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GIFFORD PINCHOT, Forester.

FOREST PLANTING ON COAL LANDS IN WESTERN PENNSYLVANIA.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Forest Service,
Washington, D. C., June 27, 1906.

Sir: I have the honor to transmit herewith a report entitled "Forest Planting on Coal Lands in Western Pennsylvania," by S. N. Spring, Forest Assistant, Forest Service, and to recommend its publication as Circular 41 of the Forest Service.

Very respectfully,

Gifford Pinchot,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

CONTENTS.

FOREST PLANTING ON COAL LANDS IN WESTERN PENNSYLVANIA.

HISTORY OF THE ORIGINAL FOREST.

In the eighteenth century the upper Ohio Valley was covered by a dense hardwood forest, in which oak, hickory, ash, yellow poplar (tuliptree), walnut, maple, and other valuable species attained fine proportions. The white oak was one of the most important trees in the forest. Michaux, the French botanist, who traveled through the region near the close of the century, wrote: "The white oak abounds chiefly in the Middle States and in Virginia, particularly in that part of Pennsylvania and Virginia which lies between the Alleghenies and the Ohio, a distance of 150 miles, beginning at Brownsville, on the Monongahela. Near Greensburg, Macconnelsville, Unionville, and Washington Court House I have seen large forests, nine-tenths of which consisted of white oak whose healthful appearance evinced the favorable nature of the soil." [a]

Of this great forest in the northern end of the Appalachian coal field only a small percentage remains to-day. The detailed history of its consumption is in many respects different from that of other regions, since, despite some influences which tended toward conservation, the forest was ultimately reduced to isolated woodlots.

The soil was early found to be valuable for agriculture, and this was the first incentive to clear the land. The trees were felled, rolled into piles, and burned. Later the timber on lands near the principal rivers was cut for lumber and transported down the Ohio to market. When railroads began to intersect the country new territory was made accessible to lumbering.

It is uncertain when the use of wood for fuel was replaced by coal, but it is reported that by 1825 some 3,500 tons of coal were used in the vicinity of Pittsburg, and in 1846 local consumption had increased to 464,000 tons. In those localities where natural gas was abundant it replaced both coal and wood as fuel. But with the development of the charcoal iron industry another cause of rapid wood consumption arose. Even in the eighteenth century a relatively small number of blast furnaces for iron making were in operation, but during the first

[a] The North American Silva, by François Andrew Michaux; translated by Augustus L. Hillhouse, 1819.

part of the nineteenth century this industry began to grow rapidly. In 1849 the number of blast furnaces using charcoal or coal, charcoal forges, and rolling mills in Pennsylvania was 504.[a] The estimated amount of wood used in the form of charcoal in 1847 was nearly 1,500,000 cords for the whole State. Probably one-third of this was consumed in western Pennsylvania. Great areas of even-aged forest throughout the State testify to-day to the extent of clear cutting during this period for the production of charcoal to supply the iron industry.

In 1838 anthracite coal began to be used as fuel for the blast furnaces, and by 1855 had largely replaced charcoal. Anthracite in turn was replaced, about 1875, by coke, a product made from bituminous coal. The development of the coke industry meant, however, a larger demand upon the forest again, as coal mining increased. In the Appalachian coal field the production of coal for all purposes rose from 1,000,000 tons in 1847 to nearly 80,000,000 tons in 1900. This represents an enormous drain on forest resources to furnish the supply of pit props, mine ties, and other materials necessary to mining operations.

Thus the forest of eastern Ohio and western Pennsylvania has been reduced principally to isolated woodlots of small extent, the aggregate amount of which grows less each year as the stands are cut for lumber and mine props. Land thus cleared of its forest growth is usually put under cultivation or into pasture, excepting steep ridges or the sharp slopes bordering rivers; hence there is less and less productive forest land.

A description of the coal fields and the character and effect of the mining industry reveals the necessity for forest extension in this region.

COAL MINING AND ITS EFFECTS.

The most important bituminous coal region of the United States is the Appalachian coal field. It extends from the northern boundary of Pennsylvania southwestward, a distance of 800 miles, to central Alabama. Near the northern end it is 180 miles wide, narrowing southward to less than 20 miles in Tennessee and expanding to about 80 miles in Alabama.

The geologic structure of the Appalachian coal field is simple, and consists of a canoe-shaped basin or trough. The deepest portion lies along a line extending from Pittsburg, Pa., through West Virginia to Huntington, on the Ohio River. The rocks dip from either side toward this line. At the northern end they outcrop in an irregular semicircle, dipping toward the deepest part, which in Pennsylvania lies in the southwestern portion of Greene County.

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[a] Report of committee on statistics—Convention of Iron Masters of Pennsylvania, 1849.

From the northern boundary line of western Pennsylvania to central West Virginia the regularity of the dip of the rocks is modified by low, broad folds, which become pronounced ridges in the southeastern portion and are parallel to the general Appalachian folding to the east; but the general topography is that of a plateau descending gently toward the west, more or less dissected by valleys, according to the degree of erosion. The region is drained by the Ohio and its tributaries, of which the most important are the Allegheny and the Monongahela rivers.

The coal-bearing formations of the northern Appalachian coal field consist principally of shales, sandstones, and conglomerates, with occasional beds of limestone, fire clay, and coal. The chief source of coal in Pennsylvania has been the Monongahela and Allegheny formations. Statistics compiled in 1902 by the United States Geological Survey report Pennsylvania as having one-half the coal and two-thirds of the coke production of the United States.

The room and pillar system is in use in nearly all mines throughout the region. The coal is either hand or machine mined, and is removed from the mines in cars by electric, compressed-air, cable, or steam haulage. Horses or mules are used in the mines to convey the cars to the main haulages. Wood is required for the following principal uses:

1. Large and small material in buildings, tipples, etc., above ground.

2. Mine props or posts in the mines. By law the minimum size at the top end must be 16 square inches. The length varies from 6 to 10 feet, according to the thickness of the seam being worked. The more durable species, such as oak, chestnut, and locust, are used for roof support in the main haulages, but any other species of wood can be used elsewhere.

3. Ties for mine railways. The ties in common use are 5 feet in length, with a cross section from 4 to 6 inches in width and depth. Durable woods are used under the tracks of the main haulage ways, but almost any species on temporary branches.

4. Large-sized timbers in the mine. These require durability and strength, and are used at the mine entrance, or in special cases for roof support.

Mining frequently affects the physical character of the surface of the land. With the final removal of the coal between the rooms the roof of the mine tends to fall. This is an advantage in mining, since it relieves the pressure from above on the adjacent unmined portions of the seam. By withdrawing the pit posts into a line next to the unmined portion the fall of the rock above the mined portion can usually be effected. Wherever the coal lies close to the surface the fall-in extends to the surface and a sink hole of the same

depth as the thickness of the underlying coal vein is the result. When the seam is deeper underground the effect may be merely a crack with a slight settling. It is reported that this cracking of the surface has taken place when the coal lay at a depth of 300 to 500 feet. In localities where the coal lies in general 50 to 100 feet below the surface the lower margin of a hill may have a belt of sink holes due to mining and the upper portion of the hill remain unbroken, though occasionally cracked.

Breaking or cracking of the surface lowers the permanent water level to the mine. Local wells and springs run dry, and small streams sometimes disappear. On such situations older trees die as a result of the change in drainage conditions, but young sprouts and seedlings adapt themselves to the new conditions. Heavy soil that was formerly poorly drained has sometimes been improved by the increased drainage in the same way that tile draining improves similar land elsewhere. Areas where there are many sink holes are, however, comparatively valueless for agriculture.

EFFECT OF COKE PRODUCTION.

A large amount of coal mined in western Pennsylvania is used at the mines to make coke to be shipped for use at iron and steel mills. The manufacture of this product destroys the existing timber and prevents forest planting in the immediate vicinity of the works, because the fumes from the coke ovens contain sulphur gas, which causes the death of all vegetation subjected to a continuous draft of this smoke. The action of the sulphur gas on the leaves is corrosive.

Much land is protected on account of the hilly character of this region. If the ovens are situated at the base of a hill against which the prevailing wind carries the smoke, the hillside soon becomes bare of vegetation, but on the opposite side of the hill crops may be grown nearly to the top. The injurious effect of the smoke is noticeable, however, at a greater distance in those situations where the wind carries the smoke up a small, narrow valley. Crops several miles away are often blackened, but do not seem to be injured. The death of orchards and forest trees, caused by the changed conditions of drainage already described, is frequently attributed to the action of coke smoke.

In some instances by-product ovens have been established which collect and condense the sulphur gas to make commercial sulphuric acid.

OPPORTUNITY FOR FOREST PLANTING.

The occasion for forest planting rests primarily upon the growing need of pit props, and is intimately related to the whole industrial development of southwestern Pennsylvania.

The rapid rise of the coal and steel industries has caused a great increase in the population of the western part of the State. This offered an excellent chance for an intensive system of agriculture to supply these communities, but the farmers have not fully met this great opportunity. Agriculture, at one time the chief industry of the region, has been slowly going backward for many years. Its decline is largely due to the effect produced by the sale of the coal veins underlying the farms. Money so acquired has led many farmers to retire with their families to the towns and has brought additional comforts to those remaining on their lands, but has deadened the activity and ambition essential to progressive agriculture. The soil of many farms has deteriorated in fertility and productiveness through ignorance of the proper methods of managing it or the best crops for the soil.

There still remains in southwestern Pennsylvania a great source of coal to be developed, but the field is certain to shift. The coal veins were first entered where they were most accessible. The future development and progress of mining will be throughout Washington and Greene counties, Pa., and in West Virginia. There are places in Westmoreland County where the principal vein, the Pittsburg, has been exhausted; in other localities in this county thirty to fifty years will complete mining operations. In communities where prosperity now depends wholly upon the mining industry, its conclusion will be the first step in a general decline. As the communities dwindle in size, farming will continue, but less prosperously, and it will tend to become extensive rather than intensive in character. The introduction of other industries is vitally essential to such localities, and one of these should be the lumber industry, made possible by extensive forest planting commenced at the present time.

On nearly every farm there is some portion which has small productive capacity and should be utilized for the growth of forest rather than field crops. The use of such land for forest planting would furnish an added and growing value to the farm. For all the timber planted now there will be an excellent market at maturity for mine timber, railroad ties, lumber, etc. Excellent railroad facilities exist to furnish transportation of the products to the mines or to the cities and towns of the region. The farmers, however, are not sufficiently progressive to see the opportunity.

The coal companies, to whom a future supply of mine timbers is of so great importance, must take the initiative. The source of timber supply is becoming farther and farther distant. Within a few years a growing difficulty in securing pit props has been experienced, and correspondingly higher prices are being paid each year. In former years only oak was accepted for posts; to-day all kinds of wood are utilized by the coal operators. The local timber supply adjacent to

the new lands will be exhausted long before the supply of coal from the more accessible and important veins are gone.

From the standpoint of the ownership and use of the land the opportunity of forest planting presented to the coal companies is a remarkable one. In acquiring the land for a mining plant and its accessory properties a coal company gains title to considerable surface. It is sometimes necessary to purchase the whole farm in order to secure ownership of the underlying coal vein. The majority of such properties must be retained by the company until the coal has all been worked out. The use of these farms is sometimes a perplexing problem. Many coal companies do not care to enter into a system of farming, especially if only a small number of farms are acquired. Others find that their holdings steadily deteriorate through wasteful management of the farms by tenants, and that the income under such a system is relatively small. Still other companies raise crops on the better soils, and allow the poor portions of the farms or the areas covered by sink holes to lie idle except for a little grazing.

Under these conditions not only is forest planting advisable from the standpoint of complete utilization and productiveness of all the land, but a great opportunity is presented to improve the final sale value of such lands when their possession is no longer essential to mining operations. In addition, forest planting will furnish a valuable supply of pit props before the underlying coal veins are generally exhausted. Several coal companies have had this matter under consideration, and have begun to make plans for forest planting. One of these is the H. C. Frick Coke Company, which has sought the assistance of the Forest Service in making a forest planting plan for several hundred acres of waste land. An account of this plan follows later.

INSECTS AN OBSTACLE TO PLANTING.

INJURY BY A DEFOLIATING CATERPILLAR.

In southwestern Pennsylvania the forests, woodlots, and orchards have been severely damaged by a measuring worm which defoliates the trees early in the spring. In 1905 its destructive work was observed in Somerset, Westmoreland, Fayette, Allegheny, Armstrong, Butler, Washington, and Greene counties, Pa. The State zoologist, Mr. H. A. Surface, reports damage also in Cambria, Bedford, Blair, Huntingdon, and Indiana counties. This defoliation of the trees has been a serious trouble for several years throughout the forests of Laurel Hill and Chestnut Ridge. In the open agricultural country west of these ridges exceptional damage has occurred in local spots in the counties already named. This measuring worm appears to attack all hardwood trees, except locust and walnut, and is especially injurious to red and chestnut oak, chestnut, hickory, ash, and maple.

Woodlots and orchards are frequently seen in which the trees are dying from defoliation repeated for several years.

According to Mr. Surface, this defoliation is the work of the spring cankerworm,[a] and he has published some notes upon the methods of control. When the advisability of planting any land in these counties with forest trees is contemplated, this factor of insect damage must be considered carefully. Methods of control such as are commonly used in orchards will not usually be practicable in a forest plantation. The presence of this insect does not necessarily prevent forest planting, but requires, rather, a change in the local planting site or a postponement of planting until the pest has been reduced in numbers by its natural enemies or other agencies.

INSECT DAMAGE TO THE LOCUST.

The locust (*Robinia pseudacacia*), because of its rapid growth, its adaptability to different soil conditions, and its value for posts and pit props, is a valuable tree for forest planting. Injuries by certain insects, however, present a great obstacle to its use. The following observations were made in connection with a cooperative study of insect enemies of the locust by the Bureau of Entomology and the Forest Service in 1905.

The destructive work of the locust leaf-mining beetle (*Odontota dorsalis* Thunb.)[b] and the locust borer (*Cyllene robiniæ* Forst.) requires special consideration wherever the establishment of forest plantations of locust is desired in this region.

The locust leaf-mining beetle.—Severe injury by the leaf-mining beetle gives the trees a blighted, brown appearance by midsummer. The examination of a locust tree early in July reveals blister spots on the leaves, caused by the young, or grub, of the beetle, a small, flattened, whitish worm, which eats the soft tissue between the upper and lower surface. Toward the end of July the beetles begin to emerge from the leaves and feed upon the upper surface. The combined effect of the blisters and the subsequent feeding of the adult insects renders the foliage partially or wholly functionless, according to the severity of the attack. This reduction of the working leaf surface, year by year, weakens the tree, since it is not able to produce sufficient food to maintain its growth. Such a condition alone, or in conjunction with secondary causes, may result in the death of the tree within a few years. A cross section of the stem of a tree attacked for several years shows a steady decrease in the width of the rings of annual growth. During the stages of decline and death the locusts have no

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[a] Volume III, No. 5, The Monthly Bulletin of the Division of Zoology, Pennsylvania State Department of Agriculture.

[b] See United States Department of Agriculture, Division of Entomology, Bulletin No. 38, new series, 1902, "The Leaf-mining Locust Beetle," F. H. Chittenden.

tendency to renew themselves by sprouts from the roots or the base of the tree.

Doctor Hopkins, who, between 1890 and 1900, made a study of insects injurious to the locust in West Virginia, is authority for the following statement in regard to the work of the locust leaf-mining beetle in West Virginia:

> In 1890 and 1891 the locust trees in Monongalia, Marion, Harrison, and Lewis counties, W. Va., were severely damaged by the locust leaf-mining beetle (*Odontota dorsalis*). In 1891 and 1892 a large percentage of the trees died. In some localities practically all of the medium and large trees were killed. In 1892 it was not so common in the counties mentioned, but the trouble seemed to extend from this central area of infestation to adjoining counties and other sections of the State. Between 1892 and 1895 the beetle and its work were noticeably less common in the State, but from 1896 to 1898 it reappeared in great numbers and caused serious damage to the remaining locust in the counties mentioned, and, as before, extended its ravages to other sections, including those which had been exempt.

The range of severe injury observed in 1905, during the study of the possibilities of forest planting in this region, is as follows:

Pennsylvania: Westmoreland County, west of Chestnut Ridge; Fayette County, west of Chestnut Ridge, and part of the ridge; Allegheny County between the Allegheny and Monongahela rivers, and other parts of the county in varying degrees of severity. Washington County along the Monongahela River, with local spots of severe injury and of slight damage throughout the remainder of the county; Greene County along the Monongahela River, and a few local spots of severe injury in other parts of the county.

West Virginia: The Panhandle, especially along the Ohio River; Monongalia County; Marion County; Preston County, west of the mountains; Harrison County; Taylor County.

Observations in this region have shown conclusively that young natural stands and forest plantations of locust started under such adverse conditions may survive the attack for several years, but will not reach a merchantable size. Therefore it should be fully understood that within the counties where this exceptional injury occurs locust plantations should not be made, since failure is certain.

The locust borer.—Injury by this insect has not been so widespread as that by the leaf-mining beetle. Where it is numerous, however, its effect is so severe that it becomes of great importance locally. The work of this insect is very characteristic and readily recognized. The stems and larger branches of saplings and older trees were found to indicate injury by the locust borer early in July by sawdust in the crevices of the bark and around the base of the stem. On splitting the wood, mines were found extending in all directions through the sapwood and heartwood. Vigorous boring at one point on the stem of a young tree results in weakening it so much that the wind can readily break it off. Older trees frequently lose large branches or the upper part of the stem. When very numerous the borers will kill the trees

outright. This insect has been one of the worst enemies of locust plantations in the United States. In the region examined it was found causing considerable injury locally in Westmoreland and Allegheny counties. It is important, therefore, for anyone intending to plant locust to investigate carefully the local conditions before final decision is made.

Information in regard to this insect is furnished in a recent paper entitled "The Locust Borer," by A. D. Hopkins (Bulletin No. 58, Part I, Bureau of Entomology).

THE FRICK PLANTING PLAN.

THE LAND.

The H. C. Frick Coke Company owns many farms in the Connellsville basin, the great coke district in Westmoreland and Fayette counties, Pa. The principal sites considered for planting are located in the vicinity of Scottdale.

The topography consists of a succession of hills about equal in height, 1,150 to 1,200 feet above sea level, which rise from 75 to 150 feet above the intersecting runs and valleys. They are rounded in shape and gentle or moderately steep in slope. A half dozen miles to the east Chestnut Ridge rises 1,000 feet higher, and from this ridge the locality has the appearance of a plain.

The underlying rock consists principally of shales in which occasional beds or thin strata of limestone occur. The limestone is generally found outcropping near the top of the hills. The predominant soil is a fertile, stiff clay loam underlain by clay, but varying from a clay to a loam.

In general the lower slopes and runs have a deep fertile soil of slow drainage which formerly supported a nearly pure growth of white oak with a small percentage of shagbark hickory, white ash, red oak, yellow poplar, maple, etc. Along the streams this forest type included walnut, black ash, beech, and basswood. The hilltops have a thin, quickly drained, less fertile soil. Here chestnut oak was the predominant tree, with red oak, black oak, chestnut, and red maple the principal species in mixture. The intermediate situations usually bore either one of these two types of forest or a combination of both. The depth and physical condition of the soil and the steepness of the slope were the factors which determined the character and composition of the forest.

The object of the company in undertaking forest planting is to utilize to better advantage the sterile parts of the farm land or those much dotted by sink holes. It is expected to grow timber trees of permanent worth in order to increase the value of the land; and it is desired, if possible, to plant some early maturing species which will furnish pit props for the mines within a short period. The recom-

mendation of species for forest planting is usually based primarily upon the natural forest of similar sites in a locality. In the case of the Frick lands, however, the character of some of the land is modified by the breaking of the surface due to mining.

THE PLAN.

A preliminary examination of the site proposed for forest planting resulted in the rejection of about 270 acres on account of the nearness of coke ovens. A planting plan was made for approximately 456 acres of waste land of two general classes: (1) Unproductive agricultural land, and (2) areas modified by mining.

For the first class mentioned species of trees were chosen for planting which formerly grew well on these sites. For example, on sites suitable only for white oak or chestnut oak, respectively, these species were recommended for planting. Red oak, chestnut, and yellow poplar were chosen for their natural situations.

A study of the sites modified by mining showed that the quickened drainage rendered the soil drier and hence more suitable for species naturally occupying the more shallow dry soils of the upper slopes. White oak land thus modified was suitable for planting red oak, and in some instances chestnut and chestnut oak.

Two species, the European larch and hardy catalpa, which are not native to this region, were recommended for planting. The European larch is a quick-growing conifer adapted to this region. The wood is strong and durable, suitable for ties, poles, fence posts, and pit props. The tree requires a well-drained but not necessarily fertile soil, and should do well on some of the sites modified by mining. It has been grown successfully in Illinois and other States.

The western or hardy catalpa was recommended for trial on 3 acres to test its value for the region. It grows quickly to post size and is very durable. If it proves successful, this will be an important tree for the production of fence posts and pit props. It has been grown successfully in Ohio. This tree requires a fertile, well-drained soil of moderate depth and a carefully selected site is of primary importance.

The following is a summary of the acreage and the species recommended:

	Acres.
Red oak	110
Red oak and chestnut	122
Red oak and hard maple	79
Red oak and European larch	45
Red oak and yellow poplar (tuliptree)	12
Chestnut oak (rock oak)	24
White oak	31
European larch	25
Yellow poplar	5
Hardy catalpa (western catalpa)	3
	456

The sites rejected for forest planting at present on account of the injurious effect of the coke smoke may be reforested as soon as the adjacent coke ovens are abandoned. It was recommended that on some of the sites not subjected continuously to coke smoke, but doubtful in character, small test areas be planted now to determine definitely the advisability of planting.

The cost of carrying out the provisions of the Frick planting plan will depend upon the cost of the trees per thousand and the efficiency of the laborers under proper superintendence. Since a little over a half million young trees will be required, the establishment of a nursery by the company was advised. This generally affords a good quality of stock and is convenient and economical if the owner can secure a capable man to care for the nursery. The larch will require two years' growth in nursery beds; the other species will be ready for planting after one year's growth. For the Frick plan it was estimated that the total outlay per acre for forest planting would be approximately $10 if the seedlings were home grown.

The first returns from planted timber on these lands may be expected from the quicker growing species. The European larch may be cut for mine props between the ages of 15 and 20 years. In the oak and chestnut plantations moderate returns will be yielded from thinnings when the trees are 20 to 25 years old, and a final crop will be secured from 40 to 60 years after planting, when the forest may be cut clear for lumber and mine timbers. Exact estimates of yield under the conditions in western Pennsylvania are not available, since no planted timber of sufficient age exists. It is, however, practically assured from the history of planted stands in other States of this general region that forest plantations on these sites will equal the net annual income obtained from field crops on fertile agricultural soils in this locality. Furthermore, these waste lands on which planting is recommended are not capable of yielding any valuable returns except in forest.

With a growing forest upon nonagricultural portions of the farms this company will also realize returns in the increased value of such lands, since each farm will be producing both annual field crops and a future timber crop.

GENERAL APPLICABILITY OF THE FRICK PLAN.

In its specific recommendations the planting plan for the H. C. Frick Coke Company is locally applicable to the Connellsville basin in Pennsylvania. In the general principles governing the planting this plan applies to that portion of the Appalachian coal field in eastern Ohio and west of the Allegheny ridges in Pennsylvania, since the general conditions of topography and soil are similar throughout the region.

The main source of mine timbers in the future will largely be the Allegheny Mountains of West Virginia. Mines located far from this source of supplies will have increasing difficulty in securing mine props at a reasonable cost, and it is essential that forest planting should be commenced at once, before the supply from local woodlots is exhausted.

There is no lack of suitable sites for forest planting. Throughout this region there is much land lacking in fertility, or too steep to be farmed profitably. In addition, on the outskirts of the various coal veins, lands are common on which the surface has been broken in mining.

Considering the loss of income from waste farm lands in the hands of coal companies, the feasibility of increasing the sale value of such lands and the great need of pit props and timber in mining operations, the advisability of forest planting is established beyond doubt. Extensive activity in forest planting throughout the region will result in a great saving, to be realized by returns within a relatively short time and with a small initial outlay.

O