

Hardwood Tree Planting on Strip Mine Spoil Banks

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In 1949 the Purdue University Agricultural Experiment Station, in cooperation with the Indiana Coal Association, started an experimental project to determine which hardwood species would be most desirable for tree planting on the spoil banks.¹ A series of eleven 5-acre plots were established in the spring of 1949. The experimental plots were set up so that the progress of individually marked sample trees could be checked.

Ten hardwood species were selected to be tested on the experimental plots. They were as follows:

Ailanthus	<i>Ailanthus altissima</i> Mill.
Ash, Green	<i>Fraxinus pennsylvanica</i> var. <i>subintegerrima</i> (Vahl) Fern.
Cottonwood	<i>Populus deltoides</i> Marsh.
Gum, Sweet	<i>Liquidambar styraciflua</i> L.
Locust, Black	<i>Robinia pseudoacacia</i> L.
Maple, Red	<i>Acer rubrum</i> L.
Maple, Silver	<i>Acer saccharinum</i> L.
Poplar, Tulip	<i>Lireodendron tulipifera</i> L.
Sycamore	<i>Platanus occidentalis</i> L.
Walnut, Black	<i>Juglans nigra</i> L.

Planting diagrams were designed so that nine of the ten species tested would be planted both in pure blocks and in mixture with black locust. The tenth species—sweet gum—was planted only in pure stands.

The planting stock consisted of 1 year old seedlings except sycamore which were large 2 year seedlings. Every fifth tree in the experimental plots was marked as a sample tree with a numbered aluminum tag attached to a wire pin.

Seven survival checks have been made on the plots.

Character of the Spoil Banks

One of the major problems encountered when trees are planted on the spoil banks is the spoil itself. Much has been written about the various kinds of spoil banks and it is generally accepted that the spoil itself, regardless of the kind of equipment used in the mining process, is extremely variable.

In considering the effects of acidity on planted trees, three broad ranges, based on pH values, are generally used. These are:

Calcareous—pH is 7.0 or more

Acid—pH is from 4.0 to 6.9

Toxic—pH is less than 4.0

The acidity of spoil banks varies with stripping operations. In some cases the overturned strata consists of a comparatively uniform mixture; in others the mixture will be variable. Spoil banks entirely calcareous, acid or toxic are not common.

1. DenUyl, Daniel, 1955. Hardwood Tree Planting Experiments on Strip Mine Spoil Banks of Indiana, Purdue University Agricultural Experiment Station Bull. 619.

A classification of spoil banks for tree planting purposes and recognizing these varying conditions of surface material acidity has been presented by Limstrom². The general classification is:

Acid banks—More than 50 percent of these banks is acid.

Calcareous banks—More than 50 percent of surface area is calcareous.

Mixed banks—As the name indicates, these banks are so mixed that no acidity class is predominant. By definition, less than 51 percent of the area is acid, less than 51 percent calcareous, and less than 50 percent toxic. In other words, patches of toxic, acid and calcareous areas are about equal in size, and of such proportions that the area cannot be placed in any of the foregoing classes.

Four general types of spoil are recognized by those associated with spoil bank revegetation. The most extensive group of spoil is that composed of a mixture of clay and silt loams, associated with much coarse rock and shale. Most of the experimental plots were established in this group of spoil. Consequently, the results of the experiments are primarily applicable to this kind of spoil. The other groups include the sands, glacial tills and sedimentary material.

Results

In evaluating the results of the experimental plantings at the end of five growing seasons, four factors are considered: (1) survival of trees; (2) height growth of planted trees; (3) form of trees; (4) type of spoil.

When the combined factors of tree survival, height growth, tree form and character of spoil banks are used as the basis for judging the success or failure of planted hardwood seedlings, then the species fall into two broad groups, (1) species generally adapted for spoil bank planting, and (2) species whose use is limited for spoil bank planting.

On the basis of their records on the experimental plots, each of the ten species characteristics are summarized. These summaries should be considered representative of seedling growth for the period 1949-1953 inclusive. Five years is a comparatively short time to use in describing the growth characteristics of any tree because factors of climate during the coming years may reveal that these were only initial survival and growth responses.

Species Generally Adapted for Spoil Bank Planting

ASH, GREEN

Green ash has shown excellent survival on all except the most acid spoils. On the calcareous spoil its survival is about 90 percent—both in pure stands and in mixture with black locust. On the more acid spoil its average survival is 75 percent.

Early height growth is best in black locust mixtures on calcareous spoil where the 5-year-old trees have attained an average height of

2. Limstrom, G. A., 1948. Extent, Character and Forestation Possibilities of Land Stripped for Coal in the Central States. Central States Forest Experiment Station Technical Paper No. 109.

about 7 feet. In pure stands on the acid spoil average total height growth attained by the green ash is about 4 feet compared to an average height of 6 feet on the less acid spoil.

In pure plantings topographic position seems to have no influence on its height growth. In mixture with black locust, the best height growth occurs on the lower slopes and bottoms where 5-year-old trees average 7 feet in height.

The terminal shoots of green ash have the tendency to die back and the two branches at the next node become leaders. Multiple stems occur more frequently in pure stands than in green ash-black locust mixture. Compared with the other hardwood species that were tested, the form of green ash is better than average.

A disease, tentatively identified as *diplodia* canker, has been observed on about 5 percent of the green ash sample trees. The damage to the planted trees seems to be very slight.

Green ash appears to be one of the most desirable hardwoods for planting on spoil banks.

COTTONWOOD

Cottonwood survives best in pure plantings on spoil which is entirely or mostly free of toxic areas. On similar spoil the survival of cottonwood is less when grown in mixture with black locust than in pure plantings. Survival on acid spoils is about 50 percent.

Average height growth in pure stands is much like that of cottonwood grown in mixture with black locust. It attains its best height growth on calcareous spoil.

The form of cottonwood is slightly better in mixture with black locust than in pure stands. There are about 10 percent more single stemmed trees in the mixed stand.

A disease which has been observed on 10 percent of the surviving sample trees has been tentatively identified as *Valsa* canker. The incidence of this disease is most frequent on acid spoil.

The twig pruner has been observed working on the cottonwood. This insect injures the trees by chewing off the new shoots.

Cottonwood is one of the best hardwoods for spoil bank planting when planted in pure stands on calcareous spoil.

GUM, SWEET

Sweet gum has the best survival and height growth on the spoils which are rather acid but not so acid as to be toxic. On calcareous or slightly acid spoil which support dense stands of sweet clover or other vegetation, sweet gum has the lowest survival and poorest height growth.

The height growth of sweet gum seedlings during the first 2 years following planting is very poor but the trees that survive are persistent growers. Height growth averages from 1 to 2 feet per year after this early period of comparatively little growth.

The form of sweet gum is generally very good, as many have a single stem. Compared to the other species tested, its form rated above that of all species except sycamore.

Sweet gum in mixture with black locust was not tested on the experimental plots. However, studies of some 1946 plantings of sweet gum in both pure stands and in black locust mixture on comparable spoil show that it attains its best growth in mixture with black locust.

Sweet gum appears to be a species that can be planted on many acid spoils in mixture with black locust or in pure stands.

BLACK LOCUST

Of the ten species tested on the experimental plots, black locust has the best overall record of survival, height growth and capacity to grow on all but toxic spoil. Its tendency to develop multiple stems places it last on the form rating list of the ten species tested.

Black locust has survived and grown on adverse sites, erosive slopes and exposed ridge tops. It has survived on acid areas where the other hardwoods failed to grow. It will not tolerate extremely acid spoils nor areas that are very poorly drained.

The locust borer (*Megacyllene robiniae*) attacks most of the planted trees and apparently few trees will grow to fence post size. On the plots about 80 percent of the locust have been attacked by the borer.

Species like silver maple, black walnut and tulip poplar develop better form when grown in mixture with black locust. The form of other species appears to be little influenced by being planted in mixture with black locust.

Black walnut and tulip poplar attained their best total height growth in mixture with black locust. Black locust is best suited for establishing quick tree cover on spoils where other species would fail to become established. It may also have a place in the mixed hardwood planting even though the studies did not reveal the best mixture to use.

SILVER MAPLE

Silver maple planted on the experimental plots has survived and grown fairly well on most spoil. It has survived best and attained its maximum height growth on calcareous spoil. On acid spoil its survival and height growth are influenced by topographic position, with trees on slopes and bottoms showing the best development.

On similar spoil its survival and height growth are essentially the same whether it is grown in pure stands or in a black locust mixture.

Silver maple has the tendency to develop multiple stems. Compared with other hardwoods planted on the plots in pure stands exclusive of black locust, silver maple had the smallest percentage of single-stemmed trees. In black locust mixture there are 24 percent more single-stemmed trees than occur in pure stands.

Silver maple can be planted on most spoil banks except on toxic portions of mixed spoil. Its multiple stem growth is not desirable; this tendency may be partly offset by planting it in mixture with black locust.

SYCAMORE

The survival and height growth of sycamore is good on all but the most acid spoil. At the end of five growing seasons the survival of sycamore is best in the bottoms on the calcareous spoil.

Sycamore appears to grow best in pure stands. Its survival and height growth tend to be poorer in black locust mixtures.

The form of sycamore is generally good both in pure plantings and in mixture with black locust. The multiple stems that do occur are usually caused by anthracnose.

Anthracnose (*Gnomonia veneta*) has attacked some of the planted sycamore. It has caused some mortality and has deformed some trees by killing the main stem which in turn promotes sprouting.

Sycamore's generally good survival, rapid height growth and single stem growth makes it a very good species for planting on most spoil banks.

Species With Limited Use for Spoil Bank Planting

AILANTHUS

The 5-year record of this species on the experimental plots would exclude it from the list of species generally suitable for spoil bank planting. A few trees on portions of the machine trail area have attained comparatively good total height growth. However, most of these trees have not survived nor have the survivors grown well on the spoil banks.

RED MAPLE

The survival of red maple in both pure and mixed stands, when compared with most of the other hardwoods tested, is poor.

Although a few individual trees attained a height of 10 feet, most of the 5-year-old trees are about 4 feet in height.

The form of red maple on the basis of the percentage of single stemmed trees occurring in both pure and mixed stands places it close to the bottom of the list of the species tested.

Its overall record would exclude it from the list of species generally adapted for planting on spoil banks.

POPLAR, TULIP

The survival and height growth record of this species on the experimental plots is such that it is excluded from the list of species generally adapted for spoil banks. Even its best record on Plot 3, when compared with the other species tested, very much restrict the use of tulip poplar. Its overall survival record is next to the poorest of the 10 species tested.

Because it is a very desirable species, it may have very limited use in spoil bank planting. Its planting should be confined to the very best spoil of the calcareous and acid spoil groups.

WALNUT, BLACK

A few individual trees have made fairly good height growth where walnut seedlings were planted in mixture with black locust. However, most of the planted seedlings have grown very little in height.

The record of black walnut seedlings, when compared with the other nine hardwoods tested, warrants black walnut's exclusion as a species to be generally planted on spoil banks.

Since it is a very desirable species, its planting should be restricted to calcareous spoils. It should be planted in mixture with black locust where it will show fair survival and height growth, especially on lower slopes and bottoms.