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RESPONSE OF PINE SEEDLINGS TO SITE SELECTION ON ERODED SOILS[1]

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Pine seedlings have been planted by the millions, during the last decade, as a part of the operations program of the Soil Conservation Service. Although a plantation was usually made primarily as a soil conservation measure, interest often centered in its utilization for one or more other purposes: wildlife cover, shelterbelt, poles, lumber, landscape beautification.

The trees were planted in a wide variety of locations: gullies, slides, eroded slopes, spoil banks, borrow pits and others. The variation in site quality has been greater than in site location. All aspects and almost every degree of slope is represented in these plantings as well as wide variations in soil structure, texture, fertility, pH, soil moisture supply, and the climatic factors of temperature, light, humidity and wind. In many plantings, the biotic factors seem to exert control. The more important of these are plant competition, plant disease, insects, rodents, grazing animals and man.

In spite of the large number of plantations made, very few research data are available relative to the response of the trees to the conditions of the site. The purpose of this paper is to present data on the response, during a five-year period 1940-44), of one species of pine to a variety of sites common to most farms in the erosion problem area of southern Iowa and to discuss the relation of growth response of the species to general differences in site quality. Establishment and rate of growth of this species, for the same period, are compared with those of three other species of pine commonly planted in the area.

The plantings made in these 1940 experiments were a part of a series on the adaptation of coniferous species to eroded soils begun in 1938 at the Floris Field Station of the Iowa Cooperative Hillculture Project. Previous experiments had indicated that the red or Norway pine, *Pinus resinosa* Ait, was well adapted to a wide variety of sites under different degrees of erosion. For this reason red pine was selected for planting on 5 different sites on Lindley loam and on Plainfield fine sandy loam. One or more of the following species were planted for comparison on each of the sites: ponderosa or western yellow pine, *Pinus ponderosa* Laws.; Austrian pine, *Pinus nigra austriaca* A. & G. and eastern white pine, *Pinus strobus* L.

Six habitats of varying degrees of erosion were selected as planting sites. The selected sites had the following general characteristics:

Site 1. Lindley loam with no surface soil and the B horizon eroded to an average depth of 2 feet; the top 4 inches of the B horison Lidley friable; poor herbaceous cover causing little or no competition; 20 per cent southwest slope with partial protection.

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Site 2. Lindley loam with no surface soil and the B horizon eroded to an average depth of 1 foot; the exposed soil of comparatively poor structure; added moisture from the slope above but drainage adequate; almost bare of herbaceous cover, no competition; 10 per cent south slope, protected on the south.

Site 3. Lindley loam with no surface soil but with a 3-foot depth of B horizon remaining; top 8 inches of the B horizon friable and of good structure; poor herbaceous cover causing little or no competition; top of gully bank of 30 per cent southwest slope with little protection.

Site 4. Lindley loam with 10 inches of surface soil (A horizon) and a 3-foot depth of B horizon; soil fertile, and of good structure supporting a dense stand of Kentucky bluegrass; 30 per cent south slope with little protection.

Site 5. Similar to site 4 except with protection from the south and north and with less competition from bluegrass; more dead grass, leaves and other duff than in site 4.

Site 6. Plainfield fine sandy loam, fertile and of good structure, supporting a tall stand of Kentucky bluegrass, resembling site 5 in presence of duff and reduced competition from the grass; on almost flat upper floodplain with no evidence of recent flooding; the only limed site, 2 tons per acre; trees well protected on all sides.

The planting stock varied as to age and nursery treatment. The red pine seedlings were 2-1 stock, the Austrian and white pine were 2-2 and the ponderosa pine seedlings were 3-2. The stock selected for each site was matched as well as possible for size with the greatest discrepancy in size between species appearing in site 4. Site 1 is the only site in which ponderosa pine did not have an advantage in both size and age. The red pine stock probably had a slight disadvantage because of only one transplanting.

The trees were planted, 4 feet apart in rows spaced 4 feet apart, on the near contour without furrowing. There were at least 3 replications of five trees each, randomized. They were planted with a spade in holes large enough to allow natural spread of the roots, in scalps two feet in diameter. The 2-foot scalp was hoed twice each of the first two years, chiefly to reduce competition in the sodded sites. Thereafter they were not cultivated.

Survival of the transplanted trees varied between 90 and 100 percent with no significent species or site difference. The sites with top soil, however, seem to have a slight advantage in the establishment of weak trees, provided grass competition is removed. Growth data (Table 1) covering a 4-year period and the evident good condition of the trees indicate that the trees of all species are now established in all of the sites.

A comparison of the growth response of the red pine in the 6 sites (Table 1) gives an indication of the differences in site quality. Three criteria are used in this comparison: height, diameter of trunk and computed volume of the crown. For the first four or five years it

TABLE 1. COMPARISON OF ANNUAL HEIGHT GROWTH AND SIZE, IN 1944, OF SPECIES OF PINE PLANTED IN 2-FOOT SCALPS IN 3 ERODED LINDLEY LOAM SITES AND IN BLUEGRASS SOD IN 3 SITES WITH AT LEAST 10 INCHES OF TOPSOIL.

Planting sites, Species planted	Ht. in. 1940	Rate of growth, inches					Measurements, 1944		
		1940	1941	1942	1943	1944	Ht. ft.	Diam in.	Crown cu. ft.
Site 1: Lindley loam, 2 ft. of B horizon, no A horizon									
Pinus resinosa	4.2	4.7	5.7	10.7	13.7	18.6	4.8	1.4	15.5
Pinus austrica	4.4	4.5	5.2	7.9	9.9	14.9	3.9	1.3	8.9
Pinus ponderosa	2.9	3.0	5.2	8.3	8.8	12.6	3.4	1.1	5.5
Site 2: Lindley loam, 1 ft. of B horizon, no A horizon									
Pinus resinosa	5.5	4.2	4.7	8.5	10.9	14.2	4.0	1.4	12.5
Pinus austriaca	5.3	4.0	4.7	8.0	9.8	15.0	3.9	1.6	11.3
Pinus strobus	3.1	3.6	3.5	6.6	12.8	14.8	3.8	.9	5.9
Pinus ponderosa	7.7	2.9	4.7	6.7	8.5	11.5	3.5	1.2	5.4
Site 3: Lindley loam, 3 ft. of B horizon, no A horizon									
Pinus resinosa	5.5	6.0	10.0	14.8	18.5	29.0	7.0	2.6	55.8
Site 4: Lindley loam, 10 in. of A horizon, 3 ft. of B horizon									
Pinus resinosa	3.4	3.2	8.0	10.3	13.7	17.8	4.7	1.6	15.1
Pinus ponderosa	8.3	4.6	7.2	12.3	9.7	15.5	4.8	1.7	12.9
Site 5: Lindley loam, 10 in. of A horison, 3 ft. of B horizon									
Pinus resinosa	4.4	4.8	8.8	11.8	14.4	23.2	5.6	2.1	24.2
iPnus ponderosa	5.2	3.8	8.4	11.0	13.0	22.0	5.3	2.2	22.0
Site 6: Plainfield fine sandy loam, uneroded									
Pinus resinosa	6.6	7.5	10.3	13.8	16.4	19.8	6.2	1.6	25.8
Pinus ponderosa	7.0	5.2	8.7	9.0	11.7	13.7	4.6	1.3	9.0

is necessary to take the trunk diameter at the base, above any buttressed effect instead of D.B.H. This measurement seems to be a sure but not very "sensitive" indicator of the growth response of the red pine to different sites because of the very slight degree of taper in this species. Unlike many conifers, red pine maintains a low degree of taper even under adverse growing conditions during establishment. For this reason a red pine tree may have a basal diameter equal to or even less than that of a smaller tree of another species (Table 1). Computed volume of crown of young pines can be used to good advantage in the evaluation of sites because it tends to accentuate small differences in growth response. It indicates a difference in response that may not as yet be evident by trunk diameter measurement. By means of this computation and also by height measurement, site 6 is indicated as a more favorable site for red pine than site 4, although average diameter values do not so indicate. On the other hand, based on diameter measurements, red pine would seem to be making better growth in site 5 than in site 6, although height measurements are lower.

On the basis of all three measurement criteria, site 3 was the most favorable to the establishment and growth of red pine. The deep Lindley subsoil, friable for a depth at least 8 inches because of weathering and the leaching of colloidal clays to greater depths, provided an excellent substratum for the establishment of the pines. Rate of percolation was high resulting in favorable moisture relations in view of the fact that there was little or no competition from grass or weeds. However, on sites of this kind on the farm, Korean lespedeza is easily established and makes an excellent herbaceous cover in and near pine plantations. The pioneer position of pines in natural plant succession would indicate their adaptation to bare, deep, friable Lindley loam subsoil but the favorable response of red pine to this site is somewhat surprising because, with the exception of white pine, it is more nearly a climax tree in its native habitat than any of the other pines tested.

Sites 5 and 6 ranked next as favorable habitats for the establishment of the red pine. There was no significent difference between the response of the red pine on the two sits. The trees on site 6 were taller than those on site 5 but were smaller in diameter. Diameter would seem to be a surer criterion of favorable response in the red pine than height, especially, in this instance, considering the increased rate of height growth of the trees in site 5 in 1944. Both of these sites seem to be favorable to the establishment and growth of red pine if bluegrass competition is controlled for the first two years. As the quantity and vigor of the bluegrass is being gradually reduced because of the influence of the trees, the fertile soil of these sites may contribute to a more favorable response of the pines than the conditions in site 3. In view of the average 29-inch height growth of the trees in site 3 in 1944, however, the response will have to be extremely favorable.

Sites 1 and 4 ranked third in the response of the red pine to site quality. Site 1, which resembles site 3, seemed chiefly to lack depth of soil and favorable soil structure. Excessive competition of the bluegrass was the critical factor in the establishment and growth of red pine in site 4. Competition is still operating as a deterrent to the growth of the pine although the rate of growth in 1944 (Table 1) was adequate to overcome the competition of the bluegrass. It is well to note, however, that the red pine has become established in these two sites and that sites which are the equivalent of either of these will be at least adequate for the planting of adapted species of pine.

Site 2 had the lowest rank as a planting site for red pine. However it was adequate for establishment of the trees chiefly because of drainage water from the slope and the unusual percolation rate of the underlying C horizon of the Lindley loam.

The data in the table also shows the comparative rate of growth of the pine species in the different sites. In sites 1 and 6, red pine had a significantly higher rate of growth than the other pines with which it was associated and had at least an equal rate of growth in sites 2, 4 and 5. Although growing alone in site 3, its response to this site was at least equal to that of any pine which has been tried in such sites. In sites 1 and 2, from which the top soil and part of the B horizon has been eroded, the rate of growth of the red pine was more nearly approached by the Austrian pine. Under competition with bluegrass in sites 4 and 5 its response was more nearly equaled by that of ponderosa pine, a sturdy, moderately fast-growing tree which seems to be well adapted to competition with bluegrass. Under these conditions the response of ponderosa pine is comparable to that which it shows under competition with grassland vegetation on the border of its range in the Rocky Mountain region.

The six selected sites are representative of the sites which will be chiefly utilized for the planting of pines in the erosion problem area of southern Iowa and northern Missouri. They will be planted chiefly on Lindley loam or its equivalent for this is the steep timber soil of the region. A large percentage of the sites will be eroded in various degrees as are sites 1, 2 and 3 in these experiments. The chance of establishment on all three degrees of erosion, represented by these three sites, is good. Care must be taken, on sites with only about a foot of B horizon remaining, that the C horizon has adequate percolation and that soil mosture conditions are favorable. There are many sites in this area from which almost all of the B horizon has been eroded down to the C horizon, which are favorable to the growth of pines because of the friable condition and the high percolation rate of the soil. On these extremely thin soils, structure of the soil seems to be the critical factor.

A number of sites which will be utilized for the planting of pines in this erosion problem area may be represented by sites 4, 5 and 6 which are small areas on steep slopes, bordering streams or gullies, in fence corners or near the house or barn. They may be small flood-plain sites in the bend of a creek as is site 6. These sites may be uneroded or partly or entirely recovered. On sites of this type, which have all or a portion of the top soil in place, the critical factor will be competition with grass and weeds. Protection from excessive competition for a few years will be necessary for the establishment of pines.

Utilization of the trees for holding and building soil and for windbreaks, wildlife cover, woodlot uses, lumber or landscape beautification would seem to constitute proper justification for establishing numerous small plantings of pines in the erosion problem area.

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