Reforestation in the Spruce Type in the Southern Appalachians

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Because of soil and climatic conditions, red spruce is the only timber-producing species available on a considerable portion of the original type. The lack of spruce seed precludes natural reforestation for a very long time. In lieu of complete planting, it is suggested that strategically located seed-source plantations be established. Mainly because of heavy vegetative competition, reforestation is a difficult and costly job. Success has often been poor or indifferent, but may be increased by release treatments and possibly by the use of fire and grazing.

THE task of reestablishing spruce forests on some 1,500,000 acres[2] of devastated land in the southern Appalachians in West Virginia, Virginia, North Carolina, and Tennessee, originally occupied by red spruce (*Picea rubra*) and southern balsam fir (*Abies fraseri*), has hardly begun. Hardwood reproduction, which now covers much of the spruce type, will develop into a satisfactory timber crop on the better sites and at the lower elevations, but not on the thin-soiled, rocky sites, especially at higher elevations. Planting of spruce on this latter type of site is justified but probably less than 5,000 acres of successful reforestation has been accomplished.

The original stand was destroyed by complete cutting for logs and pulpwood, opportunity for reproduction was eliminated by fire, and usually the organic soil was partly or wholly destroyed by fire and subsequent erosion. Sometimes as much as 2 feet or more of organic soil was lost in this way. Figure 1 shows an area formerly occupied by a dense stand of spruce after steam-skidder logging and pulpwood cutting. After the pulpwood was cut, the area burned over probably 2 or 3 times and soil was completely lost from a portion of the steeper, thinner soiled, upper slopes. The lower and middle slopes are now densely covered with fire cherry and blackberry with some yellow birch on the better sites.

Another striking example of the effect of a severe burn on a clearcut, dense, pure spruce stand at high elevation is shown in Figure 2. The original organic soil is almost completely burned away. Hardly more than a surface of rocks with a few soil pockets remains. On such sites there was virtually no mineral soil. The organic soil required ages to build, and ages will be required to restore it. However, probably not over 10 percent of the spruce type soils have been so completely destroyed.

As a broad estimate it can be stated that most of the cutover and burned areas in the spruce type, unaided by man, will require 500 to 1,000 years or more to again clothe themselves with spruce or fir. The chief reason for this is a very inadequate or entirely absent source of seed. Natural invasion must proceed by gradual steps from the very few seed-source centers.[3]

Major Planting Sites and Problems

During the summer of 1938 a field survey of plantations and planting sites in the spruce type in West Virginia, Virginia, Tennesee, and North Carolina formed the basis for a program of research on reforestation of the denuded lands. The salient fact emerging from the study was the critical effect of vegetative competition on plantation success.[4] A concept of vegetative density was formulated, and the conditions were determined under which planting is possible without special treatment and under which some treatment is needed to obtain success. Study of methods of reforestation on the latter sites constituted the research problem. Density was expressed in tenths and is the estimated proportion of ground shaded by plants higher than the planted trees.

Three major planting sites are involved:

1. *Sites with dense herbaceous and shrubby vegetation.* The predominant vegetation is chiefly

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[2]Hopkins, A. D. Report on investigations to determine the cause of unhealthy conditions of the spruce and pine from 1880-1893. W. Va. Agric. Expt. Sta. Bul. 56. 1899.

[3]The following articles contain additional information on the type:

Korstian, Clarence F. Perpetuation of spruce on cutover and burned lands in the higher Southern Appalachian mountains. Ecol. Monographs 7:125-167. 1937.

Minckler, Leon S. Early planting experiments in the spruce-fir type of the Southern Appalachians. Jour. Forestry 38:651-654. 1940.

[4]Minckler, Leon S. Vegetative competition as related to plantation success in the Southern Appalachians. Jour. Forestry 38:68-69. 1940.

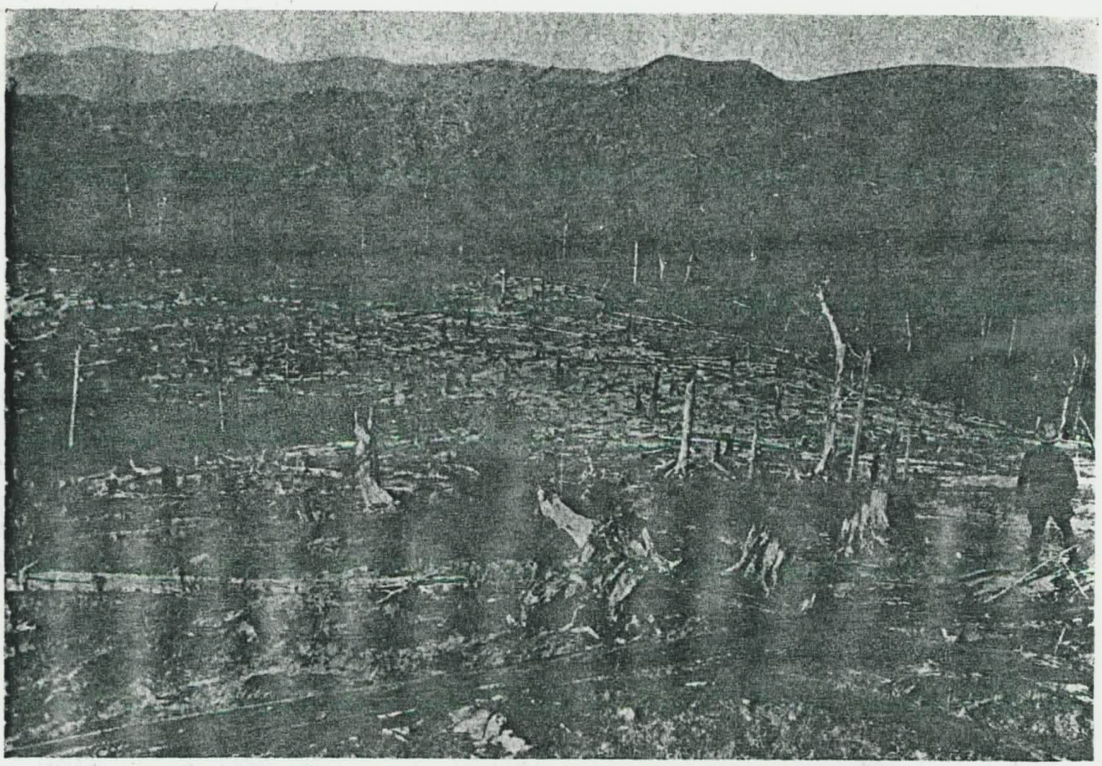

Fig. 1.—Portion of Pigeon River Watershed, N. C., April, 1938. This whole watershed was cut over for logs and pulpwood and heavily burned. The vegetation on the mountain sides is mostly blackberry and fire cherry with scattered clumps of yellow birch. The foreground is part of a grassy bald near the top of the mountain.

Fig. 2.—A severe burn on Black Mountain, W. Va., about 10 years after burning. Most of the original organic soil has been burned away. It is possible that red spruce or balsam of seed-bearing size can be grown in the soil pockets.

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ferns or weeds, blackberry vines, and low shrubs up to 5 feet tall with a density of 0.8 or more. Scattered fire cherry is often present as a very light overstory. Sites with cover densities of 0.8 to 0.9 are borderline cases with respect to planting. Fair success can usually be achieved with red spruce without special treatment, but survival will be erratic and emergence from competition very slow. On sites with a density of 0.9 or more, planting without special treatment will nearly always fail. The unfortunate fact is that the best timber-growing sites also have the greatest vegetative density and are therefore the most difficult to reforest.

2. *Sites with young stands of undesirable, brushy hardwoods.* The predominant vegetation is chiefly fire cherry or red maple, deciduous holly, sassafras, sumac, alder, rhododendron, and yellow birch, with a density of 0.7 or more. A ground cover of fern or blackberry of varying density is usually present. Relatively worthless hardwood reproduction is now the most extensive cover in the original spruce type. On good sites with a deep mineral soil, species such as birch, maple, and black cherry will produce a timber crop. But on sites at the higher elevations with a thin, rocky, moist, organic soil, spruce and possibly fir are the only species known that will produce a merchantable stand. The hardwoods are stunted, crooked, and brushy; and often die before they are out of the sapling stage.

If overstory densities are much less than 0.7, and ground cover is not dense, planting usually succeeds without special treatment. On good sites, however, when the overstory is less than 0.7, the ground cover constitutes the chief competition for planted trees.

3. *Severe rocky sites with very thin soil and sparse vegetation.* These sites have most of the original organic soil burned away and vegetative density is usually less than 0.4. Figure 3 shows what clearcutting and fire have done to an originally productive site. The object here should be the production of seed-bearing trees, as the production of pulpwood or timber cannot be expected for several tree generations. The problem is not vegetative competition but whether planting or seeding in the soil pockets can be successfully accomplished.

There are still considerable areas in the spruce type that can be planted without any special treatment with a good chance of producing timber or pulpwood. Such areas have vegetative density of 0.75 or less and sufficient soil for good tree growth.

Sites with Dense Herbaceous and Shrubby Vegetation

Sixty experimental plots were established on the Pisgah National Forest in North Carolina and 180 on the Monongahela National Forest in West Virginia. Each plot contained 60 planted trees or seed spots, half red spruce and half red pine. The Pisgah plots and half the Monongahela plots were planted or seeded in the spring of 1940, the remainder of the Monongahela plots in the spring of 1941. The vegetation on the Pisgah was chiefly blackberry with a light overstory of fire cherry. On the Monongahela, in addition to this type, bracken fern occurred both pure and with a light overstory of fire cherry. In all cases the ground vegetation, not the overstory, constituted the chief competition for planted trees. As density, rather than species make-up, was found to be the important factor in plantation success, results for the three types on the Monongahela have been combined.

Ten methods of planting or treatments were employed in the experiments. All planting treatments were the same as the check except for the one factor given. All planting stock was 2-1 transplants.

1. Check, regular planting technique, 18-inch scalp and center-hole method.
2. Planted trees released by cutting an opening 3 to 4 feet in diameter in early July of the first season; release to be repeated as necessary.
3. "Super" planting stock used.
4. Plot burned over before planting.
5. Roots of competing vegetation cut and eradicated on a 3-foot spot to a depth of 4 inches.
6. A complete fertilizer applied at time of planting.
7. Treatment of tree roots with Hormodin A and Transplantone, hormone-vitamin root stimulants.
8. A 3-foot scalp.
9. Direct seeding in a 3-foot spot with intensive ground preparation; screened and mulched.
10. Same as No. 9 except that a complete fertilizer was applied at time of seeding.

For the second-year (1941) planting on the Monongahela, certain changes in treatments were made: (1) Super-stock was selected on a basis of stem caliper and root-top ratio instead of size alone as in 1940; (2) fertilizer was placed in a shallow hole alongside the planting hole instead of in it; (3) the vitamin-hormone root stimulation treatment was replaced by direct seeding in small screened spots; (4) the large scalp treatment was replaced by direct seeding in large prepared but unscreened spots; (5) the burning treatment was replaced by direct seeding in small unscreened spots. All direct seeding treatments included mulch.

RESULTS WITH PLANTING STOCK

A summary of the results is given in Table 1. The superiority of red spruce as compared with pine is evident. It should be planted on sites characterized by relatively shallow and rocky, organic soils, a tendency toward podsolization, moist to wet conditions, and a moderate to heavy vegetative cover. Red pine will do well only on the drier, more exposed sites, with a relatively deep mineral soil, and sparse to moderate vegetation.

Release of planted trees in early July of the first season is the best treatment from the standpoint of survival, thrift, and growth. The superiority of the released trees is actually greater than that shown by the figures. Suppressed spruce tends to persist for several years, but mortality continues until the suppression is relieved. Red pine dies soon after complete, unrelieved suppression. It is very likely that much additional mortality will occur on the unreleased plots.

Release in late June or early July is important because it allows maximum first-season benefit to the tree and produces minimum sprouting of the competing vegetation (just after flush of early growth when most of stored food has been used). The planted trees benefit from release because of increased light and consequent opportunity for food manufacture and storage. Competition for soil moisture is not an important factor in the spruce type.

The year of subsequent release will depend upon the density and height (usually positively correlated) of competition. Planted trees in the present study required release at the beginning of the first and fifth seasons. On two sites, blackberry, fern, and fire cherry competition was so dense that this was not sufficient, and by the beginning of the fifth season mortality was very heavy. On the borderline sites with density 0.8 to 0.9, a release the first season would be sufficient. Sites with a density of 0.9 or more should not be planted unless some provision has been made for release.

Although super-stock, selected on a basis of stem caliper and root-top ratio, gave fair results,

TABLE 1.—THIRD-YEAR SUCCESS AND GROWTH OF PLANTED TREES ON SITES WITH DENSE HERBACEOUS AND SHRUBBY VEGETATION

Experimental treatment[1]	Plantation success[2]				Average growth[3]			
	Red spruce		Red pine		Red spruce		Red pine	
	Monongahela plots	Pisgah plots	Monongahela plots	Pisgah plots	Monongahela plots	Pisgah plots	Monongahela plots	Pisgah plots
	Percent				Feet			
Check[4]	69 (24)[5]	58 (12)	51	44	0.20	0.27	0.23	0.29
Release	84 (15)	90 (6)	64	83	0.36	0.41	0.41	0.57
Super-stock, size basis	72 (9)	60 (6)	55	43	0.23	0.34	0.23	0.28
Super-stock, stem caliper and root-top ratio basis	78 (6)	-----	67	---	0.27	-----	0.34	-----
Burning	55 (3)	72 (6)	63	45	0.15	0.32	0.23	0.34
Intensive ground preparation	73 (15)	68 (6)	60	46	0.21	0.28	0.34	0.30
Fertilizer in planting hole	50 (9)	25 (6)	32	22	0.17	0.25	0.17	0.21
Fertilizer beside planting hole	64 (6)	-----	44	---	0.20	-----	0.28	-----
Hormodin A	60 (9)	41 (6)	52	40	0.15	0.27	0.22	0.32
Transplantone	54 (9)	54 (6)	51	40	0.16	0.22	0.14	0.25

[1]Descriptions of treatments are given in the text.
[2]Percent of all trees planted that are now thrifty. An unthrifty tree is one that usually will die within a year.
[3]Growth of all live trees during the second and third years.
[4]Includes regular check plots and plots with 3-foot scalp, which gave the same results.
[5]Numbers in parentheses are the number of plots included in the mean. They are the same for pine as for spruce. On the Monongahela, one block was burned before the third-year examination. Two other blocks on a site subject to flooding and with extremely dense vegetation were omitted because of almost complete failure.

it has very limited usefulness since it does not constitute over 10 percent of nursery production. A combination of super-stock and release would be one way of successfully reforesting sites with vegetation of extreme density.

Treatment by intensive ground preparation before planting gave somewhat better results than the check, but would probably triple the cost of planting. It cost much more than release, and results for both survival and growth were considerably poorer.

Burning before planting gave fair results for red spruce in the blackberry–fire cherry type but not on the bracken fern or weed-covered sites. In the former type, fire killed most of the scattered fire cherry and the canes of blackberry. New shoots of blackberry grew but fire did reduce density the first summer. In bracken fern, burning did not reduce density.

The author has believed for some time that the proper use of fire in combination with rather intensive grazing probably is the cheapest and most effective means of preparing the difficult sites in the spruce type for successful planting. It is believed that this method would (1) insure survival of planted trees, (2) eliminate or greatly decrease the period of suppression, (3) be less expensive than release treatments, and (4) decrease the cost of planting because of much easier planting conditions. Pilot-plant studies are needed before any definite method can be recommended, but the method might be about as follows:

1. Burn areas by watersheds in early spring with a relatively heavy burn. The fire should be hot enough to kill all vegetation but not to destroy organic soils.

2. Graze areas rather heavily as soon as they become green in the spring, and continue relatively heavy grazing with sheep or cattle for 2 or 3 years. Grazing should not be excessive but heavy enough to keep down vegetation.

3. When competition has been sufficiently reduced, plant in all favorable places. Any small areas of unreduced competition should be avoided.

4. Continue grazing at a reduced intensity until planted trees are out of danger of being overtopped. Grazing will have to be light enough so that stock will not eat the trees.

RESULTS WITH DIRECT SEEDING

Direct seeding was done on intensively prepared 3-foot spots with mulch and protective screens. Results on both the Pisgah and Monongahela Forests were disappointing. Success the first summer was very good for both species, but winter mortality was very great. Table 2 shows that seed spots on the Pisgah were virtually wiped out the first winter by frost-heaving. Table 3 shows the progressive mortality of seedlings through 3 years. The very poor initial success of the 1941 seedings was caused by an unusually dry and hot spring.

The seed spots on the Pisgah were reseeded, half in the spring of 1941 and half in the fall of 1941. Special attention was given to mulching to prevent frost-heaving, but at the end of a year less than 20 percent of the spots were successful. On the Monongahela various intensities of ground preparation and spots without screens were tried. All were virtual failures. The seedlings in unscreened spots were usually covered by dead vegetation the first winter. The use of a complete fertilizer gave no beneficial results and decreased success somewhat on the Monongahela plots. There was a noticeably greater growth of grass and weeds where fertilizer was used. Although red pine plots were still 61 per-

TABLE 2.—RESULTS OF DIRECT SEEDING IN MARCH, 1940, ON THE PISGAH NATIONAL FOREST

Species	Seed spots with 1 or more seedlings			No. of seedlings per successful spot	
	July, 1940	Oct., 1940	Mar., 1941	July, 1940	Oct., 1940
	Percent				
Red spruce	89[1]	84	Failure[2]	4.9	4.3
Red pine	96	92	Failure	9.4	7.2

[1]Each value is a mean of 12 subplots with 30 seed spots each. Both fertilized and unfertilized spots are included.

[2]Less than 10 percent of spots had 1 or more seedlings.

TABLE 3.—RESULTS OF DIRECT SEEDING IN APRIL, 1940 AND 1941, ON THE MONONGAHELA NATIONAL FOREST

Species	Seed spots with 1 or more seedlings					
	1940 seeding				1941 seeding	
	First fall	First spring	Second spring	Third spring	First spring	Third spring
	Percent					
Red spruce	92[1]	58	26	10	23	Failure
Red pine	97	93	75	61	27	Failure

[1]Each value is a mean of 9 subplots with 30 seed spots each. Only unfertilized spots are included. Seed spots with fertilizer were inferior.

cent successful at the end of the third year, most of the seed spots were heavily shaded by vegetation and seedlings were in poor condition.

Direct seeding in the dense cover types of the spruce lands is definitely not recommended because of (1) failures due to frost-heaving and unusually dry springs, (2) high initial cost of seeding because of necessity for rather intensive ground preparation and protective screens, and (3) necessity of several releases to bring the tiny seedlings through the characteristic dense, high vegetation. As mentioned later, there are some sites in the spruce type where these objections do not apply with equal force.

Sites with Young Stands of Undesirable and Brushy Hardwoods

Six experimental blocks on the Pisgah and 6 on the Monogahela National Forest in young hardwood stands make up this experiment. Each block consists of 20 4-tree groups of planted 2-1 red spruce, for each of 7 different treatments, or a total of 140. Each group of 4 trees was planted within a circle about 4 feet in diameter. Treatments were made by tree groups as follows: (1) cut a small opening (5 to 7 feet) in the canopy in early July of the first summer, (2) cut a large opening (10 to 12 feet) the first summer, (3) cut a small opening the third summer, (4) cut a large opening the third summer, (5) cut a small opening the fifth summer, (6) cut a large opening the fifth summer, (7) check, no cutting. It was planned to make subsequent releases when and if necessary.

The experiment sampled covers with high, medium, and low total density. High-density cover was mostly fire cherry, 20 to 40 feet tall with 0.8 density or more, while the ground cover (usually blackberry) had a density up to 0.8. Such cover usually occurs on good sites. The blackberry vines are often 8 to 10 feet tall and, together with the fire cherry, make an extremely difficult planting site. A discouraging feature is the increased density of blackberry which occurs in the holes caused by cutting or natural death of the overstory.

Stands of medium total density are mixtures of fire cherry and red maple with deciduous holly, alder, sassafras, rhododendron, and birch. These stands have heights of 15 to 30 feet and a density of 0.9 or more. Ground cover is sparse or absent.

Stands of low total density are either on poor sites or in an early stage of development, usually the former. They are mixtures of the above species 5 to 20 feet in height, with a density of about 0.7 to 0.8. Ground cover is light to moderate, the density generally not exceeding 0.5.

Although this experiment is not complete, it is evident from Table 4 that any program of planting on these hardwood sites would meet with considerable difficulty. In high-density and medium-density sites release early the first summer and some subsequent releases are necessary. In the present study, plots released the first summer in stands with high and medium density were released again early the fifth summer. Based on results in Table 4 and general field observations, the following tentative recommendations can be given:

1. In stands of high total density, planted red spruce will need release the first and third summers and at least two subsequent releases. These are the best timber-growing sites and the most difficult to reforest.

2. In stands of medium total density, a release the first and fifth summers with one additional release would probably suffice.

3. In stands of low density, one release probably would be sufficient but it is not yet determined just when this should be done.

The size of the opening at crown level should be about 10 to 12 feet in relatively tall stands

Table 4.—Third-Year Results of Underplanting Young Stands of Undesirable and Brushy Hardwoods with Red Spruce

Total density of cover[1]	Spruce released—opening 10 to 12 ft.: Released 1st summer	Spruce released—opening 10 to 12 ft.: Re-leased 3rd summer	Spruce released—opening 5 to 7 ft.: Re-leased 1st summer	Spruce released—opening 5 to 7 ft.: Re-leased 3rd summer	Check—not released
	Percent successful[2]				
High	50 (6)[3]	20	40	15	14 (18)
Medium	69 (3)	43	63	44	44 (9)
Low	74 (3)	67	75	65	63 (9)
	Mean height of all live trees, feet				
High	0.67	0.61	0.64	0.58	0.56
Medium	0.64	0.56	0.61	0.56	0.57
Low	0.75	0.67	0.71	0.68	0.66

[1]See text for descriptions of cover densities.

[2]Percent of all trees planted that are now thrifty. An unthrifty tree is one that usually will die within a year.

[3]Numbers in parentheses are the numbers of plots included in the means. They are the same for all of the released plots. Each plot consists of 20 4-tree groups of planted red spruce.

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Species
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of 20 to 40 feet in height. In shorter stands the diameter of openings may be correspondingly less.

It is apparent that the reforestation of that part of the spruce type covered with virtually worthless hardwoods would be a difficult, slow, and expensive process. Still, there is one possible path of escape—the combination of burning and grazing already discussed. Some areas, with high fire cherry and blackberries so dense that walking is nearly impossible, probably cannot be handled in any other way.

Rocky Sites with Very Thin Soil and Sparse Vegetation

Four experimental blocks of 10 plots each were established on Black Mountain, West Virginia (Fig. 2), in early May, 1940, to test methods of reforesting very thin-soiled sites. The purpose of reforestation here and on similar sites must be limited to the production of seed-producing trees, since there is little hope of timber or even pulpwood production for several tree generations.

Each plot of 60 planted trees, and each seed spot, was half spruce and half balsam. Planting or seeding was done in the more favorable spots or soil pockets at the average rate of 550 per acre. The following treatments were used: (1) check, regular planting method; (2) regular method of planting plus 4-12-4 fertilizer; (3) super-stock based on size; (4) vitamin-hormone root stimulation with Hormodin A and Transplantone; (5) super-stock plus fertilizer; (6) direct seeding in one-square-foot spots, mulched and screened, very little ground preparation needed; (7) direct seeding as above plus fertilizer; (8) direct seeding in "osmo" paper cups filled with top soil, mulched, placed in ground flush with top, and screened; (9) direct seeding in cups as above plus fertilizer; (10) direct seeding with one-cubic-inch pellets of nutrient agar containing the seed, pellets placed in small prepared spots, mulched and screened.

Red spruce planted by the regular method was 82 percent successful and there was no distinct advantage in the use of super-stock, fertilizer, or chemical root stimultaion. Because of planting stock with a poor root-top balance the success of balsam was much poorer. The check treatment gave 64 percent success, and fertlized regular and super-stock treatments were only 45 and 32 percent successful, respectively. Super-stock and root stimulation gave about the same results as the check. Growth of red spruce was about twice that of balsam; it was about 3 times as great as unreleased and almost twice as great as released spruce in dense cover, as given in Table 1. This relatively rapid early growth is due to freedom from competition. Because of the very poor site quality, however, the future growth rate and ultimate size of trees will be strictly limited.

Success with direct seeding on the Black Mountain site was much better than on the sites with dense vegetation (Table 5). This resulted from (1) less frost-heaving, (2) virtual absence of competing vegetation, and (3) moister conditions. The reduction in frost-heaving probably was the result of a rather constant frozen condition during the winter instead of the more frequent freezing and thawing at lower elevations. The reason for the superiority of seed spots screened for 3 years probably is the light shade cast by the screens and their snow-catching tendency on the windswept mountain. The shade would tend to reduce alternate freezing and thawing and provide protection for the seedlings in the summer against desiccation.

Summary

This report reviews the causes of spruce-type devastation, identifies the problem sites, and describes the results of experiments to determine the best methods of successfully reforesting these sites. Based on the specific information from the experiments and the problem analysis, the

Table 5.—Third-Year Success[1] of Direct Seeding in Prepared Spots on Severe and Rocky Sites

Species	Mulched and screened: Screened 3 years	Mulched and screened: Screened 1st year only	Fertilized, mulched, and screened: Screened 3 years	Fertilized, mulched, and screened: Screened 1st year only	Fertilized, "osmo" cups, mulched and screened: Screened 3 years	Fertilized, "osmo" cups, mulched and screened: Screened 1st year only
	Percent					
Red spruce	60	48	51	41	53	42
Southern balsam fir	60	46	72	54	76	58

[1]Percent of spots having one or more live seedlings.

following general recommendations are offered:

1. Typical spruce sites characterized by relatively shallow organic soils, a tendency toward podsolization, moist to wet conditions, and a moderate to heavy vegetative cover should be planted to red spruce. Red pine should be planted only on drier, more exposed sites, with a relatively deep mineral soil and sparse to moderate vegetation.

2. Sites with dense herbaceous and shrubby vegetation and with young stands of undesirable hardwoods should not be planted unless some provision is made for needed release, which should be done in late June or early July. Release the first summer usually is essential. The time of subsequent releases will depend on the type and density of the cover. Sites with blackberry, fern, or similar species as the predominating cover are plantable without release if the density is 0.75 or less. Sites with cover densities of 0.8 to 0.9 are borderline, whereas those with a cover density of 0.9 or more definitely need release.

3. Super-stock, when obtainable, could best be employed in planting sites with extreme conditions of heavy herbaceous and shrubby cover. Release treatments would also be required, but not the almost yearly release needed to bring ordinary spruce transplants through such competition. On borderline sites super-stock without release should give good results.

4. Severe rocky sites with thin soils and very sparse vegetation can be successfully planted or seeded in the soil pockets. The limitations of soil will greatly restrict the value of the stand but the object would be the production of seed-bearing trees rather than timber.

Recommendations based partly on experiments but mostly on general field observations in the spruce type are as follows:

1. A combination of burning and grazing followed by planting probably is the cheapest and most effective treatment for establishing spruce on heavily vegetated sites. This method should be tested on an experimental or pilot-plant basis.

2. Many of the cutover and burned lands in the spruce type, because of soil and climate, are unfitted for the growth of any timber species except red spruce, southern balsam fir, and red pine. Hardwoods such as fire cherry, red maple, and birch will not produce timber on many of these sites. Unaided by man, nature probably will require 500 to 1,000 years or more to restore these lands to timber. Although complete planting may not be possible or desirable, the establishment of strategically located blocks of seed-source plantations will hasten tremendously the attainment of a timber cover.

All-Wood Fighter Plane Developed for the Army Air Forces

A challenge to the trend toward larger and heavier fighter planes is seen in the Bell Aircraft Corporation's recently announced XP-77, the Army Air Forces only all-wood fighter.

The all-wood XP-77, powered by a single in-line Ranger V-770 engine, is 22 feet, 10½ inches long with a wing span of 27½ feet. It mounts two synchronized, 50-caliber machine guns and a cannon firing through the propeller hub.

The wood structure of the XP-77, Bell Aircraft states, is believed to be representative of the best knowledge of wood airframe design today. Materials used in binding conform to existing government requirements throughout. Sitka spruce was used in the experimental machines, but Bell technicians realize that other species would also be satisfactory material.

Every effort has been made in the design and construction to avoid complicated processes or fabrication. Most of the metal fittings are attached to the wood structure by the cycle-weld process.

No construction is employed in the wood parts which is beyond the scope of any shop equipped to make molded plywood structures with thermal-setting resin glues. The plane has been designed to permit sub-assembly manufacture. A brief survey by the Bell Corporation disclosed 35 independent shops that could produce finished component parts.