REFORESTATION BY SEED SOWING IN THE NORTHERN ROCKY MOUNTAINS [1]

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INTRODUCTION

Planting denuded forest lands with nursery stock is the dependable and established way to get new forest crops started. The fact, however, that it is in many places an operation involving heavy expenditures has led the American forester to try out other methods to a considerable extent. His characteristic discontent with established practice as such, and his constant and persistent efforts to discover better ways, have led him to give not a little attention to field sowing as a possible short-cut in the artificial regeneration of forests. He considers that it is certainly successful under many conditions in nature, and he is disinclined to abandon the idea, even under very adverse conditions, because the procedure appears to be simple and close to nature's plan. When seeds germinate and the plants grow to maturity undisturbed by man there is at any rate the certainty that the root system will be normal and that the trees will not be unduly subject to windfall or similar dangers which might result from planting.

Such attempts at direct seeding in the northern Rocky Mountain region fall into two distinct classes: (1) The early extensive projects and (2) the later intensive experiments.

EXTENSIVE EXPERIMENTS

In 1910, large and very destructive fires occurred throughout the Rocky Mountain region, and the earnest desire to get new forest crops started led to extensive direct seeding projects during the following years. In all, 2,899 acres were broadcast, 10,511 acres were sown by means of corn planters, and 1,969 acres were sown in spots—a total of 15,379 acres on the national forests in the western mountains. Of this area, 53 per cent was seeded to western white pine (*Pinus monticola*), 36 per cent to western yellow pine (*P. ponderosa*), 5 per cent to Douglas fir (*Pseudotsuga taxifolia*), and 6 per cent to other species, such as lodgepole pine (*Pinus contorta*), Engelmann spruce (*Picea engelmanni*), Norway spruce (*P. excelsa*), western larch (*Larix occidentalis*), limber pine (*Pinus flexilis*), and hardwoods. Most of these areas have been examined at least once since sowing.

Out of 343 trials, only 20 succeeded. Failures were found to be absolute in practically all cases, and all areas found to have less than 100 trees per acre were classed as failures. Broadcasting was tried generally without preparation of soil or use of poison. Of 101 attempts to reforest by this method, all failed except 9. The 153 attempts to reforest by the use of a corn planter failed likewise, with 9 exceptions. Of 89 attempts to use the seed-spot method, only 2 were successful.[2]

There is one notable success, however, on the Lolo National Forest. The ranger who made this sowing attributes the exceptional success to four things: (1) Prompt sowing after a burn; (2) seed poisoned with red lead and the area strewn with poisoned oats; (3) favorable sites; and (4) a moist season. In this case the sowing cost $4.46 per acre for labor. Other expenses brought the total cost to $6.31 per acre.

Failure is the outstanding fact in the vast majority of cases. It would be desirable, if possible, to look more closely into the reasons for the few instances of success, for the causes which made possible these exceptions might furnish some data for further observation. Unfortunately, recorded information is lacking concerning details of sowing, site, or seed conditions, some of which may have been vitally important.

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[1] Received for publication June 23, 1924; issued June, 1925.

[2] In the cases both of broadcast and spot plantings there was one additional trial which appeared successful at the end of the first season but has not been examined since.

Experiments in direct seeding carried on at the Priest River branch experiment station in northern Idaho led conclusively to the opinion in 1916 that broadcast and corn-planter sowing were in general unreliable and too expensive. Since then the seeding experiments of the Forest Service in this region have been confined to sowing in prepared spots.

INTENSIVE EXPERIMENTS

In western Montana the Forest Service has had detailed seed-spot experiments under way since the spring of 1916 as a part of the planting research work at Savenac Nursery. As a preliminary step, the comparison of the adaptability of different species to seeding methods was undertaken. For this purpose it was necessary to group the species on the same site, the plan being to make later tests of the promising species on sites well adapted to each. The location selected near Haugan, Mont., is typical of the areas in need of reforestation in the region. The sites used had been severely denuded by fire in 1910, only a few snags having been left standing. Fallen trees were partly consumed by fire. The aspects are north and northwest, and the elevation ranges from 3,500 to 4,500 feet. The slopes are 35 to 65 per cent, averaging about 50 per cent, and, aside from a mixture of herbaceous plants, are being reclaimed by occasional willows (Salix), buckbrush (Ceanothus), and flowering raspberry (Rubus). The soil is a loam, clayey and stony in places.

On these areas, seed spots were installed every spring from 1916 to 1921, and during the fall in 1916 and 1918. Thirty tests consisting of 300 prepared spots each were installed during the six-year period.

A method of preparing and sowing spots which seemed to give most promise of success was adopted as standard and adhered to throughout, except in the case of sample lots of seed spots treated differently to give a check on methods. The standard method was as follows:

A surface 6 to 8 inches square was denuded of sod and herbaceous cover by means of a planting mattock. Twenty to twenty-five seeds were scattered on the resulting fresh soil surface and tamped into this soil by pressing with the flat of the mattock blade. The seeds were then hand-covered by scattering on loose soil to the desired depth, or approximately 3/8 inch for western yellow pine, 1/4 inch for Douglas fir and Engelmann spruce, and 1/8 inch for western red cedar (*Thuja plicata*). The soil cover was not tamped.

The variations of this method included tamping the surface soil, soil sterilization against fungi by a treatment with sulphuric acid, covering with leaf litter to make spots less conspicuous to rodents and birds, and screening against these enemies.

Observations were made and recorded every 7 to 10 days during the first two growing seasons, with spring and fall survival counts the third season. The records at 10-day intervals showed germination, loss by causes, and survival. Seedlings were marked individually at the time of germination with toothpicks stained a distinctive color for each month. Subsequent notes on seedlings were recorded according to month of germination.

In 1916 western yellow pine failed because of the activity of rodents, although the survival of the seedlings, once germinated, was the highest of all species. Western red cedar failed because of low germination and drought, rodents being of no importance. The Douglas fir sowing was only a partial success, for most of the seed was damaged by rodents previous to germination, although the percentage of survival was high. Engelmann spruce, although it lost more than one-third of the plants from various causes, principally drought and cutworms, and to some extent damping-off, had survivors in three-quarters of the unprotected spots averaging more than three per spot.

In order of importance the causes of loss during 1916 were drought, insects, and fungi. The sulphuric-acid treatment did not materially lessen damping-off. The expense of using a litter cover to mask the spots against rodents did not appear to be justified, for it had but slight effect. Rodents interfered only with the large seeds. The conclusion of the season was that the work gave promise of success and justified further attempts.

In 1917 the sowings of 1916–17 were watched closely. Douglas fir proved to be not much troubled by rodents and nearly as drought resistant as the western yellow pine. Of this species, 50 per cent of the spots sown in the spring and 22 per cent of those sown in the fall of 1916 had survivors in the fall of 1917. Western larch was second with survivors in 11 per cent of fall-sown and 3 per cent of spring-sown spots. Yellow pine and Engelmann spruce were reduced to 6 per cent and 3 per cent, respectively, in the fall series, and to zero in the spring of 1917 series. The western yellow pine proved to be very drought resistant, but both series were complete failures because of the rodents. Western white pine and red cedar were also complete failures, largely because of drought.

The conclusions of the 1917 season were similar to those of a year before but were less optimistic. The practice of seed spotting appears at best an uncertainty, much more so than planting. The results obtained certainly indicated the advisability of giving up attempts at seed spotting and of placing all attention on the surer method of planting. But in view of the greater amount of work done on planting experiments in comparison with seed spots, it was thought that the work to date warranted further attempts with Douglas fir and, to some extent, with Engelmann spruce.

The season of 1918 was more favorable. The examinations made at 7 to 10 day intervals showed a loss from drought of approximately 50 per cent in Engelmann spruce and larch. The larch was the least resistant to harmful agencies, mainly drought and fungi. Douglas fir was decidedly superior to the others, showing a survival of 58 per cent at the close of the season.

During the following season the sowings of spring and fall of 1918 and spring of 1919 were watched. The superiority of Douglas fir appeared in each case. Western white pine was next in the fall sowings, and larch and spruce were last with but 5 per cent survival in 2-year-old spots. The spring sowings of 1919 succumbed to drought. Because of the extreme dryness of the season, drought was the foremost cause of loss.

In 1920, observations of all sowings, from the spring of 1918 to those of the spring of 1920, showed Douglas fir to be superior without exception.

In 1921, the survivals from previous series were still decreasing perceptibly in numbers. That season's sowings failed completely because of drought and cutworms.

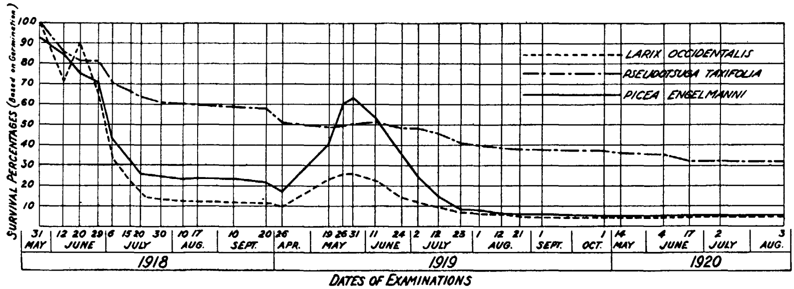

FIG. 1.—Series sown, spring of 1918

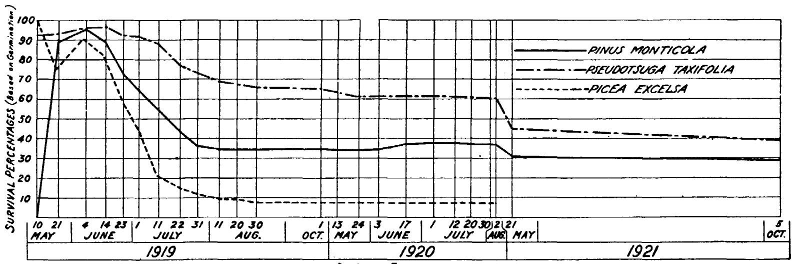

FIG. 2.—Series sown, fall of 1918

RESULTS

What has been the result as a whole of the six years of painstaking effort? What percentage of the total number of spots now contain one or more survivors? The best record is about 20 per cent for Douglas fir. Other species are not above 15 per cent in any case.

The marked superiority of Douglas fir in every sowing is evident. Although its germination as compared with its associates was less in most cases, fewer of the seedlings of this species were lost; and in every case the last examination showed Douglas fir to have more survivals per spot and a larger portion of spots with survivals.

The application of a covering of litter to mask the spots against the raids of rodents, and the use of sulphuric acid as a fungicide were ineffective. The results did not justify the expense of these operations.

In general more deaths were due to drought than to any other two causes. (Table I.) During dry summers, which have been frequent in this region of late years, the soil easily dries out completely to a greater depth than the roots of the very young seedlings have been able to penetrate. A high evaporation rate occurring at the same time soon kills them. Cutworms were next in destructiveness. Fungi were not a large factor. The remaining classes of loss, "accident," and "missing," represent numerous deaths from miscellaneous causes. Frost heaving is often an important cause of loss.

shrubs filled some of the spots and were pressed into a solid mat by snow, thus forming a mechanical barrier to germination the next spring.

Yellow pine was early abandoned in this work because of the abundance of rodents, which seek especially these large seeds. On the experimental area the western chipmunk (*Tamias quadrivitatus*) and a similar animal, Say's spermophile (*Spermophilus lateralis*), have been observed to fairly "swarm" in August and early September, while in late October one is rarely seen. Perhaps sowing should be done late, even at a sacrifice of some germination, in order to avoid them. It is likely that one of the principal reasons for the success of restocking on certain areas by broadcast seeding after the 1910 fires was the wholesale destruction of rodents by the fire.

TABLE I.—*Causes of loss of seedlings in seed spots, Haugan experiment area, Trail Gulch*

Species	Row No.	Date of sowing	Years considered	Percentage of loss from various causes						
				Fungi	Cutworms	Drought	Accident [a]	Missing	Other	Total
Picea Engelmanni	1	Apr. 26, 1918	1918–1920	7.9	15.7	64.1	1.8	7.2	3.3	100
Larix occidentalis	2	Apr. 27, 1918	1918–1920	17	9.2	59	1.5	9.3	4.0	100
Psd. taxifolia	3	Apr. 29, 1918	1918–1920	22.2	14.4	34.3	.9	10	18.2	100
Pinus monticola	4	Sept. 11, 1918	1919–1921	2.2	30.9	52.9	.7	11.8	1.5	100
Psd. taxifolia	5	Sept. 27, 1918	1919–1921	0	9.3	49.5	6.2	35.1	0	100
Larix occidentalis	6	Sept. 28, 1918	1919–1921	3.9	12.8	62	4.2	14.3	2.9	100
Picea excelsa	7	Oct. 3, 1918	1919–1920	2	22	71	1	4	0	100
Picea Engelmanni	8	Oct. 2, 1918	1919–1920	2.9	14.8	75.2	1.6	4.2	1.3	100
Do	9	Oct. 4, 1918	1919–1920	3.5	20.1	67.3	2.1	5.8	1.2	100
Psd. taxifolia	10	May 10, 1919	1919–1921	10.3	18.3	55.9	0	15.6	0	100
Picea Engelmanni	11	May 22, 1919	1919–1921	5.7	17.1	56.5	.4	20.2	.1	100
Pinus monticola	12	Sept. 11, 1919	1919–1921	2.6	25.7	44.7	5.9	21.1	0	100
Larix occidentalis	13	Sept. 12, 1919	1920–1921	11.1	14.6	24.6	22.7	27	0	100
Psd. taxifolia	14	Oct. 6, 1919	1920–1921	3	30.2	20.7	16	30.2	0	100
Picea Engelmanni	15	Oct. 7, 1919	1920–1921	6.4	32.2	27.1	13.6	20.8	0	100
Larix occidentalis	16	June 2, 1920	1920–1921	2.7	10.8	8.1	18.9	59.4	.1	100
Picea Engelmanni	17	June 3, 1920	1920–1921	1.7	22.4	38.7	12.5	24.6	.1	100
Psd. taxifolia	18	June 4, 1920	1920–1921	8.5	21.3	17	34	19.3	0	100
Picea Engelmanni	19	May 5, 1921	1921	5.2	51.9	30.8	1.1	11.1	0	100
Larix occidentalis	20	do	1921	4.8	44.4	29.1	.5	21.1	.1	100

[a] Among the miscellaneous causes of loss listed as accident, frost heaving seems to have been the most important.

Stones in seed spots and lying near the sowing surface presented mechanical obstacles to seedlings starting on the thin layers of soil. When the life of a seedling depends upon the deep penetration of its root before the dry summer season arrives, such obstacles are often fatal. Stones lying on the surface become very hot in the sun, attaining temperatures injurious to growing tissue; these possibly caused the death of seedlings next to them in some instances. In other cases the seed spots formed little pockets on the slope which caught rolling stones and débris. Leaves from hardwood

The tendency for western white pine seed to reserve a large part of its germination until the second season after sowing is well known. Contrary to expectations, Engelmann spruce twice exhibited such delayed germination. Both times the occurrence was in series sown in the spring, whereas fall sowings were entirely free from such hold-over germinations.

There was a complete loss before August of all germinations in screened spots sown in 1921. This is apt to happen to seed spots in this region when a dry year follows sowing. Survival data show that in most cases, although the remaining seedlings are approaching establishment, they are still decreasing in numbers.

In this connection a statement made by a German forester since the recent war is interesting. Conditions in Germany, of course, are different from ours, and conclusions from work elsewhere can not be adopted as they stand. Nevertheless, it is well to keep in mind the development in a country older in forestry than our own. Kienitz [3] concludes that " . . . natural regeneration has its rightful sphere as has sowing and planting; but, in general, artificial culture has progressed far in advance and now is passing out of the sowing stage into that of the higher forest industry, namely, planting." Germany has found direct seeding successful only when a continuous moisture supply is available. The short superficial root system of first-year seedlings makes them succumb easily to drought. Planting results in a better distribution of soil moisture about the roots because of the loosened soil in the planting holes. It is the preferred method, and German experiments have shown that the cost of planting, calculated through the first three years, is less than the cost of sowing.

CONCLUSIONS

Of all the early direct-seeding projects in the northern Rocky Mountain region, only 6 per cent were successful or partially successful. Later intensive experiments with seeding in prepared spots also failed to indicate practicable methods of direct seeding for this region. Douglas fir was found to be much better adapted to success than the other local species, but all trials failed to produce a stand of survivors in sufficient numbers. Because of rodents most of the large seed sown was never allowed to germinate. Among the seedlings drought was the foremost cause of loss; cutworms were next in destructiveness, and frost heaving caused many deaths. Fungus trouble was experienced, but ordinarily was not severe. Speaking in terms of the percentage of spots with one or more survivors, about 20 per cent survival was obtained with Douglas fir under the best conditions, whereas other species were below 15 per cent in survival in all cases. Western white and western yellow pine and Engelmann spruce, important commercial timber trees of the region, are essential in reforestation and are included in the group of species making an extremely poor showing in the experiments.

It may be that direct seeding has its rightful sphere in the northern Rocky Mountain region, but if so, it has not yet been discovered. On the basis of the results here recounted, no more experiments in direct seeding are contemplated, except a test of sowing in fresh ashes after fires. A little hope for this method is cherished, but, if it succeeds, application in the region would necessarily be restricted to sites free from rodents, which possibly can be found only in the center of large, newly burned areas.

The only hope seems to lie in man's ability to reproduce the conditions which make possible nature's own direct seeding, or at least to recognize and approximate them. Nature, however, sows her seed more lavishly than the forester can afford to in his work, even to the extent of several hundred thousand large seeds and several million smaller seeds per acre, in order to secure a stand of 5,000 seedlings.[4] And she is more patient with her many delays and failures than the forester can afford to be with his.

[3] KIENITZ, M. WAS IST DENN JETZT MODE: SAAT ODER PFLANZUNG? Ztschr. Forst u. Jagdw. 51: 417–436. 1919.

[4] Based on careful counts made in the region by J. A. Larsen.