TREE SPECIES COMPOSITION, CANOPY COVERAGE, AND IMPORTANCE ON SEVERAL AML SITES IN NORTHERN WEST VIRGINIA[1]

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Abstract. Woody plant cover and composition were evaluated on seven Abandoned Mine Land (AML) sites in northern West Virginia during the summer of 1989. Five sites had been mined for the Freeport coal seam and two sites from the Pittsburgh coal seam. The thickness and pH of minesoil A horizons on each site were measured in the field and related to tree composition and importance. A total of 24 tree species occurred across our seven AML sites. All sites, except for one site, included the following tree species: big-toothed aspen (Populus grandidentata Michx.), black birch (Betula lenta L.), black locust (Robinia psuedoacacia L.), Hercules' club (Aralia spinosa L.), pin cherry (Prunus pensylvanica L. f.), red maple (Acer rubrum L.), and sourwood (Oxydendrum arboreum (L.) DC.). Canopy coverage and community structure increased as surface minesoil pH decreased. There were indications that both surface minesoil pH and thickness influenced a few tree species' importance and canopy coverage across our sites.

Additional key words: revegetation, minesoil acidity.

Introduction

Approximately 34,000 hectares of mined land in West Virginia have been designated as Abandoned Mine Land (AML) (SCS 1979). An AML site is an area of past mining disturbance which was not adequately reclaimed prior to the passage of the Surface Mining Control and Reclamation Act (SMCRA) on August 3, 1977; and where no company, individual, or agency has any reclamation responsibility under state or federal laws.

Natural processes have operated and continue to allow natural reclamation to amend in some degree these inadequately reclaimed sites. Although considerable research has been conducted toward revegetation of coal mine lands (Bradshaw and Chadwick 1980, Chadwick and Goodman 1973, Powell 1988), less research has been done on natural revegetation.

Succession has been studied on many AML sites by assuming that a series of increasingly older AML sites from the same area with similar geology infers a temporal sequence of a single site (Drury and Nisbet 1973, Kimmerer 1984, Skousen et al. 1988). Generally, such sites are first dominated by pioneer plants that are tolerant to extremes in temperature, moisture, and light; and later inhabited by plant species that establish and/or become conspicuous after some amelioration of the extreme condition. Coal mine sites (Bramble and Ashly 1955, Hall 1957) were colonized by

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those local species which have the capacity to disperse seeds over long distances. Site age or time since abandonment has been shown to affect community composition on disturbed soils in England (Hall 1957, Roberts et al. 1981) and minesoils in Illinois (Lindsay and Nawrot 1981).

Soil acidity was found to suppress the rate of revegetation on Missouri minesoils (Game et al. 1982). On Ohio minesoils (Bell and Ungar 1981), unvegetated areas surrounded vegetation patches of approximately the same low pH, low nutrient levels, and toxic aluminum concentrations. However, the unvegetated areas were unable to support seed emergence due to low soil moisture.

Concurrent with plant community development and succession is the development of a soil profile (Drury and Nisbet 1973). During minesoil development, chemical and physical weathering processes occur which eventually improve physical and chemical properties for enhanced plant establishment and growth.

Depth of the A horizon increased with age in minesoils in Virginia (Daniels and Amos 1981). Minesoil pH of acid sites in Kentucky increased with time while pH of near neutral minesites decreased slightly (Davidson et al. 1988). This indicated that the minesoils were developing toward a soil pH range of 4.0 to 4.9, which is the general pH range of forested areas in Kentucky. On minesoils in Pennsylvania (Pedersen et al. 1978), the pH values were similar to native soils.

The purpose of this paper is to evaluate the thickness and pH of minesoil A horizons on seven AML sites in northern West Virginia and relate these soil properties to tree composition, canopy cover, and importance value. This study is part of a larger project which is attempting to identify and describe minesoil genesis in relationship to plant community development on abandoned mine sites.

Materials and Methods

A total of seven AML sites in West Virginia were sampled during the summer of 1989. The AML inventory list developed by the West Virginia Department of Energy was used as the pool of available sites for selection. This pool was then reduced to sites with south- to west-facing highwall aspects to control micro-climatic variation (Hicks et al. 1982, Hicks and Frank 1984). These sites were then examined to identify the coal seam that had been mined by using the West Virginia Geological and Economic Survery's General and Economic Geology maps (Hennen and Reger 1912, 1913, 1914). After identifying which coal seam was mined on each site, the Freeport and Pittsburgh sites were each assigned a number. A computer random number generator was then utilized to select five sites which had been mined for the Freeport coal seam and two sites from the Pittsburgh coal seam. Blocking by coal seam was used to reduce the variation between parent materials from the different coal seams. Time since abandonment was not selected but through random sampling the selected sites constituted sites of different age.

Vegetation Sampling

Vegetation was sampled at each AML site at five stations. Each station measured 10 m x 10 m. The stations were sited by placing a grid over a map of each site and randomly selecting the five stations with a computer coordinate generator. All tree species in each station were identified and each species' canopy cover was measured by the line intercept method on a 10 m transect. The importance of each tree species was assessed by the Importance Value (IV) (Curtis and McIntosh 1951) by the following formula:

$$\text{IV} = \text{Relative density} + \text{Relative frequency} + \text{Relative dominance} \quad (1)$$

$$\text{RDen} = \frac{\text{number of individuals of Species} \times 100\%}{\text{total number of individuals}} \quad (2)$$

$$\text{RFre} = \frac{\text{frequency of a species} \times 100\%}{\text{(sum frequency of all species)}} \quad (3)$$

$$\text{RDom} = \frac{\text{dominance of a species} \times 100\%}{\text{dominance of all species}} \quad (4)$$

Soil Sampling

Three soil pits were dug to a depth of 1 m next to three of the stations (randomly selected). The pH and thickness of the minesoil A horizons were measured in the field.

While other vegetation measurements were taken, this paper reports only on tree species: composition, importance value, and cover. Additional minesoil analyses of chemical and physical properties are ongoing.

Results and Discussion

Table 1 depicts the presence or absence of 24 tree species across our seven AML sites. Most sites included the following species: big-toothed aspen (*Populus grandidentata* Michx.), black birch (*Betula lenta* L.), black locust (*Robinia psuedoacacia* L.), Hercules' club (*Aralia spinosa* L.), pin cherry (*Prunus pensylvanica* L.), red maple (*Acer rubrum* L.), and sourwood

Table 1. Presence (P) or Absence (-) of 24 tree species found on Freeport (F) and Pittsburgh (P) AML sites in West virginia.

Species	AML sites						
	BR-F	JS-F	JP-F	LG-F	VP-F	HU-P	FR-P
Bigtooth Aspen *Populus grandidentata* Michx.	P	-	P	P	P	P	-
Black Birch *Betula lenta* L.	P	P	P	P	P	P	-
Black Locust *Robinia psuedoacacia* L.	P	P	P	P	P	-	-
Hercules' Club *Aralia spinosa* L.	-	-	-	P	P	P	-
Pin Cherry *Prunus pensylvanica* L. f.	P	P	P	P	P	-	P
Red Maple *Acer rubrum* L.	P	P	P	P	P	P	-
Red Oak *Quercus rubra* L.	P	-	P	P	P	P	-
Sassafras *Sassafras albidum* (Nutt.)	-	-	P	P	P	P	-
Sourwood *Oxydendrum arboreum* (L.) DC.	-	P	P	-	-	P	-
Tuliptree *Liriodendron tulipifera* L.	P	-	P	-	P	P	-
Other Species							
Autumn Olive *Elaeagnus umbellata* Thunb.	-	-	-	P	P	-	-
Beech *Fagus grandifolia* Ehrh.	-	-	-	-	-	P	-
Black Cherry *Prunus serotina* Ehrh.	-	-	-	-	-	P	-
Chestnut *Castanea dentata* (Marsh.) Borkh.	-	-	-	P	-	-	-
Cucumber Tree *Magnolia acuminata* L.	-	-	-	P	P	-	-
Dogwood *Cornus florida* L.	P	-	-	-	-	P	-
Mountain Laurel *Kalmia latifolia* L.	-	-	P	-	-	-	-
Pignut Hickory *Carya glabra* (Mill.)	-	-	-	-	-	P	P
Red Elm *Ulmus rubra* Muhl.	P	-	-	-	-	-	P
Smooth Alder *Alnus serrulata* (Ait.) Willd.	-	-	P	-	P	-	-
Smooth Arrowwood *Viburnum recognitum* Fernald	-	-	-	P	P	-	-
Sycamore *Platanus occidentalis* L.	-	-	-	-	-	P	P
White Oak *Quercus alba* L.	-	-	-	P	P	-	-
Yellow Birch *Betula alleghaniensis* Britt.	-	-	-	-	P	-	-

Table 2. Canopy coverage (%) of major tree species on seven AML study sites in northern West Virginia.

Species	AML SITES BR	JS	JP	LG	VP	HU	FR
Aspen	51.2	0.0	3.8	30.2	15.8	20.0	0.0
Birch	0.0	15.0	71.8	0.4	98.6	25.5	0.0
Black locust	39.2	52.6	21.4	6.6	40.0	0.0	0.0
Cherry	0.0	39.0	1.6	89.2	3.8	0.0	0.0
Hercules' club	0.0	0.0	0.0	40.7	0.5	0.0	0.0
Red maple	0.0	7.2	32.3	19.8	49.4	26.8	0.0
Sourwood	0.0	0.0	10.7	0.0	0.0	0.5	0.0
Other species	9.8	0.0	4.8	2.2	3.8	11.5	0.0
Total species	100.2	113.8	135.7	189.1	211.9	84.3	0.0

(Oxydendrum arboreum (L.) DC.). The AML sites were also vegetated by several other tree species including red oak (Quercus rubra L.), sassafras (Sassafras albidum (Nutt.) Nees.), and tuliptree (Liriodendron tulipifera L.). These three species along with several others were combined into one group and will hereafter be termed "other species". Red oak, sassafras, and tuliptree, while occurring on 4 or 5 sites, were not prominent species on our sites.

Table 2 depicts the percent canopy coverage of several tree species on our AML sites. The FR site had no canopy coverage while the BR site had a low level of canopy coverage. This varying amount of canopy coverage was due to the respective community types across these AML sites. The FR site was predominately a meadow with a few scattered small trees, BR site was a relatively open forest dominated by small trees, and the other AML sites we studied were forests. Percent canopy coverage was negatively correlated with minesoil pH in the surface horizon ($r = -.76$) (Tables 2 and 3). The two high pH sites had 0 and 100% canopy coverage (FR and BR sites, respectively), while the low pH sites had from 85 to 200% canopy coverage. Canopy coverage was also negatively correlated with thickness of the A horizon ($r = -.81$) (Figure 1).

This indicates that A horizon development was greater under herbaceous cover than woody cover likely due to differences in biomass accumulation and incorporation into the soil (Leisman 1957).

There was a negative correlation between number of tree species and surface minesoil pH ($r = -.61$) (Figure 2) and also with the thickness of the A horizon ($r = -.74$) (Figure 3).

Linear correlations indicated marginal relationships between either thickness and pH of the surface minesoil horizon with individual tree species importance values (Table 4) across our AML sites (Table 5). Only black birch, Hercules' club) and red maple had absolute r values greater than .50. However, several relationships could be drawn between minesoil surface properties and IV for different tree species. For example, red maple had moderate IVs on the low pH sites followed by its highest IV on the moderate pH site (BR), but had no IV on the highest pH site (FR). Red maple also steadily increased in IV with increased thickness of the A horizon, but had a sharp decrease in IV on sites with A horizons greater than 7 cm (JS and FR). Black birch and sourwood only had large IVs on the sites with low pH

Table 3. Thickness (cm) and pH of minesoil A horizons on AML sites in northern West Virginia.

Parameter	AML SITES BR	JS	JP	LG	VP	HU	FR
Thickness (cm)	6.7	8.0	4.2	0.0	1.5	6.8	7.3
pH	5.9	4.3	4.2	4.3	4.6	4.5	7.3

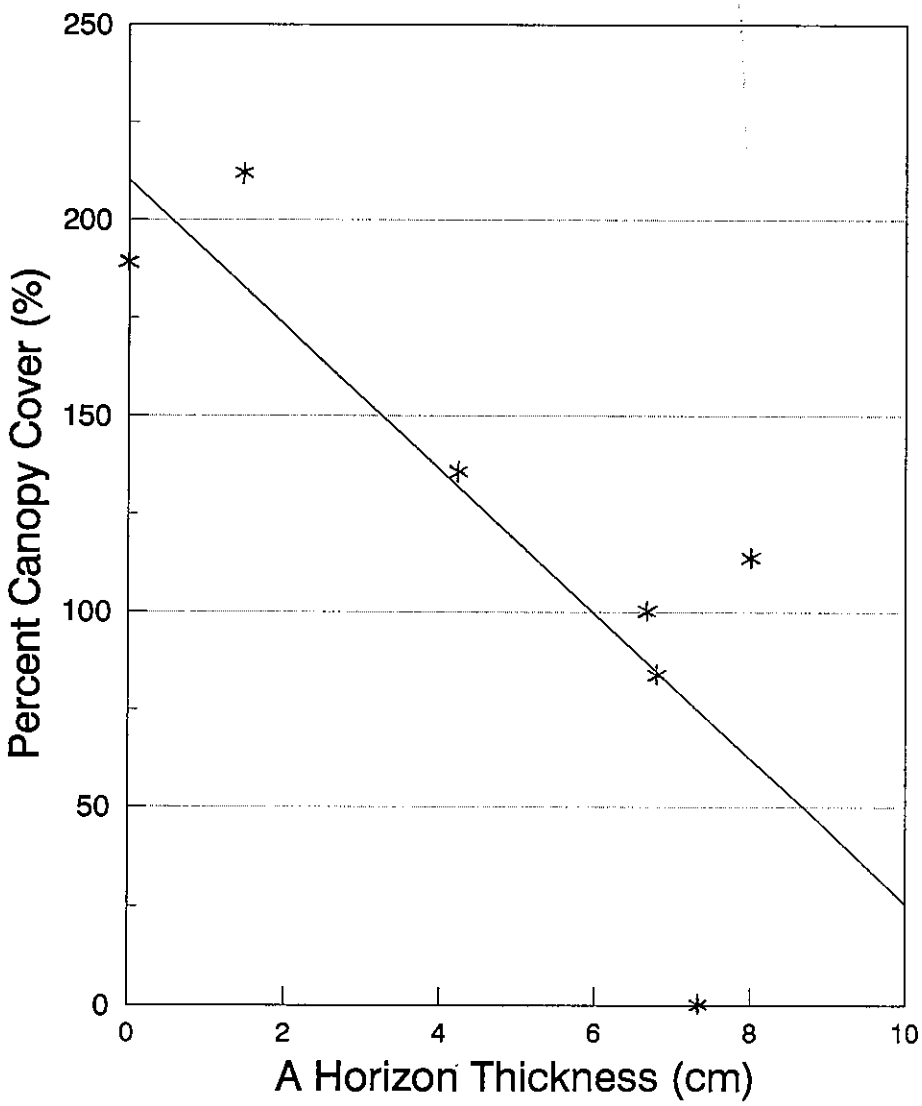

Figure 1. Percent canopy cover of tree species vs. thickness (cm) of minesoil A horizons on AML sites in northern West Virginia.

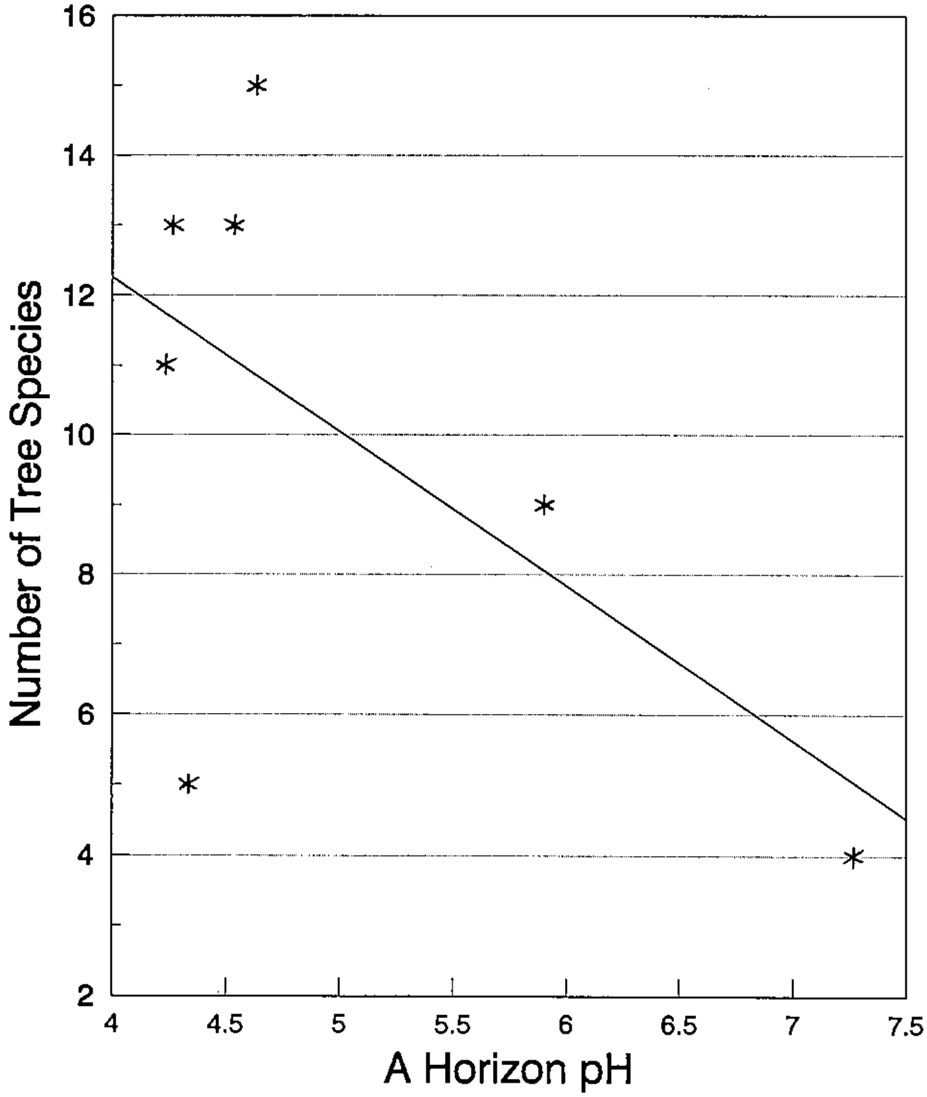

Figure 2. Number of tree species vs. pH of minesoil A horizons on AML sites in northern West Virginia.

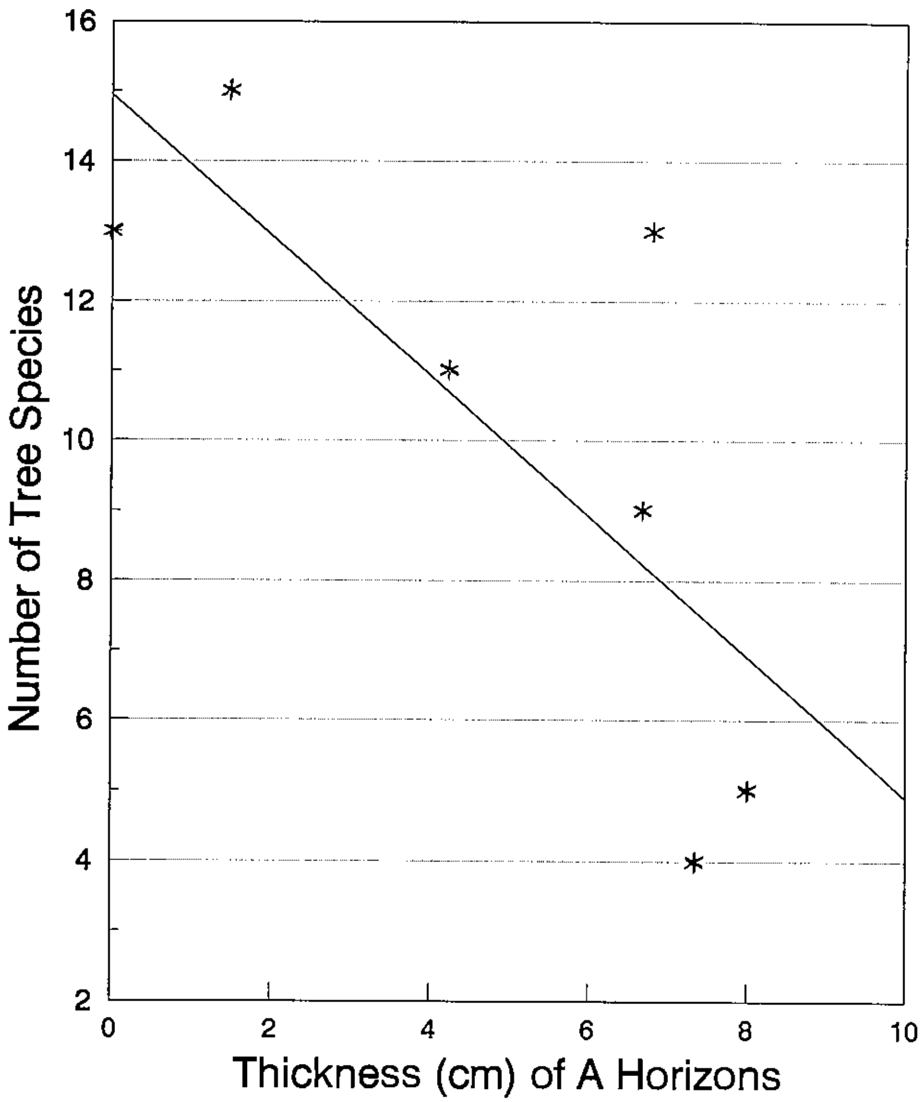

Figure 3. Number of tree species vs. thickness (cm) of minesoil A horizons on AML sites in northern West Virginia.

Table 4. Importance value (IV) of major tree species on seven AML study sites in northern West Virginia.

	AML SITES						
Species	BR	JS	JP	LG	VP	HU	FR
Aspen	100.8	0.0	8.3	31.2	11.5	19.3	0.0
Birch	19.8	20.9	115.9	9.6	122.5	76.0	0.0
Black locust	20.6	148.5	18.0	28.5	28.2	0.0	0.0
Cherry	7.6	78.0	9.9	57.0	13.9	0.0	96.7
Hercules' club	0.0	0.0	0.0	68.0	7.2	16.5	0.0
Red maple	78.5	39.6	64.9	46.8	59.3	71.4	0.0
Sourwood	0.0	13.0	49.8	0.0	0.0	45.4	0.0
Other species	32.7	0.0	33.3	58.9	57.3	71.5	123.3
Total species	260.0	300.0	300.0	300.0	300.0	300.0	220.0

and moderately thick A horizons. Black locust dominated the canopy cover on two moderately deep A horizon sites (BR and JS) but only had a high IV on the low pH JS site. Whereas, big-toothed aspen dominated the canopy and had a high IV on the BR site. Trends can also be seen for Hercules' club and pin cherry.

Analysis of other minesoil properties (e.g. particle size distribution, surface bulk density, water-holding capacity, electrical conductivity, potassium, calcium, magnesium, sulfur, aluminum, phosphorous, and copper, iron, manganese, and zinc may provide more insight into the reasons for tree establishment and dominance on particular AML sites in this study. From this work we can better understand the relationships between minesoil properties and species adaptations to specific conditions.

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Table 5. Correlation coefficient (r) between each major tree species' importance value (IV) and thickness (cm) and pH of the surface minesoil horizon across seven AML sites in northern West Virginia.

Species	Thickness (cm)	pH
Aspen	0.018	0.18
Birch	-0.32	-0.51
Black locust	0.25	-0.37
Cherry	0.20	0.42
Hercules' club	-0.70	-0.36
Red maple	-0.18	-0.57
Sourwood	0.21	-0.46
Other sp.	-0.034	0.67

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