# WOODY SPECIES ESTABLISHMENT FROM A FOREST SOIL SEED BANK IN WEST VIRGINIA[1]

by
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Abstract. In June 1989, we started a study using forest soil seed banks for establishing vegetation on an old, unvegetated deep-mine refuse pile. Study plots were established in June and October 1989 and April and June 1990. Lime and fertilizer were applied to the surface of the refuse and covered with about 2 inches (290 cu yd/a) of forest topsoil. Three replicates (reps) were installed on each date. Due to the lack of available topsoil, we had to use 3 borrow areas. All borrow areas are near the refuse pile, but each is different. First year establishment on the June 1989 reps included numerous paulownia (*Paulownia tomentosa*); 2 reps had over 100 stems each. There were lesser numbers of black birch (*Betula lenta*), white ash (*Fraxinus americana*), and black locust (*Robinia pseudoacacia*). Other woody species included sumac (*Rhus* sp), grape (*Vitis* sp), and Virginia creeper (*Parthenocissus virginia*). Further evaluations were made in the fall of 1990–2 growing seasons for the June 1989 reps and 1 growing season for the others. The numbers of paulownia had dropped considerably, but it was present on 4 reps, with a total of 14 stems counted. Black locust was present on all 12 reps, tulip poplar (*Liriodendron tulipifera*) and white ash on 7 reps, and black birch on 4. Red maple (*Acer rubrum*), sycamore (*Plantanus occidentalis*), chestnut oak (*Quercus prinus*), beech (*Fagus grandifolia*), hickory (*Carya* sp), and river birch (*B. nigra*) were found on 1 rep each. Other woody species included sumac and grape on 9 reps, poison ivy (*Toxicodendron radicans*), blackberry and raspberry (*Rubus* sp) on 7, and Virginia creeper on 4. In addition to the woody species, 39 species of annual and perennial herbaceous plants were identified on the study plots. Of this total, pokeweed (*Phytolaca americana*) and Asiatic dayflower (*Commelina communis*) came from all 3 borrow areas. There were 11 species from two borrow areas and 26 from only 1 borrow area. These results show that viable woody and herbaceous plant seed is available in forest soil seed banks in the 3 seasons of this study–early spring, early summer, and fall.

Additional Key Words: reclamation, deep-mine refuse, native species

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## Introduction

The use of native topsoil seed banks for reclamation is not a new concept. Numerous reports show the potential of this technique for reclamation. However, many of the reports pertain to western U.S. situations, some are pot studies, others include the addition of introduced seed to the topsoil, and a few included supplemental watering in dry periods. In this study, we used only the topsoil seed bank materials supplemented with lime and fertilizer. Then we stood back and evaluated the results.

## The Study

### Objectives

The primary objective of this study was to test a forest soil seed bank as a seed source and mulch to introduce native vegetation onto an orphan gob pile. And, a secondary objective was to determine if the time of application of the forest soil would affect the number of species and volume of plant material established.

### Site

In June 1989 we started the study on an orphaned, deep-mine gob pile within the boundaries of the New River Gorge National River, Raleigh County, West Virginia. This mine was active from the 1940s to about 1952. When mining ceased, no attempt was made to vegetate the gob pile. Over the years, the gob pile has become somewhat stable; however, there is some evidence of erosion. Volunteer vegetation is sparse, consisting of isolated stems of black birch, northern red oak, paulownia, and Virginia pine (*Pinus virginiana*). There was no ground cover except on those edges of the gob pile adjacent to the native forest.

Six random soil samples were collected from the gob pile and analyzed at the Plant, Soil, and Water Laboratory in Berea, Kentucky. Acidity, determined by the titration method, showed pH values from 3.5 to 4.8. P, K, Fe, and Al were determined by plasma emission spectrometry. Major nutrients were low–P was 1.6 to 4.1 ppm and K was 0.2 to 2.0 ppm. Fe and Al were high–70.6 to 183.4 ppm and 324.6 to 501.3 ppm, respectively. Sulfur, measured with a LECO carbon sulfur determinator model CS44, was relatively low at 0.3 to 0.6%. Nitrogen was not measured.

### Methods

The study design was a randomized block replicated 3 times. Within each block a 20 x 20 ft subplot was designated for each date. Seed bank topsoil was applied in June and October 1989 and April and June 1990. Topsoil and litter from the adjacent forest were collected and spread on each subplot on each treatment date. One pickup truck load of topsoil was spread on each subplot. This was the equivalent of about 72 $ft^3$(2 $m^3$) of topsoil or a covering of about 2 inches (5 cm). All work was done by hand. Because native topsoil is sparse in the mountains of West Virginia, we had to use 3 borrow areas to complete the study installation: 1 for the June 1989 treatment, another for the October 1989 and April 1990 treatments, and a third for the June 1990 treatment.

Soil analyses indicated a need for lime and fertilizer. Therefore, agricultural lime, at the rate of 600 lb/a (670 kg/ha), and 10-20-20 fertilizer, at the rate of 40 lb N (45 kg), 80 lb P (90 kg), and 80 lb K/a (90 kg/ha), were broadcast on each subplot prior to forest soil seed bank application.

### Measurements

The June 1989 subplots were inspected in August 1989. At that time there was about 80% cover in rep 1, 50% in rep 2, and 70% in rep 3. Woody species included numerous paulownia (over 100 in reps 1 and 3), sumac, black birch, white ash, black locust, and Virginia creeper. There were also about 13 different non-woody species noted. Another inspection in November 1989 showed that germination was occurring in the October subplots. However, the germinants were too small to identify. Final counts were made at the end of August 1990. Thus, the data reported herein are for 2 growing seasons for the June 1989 treatment and 1 growing season for the other 3 treatments.

## Results

Table 1 shows the tally of woody stems by season of treatment and replication. No statistical analysis was attempted because the seed bank materials came from different borrow areas. The results do show, however, that a great variety of viable seed from woody species was present in the seed banks. Eleven tree species and 5 shrub and vine species were identified. There were 191 trees and 160 shrubs and vines counted in the tally. This equals about 1,590 trees per acre and 1,330 shrubs and vines per acre. Stocking was estimated by multiplying the number of seedlings by 100 (the replicates are approximately 0.01 acres) and dividing by 12 (the number of replicates).

Table 1. Species and distribution of woody plants established from forest soil seed banks on an orphaned coal refuse pile.

| Species | Treatments: June '89 Reps 1 | 2 | 3 | Oct '89 Reps 1 | 2 | 3 | April '90 Reps 1 | 2 | 3 | June '90 Reps 1 | 2 | 3 | Totals |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Black locust | 1 | 8 | 3 | 7 | 2 | 1 | 12 | 2 | 5 | 27 | 15 | 6 | 89 |
| Paulownia | 4 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 14 |
| Sumac | 13 | 12 | 5 | 0 | 0 | 1 | 6 | 0 | 6 | 17 | 9 | 7 | 76 |
| Yellow-poplar | 5 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 1 | 10 | 6 | 18 | 44 |
| White ash | 3 | 0 | 1 | 0 | 2 | 0 | 1 | 2 | 0 | 2 | 7 | 0 | 18 |
| Black birch | 0 | 0 | 1 | 2 | 0 | 2 | 0 | 2 | 8 | 0 | 0 | 0 | 15 |
| River birch | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 3 |
| Hickory | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Red maple | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Sycamore | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Chestnut oak | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Beech | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Grape | 5 | 2 | 3 | 1 | 1 | 0 | 0 | 2 | 2 | 4 | 2 | 0 | 22 |
| Blackberry/ Raspberry | 2 | 0 | 1 | 4 | 3 | 4 | 0 | 0 | 0 | 0 | 1 | 1 | 16 |
| Poison ivy | 3 | 0 | 0 | 5 | 20 | 1 | 3 | 3 | 0 | 0 | 0 | 1 | 36 |
| Virginia creeper | 0 | 0 | 0 | 4 | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 1 | 10 |
| Totals | 39 | 22 | 22 | 27 | 31 | 9 | 22 | 16 | 26 | 60 | 40 | 37 | 351 |

Black locust was the most common tree species, occurring in all 12 reps. Seeds of black locust are hard and impermeable and are known to lie dormant for many years in the seed bank. Thus, it is no surprise that black locust was so common.

White ash and yellow-poplar, both spring seed producers, were present on 7 replicates in 3 treatments. None were found in the October 1989 treatment. Also, there were white ash and yellow-poplar in the adjacent natural forest; thus, the seed may have come from these trees and not the seed bank.

Paulownia was present in all spring treatments but only in 4 replicates. The June 1989 treatment had over 100 seedlings at the end of the first growing season, but this number had dropped to only 10 by the end of the second season. Competition from both the other woody plants and the herbaceous plants may possibly have caused this decline.

Black birch and river birch were also present in the adjacent forest; therefore, we cannot ascertain if the seedlings were from the seed bank or trees near the treatment plots. The black birch found in the June 1989 treatment probably came from the adjacent forest. Black birches in the October 1989 and April 1990 treatments could have come from either source. It is a fall seed producer. River birch, a spring seed producer, was present only in 1 rep of the April 1990 treatment. Again, the source of seed could have been either seed bank or adjacent forest.

Red maple is the only other tree species that could have come from either source. It too is a spring seed producer and the seedlings occurred in both the June 1989 and June 1990 treatments.

One rep of the October 1989 treatment had 3 hickory seedlings. They were too small to identify to species. The weight of hickory nuts suggests this seed was in the seed bank. The source of seed for the other tree species was probably the seed bank.

Sumac, the most abundant shrub, has hard seed with an impermeable seed coat; therefore, seed was probably present in the seed bank. However, the presence of numerous sumac adjacent to the study area does not rule out the possibility of seed from that source. The other shrub and vine species probably were of seed bank origin.

Thirty-nine species of herbaceous plants were identified on the study plots. These are listed by frequency of occurrence in Table 2. Many of the species found are hydrophytic and may not persist; however, their initial presence indicates the wealth of seed variety in the seed banks.

## Discussion

This study demonstrates that native plant materials can be established on abandoned deep-mine refuse using the seed bank technique. The fact that we had to use 3 borrow sites for the seed bank soil does not diminish the value of the results. The presence of 11 tree species, 5 woody shrub and vine species, and 39 herbaceous species clearly demonstrates that this is a viable technique. Some of the woody plants may have become established from seed of adjacent trees and shrubs. This too is important because it shows that the seed bank soils provided a more hospitable environment for plant establishment than the gob.

Once started, woody species should persist to maturity. The presence of a few scattered trees on the site indicates some seeds found suitable niches for germination and establishment. The seed bank soil will provide such niches for either seed it contains or seed that is deposited on the surface. Many of the herbaceous species will probably not persist. Two of the borrow sites were rather moist environments and plants that were thriving there will not be adapted to the drier conditions on the gob pile.

Table 2. Frequency of herbaceous plant occurrences.

| Species[1] | Total number | By number of reps 6/89 | 10/89 | 4/90 | 6/90 |
|---|---|---|---|---|---|
| Smartweed (*Polygonum hydropiper*) | 200+ | 2 | 1 | 3 | 0 |
| Sweetclover (*Medicago lupulina*) | 200+ | 0 | 3 | 3 | 0 |
| Indian strawberry (*Duchesnea indica*) | 200+ | 3 | 0 | 2 | 0 |
| Ground ivy (*Glechoma hederacea*) | 200+ | 0 | 3 | 2 | 0 |
| Cinnamon vine (*Dioscorea batatas*) | 200+ | 3 | 0 | 0 | 0 |
| Pokeweed (*Phytolacca americana*) | 141 | 3 | 0 | 2 | 3 |
| Yellow wood sorrel (*Oxalis europaea*) | 119 | 1 | 0 | 0 | 0 |
| Asiatic dayflower (*Commelina communis*) | 102 | 3 | 0 | 2 | 3 |
| Japanese knotweed (*Polygonum cuspidatum*) | 98 | 1 | 0 | 0 | 3 |
| Goldenrod (*Solidago* sp) | 80 | 3 | 2 | 2 | 0 |
| Common evening primrose (*Oenothera biennis*) | 72 | 2 | 1 | 2 | 0 |
| Cinquefoil (*Potentilla simplex*) | 50 | 0 | 1 | 0 | 0 |
| Black nightshade (*Solanum nigrum*) | 45 | 0 | 0 | 3 | 3 |
| Violet (*Viola* sp) | 43 | 3 | 0 | 1 | 0 |
| Small-flowered leafcup (*Polymnia canadensis*) | 42 | 0 | 0 | 0 | 1 |
| Ragweed (*Ambrosia artemisiifolia*) | 37 | 0 | 2 | 2 | 0 |
| Chinese lantern (*Nicandra physalodes*) | 25 | 0 | 0 | 0 | 3 |
| Tickseed (*Coreopsis mariana*) | 22 | 0 | 3 | 1 | 0 |
| White snakeroot (*Eupatorium rugosum*) | 16 | 1 | 0 | 1 | 0 |
| Wild cucumber (*Echinocystis lobata*) | 13 | 0 | 0 | 0 | 3 |
| Elephant grass (*Typha elephantina*) | 11 | 1 | 2 | 2 | 0 |
| Mullien (*Verbascum thapsus*) | 11 | 1 | 0 | 3 | 0 |
| Jimsonweed (*Datura stramonium*) | 10 | 0 | 0 | 0 | 3 |
| Sedge (*Cyperus* sp) | 7 | 0 | 1 | 1 | 1 |
| Sweet everlasting (*Gnaphalium obtusifolium*) | 6 | 1 | 0 | 0 | 0 |
| Bluecurls (*Trichostema dichotomum*) | 4 | 0 | 1 | 1 | 0 |
| Catnip (*Nepeta cataria*) | 4 | 1 | 0 | 0 | 0 |
| Great lobelia (*Lobelia siphilitica*) | 4 | 1 | 0 | 0 | 0 |
| False nettle (*Boehmeria cylindrica*) | 3 | 0 | 0 | 0 | 2 |
| Dock (*Rumex obtusifolius*) | 4 | 1 | 0 | 0 | 0 |
| Aster (*Aster* sp) | 3 | 1 | 0 | 0 | 0 |
| Morning glory (*Convolvulus* sp) | 2 | 0 | 0 | 0 | 2 |
| Wild ginger (*Asarum canadense*) | 1 | 1 | 0 | 0 | 0 |
| Blue lettuce (*Lactuca spicata*) | 1 | 1 | 0 | 0 | 0 |
| Jewel weed (*Impatiens* sp) | 1 | 0 | 0 | 1 | 0 |
| Common white daisy (*Chrysanthemum leucanthemum*) | 1 | 1 | 0 | 0 | 0 |
| Bog nettle (*Boehmeria* sp) | 1 | 0 | 0 | 1 | 0 |
| Copperleaf (*Acalypha* sp | 1 | 0 | 0 | 1 | 0 |
| Wild bean plant (Strophostyles helvola) | 1 | 0 | 0 | 1 | 0 |

[1]The first 5 species listed were so numerous in at least 1 of the reps that a count was not made and the total number is shown as more than 200.