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Mycorrhizae of Planted and Volunteer Vegetation on Surface-Mined Sites

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Abstract

This paper records the mycorrhizal status of a number of plant species collected on orphan surface-mined sites and adjacent unmined sites, and on artificially planted surface-mined sites in eastern Kentucky and Tennessee.

Introduction

Before the enactment of reclamation laws, many of the spoils formed by surface mining were left to vegetate entirely by natural means. The natural establishment of plant species and the rate and extent of plant succession were influenced by the chemical, physical, and biological properties of the spoils. Where efforts were made to revegetate surface-mine spoils artificially, native species of trees were usually planted (Limstrom 1960).

After the enactment of reclamation laws, a greater variety of plant species was used, including introduced herbaceous and woody plants. Much of the revegetation effort and research was concerned with evaluating plant species for their adaptation to surface-mined sites. The significance of microbiological influences on plant establishment was mostly overlooked until Wilson investigated and reported in 1965 on the microbiology of surface-mined spoils. About the same time, Schramm (1966) identified the significance of bacterial and fungal symbionts for woody species that were successfully pioneering on anthracite wastes. More recently, the beneficial aspects of mycorrhizal fungi have been demonstrated for a number of host plants growing under similar harsh conditions (Marx 1975, 1976, 1977; Daft and Hacskaylo 1976; Williams et al. 1974).

Through the years, a variety of volunteer plants have developed on many of the artificially planted as well as the orphan or abandoned surface-mined sites (Vogel 1977). For some postmining land uses, this natural plant succession is desirable. In some instances the planted vegetation has appreciably influenced the successional pattern on these sites. For example, Ashby (1964) reported that *Robinia pseudoacacia* L. (black locust), which is both a nodulated and vesicular-arbuscular (VA) endomycorrhizal host, enhanced the establishment of a mesic forest ecosystem in tree plantings in Illinois. The benefit to plants of a dual infection by symbiotic microorganisms was also observed by Daft and Hacskaylo (1976). They found that several of the plant species that grew naturally on coal wastes in Pennsylvania were both nodulated and mycorrhizal.

Information presented in this report extends our knowledge of mycorrhizal associates of both planted and volunteer species growing on surface-mined sites and may be useful in selecting plant species or mixtures of species in future revegetation efforts.

Materials and Methods

Site Description

Plant and root specimens were collected from (1) four orphan surface-mined sites that were revegetated by volunteer species, (2) unmined areas adjacent to the orphan mine sites, and (3) eight artificially planted surface-mined sites. Two of the orphan mine sites are in Kentucky; they were mined in the late 40s and early 50s. The sites have a ridge and trough profile; the chemical properties of the minesoils are similar to those of adjacent unmined forest soils (Table 1). Many of the plant species, including such hardwoods as *Acer*, *Liriodendron*, and *Tilia*, and numerous understory species found in the adjacent deciduous forests, have been reestablished on the mined sites.

The other two orphan mine sites are in north-central Tennessee and were mined in the early to mid-60s. These sites have backfilled and leveled benches with minesoils that are more acid and less productive of vegetation than the Kentucky sites (Table 1). Early successional weeds and *Pinus virginiana* Mill. are the predominant volunteer species; however, plant growth is generally poor.

The artificially planted sites all are located in southeastern Kentucky and were mined between the early 60s and the mid-70s. These sites include seven different coal seams; the spoils differ widely in chemical and physical properties. All of the sites received some grading (Table 2). Trees, shrubs, and herbaceous species were planted on most of the sites with no mulch additions. Lime and fertilizer were applied to some of the sites, although in two instances the phosphorus level of the minesoil was high enough to support good legume growth without nitrogen and phosphorus fertilizers. Most of the sites also support vegetation by natural seeding both from experimental plantings and from surrounding native stands. The natural revegetation was more prevalent on the areas that initially supported the least cover of artificially planted species.

Sampling Procedures

Voucher specimens of plant species were collected at all sites from contiguous plots along randomly established transects.[1]

[1] Voucher specimens were identified by the Botany Departments at the University of North Carolina and Berea College under cooperative research agreements with the Northeastern Forest Experiment Station, Research Work Unit NE-1605.

Table 1. — Description of orphan mine and adjacent unmined collection sites in Kentucky and Tennessee

Site No.	Site name and location	Approximate age	Grading	Soil pH[a] Range	Soil pH[a] Median	Soil P[b] Range	Soil P[b] Median	Soil K[c] Range	Soil K[c] Median
		years			*ppm*				
			SURFACE MINED						
1	Kentucky								
	Bell County	25	None	3.2-5.8	4.9	1.6-19.8	8.5	52-178	114
	Harlan County	25	None	3.8-7.2	4.5	0.4-17.3	2.8	38-209	115
2	Tennessee								
	Campbell County								
	Site 1	15	Backfilled and leveled	2.7-6.5	3.9	0.1-7.0	1.4	19-189	69
	Site 2	15	benches	2.7-5.7	3.5	0.3-18.0	3.0	18-147	43
			UNMINED						
3	Kentucky								
	Bell County	NA[d]	NA	3.8-6.0	4.2	1.4-8.0	4.2	53-155	93
	Harlan County			3.6-4.5	4.0	1.1-6.3	2.4	63-118	99
4	Tennessee								
	Campbell County								
	Site 1	NA	NA	4.0-4.3	4.1	1.7-5.3	1.8	32-83	51
	Site 2			3.8-5.0	4.2	1.7-28.0	4.0	43-158	84

[a] 1:2 soil-water mix
[b] Bray #1 extractable phosphorus
[c] 0.05 *N* HC1 + 0.025 *N* H_2SO_4 extractable potassium
[d] Not applicable

Table 2. — Description of artificially planted collection sites in Kentucky

Site No.	Site name and location	Coal seam mined	Type of mining	Spoil pH[a] range	Year mined	Year planted	Grading
5	Hazel Green, Laurel County	Jellico	Contour	4.0-6.5	1965	1966	Minimum
6	Lily, Laurel County	Lily	Area	3.1-6.5	1964	1965-66	Leveled to gently rolling
7	Fonde, Bell County	Mingo (Pathfork)	Contour	3.0-5.5	1959 1963	1965	Controlled drainage
8	Log Mountain, Bell County	Red Springs	Contour	6.5-7.5	1963	1964-65	Bench leveled and backsloped to highwall
9	Ano, Pulaski County	Stearns #3	Contour	6.5-7.5	1971	1972	Leveled bench
10	Trace Branch, Rockcastle County	Name undetermined	Contour	2.9-5.9	1974	1975	Leveled bench
11	Indian Creek, Laurel County	Jellico	Contour and area	4.5-7.0	1971	1972	Leveled bench
12	Hignite, Bell County	Hignite	Contour	4.5-5.9	1967	1968	Leveled bench

[a] 1:2 soil-water mix

Root materials appropriate for mycorrhizal analysis were collected from additional plants of the same species along or near the transects. Herbaceous plant specimens were carefully dug with the soil ball intact and placed in a plastic bag. Young seedlings of woody plant specimens were similarly collected or, where small seedlings were unavailable, three 8-inch (20 cm) soil plugs were taken at each of the compass points from around the drip line of larger tree or shrub specimens and placed in a plastic bag. Roots from both soil balls and plugs were washed free of soil and collected on sieves. The root tissue was cut into small segments, stained, and examined microscopically for mycorrhizal associates in the manner described by Phillips and Hayman (1970).

Results and Discussion

The mycorrhizal status of plants collected is given in Table 3. A number of species are members of families that Gerdemann (1968) lists as possibly nonmycorrhizal or rarely mycorrhizal. With the exception of Urticaceae, families that were on the list and found on orphan mines were nonmycorrhizal. They include Commelinaceae, Cyperaceae, Juncaceae, Caryophyllaceae, Chenopodiaceae, Phytolaccaceae, and Polygonaceae. Families from the artificially planted sites that were nonmycorrhizal and represented in Gerdemann's list include the Cyperaceae, Juncaceae, and Phytolaccaceae; however, two of the genera in the Caryophyllaceae and some collections of *Polygonum* in the Polygonaceae were mycorrhizal. The mycorrhizal variation found in several genera from our collections may possibly be explained on the basis of the information obtained with several isolates of *Polygonum*.

Some species of *Polygonum* escape cultivation into waste areas and have been observed as pioneer plants on recently disturbed surface-mined lands. Annual species may initially volunteer on such areas, but they usually do not persist. Annual species from our orphan mine sites (*P. pensylvanicum* L.) (Table 3) and from recent road construction sites in Colorado (*P. aviculare* L.) (Reeves et al. 1979) all have been nonmycorrhizal, although *P. cespitosum* Blume was reported as VA mycorrhizal in a collection from a topsoiled site in Illinois (Carter et al. 1978). Perennial species such as *P. cuspidatum* Siebold & Zucc. (Japanese knotweed or fleeceflower) often produce dense persistent stands on surface-mined sites as a result of vigorous rhizomatous activity. In collections from the artificially planted sites of our study the isolates of *P. cuspidatum* that were infected with VA mycorrhizal fungi were found growing next to plant species usually considered as VA hosts. However, most of the nonmycorrhizal isolates were found close to plants that were not hosts of VA fungi or were not close to any other vegetation. The proximity of VA host plants may have influenced the mycorrhizal condition of the VA-infected plants of *P. cuspidatum* as it did for the Chenopodiaceae reported by Ocampo and co-workers (1980). They noted a slight infection in plants and supposedly nonhost species when pairs of host and nonhost crop plants were grown together in soil. It is also possible that at our artificially planted site the VA propagules attained a density sufficient to influence mycorrhizal association in the rarely mycorrhizal *Polygonum*.

A great deal of variability in endophyte development was noted also for some members of the Compositae and Leguminosae. This variability has been reported also by Marx (1977) for some revegetated coal mine spoils in Kentucky and Virginia. He found, for instance, that among grasses, not all seedlings, even of the same species, were endomycorrhizal. The lack of VA associates for isolates of *Lespedeza* and *Robinia* in our study was very likely due to low levels or complete absence of VA spores since the two legumes were collected in a predominantly pine stand.

In other collections from the artificially planted sites a unique degree of symbiotic development was noted. Some members of the Betulaceae, *Alnus glutinosa* (L.) Gaertn. (European black alder), were not only nodulated with an actinomycete nitrogen-fixing species, but were endo- and ectomycorrhizal as well. *Betula* (birch) species in the Betulaceae, and the *Populus* (hybrid poplar) specimens from the Salicaceae were also both endo- and ectomycorrhizal.

Conclusion

Data presented in this paper show that most volunteer plant species on orphan mine sites develop mycorrhizal associates, but that the age of the spoils seems not to be a factor influencing the mycorrhizal condition of the species. More information is needed on the interaction of microbial symbionts of pioneering plant species such as the *Polygonum* that was found growing in close proximity to plant species that are hosts of VA fungi. Initial benefits of mycorrhizal relationships indicate a need for additional research on selection of plant-microbial combinations that lead to successful establishment of desirable vegetation on surface-mined sites.

Table 3. — Plant species and mycorrhizal status of specimens from orphan-mine, unmined, and artificially planted sites in Kentucky and Tennessee

Family and collection site[a]	Scientific name	Mycorrhizal status[b] on orphan and unmined sites	Mycorrhizal status[b] on planted sites
	Pteridophyta		
Lycopodiaceae			
2, 5	*Lycopodium flabelliforme* (Fern.) Blanchard	NON	VA
Ophioglossaceae			
3	*Botrychum virginianum* (L.) Swartz	NON	—
8	*Botrychum* sp.	—	NON
Polypodiaceae			
4	*Adiantum pedatum* L.	NON	—
5	*Asplenium platyneuron* (L.) Oakes	—	NON
2, 4	*Polystichum acrostichoides* (Michx.) Schott	VA	—
4	*Pteridium aquilinum* (L.) Kuhn	NON	—
3	*Thelypteris hexagonoptera* (Michx.) Weatherby	VA	—
2, 4, 9	*Thelypteris noveboracensis* (L.) Nieuwl.	VA	VA
	Spermatophyta		
	Gymnospermae		
Pinaceae			
2	*Pinus rigida* Mill.	EC	—
5	*Pinus taeda* L.	—	EC
2, 4, 6, 11	*Pinus virginiana* Mill.	EC	EC
3	*Tsuga canadensis* (L.) Carriere	EC	—
	Angiospermae—Monocotyledoneae		
Araceae			
1, 3	*Arisaema triphyllum* (L.) Torr.	VA	—
Commelinaceae			
2	*Commelina communis* L.	NON	—

[a] Collection sites:
Orphan and unmined sites (data combined from two collection sites in each state)
1 — Orphan mine site — Kentucky
2 — Orphan mine site — Tennessee
3 — Adjacent unmined site — Kentucky
4 — Adjacent unmined site — Tennessee

Artificially planted sites
5 — Hazel Green
6 — Lily
7 — Fonde
8 — Log Mountain
9 — Ano
10 — Trace Branch
11 — Indian Creek
12 — Hignite

[b] Mycorrhizal status:
VA — Vesicular-arbuscular endomycorrhizae
EC — Ectomycorrhizae
ER — Ericoid endomycorrhizae
VA-EC — Both endo- and ectomycorrhizae
NON — No mycorrhizae observed

(Continued)

Table 3. -- Continued

Family and collection site[a]	Scientific name	Mycorrhizal on orphan and unmined sites
Cyperaceae		
1	*Carex aestivalis* M. A. Curtis	NON
1, 3	*Carex pensylvanica* Lam.	NON
1, 3, 10	*Carex* sp.	NON
2, 9	*Eleocharis obtusa* (Willd.) Schult.	NON
2	*Scirpus cyperinus* (L.) Kunth	NON
7, 11	*Scirpus* sp.	—
Dioscoreaceae		
2, 4	*Dioscorea villosa* L.	VA
Gramineae		
1	*Agrostis hyemalis* (Walt.) BSP	NON
5	*Andropogon gerardi* Vitm.	—
2, 6	*Andropogon virginicus* L.	VA
12	*Aristida* sp.	—
5	*Arrhenatherum elatius* (L.) Presl	—
4	*Brachyelytrum erectum* (Schreb.) Beauvois	VA
5	*Dactylis glomerata* L.	—
2, 4	*Danthonia compressa* Austin	VA
11	*Echinochloa crusgalli* (L.) Beauvois	—
11	*Eragrostis curvula* (Schrad.) Nees	—
5	*Eriochloa* sp.	—
7	*Holcus lanatus* L.	—
9	*Leersia oryzoides* (L.) Swartz	—
2	*Microstegium vimineum* (Trin.) A. Camus	VA
2	*Microstegium vimineum* (Trin.) A. Camus	NON
2, 4	*Panicum boscii* Poir	VA
11	*Panicum depauperatum* Muhlenb.	—
11	*Panicum lanuginosum* Elliott	—
2	*Panicum polyanthes* Schult.	NON
2, 4	*Panicum sphaerocarpon* Elliott	VA
5	*Panicum virgatum* L.	—
6	*Panicum* sp.	—
5	*Phalaris arundinacea* L.	—
6	*Schizachyrium scoparium* (Michx.) Nash	—
5	*Sorghastrum nutans* (L.) Nash	—
9	*Uniola laxa* (L.) BSP	—
Iridaceae		
3	*Iris cristata* Ait.	VA
Juncaceae		
2	*Juncus acuminatus* Michx.	NON
8	*Juncus canadensis* J. Gay	—
2	*Juncus effusus* L.	NON
10	*Juncus* sp.	—
Liliaceae		
1, 3	*Disporum lanuginosum* (Michx.) Nichols.	VA
1	*Lilium philadelphicum* L.	NON
3	*Medeola virginica* L.	VA
1	*Polygonatum biflorum* (Walter) Elliott	NON
2	*Smilacina racemosa* (L.) Desf.	NON
4	*Smilacina racemosa* (L.) Desf.	VA
2, 4	*Smilax rotundifolia* L.	VA
1, 3	*Trillium erectum* L.	VA
2, 4	*Uvularia perfoliata* L.	NON
Orchidaceae		
2, 4	*Goodyera pubescens* (Willd.) R. Br.	NON

ued

a	Scientific name	Mycorrhizal status[b]	
		on orphan and unmined sites	on planted sites
	Typha latifolia L.	NON	—
	Angiospermae-Dicotyledoneae		
	Acer rubrum L.	VA	VA
	Acer saccharum Marsh.	VA	VA
	Acer saccharum Marsh.	—	NON
	Rhus copallina L.	NON	—
	Rhus copallina L.	VA	—
	Rhus glabra L.	NON	—
	Rhus sp.	—	NON
	Apocynum cannabinum L.	VA	—
	Apocynum sp.	—	VA
	Ilex opaca Ait.	VA	—
	Aralia racemosa L.	VA	—
	Aristolochia serpentaria L.	NON	—
	Asarum canadense L.	VA	—
	Asarum arifolium Michx.	VA	—
	Asarum sp.	VA	—
	Asclepias syrica L.	—	VA
	Asclepias tuberosa L.	—	VA
	Impatiens pallida Nutt.	VA	NON
	Caulophyllum thalictroides (L.) Michx.	VA	—
	Podophyllum peltatum L.	VA	—
	Alnus glutinosa (L.) Gaertn.	—	VA-EC
	Alnus sp.	—	VA
	Betula lenta L.	EC	EC
	Betula sp.	—	VA-EC
	Carpinus caroliniana Walt.	EC	—
	Ostrya virginiana (Mill.) Koch	EC	—
	Campanula divaricata Michx.	NON	NON
	Lonicera japonica Thunb.	VA	—
	Sambuncus canadensis L.	VA	—
	Viburnum acerifolium L.	VA	—
	Agrostemma githago L.	—	VA
	Dianthus armeria L.	—	VA
	Paronychia fastigiata (Raf.) Fern.	NON	—
	Saponaria officinalis L.	—	NON
	Stellaria pubera Michx.	NON	—

(Continued)

Table 3. -- Continued

Family and collection site[a]	Scientific name	Mycorrhizal status[b] on orphan and unmined sites	Mycorrhizal status[b] on plant sites
Chenopodiaceae			
1	*Chenopodium album* L.	NON	—
Compositae			
2	*Ambrosia artemisiifolia* L.	VA	—
12	*Ambrosia* sp.	—	VA
6	*Anaphalis* sp.	—	VA
2	*Antennaria plantaginifolia* (L.) Hook.	VA	—
2, 4	*Aster divaricatus* L.	VA	—
7	*Aster paternas* Cronq.	—	VA
2	*Aster pilosus* Willd.	VA	—
2	*Aster pilosus* Willd.	NON	—
2, 8, 10	*Aster* sp.	VA	VA
2	*Aster* sp.	NON	—
8	*Cacalia atriplicifolia* L.	—	NON
2	*Chrysanthemum leucanthemum* L.	VA	—
10	*Chrysopsis* sp.	—	VA
6	*Cirsium* sp.	—	VA
2, 4	*Coreopsis major* Walt.	VA	—
6	*Coreopsis* sp.	—	VA
1, 11	*Erechtites hieracifolia* (L.) Raf.	VA	VA
2	*Erigeron annuus* (L.) Pers.	VA	—
7	*Erigeron canadensis* L.	—	VA
1	*Erigeron philadelphicus* L.	NON	—
2	*Eupatorium fistulosum* Barratt	VA	—
6	*Eupatorium hyssopifolium* L.	—	VA
6, 11	*Eupatorium perfoliatum* L.	—	VA
2, 7, 8	*Eupatorium purpureum* L.	VA	VA
4	*Eupatorium purpureum* L.	NON	—
7	*Eupatorium rotundifolium* L.	—	VA
1, 4, 8	*Eupatorium rugosum* Houtt.	VA	VA
8	*Eupatorium serotinum* Michx.	—	VA
6	*Eupatorium* sp.	—	VA
7	*Helianthus decapetalus* L.	—	VA
1, 3	*Helianthus tuberosus* L.	VA	—
8, 12	*Helianthus* sp.	—	VA
2, 6	*Lactuca canadensis* L.	NON	VA
12	*Lactuca* sp.	—	VA
1, 3	*Polymnia canadensis* L.	NON	—
1	*Prenanthes roanensis* (Chicker.) Chicker.	VA	—
1, 2, 3, 4	*Prenanthes serpentaria* Pursh	VA	—
2, 4	*Senecio smallii* Britt.	VA	—
12	*Silphium* sp.	—	VA
2, 4	*Solidago arguta* Ait.	NON	—
2	*Solidago altissima* L.	VA	—
2, 4	*Solidago caesia* L.	VA	—
2	*Solidago erecta* Pursh	VA	—
1, 3	*Solidago flexicaulis* L.	VA	—
2, 11	*Solidago gigantea* Ait.	VA	VA
7	*Solidago puberula* Nutt.	—	VA
2, 6, 7, 9, 10, 12	*Solidago* sp.	VA	VA
10, 12	*Solidago* sp.	—	NON
2	*Taraxacum officinale* Wiggers	VA	—
5	*Tragopogon pratensis* L.	—	VA
6	*Vernonia* sp.	—	VA
Convolvulaceae			
2	*Calystegia sepium* (L.) R. Br.	NON	—

(Conti

Table 3 -- Continued

Family and collection site[a]	Scientific name	Mycorrhizal status[b] on orphan and unmined sites	on planted sites
Cornaceae			
2, 4	*Cornus florida* L.	VA	—
6	*Cornus* sp.	—	NON
2, 4, 6	*Nyssa sylvatica* Marsh	VA	VA
Crassulaceae			
3	*Sedum ternatum* Michx.	NON	—
Elaeagnaceae			
5	*Elaeagnus umbellata* Thunb.	—	VA
Ericaceae			
2	*Chimaphila maculata* (L.) Pursh	ER	—
2	*Epigaea repens* L.	ER	—
2, 4	*Kalmia latifolia* L.	ER	—
2, 7	*Oxydendrum arboreum* (L.) DC.	ER	ER
9	*Rhododendron* sp.	—	ER
4	*Vaccinium constablaei* Gray	ER	—
4	*Vaccinium stamineum* L.	ER	—
2, 4	*Vaccinium vacillans* Torr.	ER	—
Euphorbiaceae			
4, 6	*Euphorbia corollata* L.	VA	VA
Fagaceae			
5	*Castanea* sp.	—	VA
2, 4	*Fagus grandifolia* Ehrh.	EC	—
2, 4, 5	*Quercus alba* L.	EC	EC
4	*Quercus falcata* Michx.	EC	—
2, 4	*Quercus prinus* L.	EC	—
2, 6, 8	*Quercus rubra* L.	EC	EC
Gentianaceae			
7	*Sabatia angularis* (L.) Pursh	—	VA
Geraniaceae			
2, 4	*Geranium maculatum* L.	VA	—
Hamamelidaceae			
1, 3	*Hamamelis virginiana* L.	VA	—
5	*Liquidambar styraciflua* L.	—	VA
Hippocastanaceae			
1, 3	*Aesculus octandra* Marsh.	VA	—
Hypericaceae			
11	*Hypericum hypericoides* (L.) Crantz	—	VA
5	*Hypericum* sp.	—	VA
Juglandaceae			
4	*Carya ovalis* (Mill.) Koch	EC	—
2, 4	*Carya tomentosa* Nutt.	EC	—
7	*Juglans nigra* L.	—	VA
Labiatae			
4	*Cunila origanoides* (L.) Britt.	VA	—
1, 2	*Hedeoma pulegioides* (L.) Pers.	VA	—
6	*Lycopus* sp.	—	VA
8	*Mentha* sp.	—	NON
1, 3	*Monarda clinopodia* L.	VA	—
2, 7	*Prunella vulgaris* L.	VA	VA
1	*Scutellaria elliptica* Muhlenb.	VA	—
1	*Stachys nuttallii* Shuttl.	VA	—

(Continued)

Table 3 -- Continued

Family and collection site[a]	Scientific name	Mycorrhizal status[b] on orphan and unmined sites	on planted sites
Lauraceae			
1	*Lindera benzoin* (L.) Blume	NON	—
2	*Sassafras albidum* (Nutt.) Nees	VA	—
4	*Sassafras albidum* (Nutt.) Nees	EC	—
Leguminosae			
6	*Albizia julibrissin* Durazz.	—	VA
6	*Amorpha fruticosa* L.	—	VA
2	*Amphicarpaea bracteata* (L.) Fern.	VA	—
8	*Amphicarpaea* sp.	—	VA
1, 8	*Cercis canadensis* L.	NON	VA
5	*Coronilla varia* L.	—	NON
2, 4	*Desmodium glutinosum* Muhl. ex (Willd.) Wood	NON	—
4	*Desmodium nudiflorum* (L.) DC.	NON	—
1	*Desmodium nudiflorum* (L.) DC.	VA	—
1, 2	*Desmodium paniculatum* (L.) DC.	VA	—
4	*Desmodium pauciflorum* (Nutt.) DC.	VA	—
2	*Desmodium rotundifolium* DC.	NON	—
6	*Desmodium* sp.	—	VA
5	*Dorycnium* sp.	—	VA
2	*Galactia volubilis* (L.) Britt.	VA	—
5	*Lathyrus sylvestris* L.	—	VA
6	*Lespedeza bicolor* Turcz.	—	NON
5	*Lespedeza cuneata* (Dum.-Cours.) G. Don	—	NON
2	*Lespedeza hirta* (L.) Hornem.	VA	—
7	*Lespedeza stipulacea* Maxim.	—	VA
7	*Lespedeza striata* (Thunb. ex J. Murr.) Hook. & Arn. var. Kobe	—	VA
4, 6	*Lespedeza violaceae* (L.) Pers.	NON	VA
6	*Lespedeza* sp.	—	VA
5	*Lotus corniculatus* L.	—	VA
2	*Medicago lupulina* L.	VA	—
2	*Melilotus alba* Desr.	VA	—
2	*Melilotus officinalis* (L.) Lam.	VA	—
2, 4, 5, 6	*Robinia pseudoacacia* L.	VA	VA
6	*Robinia pseudoacacia* L.	—	NON
2	*Trifolium pratense* L.	VA	—
2	*Trifolium repens* L.	NON	—
Lobeliaceae			
5	*Lobelia cardinalis* L.	—	VA
6, 7	*Lobelia* sp.	—	VA
Magnoliaceae			
2, 4, 7	*Liriodendron tulipifera* L.	VA	VA
3	*Magnolia acuminata* L.	VA	—
3	*Magnolia fraseri* Walt.	VA	—
Moraceae			
4	*Morus rubra* L.	VA	—
Oleaceae			
1, 3, 4	*Fraxinus americana* L.	VA	—
7	*Fraxinus pennsylvanica* Marsh.	—	VA
8	*Fraxinus* sp.	—	VA
Onagraceae			
2	*Circaea lutetiana* L.	NON	—
2, 7	*Ludwigia alternifolia* L.	VA	VA
5	*Oenothera* sp.	—	NON

(Continued)

Table 3 -- Continued

Family and collection site[a]	Scientific name	Mycorrhizal status[b] on orphan and unmined sites	Mycorrhizal status[b] on planted sites
Oxalidaceae			
2	*Oxalis dillenii* Jacq.	NON	—
1, 3	*Oxalis grandis* Small	NON	—
Papaveraceae			
1, 3	*Sanguinaria canadensis* L.	VA	—
Phrymaceae			
1, 3	*Phryma leptostachya* L.	VA	—
Phytolaccaceae			
2, 4, 6	*Phytolacca americana* L.	NON	NON
Plantaginaceae			
1	*Plantago Rugelii* Decne. var. *Rugelii* Rugel	NON	—
Platanaceae			
2, 5, 8	*Platanus occidentalis* L.	NON	VA
Polygalaceae			
2	*Polygala curtissii* Gray	VA	—
7	*Polygala verticillata* var. *ambigua* (Nutt.) Wood	—	VA
Polygonaceae			
6	*Polygonum cuspidatum* Siebold & Zucc.	—	VA
6	*Polygonum cuspidatum* Siebold & Zucc.	—	NON
1	*Polygonum pensylvanicum* L.	NON	—
Primulaceae			
7, 8	*Lysimachia radicans* Hook.	—	NON
Ranunculaceae			
1	*Actaea pachypoda* Elliott	VA	—
1	*Anemone virginiana* L.	NON	—
2, 4	*Cimicifuga racemosa* (L.) Nutt.	VA	—
2	*Clematis virginiana* L.	VA	—
3	*Hepatica acutiloba* DC.	VA	—
2	*Ranunculus abortivus* L.	NON	—
2, 4	*Thalictrum thalictroides* (L.) Boivin	VA	—
Rosaceae			
5	*Agrimonia eupatoria* L.	—	VA
2, 4	*Amelanchier arborea* (Michx.) Fern.	VA	—
2	*Crataegus flabellata* (Spach) Kirchn.	VA	—
2	*Duchesnea indica* (Andrz.) Focke	VA	—
2	*Fragaria virginiana* Duchesne	VA	—
1	*Geum canadense* Jacq.	NON	—
2, 4	*Potentilla canadensis* L.	VA	—
2	*Potentilla simplex* Michx.	VA	—
8	*Potentilla* sp.	—	VA
2, 4, 6	*Prunus serotina* Ehrh.	VA	VA
1	*Rosa multiflora* Thunb. ex J. Murr.	VA	—
2	*Rubus argutus* Link	VA	—
2	*Rubus hispidus* L.	VA	—
1, 6, 7	*Rubus* sp.	VA	VA
8	*Spirea tomentosa* L.	—	NON
Rubiaceae			
2	*Galium circaezans* Michx.	VA	—
2, 4	*Galium triflorum* Michx.	VA	—
12	*Galium* sp.	—	VA
2, 4	*Houstonia purpurea* L.	VA	—
3	*Mitchella repens* L.	VA	—

(Continued)

Table 3 -- Continued

Family and collection site[a]	Scientific name	Mycorrhizal status[b]	
		on orphan and unmined sites	on planted sites
Salicaceae			
5	*Populus* sp.	—	VA-EC
5, 6	*Populus* sp.	—	EC
2	*Salix sericea* Marsh.	VA	—
Santalaceae			
7	*Pyrularia pubera* Michx.	—	NON
Saxifragaceae			
2, 4	*Heuchera americana* L.	NON	—
6	*Hydrangea quercifolia* Bartr.	—	VA
1, 3	*Tiarella cordifolia* L.	VA	—
Scrophulariaceae			
4	*Aureolaria flava* (L.) Farw.	NON	—
9	*Chelone glabra* L.	—	VA
Simaroubaceae			
6	*Ailanthus altissima* (Mill.) Swingle	—	VA
Solanaceae			
7	*Solanum carolinense* L.	—	VA
Styracaceae			
3	*Halesia carolina* L.	VA	—
Tiliaceae			
2, 4	*Tilia heterophylla* Venten.	EC	—
Ulmaceae			
6	*Ulmus parvifolia* Jacq.	—	EC
Umbelliferae			
6	*Angelica* sp.	—	VA
1	*Cryptotaenia canadensis* (L.) DC.	VA	—
2, 8	*Daucus carota* L.	NON	VA
1	*Osmorhiza longistylis* (Torr.) DC.	VA	—
1, 3, 4	*Sanicula canadensis* L.	VA	—
3	*Thaspium trifoliatum* (L.) Gray	VA	—
Urticaceae			
1, 3	*Laportea canadensis* (L.) Wedd.	VA	—
1	*Pilea pumila* (L.) Gray	VA	—
Verbenaceae			
1	*Verbena urticifolia* L.	VA	—
Violaceae			
4	*Viola canadensis* L.	VA	—
4	*Viola pedata* L.	VA	—
2	*Viola primulifolia* L.	VA	—
1, 3	*Viola* sp.	VA	—
Vitaceae			
4	*Parthenocissus quinquefolia* (L.) Planch.	VA	—
1, 3	*Vitis aestivalis* Michx.	VA	—
6	*Vitis* sp.	—	VA

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Rothwell, Frederick M. and Willis G. Vogel. Mycorrhizae of planted and volunteer vegetation on surface-mined sites. Broomall, Pa. Northeast. For. Exp. Stn.; 1982; USDA For. Serv. Gen. Tech. Rep. NE-66. 12 p.

This paper records the mycorrhizal status of a number of plant species collected on orphan surface-mined sites and adjacent unmined sites, and on artificially planted surface-mined sites in eastern Kentucky and Tennessee.

Keywords: Microbial symbionts; vesicular-arbuscular endomycorrhizae; ectomycorrhizae; ericoid endomycorrhizae; surface mining; orphan mines sites; natural revegetation; artificial revegetation.

Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories and research units are maintained at:

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