planting should be allocated to the total area improved or made more attractive to grouse because of the establishment of cover. For example, a 1-acre planting may result in an increase in use by grouse of 60 acres in the vicinity of the new cover planting.

Seeding of hemlock in the orchard type under the conditions of this study gave encouraging results, especially in stands on the south aspect. But longer stratification of seed to hasten germination, and seeding early in the spring—especially in poletimber stands — should be tested before a judgment is made about the success of this method for establishing hemlock cover.

Where deer browsing pressure is high, seedlings should be protected from deer browsing. Fencing costs per unit of cover established may be justified if cover is the limiting factor and intensive management for grouse is a planned objective.

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