THE PERFORMANCE OF AUSTRIAN PINE SEED SOURCES ON VARIOUS SITES IN WEST VIRGINIA AND PENNSYLVANIA

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ABSTRACT.-- Twelve sources of Austrian pine were tested of six sites (5 mine spoils and 1 agricultural site). Lime Or fly ash application enhanced the planting survival on extremely acid sites. In West Virginia, the survival of Austrian pine was best at about 2500 feet above sea level. Yugoslavian source 66-105 and Austrian source 66-87 are recommended for planting in Pennsylvania and West Virginia. P. brutia is not recommended for planting in the study region. And sources 66-86 and 66-94 are not recommended for planting at elevations greater than 3000 feet above sea level.

Between 1930 AND 1971, there were 385,500 ha of land disturbed by strip mining in Appalachia. Industry reclaimed approximately 62 percent (251,00 ha) of this area according to existing legal requirements. Approximately 32,000 km of highwall and 2700 km of outslope remain. Almost 70 percent of these strip mine spoils are on slopes 15 degrees. Almost 88 percent of the total stripped land in Central Appalachia (southern West Virginia, eastern Kentucky, western Virginia, and northeastern Tennessee) is on slopes 20 degrees (hutchins 1978). Although the total disturbed area is only 1 percent of the land mass, local areas may have extensive amounts of disturbed land. In the anthracite coal fields of Pennsylvania, 19 percent of the land has been disturbed by strip mining (Czapowskyj and McQuilkin 1966).

Surface mines and deep mines leave spoils and refuse piles which are unsightly, subject to extreme erosion, and sources of acid mine drainage and siltation which can damage surrounding land and streams. Because of extreme rockiness and/or high

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acidity, it is usually difficult for natural vegetation to become established on these sites. It is desirable to obtain cover as soon as possible in order to minimize erosion. An initial planting of grasses and legumes can rapidly provide this cover if sites are treated to raise the spoil pH. A cover of trees can be established later to further stabilize the spoil material and to cover unsightly areas. Fast-growing, acid-tolerant hardwoods, such as black locust (Robinia pseudoacacia L.) and alder (Alnus sp. B. Ehrh.), are suitable for this purpose. Pines are generally too slow-growing to provide adequate ground cover in a short time. However, they provide wildlife cover and are desirable aesthetically because they provide year-round camouflage. Hence, they are useful when planted in combination with other species. In addition, pines are adapted to sites with a pH of 4.0-6.0. Thus, prior to planting, most spoils would require no treatment to raise the pH. Austrian pine (Pines nigra Arn.) has been planted suc cessfully on some strip mine spoils (Magnuson and Kimball 1968, Czapowskyj 1970; Plass 1975). This study was established to determine the response of several seed sources of P. nigra on various sites in West Virginia and Pennsylvania.

SITE DESCRIPTIONS

1. Stewartstown, WV

In 1970, 65 acres on the Stewartstown strip mine spoil were treated with fly ash, a by-product of coal-burning power plants. Fly ash is alkaline , and it contains large amounts of plant nutrients (Adams, et. al., 1976; Cech, et. al., 1974). It was applied. at the rate of 150 tons per acre using a high lift with a single ripper tooth. A 10-10-10 fertilizer was also applied at the rate of 1000 pounds per acre. This treatment raised the pH of the sandstone spoil from 2.5-3.3 to 7.0-8.0. The pH averaged 7.3 in 1977. A mixture of grass seed was sown after treatment. The elevation of this site is 1160 feet above sea level.

2. Rt. 119, Morgantown, WV

A second strip mine spoil along Rt. 119, near Morgantown, contained two types of spoil material. One half was crushed sandstone with a pH of 4.4. The other half consisted of a subsurface layer of clay covered with 2 to 12 inches of black, carbonaceous spoil. The average ph on this half was 3.8. This site received no treatment prior to planting. The elevation of this site is 1180 feet above sea level.

3. Blakely, PA

The Blakely site is anthracite coal-breaker refuse. This is material which was rejected by the coal-breaker in the cleaning process. It consists of extremely acid (pH 3.7 to 4.0), black

carbonaceous shale and coal fragments. The site was leveled and treated with granular limestone at the rate of 1.5 tons per acre. In May, 1972, 180 pounds per acre of ammonium nitrate were applied. The next spring, 110 pounds per acre of super phosphate were applied. The elevation of this site is 800 feet above sea level.

4. Stotesbury, WV

The Stotesbury site is an untreated sandstone and shale strip mine spoil. The pH ranged from 4.5 to 5.5. The elevation of this site is 2500 feet above sea level.

5. Shavers Fork, WV

The Shavers Fork site is an untreated shale strip mine spoil. The ph ranged from 5.0 to 6.0. The elevation of this site is 3500 feet above sea level.

6. Reedsville, WV

The Reedsville site is an agricultural site located on the Reedsville Experimental Farm. This site had lain fallow for three years prior to planting. The soil pH was 6.1. The elevation of this site is 1760 feet above sea level.

MATERIALS AND METHODS

Seed for this study were provided by William Plass, USDA Forest Service, Princeton, WV. Twelve sources of P. nigra (Table 1)

Table 1. Austrian pine seed sources.

Source Number	Nation	State or Province	Latitude	Longitude	Altitude (m. above sea level)
66-76	Yugoslavia	Serbia	43° 38'	19° 38'	1055
66-77	Yugoslavia	Croatia	44° 53'	15° 24'	800
66-86	France	Unknown	Unknown	Unknown	Unknown
66-87	Austria	Unknown	48° 00'	15° 00'	Unknown
66-94	Cyprus	Limassol	34° 55'	32° 52'	1678
66-103	Yugoslavia	Croatia	44° 32'	15° 24'	560
66-104	Yugoslavia	Bosnia	43° 59'	17° 21'	1050
66-105	Yugoslavia	Croatia	45° 25'	17° 42'	325
66-106	Yugoslavia	Bosnia	44° 04'	17° 22'	850
66-107	Yugoslavia	Croatia	43° 08'	16° 42'	150
67-141	Turkey	Balikesir	39° 40'	27° 50'	1050
68-153	Turkey	Egui	37° 35'	35° 20'	1400
68-156	Turkey	Burdur	37° 20'	30° 45'	650

were planted in various combinations (Table 5). In addition, one source of Calabrian pine (P. brutia Ten.) was planted on all but the Blakely site. One row per replication of black locust, European alder, and autumn olive were interplanted with the pines on the Rt. 119 and Stewartstown sites. Seedlings were grown at the Clements Nursery of the West Virginia Department of Natural Resources. The 2-0 seedlings were outplanted in 1972. The planting design for each site is shown in Table 2.

Table 2. Planting designs on the various sites.

Site	Number of replications	No. of trees per plot	Spacing (feet)	No. of seed sources
Stewartstown	13 (analyzed 9)[a]	5	6x6	9
Reedsville	10	5	6x6	9
Rt. 119	4 (analyzed 3)[b]	5	6x6	9
Blakely	5	16	4x4	9
Shavers Fork	3	10	6x6	12
Stotesbury	3	10	6x6	12

a/ Three replications were washed out and one was lost to later reclamation activity.
b/ One replication which had poor survival due to low pH was dropped from the analysis.

The sites were evaluated during July 16-20, 1979. Height was measured to the nearest centimeter. Diameter at five cm above ground line was measured to the nearest 0.1 cm. All trees were measured on the Stewartstown, Rt. 119, and Reedsville sites. On the remaining sites, four randomly-picked trees per row plot were measured. Percent survival was determined. And needle length to the nearest 0.1 cm was determined using ten randomly-picked second-year needle bundles per row.

Two analyses of variance were run. One used the data from all sources, and the other used the data from only those sources planted on all six sites. A modified LSD test was used to determine differences among means. Linear and curvilinear regression and correlation analyses were run on comparisons to site elevation, seed source elevation, latitude, and longitude.

RESULTS

Differences due to site

Differences among sites for average height, average diameter, percent survival, and average needle length were significant at

the 1 percent level. The trees grew most rapidly on the Rt. 119 and Reedsville sites. Trees on the Stewartstown site ranked third in height, taller than on the remaining sites. The trees on the Reedsville site had the largest average diameter. Other diameter differences were less clear, but the trees on the Stewartstown site were larger than those on the Blakely and Stotesbury sites (Table 3).

Table 3. Average height, diameter, and needle length, and percent survival by planting site.

Site	Average Height (cm)	Average Diameter (cm)	Average needle length (cm)	Percent Survival
Reedsville	214.44	8.80	9.26	56.67
Rt. 119	229.05	5.66	10.82	42.96
Stewartstown	173.07	5.82	9.46	54.57
Blakely	124.96	4.99	7.78	59.76
Stotesbury	135.03	4.83	7.08	88.61
Shavers Fork	130.38	5.15	7.28	67.94

Survival was best on the Stotesbury site. A regression, using data from those sources common to all sites, shows that there is a curvilinear relationship (r=0.7223) of percent survival to the elevation of the planting site when the Blakely data are omitted. This regression is significant at the 5% level (Fig. 1).

Needles were longest on the Rt. 119 site and shortest on the Stotesbury and Shavers Fork sites. Analysis showed that there was a negative curvilinear relationship (r=0.7449) of needle length to the elevation of the planting site which is significant at the 5% level. There is also a negative linear correlation (r=-0.5328) of needle length to percent survival which is significant at the 1% level (Fig. 2).

Differences due to seed source

When all the seed sources were included in the analysis, differences for average height, percent survival, and average needle length were significant at the 1% level. When only those sources common to all sites were analyzed, differences for average height and needle length remain significant. Differences for percent survival, however, were non-significant. In both analyses, differences among sources for average diameter were significant at the 5% level. Means for these variables are shown in Table 4.

The French source 66-86 had the tallest seedlings, but they

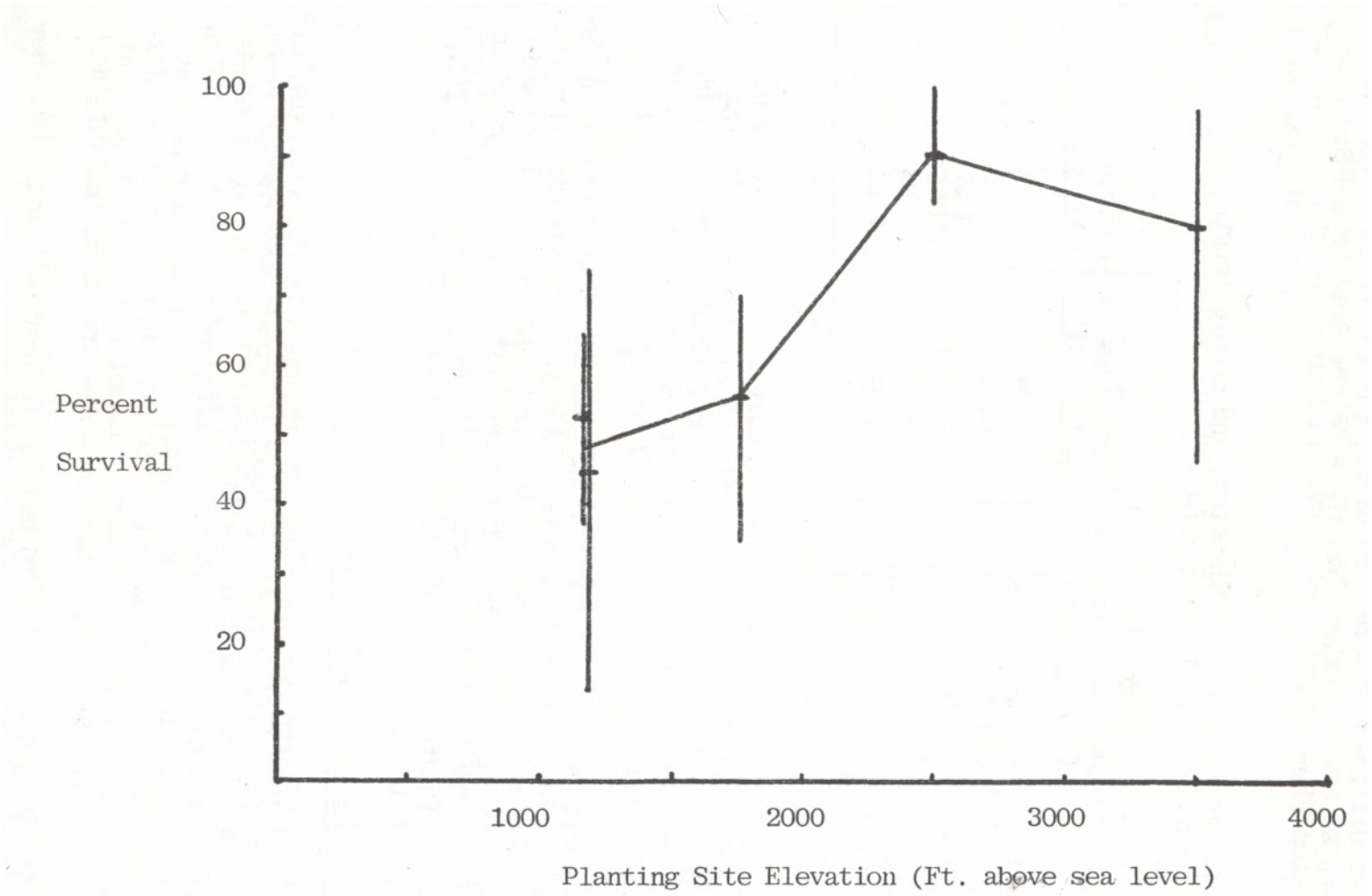

Fig. 1. Relationship of percent survival to the planting site elevation.

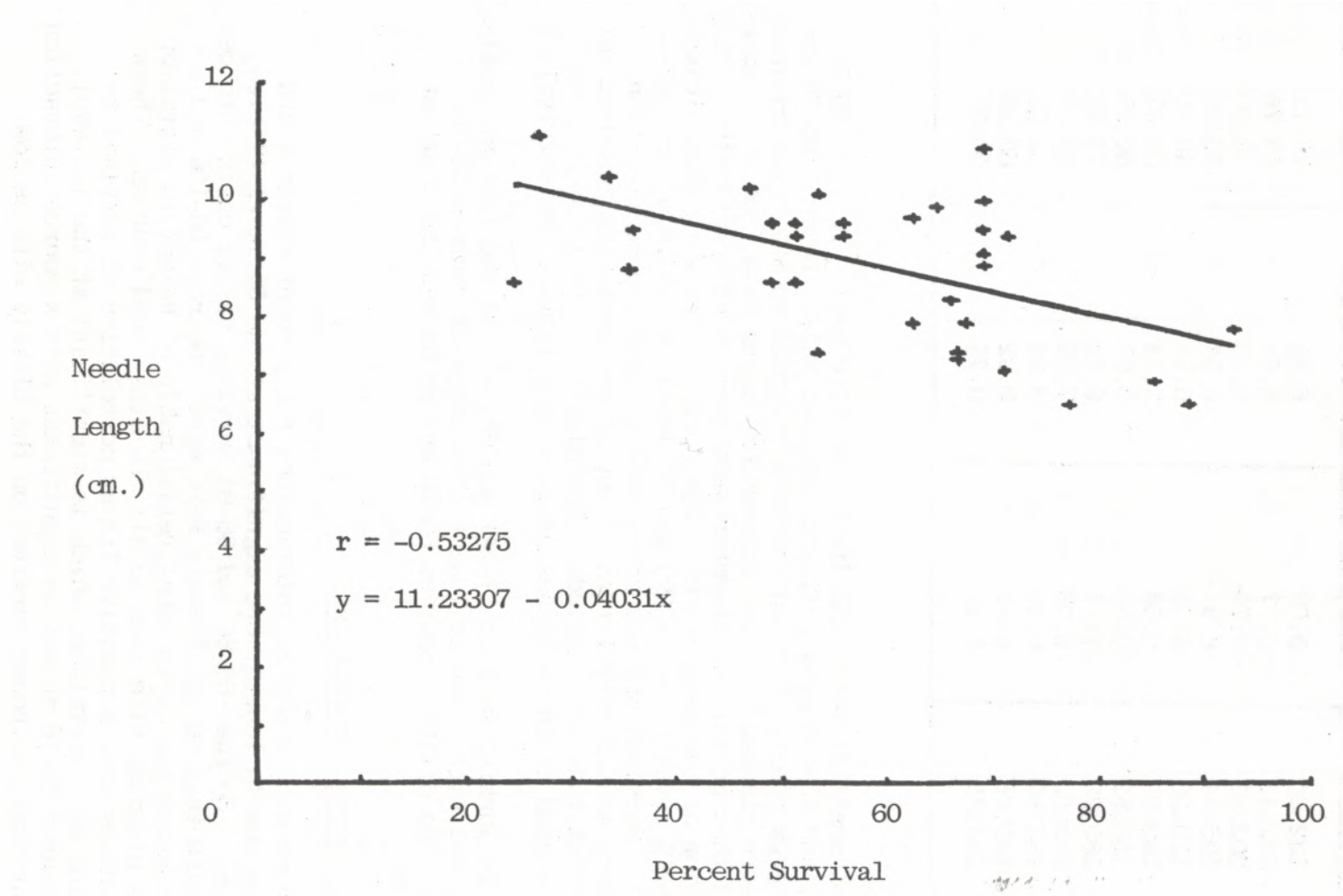

Fig. 2. Relationship of needle length to percent survival.

Table 4. Average height, diameter, and needle length, and percent survival by seed source.

Seed Source	Average Height (cm)	Average Diameter (cm)	Average needle length (cm)	Percent Survival
66-76	132.00	5.09	6.92	77.11
66-77	182.42	6.77	8.08	63.76
66-86	202.67	4.70	8.93	30.00
66-87	195.44	6.91	8.94	70.00
66-94	110.25	4.35	6.78	45.00
66-103	182.22	6.54	7.77	56.82
66-104	156.52	6.05	8.67	60.39
66-105	189.30	7.14	9.12	67.21
66-106	155.52	6.03	7.95	57.18
66-107	184.52	6.43	8.89	52.24
67-141	180.88	6.95	9.92	65.15
68-153	144.45	5.21	9.77	54.97

were of small diameter and did not survive well. Sources 66-77, 66-87, and 66-105 grew well and survived well. Sources 66-76 and 66-94 grew poorly, but had the best survival on the sites on which they were planted. Linear regressions using data from all sources showed that height and diameter were correlated negatively to the elevation at the seed source. The correlations were significant at the 1% level (r= -0.8329) and 5% level (r= -0.7649), respectively. Survival was not correlated to seed source elevation. And there was no correlation of any of the variables measured to either latitude or longitude. The single P. brutia source was not included in the analyses because of extremely low survival.

The Turkish sources 67-141 and 68-153 had the longest needles, though not significantly longer than those of sources 66-104, 66-105, and 66-107. Sources 66-76 and 66-94 had the shortest needles.

Site x source interactions

Some site x source interactions for percent survival and average needle length were significant at the 5% level (Tables 5 and 6). Sources 66-86 and 66-94 survived better on the Stotesbury site than on the Shavers Fork site. Sources 66-106 and 67-141 broke the curvilinear relationship of height to elevation of the planting site seen in all the other seed sources. These two sources show a positive linear correlation of survival to planting site elevation, which is significant at the 1% level. Only source 66-76 showed no significant site x source interaction for survival, although survival on the Blakely site is low.

Table 5. Percent survival by source and site.

Seed source	Percent survival					
	Reeds-ville	Rt. 119	Stewarts-town	Blakely	Stotesbury	Shavers Fork
66-76	—	—	—	58.80	100.00	100.00
66-77	62.00	60.00	48.89	68.80	90.00	83.33
66-86	—	—	—	—	60.00	0.00
66-87	66.00	33.33	71.11	—	96.67	90.00
66-94	—	—	—	—	83.33	6.67
66-103	40.00	73.33	57.78	65.00	90.00	46.67
66-104	64.00	13.33	64.44	48.60	100.00	63.33
66-105	70.00	60.00	51.11	63.60	93.33	93.33
66-106	60.00	13.33	46.67	57.40	83.33	96.67
66-107	44.00	40.00	37.78	64.80	90.00	76.67
67-141	68.00	53.33	53.33	56.00	90.00	93.33
68-153	36.00	40.00	60.00	54.80	86.67	86.67

Table 6. Average needle length by source and site.

Seed source	Average needle length (cm.)					
	Reeds-ville	Rt. 119	Stewarts-town	Blakely	Stotesbury	Shavers Fork
66-76	—	—	—	7.12	6.67	6.70
66-77	8.51	8.90	8.79	7.52	6.53	6.83
66-86	—	—	—	—	8.93	
66-87	9.50	10.00	9.22	—	7.13	7.37
66-94	—	—	—	—	6.87	6.50
66-103	7.17	10.10	8.23	8.04	6.27	6.87
66-104	9.07	10.40	9.17	9.18	6.23	6.90
66-105	9.94	11.80	9.44	7.10	7.46	7.53
66-106	8.44	11.80	8.06	7.50	7.03	6.53
66-107	9.46	11.55	9.59	7.62	6.97	7.77
67-141	11.29	11.00	10.85	7.94	7.50	7.53
68-153	9.79	14.80	11.48	7.60	7.70	8.60

All sources except sources 66-76, 66-77, 66-87, and 66-94 showed an interaction of needle length with site. The most distinctive is for source 67-141, which had much longer needles on the Reedsville, Rt. 119, and Stewartstown sites than on the others.

DISCUSSION AND CONCLUSIONS

The results on the untreated spoils indicate that P. nigra is suitable for planting on such acid sandstone and shale spoils within the study region. Growth and survival were comparable to that of other pines (i.e. red, white, pitch, and Scotch pines) on other strip mine sites (Finn 1958; Hart and Byrnes 1960).

As might be expected, P. nigra grew better on the agricultural site (Reedsville) than on the strip mine spoils. This result provides a good standard for comparison in determining tree vigor on the more adverse sites. Competition from herbaceous cover probably decreased survival on the Reedsville site.

The trees on the untreated Rt. 119 spoil grew surprisingly well. This is apparently a relatively good, moist site. The presence of soil-building black locust and alder which were planted on this site could have enhanced the growth of the P. nigra. At the same time, however, these hardwoods overtopped the pines, causing many to die due to the competition. Comparing the data to an earlier report by Keys and Cech (1977), survival has dropped 10 percent in three years.

The results on the Stewartstown site are good. Although survival was low, it was probably better than it would have been if the site had not been treated. The original pH of this spoil was very low (2.5 to 3.3). By comparison, the survival on the untreated, abandoned replication on the Rt. 119 site was neglible. The p11 of this latter site *was* 3.0. Survival on the Stewartstown site probably would have been just as poor if it had not been treated with fly ash.

The same is true for the Blakely site. Although height and diameter values were low, the results on this site were impressive. Coal-breaker refuse piles, such as one adjacent to the planting, can exist for several decades without the occurrance of natural revegetation. With the addition of lime and fertilizer, however, trees were established quite easily. Liming to raise the pH is the most important factor in revegetating these sites (Ed Sowa, USDA Forest Service, Kingston, PA, personal communication). "Hot spots" where no trees survived were present within this planting.

The curvilinear relationship of survival to planting site elevation suggests that P. nigra will survive best when planted on sites which are about 2500 feet above sea level. However, the design of this study was such that a definite conclusion could not be drawn from these data. Considering the variability of the site conditions, it is possible that there are other factors involved in this relationship which are not so apparent.

There is no apparent explanation of the negative linear relationship of needle length to survival. Soil and leaf nutrient analyses, now in progress, may reveal the causative factor of this relationship. The negative curvilinear relationship of needle length to the planting site elevation, however, can be explained by the relationship of needle length to survival, since survival is curvilinearly related to planting site elevation.

The elevation at the seed source is an important factor in the growth rate of P. nigra when it is planted in the study region. Sources from lower elevations (150 to 800 feet above sea level) will grow faster than those from higher elevations. And, although not statistically significant, survival of the low—elevation sources tends to be good. Of the seed sources we sampled, those from the Croatian province of Yugoslavia (sources 66-77, 66-103, 66-105, and 66-107) responded well. The Austrian source 66-87 also did well on the five sites on which it was planted. All of these are low-elevation sources. These same sources were found to be best in an earlier report by Keys and Cech (1977).

In conclusion, P. nigra responds differently depending upon the site on which it is planted and the seed source which is used. Survival was best on a site with an elevation of 2500 feet above sea level. There was some evidence of a curvilinear relationship of survival to planting site elevation. On extremely acid spoils, fly ash or lime should be applied in order to raise the pH and, consequently, improve the planting success. Sources 66-105, 66-77, and 66-87 are recommended for planting in Pennsylvania and West Virginia. P. brutia is not recommended for planting in these areas. And sources 66-86 and 66-94 are not recommended for planting at elevations greater than 3000 feet above sea level.

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