# Experimental Planting of 14 tree species on Pennsylvania's Anthracite Strip-Mine Spoils

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# FOREWORD

THIS IS THE FOURTH in a series of reports dealing with mine-spoil revegetation research in the Anthracite Region of Pennsylvania. The preceding reports were: *A guide for screen and cover planting of trees on anthracite mine-spoil areas* (USDA Forest Serv. Res. Paper NE-22, 1964); *Survival and early growth of planted forest trees on strip-mine spoils in the Anthracite Region* (USDA Forest Serv. Res. Paper NE-46, 1966); and *Response of crownvetch planted on anthracite breaker refuse* (USDA Forest Serv. Res. Note NE-78, 1968).

The Pennsylvania Power and Light Company, whose interest led to the initiation of this project on anthracite mine-spoil revegetation in 1961, financed most of the research in these reports and is continuing its support for studies in progress. The author gratefully acknowledges the cooperation and assistance of the Pennsylvania Department of Forests and Waters for supplying nursery stock, and Stephen Postupack and Joseph Paddock, contract planters, for their contributions during the planting stage of this study.

The author acknowledges William E. McQuilkin's help in preparing portions of this report.

# Experimental Planting of 14 tree species on Pennsylvania's Anthracite Strip-Mine Spoils


## The Author

MIROSLAW M. CZAPOWSKYJ received a Diplomforstwirt degree from Ludwig-Maximilians University, Munich, Germany in 1949. From 1949 to 1951 he was on the staff of Wuerttemberg's Hofkammerforstamt in Altshausen, Germany. A native of the Ukraine, he has been in this country since 1951 and an American citizen since 1957. He obtained a master's degree in forestry from the University of Maine in 1958 and a Ph.D. degree in soils from Rutgers University in 1962. He joined the Northeastern Forest Experiment Station in 1961 as a research forester, and has been assigned since that time to the Station's research unit at Kingston, Pa.

# A DESIGNED PLANTING EXPERIMENT

IN 1961 THE Northeastern Forest Experiment Station, in cooperation with the Pennsylvania Power and Light Company, began a research program on revegetation—primarily reforestation—of the coal-mine spoils of Pennsylvania's Anthracite Region. The first two studies were of survey type. Frank (*1964*) classified and mapped all the area disturbed by anthracite mining, which he found in 1962 to total 112,000 acres. Of this acreage, 76 percent was due to strip-mining; and more than half of the disturbed land was still practically devoid of tree cover. Czapowskyj and McQuilkin (*1966*) reported on a 1962 survey of all tree plantings made on anthracite spoils up to and including 1955 (plantings 7 or more years old). They also offered a tentative classification of anthracite strip-mine spoils as media for tree growth.

Because those early tree-planting efforts were small trials made without benefit of formal experimental design, the results were no more than indicative of survival and growth that might be expected from the various species. Therefore, in 1963 a designed planting experiment, involving 11 coniferous and 3 hardwood species, was established across a broad spectrum of strip-mine spoil types and grading conditions.

This paper presents the 5-year results from those plantings.

# THE STUDY

Four strip-mine spoil types representing those described earlier (*Czapowskyj and McQuilkin 1966*) were selected as experimental planting sites. These types, designated in this paper by roman numerals I to IV, are characterized by distinct differences in the predominant parent material as follows:[1]

Type I — Black carbonaceous shale.
Type II — Gray to yellow shales.
Type III — Sandstones and conglomerates.
Type IV — Glacial till and surface deposits.

Although coal operators now are required by law (*Commonwealth of Pennsylvania 1963*) to grade the stripping spoils when mining is completed, large acreages of ungraded spoils still remain from stripping operations conducted before passage of this law. So each spoil type was represented in the experimental plantings by both graded and ungraded conditions. The spoils of the ungraded sites varied from 10 to 15 years old (since stripping) and slope angles were approximately 40°. The graded sites were 1 to 3 years old (since grading), and slope angles were mostly between 5° and 10°. All planting sites were sampled systematically to a depth of 12 inches for analysis of selected physical and chemical properties.[2]

The "soil" fraction (material passing through a 2-mm. sieve) varied considerably among the spoil types, from less than 30 percent in type I to 70 percent in type IV (appendix, table 1). Moisture retention percentages also varied. So individual spoil types and grading conditions varied considerably in their capacities to store and to supply moisture for tree survival and growth. However, under average rainfall conditions in the Anthracite Region, retention capacities are adequate for normal tree survival and growth.

Although pH values varied considerably between spoil types and grading conditions (appendix, table 2), acidity itself was not

[1] See the appendix for a more detailed description.

[2] Chemical analysis was performed in the Soil Chemistry Laboratory of The Pennsylvania State University.

a problem. In spoil types I and III, pH values were appreciably higher in graded spoils than in ungraded spoils. The reasons for this are not clear. The lower pH values may be due partially to weathering processes, leaching of bases, and surface erosion on the ungraded spoils. On the other hand, grading of spoils exposed unweathered and unleached material.

Exchangeable bases, extractable phosphorus, and total nitrogen varied from one spoil type to another and from one grading condition to another. The overall natural supply of these essential plant nutrients was low; nitrogen, in particular, was probably too low for normal tree growth. The total bases (Ca + Mg + K) in graded spoil type I, II, and III were considerably higher than in their ungraded counterparts. Ca accounted for 79 to 83 percent of the total exchangeable bases in the graded spoils as compared to 53 to 64 percent in ungraded spoils. There were no appreciable differences in chemical or physical characteristics between graded and ungraded sites on spoil-type IV.

The 14 species used in the experiment (appendix, table 3) were selected to include those that had shown the most promise in earlier mine-spoil plantings in both the Anthracite and Bituminous Regions of Pennsylvania.

The field layout consisted of 32 blocks; 8 on each spoil type, with 4 replicates each on graded and ungraded spoils. Blocks were 84 by 50 feet, with the longer dimension on the contour, thus providing for 14 rows (6 feet apart and 50 feet long) running up and down slope. In each block, 11 rows as a group were assigned to the 11 coniferous species, and 3 rows were assigned to the hardwoods. The species were randomized separately, by rows, within these groups. The conifers were planted with 2-foot spacing, or 25 trees per row; the hardwoods were planted with 3-foot spacing, or 17 trees per row. Thus, in the 32 blocks, 800 seedlings of each coniferous species and 544 seedlings (or cuttings, in the case of hybrid poplar) of each hardwood species were planted. These added up to 8,800 conifers and 1,632 hardwoods for a grand total of 10,432 seedlings and cuttings.

Planting was done by crews of experienced planters, using planting bars, during typical spring weather when spoil moisture conditions were favorable.

Survival and height growth were recorded at the end of each growing season and were summarized by species, spoil type, and grading condition. During the 5-year period, particularly in 1966 and 1967, a few blocks or parts of blocks were destroyed by renewed stripping or grading operations that were not anticipated when the sites were selected. Consequently, only limited use could be made of statistical methods for analysis of data.

# RESULTS

Tree survival on graded sites was better than on ungraded sites. Overall survival was 70 percent for hardwoods and 60 percent for conifers on graded sites, compared to 40 percent for hardwoods and 32 percent for conifers on ungraded sites (fig. 1 and appendix, table 4).

The overall growth of conifers was poor to fair. Only three species—jack pine, Virginia pine, and Japanese larch—exceeded an average height of 3 feet. Growth of the hardwoods was better: average heights on graded sites ranged from 6.4 to 13.0 feet. The first three growing seasons were extremely dry, accounting for some of the mortality and retarded growth (fig. 1 and appendix, table 5).

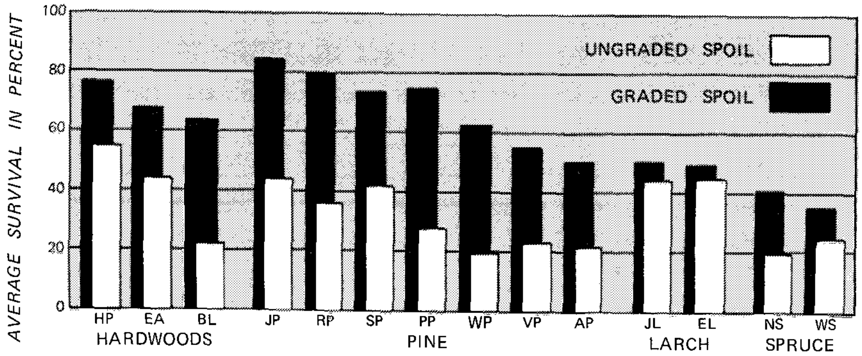
Much variation occurred between species, spoil types, and replicates. A number of instances of 90 percent or higher survival, and growth considerably better than average, were recorded.

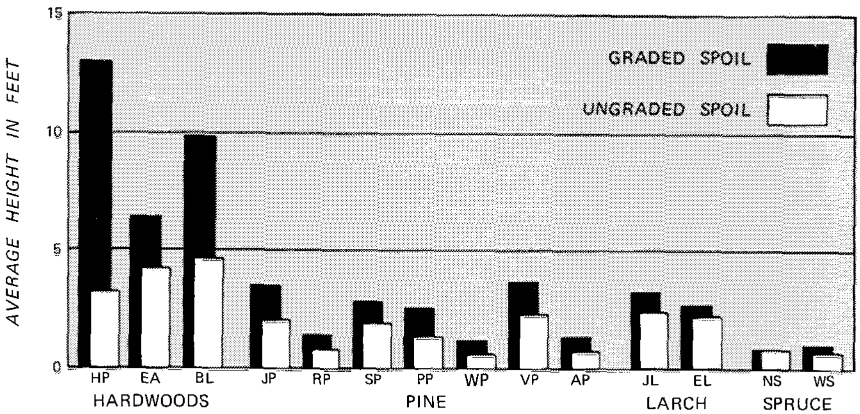
The 5-year results in terms of survival and total height (appendix, tables 4 and 5) are discussed below in relation to the three independent variables—spoil type, grading condition, and species.

## Spoil Type

The most marked spoil type effect was the poor performance on type IV (glacial till and surface deposits). This was unexpected, in view of the relatively high content of "soil"-size particles and the near neutral reaction of type IV spoil. The reason for this is not clear. However, the surface of this spoil becomes readily sealed, thus reducing rainfall infiltration, increasing water

Figure 1.—Average height and average survival of tree species 5 years after planting. (See appendix, table 3, for list of trees).




runoff, and causing intense surface erosion that resulted in tree mortality. This was not so pronounced in the other spoil types. Also, pH was possibly somewhat above the optimum for growth of essential mycorrhizal fungi and other symbiotic root organisms.

No strongly consistent differences were found among the other three spoil types. Type I usually was somewhat less favorable than types II and III, but this did not hold for all replicates and species. Because of its relatively low content of "soil"-size particles and its generally darker color, spoil-type I, and spoils like it, can be expected to be the least favorable of these three types.

Spoil types frequently vary within themselves and intergrade with each other to a degree that differences affecting plant performance are not clearly or consistently evident, at least during the early stages of growth.

The tendency of rocks to roll and slide, particularly on spoil types I and II, is another critical feature that adversely affects survival and growth. Although no attempt was made to evaluate the relative contribution of erosion and rock rolling and sliding to mortality, there is strong evidence that considerable mortality and damage was caused by rock rolling and sliding on spoil-types I and II and by erosion on spoil-types III and IV.

Erosion and rock sliding, or a combination of both, reduced tree growth by injuring and partially covering trees. Partially covered trees frequently bend, and subsequently their growth slows.

## Grading Condition

The effect of grading on tree performance was much more clearly defined than the effect of spoil type. Survival on graded spoils averaged almost twice as high as on ungraded spoils. This effect was most strongly expressed on spoil-type IV, but was remarkably consistent for all species and on all spoil types (appendix, table 5). Growth was consistently better on the graded spoils, although in some instances the differences were relatively small (appendix, table 4).

These results disagree with work reported from the Central States (*Limstrom 1960; Chapman 1967*), where grading was found to have adverse effects. However, the adverse effects there were most evident on spoils derived from limestone and having a high content of clay. Such material, when graded, becomes very compact and impervious to air and water. None of the Pennsylvania anthracite spoils are of limestone origin, nor do they have such high proportions of clay. The coarser-textured anthracite spoils obviously were improved by the degree of compaction resulting from grading operations.

Besides its compaction effects, grading also improves anthracite spoils as planting sites by reducing steepness of slopes. Thus, damage from erosion and rock slidings are lessened.

### Species

As expected, apart from spoil type and grading condition effects, individual species performed differently. In the following paragraphs an attempt is made to present the results, based on tables 4 and 5 (appendix) and supplemented by personal judgment, by pointing out the better (or poorer) performers and by relating their performance to site factors, planting stock used, and inherited characteristics of early growth.

**Hardwoods.**—The three hardwoods—hybrid poplar, black locust, and black alder—varied appreciably in their performance. Their survival and height growth appeared to be affected pri-

Figure 2.—Hybrid poplar NE-388 (foreground) and black locust (background) performed equally well on graded spoil-type 1 (sixth growing season).

marily by grading and spoil type. All three species had excellent survival and good growth on graded spoil-types I and III, and poor survival and growth, only on ungraded spoil-type IV (fig. 2). Hybrid poplar, with an overall average survival of 77 and 55 percent and a total height of 13.0 and 3.2 feet for graded and ungraded spoils respectively, performed best among the three hardwoods (fig. 3).

Figure 3.—Hybrid poplar NE-388 had the best height growth and survival after 5 growing seasons. Note the conifers in the foreground.

Figure 4.—Conifers planted on graded spoil-type II had excellent survival and height growth (sixth growing season).

**Pines.**—The performance of the seven pine species varied appreciably between grading condition and between species (fig. 4). In general, jack, red, Scotch, and pitch pines had better survival than white, Virginia, and Austrian pines. Virginia pine had the best overall height growth, followed by jack and Scotch pines. The growth of Virginia pine deserves special attention since 1-0 nursery stock was used, compared to 2-0 nursery stock used for the other pines.

**Larches.**—Japanese and European larches behaved similarly with respect to spoil type and grading condition. Both species survived adequately (45 to 50 percent) and grew relatively well (2.3 to 3.3 feet). There were no drastic differences in survival or height growth as in the hardwoods and pines. Their best performance was on spoil-type II, and their poorest on spoil-type IV. Average height growth of both species under all conditions was comparable to that of jack, Virginia, and Scotch pines.

**Spruces.**—Norway and white spruces had similar survival and growth rates, but were less successful than all other species. Adequate survival for both species was found only on graded spoil-types I and III and also, for white spruce, on ungraded spoil-type II. On the other spoil types and grading conditions, survival was poor to negligible. Average heights varied between 0.5 and 1.0 foot. Since slow growth during the early years is normal for these species at this age, this does not necessarily show whether the species is succeeding or failing. The low number of surviving trees on certain spoil types and grading conditions prohibited firm conclusions about height growth.

## DISCUSSION & CONCLUSION

Results obtained in this study apply directly only to conditions under which the study was conducted. They confirm and supplement previous findings (*Mickalitis and Kutz 1949; Czapowskyj and McQuilkin 1966*) and provide new evidence that many forest plantings on anthracite strip-mine spoils can survive and grow well. Certain species may even thrive. However, one can raise many questions about the cause of variability in performance between spoil types, and graded versus ungraded conditions, and about the suitability of individual species and genera.

Since neither the causes of mortality nor spoil characteristics affecting survival and growth were studied in detail and correlated, this study does not fully explain why such differences in performance of many species were found. However, there is no doubt that the causes of variability in survival and growth lie in obscure differences, primarily in physical make-up, of the planting media.

A few factors, based on yearly survival counts and growth data[3] and on visual observations made during visits to the experimental sites, became apparent. Most mortality occurred within 2 years after planting. It also appeared evident that erosion and rock sliding and rolling were the main factors contributing to

[3] On file at the Kingston unit of the Northeastern Forest Experiment Station, Kingston, Pa.

mortality and stunted growth. Because the rate of erosion is related to the soil fraction content and the slope angle, ungraded spoil-type III and, in particular, type IV are susceptible to the most severe erosion. This makes the environment for tree establishment and growth very critical on these types, especially during heavy rains.

Further study of erosion control on these spoils warrants consideration. It was observed that the seedlings of species having reasonable height, stem diameter, and well-developed root systems had a better chance to survive. Jack, red, Scotch, and pitch pines—and occasionally Austrian pine, the larches, and hybrid poplar—apparently are superior in withstanding the adverse effects of strip-mine spoils. On the other hand, Virginia and white pines, both spruces, and, under certain conditions, even black locust had difficulty in becoming established, especially when planted on steep ungraded spoils.

Perhaps most remarkable is the strong evidence that plantings on graded sites had considerably higher survival and better height growth.

For the sake of objectivity, it should be mentioned that the year of planting, and the following two growing seasons, were extremely dry. This, without question, contributed to mortality.

These experimental plantings are too young to provide firm conclusions, especially about height growth. However, the following generalizations can be made:

- After 5 years all four anthracite strip-mine spoil types supported planted forest trees.
- The degree of performance varied from poor to excellent, depending on tree species, spoil type, and grading conditions.
- Hardwoods survived somewhat better and had much better height growth than conifers. Hybrid poplar clone NE-388 performed best.
- Jack, red, Scotch, and pitch pines showed superior survival and attained good height growth among conifers. Virginia pine was better only in height growth.

- Larches survived well under a wide range of conditions and attained good growth on ungraded sites.
- Survival of spruces was poor to adequate. Their early slow growth makes them a poor planting choice, especially on ungraded sites where erosion and rock sliding occur continuously.
- Erosion and rock sliding are prime factors of tree mortality, especially on ungraded sites. So, graded sites, regardless of spoil type, are superior tree-growth media.

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# APPENDIX

## Spoil Type

Anthracite strip-mine spoil types as described by M. M. Czapowskyj and W. E. McQuilkin in USDA Forest Service Research Paper NE-46, 1966.

**Spoil-type I,** *black carbonaceous shales.*—Coarse, black to dark grey, thin-bedded carbonaceous shales and slates, plus coal fragments. Gray to yellow thick-bedded slaty shales, sandstones, and conglomerate fragments are commonly associated.

**Spoil-type II,** *gray to yellow shales.*—Pale gray to yellow, soft, thick-bedded shaled and slate fragments, with black shales and sandstones frequently intermixed.

**Spoil-type III,** *sandstones and conglomerates.*—Gray to brown acid sandstone and conglomerate fragments. Slates and shales, together with glacial and stream deposits, often are associated. Extreme stoniness, with rocks 4 or more feet in diameter, is common.

**Spoil-type VI,** *glacial till and surface deposits.*—Basically glacial till and stream deposits, but sandstone, conglomerates, slates, and shale fragments may be associated. The coarse elements of the till and stream deposits vary from 2 millimeters to 2 inches in diameter.

**Table 1.—*Selected physical characteristics of experimental sites (Average of eight replications)***

| Spoil type | Grading condition | Coarse fraction[1] | | | | "Soil" fraction[2] | | | | Moisture retention | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2-1 in. | 1-½ in. | ½-¼ in. | ¼ in.-2mm. | Sand | Silt | Clay | Textural class | F.C.[3] | P.W.P.[4] | A.W.[5] |
| | | *Per-cent* | *Per-cent* | *Per-cent* | *Per-cent* | *Per-cent* | *Per-cent* | *Per-cent* | | *Per-cent* | *Per-cent* | *Per-cent* |
| I | Graded | 18 | 21 | 16 | 16 | 20 | 6 | 3 | sl[6] | 7 | 2 | 5 |
| | Ungraded | 21 | 20 | 14 | 17 | 17 | 6 | 5 | sl | 10 | 2 | 8 |
| II | Graded | 11 | 16 | 16 | 15 | 27 | 10 | 5 | sl | 17 | 5 | 12 |
| | Ungraded | 11 | 15 | 11 | 15 | 29 | 10 | 9 | sl | 15 | 4 | 11 |
| III | Graded | 16 | 15 | 11 | 12 | 31 | 8 | 7 | sl | 8 | 2 | 6 |
| | Ungraded | 11 | 12 | 9 | 12 | 36 | 11 | 9 | sl | 14 | 3 | 11 |
| IV | Graded | 9 | 8 | 6 | 7 | 38 | 16 | 16 | scl[7] | 10 | 4 | 6 |
| | Ungraded | 8 | 7 | 7 | 9 | 40 | 14 | 15 | scl | 12 | 4 | 8 |

[1] Coarse fraction—Determined from twenty-pound samples taken from each spoil type and grading condition.
[2] "Soil" fraction—Sand, silt, and clay—Determined by the Bouyoucos hydrometer method.
[3] F. C.—Field Capacity—Based on field samples 24 hours after a heavy rain.
[4] P.W.P.—Permanent Wilting Point—15-bar moisture content of the less than 2mm. fraction and adjusted to actual field conditions.
[5] A.W.—Available Water = F.C. — P.W.P.
[6] Sandy loam
[7] Sandy clay loam

Table 2.—*Selected chemical characteristics of experimental sites (Average of eight replications)*

| Spoil type | Grading conditions | Reaction | Extractable P | Total N | Exchangeable bases Ca | Exchangeable bases Mg | Exchangeable bases K | Cation exchange capacity | Ca + Mg + K Total | Ca + Mg + K Saturation |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *pH* | *ppm* | *Pct.* | *Milliequivalents/kg of "soil" fraction* | | | | | *Pct.* |
| I | Graded | 5.7 | 27.4 | 0.13 | 29.3 | 4.3 | 1.9 | 63.0 | 35.5 | 56 |
| | Ungraded | 4.5 | 59.8 | .14 | 8.6 | 3.5 | 1.4 | 119.0 | 13.5 | 11 |
| II | Graded | 4.8 | 50.1 | .07 | 23.4 | 4.1 | 2.2 | 119.3 | 29.7 | 25 |
| | Ungraded | 4.6 | 26.3 | .15 | 9.0 | 4.8 | 1.7 | 67.0 | 15.3 | 23 |
| III | Graded | 6.3 | 41.9 | .10 | 28.5 | 3.2 | 2.2 | 61.0 | 33.9 | 56 |
| | Ungraded | 4.2 | 37.7 | .09 | 4.6 | 2.8 | 1.2 | 57.0 | 8.6 | 15 |
| IV | Graded | 7.1 | 64.2 | .07 | 23.6 | 3.5 | 3.3 | 40.0 | 30.4 | 76 |
| | Ungraded | 7.5 | 65.6 | .08 | 28.1 | 3.4 | 2.4 | 37.0 | 33.9 | 92 |

**Table 3.—*Tree species and age of the planting stock***

| Species | Age |
|---|---|
| Hybrid poplar, *P. maximowiczii* X *P. trichocarpa* NE-388 | ([1]) |
| European alder, *Alnus glutinosa* (L.) Gaertn. | 1-0 |
| Black locust, *Robinia pseudoacacia* L. | 1-0 |
| Jack pine, *Pinus banksiana* Lamb. | 2-0 |
| Red pine, *Pinus resinosa* Ait. | 2-0 |
| Scotch pine, *Pinus silvestris* L. | 2-0 |
| Pitch pine, *Pinus rigida* Mill. | 2-0 |
| White pine, *Pinus strobus* L. | 2-0 |
| Virginia pine, *Pinus virginiana* Mill. | 1-0 |
| Austrian pine, *Pinus nigra* Arnold | 2-0 |
| Japanese larch, *Larix leptolepis* (Sieb, and Zucc.) Gord. | 2-0 |
| European larch, *Larix decidua* Mill. | 2-0 |
| Norway spruce, *Picea abies* (L.) Karst. | 2-0 |
| White spruce, *Picea glauca* (Moench) Voss. | 2-0 |

[1] Cuttings

**Table 4.—*Average survival—after 5 years—of forest trees planted on anthracite strip-mine spoils***
[In percent]

| Species | Spoil type I | | Spoil type II | | Spoil type III | | Spoil type IV | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|
| | G[1] | U | G | U | G | U | G | U | G | U |
| Hybrid poplar | 90 | 85 | 78 | 55 | 97 | 57 | 42 | 24 | 77 | 55 |
| European alder | 88 | 70 | 69 | 51 | 85 | 40 | 31 | 14 | 68 | 44 |
| Black locust | 82 | 35 | 26 | 10 | 80 | 35 | 66 | 6 | 64 | 22 |
| Average | 87 | 63 | 58 | 39 | 87 | 44 | 46 | 15 | 70 | 40 |
| Jack pine | 75 | 46 | 96 | 84 | 97 | 33 | 72 | 13 | 85 | 44 |
| Red pine | 77 | 36 | 89 | 68 | 87 | 18 | 65 | 21 | 80 | 36 |
| Scotch pine | 70 | 32 | 86 | 88 | 82 | 38 | 56 | 12 | 74 | 42 |
| Pitch pine | 76 | 30 | 87 | 30 | 91 | 39 | 51 | 12 | 76 | 28 |
| White pine | 71 | 21 | 85 | 32 | 63 | 13 | 34 | 12 | 63 | 20 |
| Virginia pine | 62 | 14 | 64 | 34 | 59 | 34 | 38 | 11 | 56 | 23 |
| Austrian pine | 35 | 14 | 67 | 44 | 60 | 24 | 42 | 5 | 51 | 22 |
| Japanese larch | 54 | 65 | 80 | 74 | 42 | 27 | 28 | 12 | 51 | 44 |
| European larch | 49 | 54 | 65 | 70 | 51 | 50 | 34 | 5 | 50 | 45 |
| Norway spruce | 48 | 12 | 32 | 34 | 65 | 32 | 20 | 1 | 41 | 20 |
| White spruce | 54 | 15 | 27 | 52 | 51 | 28 | 10 | 4 | 36 | 25 |
| Average | 61 | 31 | 71 | 55 | 68 | 30 | 41 | 10 | 60 | 32 |

[1] G = Graded
U = Ungraded

**Table 5—*Average height growth—after 5 years—of forest trees planted on anthracite strip-mine spoils***

[In feet]

| Species | Spoil type I | | Spoil type II | | Spoil type III | | Spoil type IV | | Weighted average | |
|---|---|---|---|---|---|---|---|---|---|---|
| | G[1] | U | G | U | G | U | G | U | G | U |
| Hybrid poplar | 14.8 | 3.8 | 7.2 | 1.9 | 19.4 | 2.7 | 4.9 | 5.2 | 13.0 | 3.2 |
| European alder | 6.7 | 5.8 | 5.2 | .9 | 7.5 | 5.6 | 5.1 | 4.0 | 6.4 | 4.2 |
| Black locust | 12.6 | 6.8 | 6.6 | 2.3 | 10.8 | 3.2 | 6.2 | 5.4 | 9.8 | 4.7 |
| Average | 11.4 | 5.5 | 6.3 | 1.7 | 12.6 | 3.8 | 5.4 | 4.9 | 9.7 | 4.0 |
| Jack pine | 2.3 | 2.6 | 4.9 | 1.8 | 3.7 | 2.2 | 2.4 | 1.4 | 3.5 | 2.1 |
| Red pine | 1.3 | 1.0 | 2.0 | .7 | 1.3 | 1.1 | 1.0 | .8 | 1.4 | .8 |
| Scotch pine | 2.5 | 2.4 | 3.6 | 1.6 | 2.5 | 2.4 | 2.6 | 1.6 | 2.8 | 1.9 |
| Pitch pine | 2.2 | 1.2 | 4.4 | 1.2 | 2.0 | 1.7 | 1.4 | 1.5 | 2.6 | 1.4 |
| White pine | .8 | .6 | 1.9 | .5 | 1.1 | 1.1 | .7 | .5 | 1.2 | .6 |
| Virginia pine | 2.9 | 2.0 | 5.2 | 1.9 | 4.0 | 2.8 | 2.0 | 2.2 | 3.7 | 2.3 |
| Austrian pine | 1.7 | 1.0 | 1.4 | .6 | 1.5 | .8 | 1.2 | .8 | 1.4 | .7 |
| Japanese larch | 3.3 | 2.4 | 3.8 | 2.4 | 3.8 | 2.2 | 1.3 | 2.3 | 3.3 | 2.4 |
| European larch | 3.5 | 2.4 | 2.8 | 2.3 | 2.3 | 2.1 | 1.7 | 1.8 | 2.7 | 2.2 |
| Norway spruce | .9 | .8 | 1.0 | .5 | .7 | 1.0 | .8 | 1.0 | .8 | .8 |
| White spruce | 1.0 | .8 | 1.0 | .5 | .9 | .9 | .8 | .7 | 1.0 | .7 |
| Average | 2.0 | 1.6 | 2.9 | 1.3 | 2.2 | 1.7 | 1.4 | 1.3 | 2.2 | 1.5 |

[1] G = Graded
U = Ungraded

THE FOREST SERVICE of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.