Flora of the Fonde Surface Mine Demonstration Area, Bell County, Kentucky

G. L. Wade[2] and R. L. Thompson[2]

Abstract. The pre-SMCRA, 7.3-ha Fonde Surface Mine Demonstration Area supported a vascular plant flora of 299 taxa after 24 years of succession. Relative richness of this mine was 88 percent of that to be expected in an unmined area of this size in the Mixed and Western Mesophytic Forest Regions, and this relative richness is similar to that found in other completely inventoried pre-SMCRA mined areas in Appalachia. One species, *Scirpus fluviatilis*, is on the Kentucky list of threatened plant species. Native taxa comprised 82.2 percent of the flora. Out of 31 taxa that were planted for reclamation and research purposes, 26 still remained. The planted herbaceous taxa have, for the most part, yielded to native taxa. Abundances of 73 percent of the taxa were rated as infrequent or rare. This abundance distribution is similar to that obtained when lognormally distributed species are assigned to abundance categories. Other studies of reclaimed mined lands using sampling methods returned lower relative richness and located no threatened or endangered species. Given the inherent advantages and disadvantages of inventories and sampling studies, we suggest that a combination of both methods is most desirable for future studies of succession and biodiversity on reclaimed surface mines and other areas.

Additional Key Words: reclamation, revegetation, succession

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[2]Gary L. Wade is Research Ecologist, Northeastern Experiment Station, USDA Forest Service, Burlington, Vermont 05402-0968.

Ralph L. Thompson is Associate Professor of Biology and Curator of the Herbarium, Berea College, Berea, KY 40404

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Introduction

The effects of coal surface mining on biodiversity in Appalachia have long been a concern of local residents, conservationists, and environmental scientists. Prior to the Surface Mine Control and Reclamation Act of 1977 (SMCRA, also known as Public Law 95-87) many coal surface mines in eastern Kentucky were left with ungraded piles of mixed overburden, and revegetation was left to natural processes of invasion, establishment and succession. Many mining companies made modest attempts at revegetation in accordance with state laws that governed mining. The most commonly planted species were mixes of grasses and lespedezas often augmented with seed or seedlings of Virginia pine and black locust. The Fonde Surface Mine Demonstration Area was created to show how then state-of-the-art reclamation methods could improve upon those practices, result in more productive post-mining land uses, and reduce off-site environmental problems.

SMCRA dictates post-mining reclamation practices that are quite different from those used at Fonde. Nevertheless the Fonde mine is of interest because the initial conditions and reclamation procedures were well documented and the development of vegetation and soils has been studied thoroughly. Fonde is one of a suite of five variously reclaimed mines in eastern Kentucky where the development of their vegetation and floras has been studied using complete botanical inventory methods (Thompson et al. 1984 and 1996; Thompson and Wade, 1991; Rafaill and Thompson in press). Although SMCRA has supplanted reclamation methods that were used upon these mines, their floristic development is of interest because:

- Biological inventories of disturbed areas have inherent value as records of human impacts upon the environment.
- Botanical inventories of pre- and post-SMCRA reclaimed lands can be used to evaluate effects of SMCRA on the biological recovery of mined lands.
- Intensive study of development of any reclaimed sites has high value for fine-tuning reclamation regulations and techniques in order to increase reclamation success and local biodiversity.

The objective of this paper is to describe the vascular flora that has developed on the Fonde mine after a period of 25 years.

The Study Site

The 7.3 ha Fonde Surface Mine Reclamation Demonstration Area (hereafter, Fonde, the mine, or the site) is located at longitude 83°52'15"W and latitude 36°35'20"N on a mountain slope approximately 0.5 kilometer south of Fonde in southwestern Bell County, Kentucky (Fig. 1).

The Fonde contour mine ranges in elevation from 583 m at the highwall top, 562 m on the bench, to 560m on the outslope bottom, and the slope aspect ranges NW-NE. The mine is part of the Cumberland Mountains of the Appalachian Plateaus Physiographic Province (Fenneman, 1938). Bedrock consists of sandstones, siltstones, shales and coals of the Mingo Formation from Lower and Middle Pennsylvanian Series in the Pennsylvanian System (Rice and Maughan, 1978). Childress (1992) classified soils in surrounding area as part of the Fairpoint and Bethesda soils on 2-20 percent slopes and Cloverlick-Guyandotte-Highsplint complex on 35-75 percent, very stony slopes. Braun (1950) classified the Cumberland Mountains as Mixed Mesophytic Forest Region.

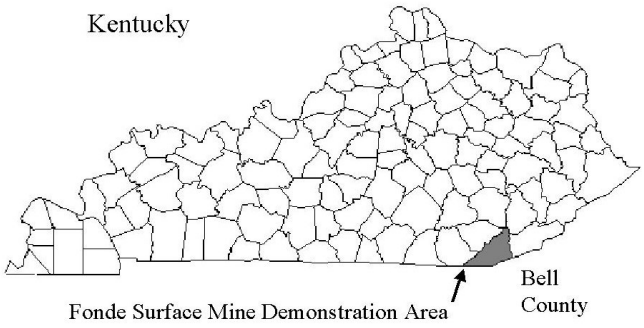

Figure 1. Location of the Fonde Surface Mine Demonstration Area in Bell County, Kentucky.

The Mingo coal seam at Fonde was mined in 1959 and remined in 1963. The site was reclaimed in 1965 to show state-of-the-art mine reclamation techniques consistent with the Kentucky mining law and regulations of that time. The reclamation demonstration area was a project of the Kentucky Strip Mine Research Coordinating Committee that was made up of the following organizations: Kentucky Coal Association, Kentucky Department of Natural Resources, Kentucky Reclamation Association, University of Kentucky, Northeastern Forest Experiment Station of USDA Forest Service, and Tennessee Valley Authority. The Forest Service maintained the site records and carried out most of the subsequent research on the site.

The mine spoils were minimally graded to contain incoming precipitation and water drainage from about 7.0 ha of upslope secondary deciduous forest. Water was directed back toward the

highwall and then to two settling ponds with controlled outlets and capacity to contain a 150-year storm. When possible, acid-forming coal wastes and shales were buried to lessen acid production. No lime or fertilizer were used except for a few small experimental plots near the dam. The original mean pH value of the mine spoils was 4.0 and the range was 2.8-5.9.

The reclaimers established mixed hardwoods plantations of yellow poplar *(Liriodendron tulipifera*), northern red oak (*Quercus rubra*), white oak (*Q. alba*), red maple *(Acer rubrum*), sugar maple (*A. saccharum*), American sycamore (*Platanus occidentalis*), and green ash (*Fraxinus pennsylvanica*) in three areas on what were considered to be the best quality spoils (Fig. 2). On lower quality spoils they established mixed pine plantations of Virginia pine (*Pinus virginiana*), pitch pine (*P. rigida*), and loblolly pine (*P. taeda*). Black locust (*Robinia pseudoacacia*) was planted in three areas with the worst spoils where little chance was given for success. Two extremely acid areas near the east and west ends of the mine were left unplanted. Near the center of the mine European black alder (*Alnus glutinosa*), Virginia pine, shrub lespedeza (*Lespedeza bicolor*), Korean lespedeza (*L. stipulacea*), and sericea lespedeza (*L. cuneata*) were planted in one

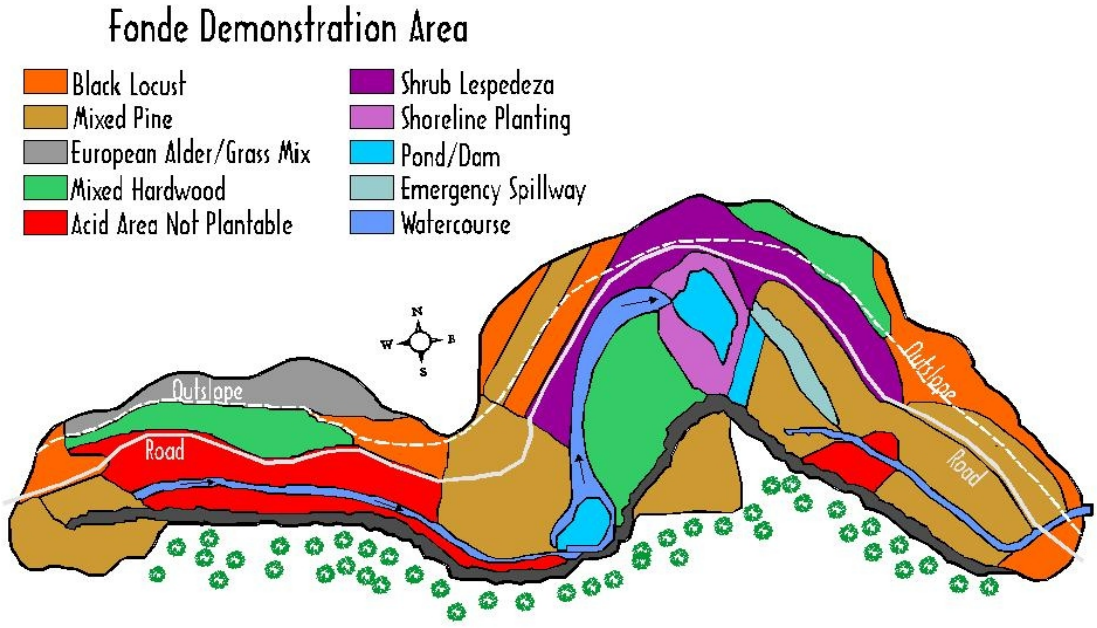

Figure 2. Features and planting on the Fonde Surface Mine Demonstration Area.

large area for wildlife use. The alder and lespedezas were included for their nitrogen-fixing capability. Shoreline plantings were made around the lower siltation pond. Two Virginia pine plantations were planted above the highwall; one with and one without a grass mix. Altogether, 31 species were planted at Fonde and 18 of these were woody (Table 1).

Table 1. Species planted on the Fonde Surface Mine Demonstration Area

Species		Bench	Out-slope	High-Wall
Virginia pine	*Pinus virginiana*	+	+	+
pitch pine	*Pinus rigida*	+	+	-
loblolly pine	*Pinus taeda*	+	+	-
yellow poplar	*Liriodendron tulipifera*	+	+	-
white oak	*Quercus alba*.	+	+	-
northern red oak	*Quercus rubra*	+	+	-
sugar maple	*Acer saccharum*	+	+	-
red maple	*Acer rubrum*	+	+	-
sycamore	*Platanus occidentalis*	+	+	-
black locust	*Robinia pseudoacacia*	+	+	-
green ash	*Fraxinus pensylvanica*	+	+	-
cottonwood	*Populus deltoides*	+	-	-
big-toothed aspen	*Populus grandidentata*	+	-	-
cucumber-tree	*Magnolia acuminata*	+	o	-
switchgrass	*Panicum virgatum*	+	+	+
*European alder	*Alnus glutinosa*	+	+	-
* multiflora rose	*Rosa multiflora*	+	+	-
*shrub lespedeza	*Lespedeza bicolor*	+	+	-
*sericea lespedeza	*Lespedeza cuneata*	+	+	-
* Korean clover	*Lespedeza stipulacea*	+	o	o

* white clover	*Trifolium repens*	+	o	o
* white sweet clover	*Melilotus alba*	+	o	o
* Chinese privet	*Ligustrum sinense*	+	o	-

Table 1 (continued)

* tall fescue	*Festuca elatior*	+	+	+
* orchard grass	*Dactylis glomerata*	+	o	o
* redtop	*Agrostis gigantea*	+	o	o
* rye	*Secale cereale*	o	o	o
* weeping lovegrass	*Eragrostis curvula*	o	o	o
* barnyard-grass	*Echinochloa crusgalli* var. *frumentacea*	o	o	-
* bird'sfoot trefoil	*Lotus corniculatus*	o	o	-
* crown vetch	*Coronilla varia*	o	o	-

* exotic species

+ planted, persisting

o planted, not persisting

- not planted

Wade and Halverson (1988) summarized development of mine soils within the different plantation types at Fonde. Additional work on the mine soils by Wade and Halverson (unpublished data) found that the Fonde mine soils could be grouped into five parent material types and these were not evenly distributed among the tree plantation types. All tree plantations contained at least two parent material types, each of varying qualities. Table 2 summarizes characteristics of mine soils at Fonde in 1988. Wade et al. (1985) and Wade and Vogel (1988) described development and productivity of the tree plantations on the Fonde mine. In general, forest productivity on the mine is equal to that in the unmined forest, but lack of thinning in the plantations has reduced diameter growth of individual trees.

Table 2. Soil materials and chemistry at the Fonde surface mine in 1988. A horizon values are set over those of the B-C horizon.

Methods are: pH in 1:1 H_2O; N by Kjeldahl; and P, K, Ca, Mg, Mn by 0.1 N HCl extract. Data are from Wade and Thompson (1999).

Mine Soil Parent Materials	pH	N %	P ppm	K pm	Ca ppm	Mg ppm	Mn ppm	exch. acid.
1. mixed old soils,	4.00	0.67	19.5	52.7	205	100	131	6.72
sandstone and coal waste	4.10	0.45	2.2	25.4	14	19	24	7.52
2. yellow clay	5.87	0.25	9.4	75.2	398	302	148	0.22
	4.97	0.07	3.3	46.4	81	140	61	2.43
3. orange shale & clay,	4.12	0.19	5.9	49.3	113	17	138	9.94
scattered fine coal	4.02	0.15	2.2	35.6	19	9	18	10.39
4. sandstone, gray shale	4.51	0.26	12.5	42.6	209	93	118	3.75
and clay	4.58	0.22	7.1	38.6	98	80	53	4.13
5. coal frags., gray and	4.53	0.44	15.1	48.7	317	118	139	4.37
black shale, yellow clay	4.45	0.28	7.3	33.4	65	70	33	4.90

Methods

We surveyed and collected vascular plants throughout the 1989 and 1990 growing seasons at two- to three-week intervals from early spring through late autumn. Voucher specimens were prepared according to standard herbarium procedures and deposited in the Berea College Herbarium

(BEREA). Gleason and Cronquist (1991) was used as the final authority for plant taxonomy. We determined relative abundance of each species during field reconnaissance and recorded abundance in each habitat encountered on the highwall, bench, and outslope. The species abundance categories were those used by Thompson et al. (1996):

Abundant (A) = 1000s of individuals or colonies.
Frequent (F) = 100s of individuals or colonies,
Occasional (O) = 26-100 individuals or colonies,
Infrequent (I) = 6-25 individuals or colonies, and
Rare (R) = 1-5 individuals or isolated colonies

We conducted a vegetation study based upon plot sampling at the same time that the Fonde site was inventoried. That study focused upon the effects of the different plantation types and soil type influences on tree species invasion of the mined and reclaimed area. Trees in the mixed hardwood, mixed pine, and black locust plantations were sampled by counting and measuring canopy trees in 4 5x30-m transects in each plantation type. Subcanopy trees and shrubs were counted using 12 1x30-m transects in each plantation type. Woody species less than 1m tall and herbaceous species were counted in 30 random 1-m^2 plots within each plantation type, and an additional 10 1-m^2 plots were placed in an unplanted area. More detailed sample methods and results of that study are reported in Wade and Thompson (1999).

Results and Discussion

Site Development

In the 24 years after reclamation, the mine soils were texturally and chemically similar to the unmined soils although there was more variation among the mined soils (Wade and Halverson 1988). There was little evidence of soil compaction from the mining and reclamation period. Most soil study pits in mine soils showed an A horizon with discernable B-C horizon differentiation.

The usually xeric highwall had wasted from 90° slope to approximately 45° in most areas although some near-vertical walls remained composed of the most durable exposed sandstone. The on-going wasting continually creates new, unvegetated, invasible areas.

The old haul road across the mine still is disturbed by occasional 4-wheel drive traffic. This

disturbance renews opportunities for ruderal species establishment, and ruts provide small ephemeral water impoundments.

Two areas considered "too acid to plant" had moderated over time and contained a few Virginia pine, red maple, black gum (*Nyssa sylvatica*), sourwood (*Oxydendron arboreum*), and some broom-sedge (*Andropogon scoparius*).

The mixed hardwoods plantations were dominated by red maple, northern red oak, and yellow poplar. Other significant canopy trees were American sycamore, black locust, Virginia pine, and white oak. Canopy trees of these species had diameters up to the 2-3 dm (8-12 inches) size class and red maple had a few in the 3-4 dm size class. The sapling layer was primarily red maple, sourwood, yellow poplar, sugar maple, red oak, and white ash. The ground layer varied in composition and was well developed in some areas, though it was noticeably less vigorous under red maple.

Mixed pine plantations were dominated by Virginia pine with successful loblolly pine in some areas. Red maple and sourwood were common invaders in the understory. Bicolor lespedeza was the most common shrub, and *Smilax* spp. and *Toxicodendron radicans* were important woody vines.

The black locust plantations were dominated by successional red maple with lesser amounts of sourwood, yellow poplar and American sycamore. Heavy black locust borer (*Megacyllene robiniae*) damage was apparent in remnant standing dead and down black locust trees. There were a few black locust saplings, shrubs and vines were unimportant, and the ground layer was very sparse.

The effects of initial plantings and soils on vegetation development at Fonde is covered by Wade and Thompson (1999).

The Flora

The Fonde mine flora consisted of 16 Pteridophyta, 5 Pinophyta, and 277 Magnoliophyta. There were 299 vascular plant taxa (246 indigenous, 53 exotic) from 86 families (Tables 3 and 4).

The numerically most important plant families and genera (Table 4) were those also found to be most important on other reclaimed mines of the pre-SMCRA era in the region although the order varies (Thompson et al. 1986).

Table 3. Vascular flora of the Fonde Surface-mined Demonstration Area

LYCOPODIOPHYTA (Lycopods)

Lycopodiaceae (Clubmoss Family)

Lycopodium digitatum Dillen. Ground Cedar. Perennial; 1 a, b, g; 2 b, c=O. 89-1568.

L. obscurum L. Ground Pine. Perennial; 1 b=R. 90-271.

POLYPODIOPHYTA (True Ferns)

Adiantaceae (Maidenhair Family)

Adiantum pedatum L. Northern Maidenhair Fern. Perennial; 1 a; 2 a=R. 89-1947.

Aspleniaceae (Spleenwort Family)

Asplenium platyneuron (L.) Oakes. Ebony Spleenwort. Perennial; 1 a, b; 2 a, b, c, d= I. 89-1618.

Athyrium pycnocarpon (Spreng.) Tidestr. Glade Fern. Perennial; 1 a; 3 a=R. 89-938.

†*Dryopteris carthusiana* (Villars) H. P. Fuchs. Toothed Wood-fern. Perennial; 1 a, d=R. 89-2346.

D. marginalis (L.) A. Gray. Marginal Wood-fern. Perennial; 1 a; 3 a=I. 89-1615.

Polystichum acrostichoides (Michx.) Schott. Christmas Fern. Perennial; 1 a, b; 2 a, c, d; 3 a=O. 89-943.

Thelypteris hexagonoptera (Michx.) Weath. Broad Beech-fern. Perennial; 1 a; 2 a, d=I. 89-942.

T. noveboracensis (L.) Nieuwl. New York Fern. Perennial; 1 a; 2 d; 3 a=I. 89-944.

Blechnaceae (Chain Fern Family)

Woodwardia aerolata (L.) T. Moore. Netted Chain Fern. Perennial; 1 h=I. 89-2010.

Ophioglossaceae (Adder's Tongue Family)

Botrychium dissectum Spreng. Lace-frond Grape Fern. Perennial; 1 a=R. 89-1956,

B. virginianum (L.) Sw. Rattlesnake Fern. Perennial; 1 a; 2 a, f=I. 90-323.

Onocleaceae (Sensitive Fern Family)

†*Onoclea sensibilis* L. Sensitive Fern. Perennial; 1 h=R. 89-941.

Osmundaceae (Royal Fern Family)

Osmunda cinnamomea L. Cinnamon-fern. Perennial; 1 h=R. 89-919.

Schizaeaceae (Climbing Fern Family)

Lygodium palmatum (Bernh.) Swartz. Climbing Fern. Perennial; 1 a, c, h; 3 a=R. 89-2011.

PINOPHYTA (Conifers)

Cupressaceae (Cypress Family)

Juniperus virginiana L. Eastern Red Cedar. Tree; 1 a, b, c, e; 2 a, b, c, e=I. 89-1590.

Pinaceae (Pine Family)

o*Pinus rigida* P. Mill. Pitch Pine. Tree; 1 b, c; 2 b, c=F. 89-922.

o*P. taeda* L. Loblolly Pine. Tree; 1 b, c; 2 b, c=F. 90-275.
o*P. virginiana* P. Mill. Virginia Pine. Tree; 1 a, b, c, d, e, f, g; 2 a, b, c; 3 a, b=A. 89-925.
Tsuga canadensis (L.) Carr. Eastern Hemlock. Tree. 1a, b; 2 b,f=R. 90-289.

MAGNOLIOPHYTA (Flowering Plants)

Aceraceae (Maple Family)

o*Acer rubrum* L. Red Maple. Tree; 1 a, b, c, d, e, f; 2 a, c, d, f; 3 a, b=A. 89-843.
o *A. saccharum* Marsh. Sugar Maple. Tree; 1 a, b, c, d, e; 2 a, b; 3 a=O. 89-844.

Amaranthaceae (Pigweed Family)

†**Amaranthus hybridus* L. Smooth Pigweed. Annual; 1 i=R. 89-2088.

Anacardiaceae (Sumac Family)

Rhus copallinum L. Dwarf Sumac. Tree; 1 b, c, e, f; 2 c=O. 89-1989.
R. glabra L. Smooth Sumac. Tree; 1 b, c, f, g=O. 89-1613.
Toxicodendron radicans (L.) Kuntze. Poison Ivy. Woody vine; 1 a, b, c, g; 2 a, b, g; 3 a=F. 89-2040.

Apiaceae (Parsley Family)

**Daucus carota* L. Queen Anne's Lace. Biennial; 1 h, i=I. 89-1328.
Osmorhiza claytonii (Michx.) C. B. Clarke. Bland Sweet Cicely. Perennial; 2 a; 3 a=l. 89-847.
Sanicula canadensis L. Canada Black Snakeroot. Biennial; 2 a=R. 89-1601.

Araceae (Arum Family)

Arisaema triphyllum (L.) Schott. Indian Turnip. Perennial; 2 a, 3 a=I. 90-267.

Araliaceae (Aralia Family)

Aralia racemosa L. American Spikenard. Perennial; 3 a=R. 89-1610.

Aristolochiaceae (Birthwort Family)

Asarum canadense L. Wild Ginger. Perennial; 1 a; 3 a=R. 90-266.

Asteraceae (Aster Family)

Ambrosia artemisiifolia L. Common Ragweed. Annual; 1 d, i; 3 a=I. 89-1977.
A. trifida L. Giant Ragweed. Annual; 1 d, h=I. 89-1974.
**Artemisia vulgaris* L. Common Mugwort. Perennial; 1 h=I. 89-1972.
Aster cordifolius L. Blue Heart-leaf Aster. Perennial; 2 a; 3 a=O. 89-2347.
A. divaricatus L. White Wood Aster. Perennial; 1 a; 2 a, b, c, d; 3 a=O. 89-1966.
A. infirmus Michx. Weak White Aster. Perennial; 2 a=R. 89-2042.
A. lateriflorus (L.) Britt. Calico Aster. Perennial; 2 a=I. 89-2333.
A. paternus Cronq. White-top Aster. Perennial; 1 b, j=R. 89-1603.
A. pilosus Willd. White Hairy Aster. Perennial; 1 j; 2 c=I. 89-2057.
A. undulatus L. Clasping Heart-leaf Aster. Perennial; 1 a, 2 a=I. 89-2045.
Bidens polylepis S. F. Blake. Bur-marigold. Annual; 1 h, i=R. 89-2025.
Cacalia atriplicifolia L. Pale Indian Plantain. Perennial; 1 a, c, f; 2 a=I. 89-2003.
Chrysopsis mariana (L.) Ell. Golden Aster. Perennial; 1 g, j=R. 89-2350.
Coreopsis major Walt. Forest Tickseed. Perennial; 1 a; 3 a=I. 89-1315.
Erechtites hieracifolia (L.) Raf. Fireweed. Annual; 1 j=R. 89-2098.
Erigeron annuus (L.) Pers. Annual Fleabane. Annual; 1 i, j; 3 a=I. 89-1329.
E. philadelphicus L. Philadelphia Daisy. Perennial; 3 a=R. 89-849.

Eupatorium fistulosum Barratt. Joe-pye Weed. Perennial; 1 a, c, e, h=O. 89-2006.
†*E. hyssopifolium* L. Hyssop-leaf Eupatorium. Perennial; 1 d, f=I. 89-2028.
E. purpureum L. Purple-node Joe-pye Weed. Perennial; 2 a=I. 89-1948.
E. rotundifolium L. Round-leaf Eupatorium. Perennial; 1 d, j=I. 89-1987.
E. rugosum Houtt. White Snakeroot. Perennial; 1 a, b; 2 a, c; 3 a=F. 89-2027.
E. serotinum Michx. Late Eupatorium. Perennial; 1 h=I. 89-1070.
**Galinsoga quadriradiata* Ruiz & Pavon. Common Quickweed. Annual; 1 i=R. 89-1611.
Helianthus microcephalus T. & G. Small-headed Sunflower. Perennial; 1 a, b=I. 89-1959.
H. tuberosus L. Jerusalem Artichoke. Perennial; 1 h=R. 89-1985.
Hieracium gronovii L. Beaked Hawkweed. Perennial; 1 b, d=I. 89-2066.
H. paniculatum L. Panicled Hawkweed. Perennial; 1 d=R. 89-2055.
Krigia virginica (L.) Willd. Dwarf Dandelion. Annual; 1 e, 2 g=I. 89-850.
Lactuca canadensis L. Tall Lettuce. Biennial; 1 h, i; 3 a=R. 89-1558.
L. floridana (L.) Gaertn. Woodland Blue Lettuce. Biennial; 2 a=I. 89-2005.
Prenanthes altissima L. Lion's Foot. Perennial; 1 a; 2 a=I. 89-2371.
Pyrrhopappus carolinanus (Walt.) DC. False Dandelion. Perennial; 1 d=R. 89-1327.
Senecio anonymus A. Wood. Appalachian Groundsel. Perennial; 1 a, c, d, j; 3 a=I. 89-851.
Solidago arguta Ait. Forest Goldenrod. Perennial; 1 d, f=O. 89-2048.
S. caesia L. Axillary Goldenrod. Perennial; 1 a; 2 a, c; 3 a=O. 89-2083.
S. erecta Pursh. Erect Goldenrod. Perennial; 1 d, j=O. 89-2338.
S. flexicaulis L. Zig-zag Goldenrod. Perennial; 2 a, c, d; 3 a=O. 89-2044.
S. gigantea Ait. Common Goldenrod. Perennial; 2 d, h=O. 89-2069.
S. nemoralis Ait. Gray Goldenrod. Perennial; 1 c, d, i, j; 3 a=I. 89-2033.
S. rugosa Mill. Wrinkled-leaf Goldenrod. Perennial; 1 b=I. 89-2072.
**Taraxacum officinale* Weber. Common Dandelion. Perennial; 1 i=R. 89-852.
**Tussilago farfara* L. Coltsfoot. Perennial; 3 a=O. 90-247.

Balsaminaceae (Jewelweed Family)

Impatiens pallida Nutt. Pale Jewelweed. Annual; 1 a, h; 3 a=O. 89-1325.

Berberidaceae (Barberry Family)

Caulophyllum thalictroides (L.) Michx. Blue Cohosh. Perennial; 3 a=R. 90-281.
Podophyllum peltatum L. May-apple. Perennial; 2 a; 3 a=I. 90-263.

Betulaceae (Birch Family)

+**Alnus glutinosa* (L.) Gaertn. European Black Alder. Tree; 1 a, c, d, e; 2 d, f; 3 a=F. 89-2191.
Betula lenta L. Sweet Birch. Tree; 1 a, b, c, d; 2 a, c; 3 a=O. 89-991.
B. nigra L. River Birch. Tree; 1 c, d, h; 3 a=I. 89-858.
Carpinus caroliniana Walt. Hornbeam. Tree; 1 a, c, h; 2 a, c; 3 a=I. 89-859.

Bignoniaceae (Crossvine Family)

**Paulownia tomentosa* (Thunb.) Steud. Chinese Paulownia. Tree; 2 a; 3 a=I. 89-965.

Brassicaceae (Mustard Family)

†*Arabis laevigata* (Muhl.) Poir. Smooth Rockcress. Biennial; 2 a, c, f=I. 90-282.
**Barbarea vulgaris* R. Br. Yellow Rocket. Perennial; 1 h, i=I. 90-249.
Cardamine concatenata (Michx.) O. Schwarz. Cut-leaf Toothwort. Perennial; 1b, g=I. 90-254.
**C. hirsuta* L. Hoary Bittercress. Annual; 1 c, f, h, i=I. 90-284.

Campanulaceae (Bellflower Family)

Campanula divaricata Michx. Appalachian Bellflower. Perennial; 2 b; 3 a=R. 89-1952.

Lobelia inflata L. Indian Tobacco. Annual; 1 d=R. 89-1973.

Triodanis perfoliata (L.) Nieuwl. Venus' Looking Glass. Annual; 1 i=R. 90-325.

Cannabinaceae (Hemp Family)

**Cannabis sativa* L. Hemp. Annual; 1 i=R. 89-2060.

Caprifoliaceae (Honeysuckle Family)

**Lonicera japonica* Thunb. Japanese Honeysuckle. Woody vine; 1 a, b, c, d, g; 2 b=O. 89-2035.

Sambucus canadensis L. Common Elderberry. Shrub; 1 b, c, d, f; 2 a, e; 3 a=O. 89-1301.

Viburnum acerifolium L. Maple-leaf Viburnum. Shrub; 1 b; 2 g; 3 a=I. 90-335.

†*V. prunifolium* L. Black Haw. Tree; 1 a=R. 89-2360.

Caryophyllaceae (Pink Family)

†**Cerastium viscosum* L. Clammy Chickweed. Annual; 1 i=I. 90-233.

**C. vulgatum* L. Common Mouse-ear Chickweed. Annual; 1 i=I. 89-865.

Paronchyia canadensis (L.) Wood. Smooth Forked Chickweed. Annual; 1 a=I. 89-1277.

†*P. fastigiata* (Raf.) Fern. Hairy Forked Chickweed. Annual; 1 g=R. 89-2041.

**Stellaria media* (L.) Cyrillo. Common Chickweed. Annual; 1 i; 2 d=I. 89-866.

S. pubera Michx. Giant Chickweed. Perennial; 1 a; 3 a=I. 90-285.

Celastraceae (Staff Tree Family)

Euonymus americanus L. Strawberry-bush. Shrub; 2 a, c, g; 3 a=R. 90-319.

Chenopodiaceae (Goosefoot Family)

**Chenopodium album* L. Lamb's Quarters. Annual; 1 i=R. 89-868.

**C. ambrosioides* L. Mexican Tea. Annual; 1 i=R. 89-2345.

Clusiaceae (Mangosteen Family)

Hypericum punctatum Lam. Spotted St. John's-wort. Perennial; 1 c, h=I. 89-1585.

H. stragalum Adams & Robs. St. Andrew's-cross. Suffrutescent Shrub; 1 b, c=R. 89-901.

Commelinaceae (Dayflower Family)

Tradescantia subaspera Ker.-Gawl. Wide-leaf Spiderwort. Perennial; 1 a=R. 89-869.

Cornaceae (Dogwood Family)

Cornus florida L. Flowering Dogwood. Tree; 1 a, b, c, d, f, g; 2 a, b, c=F. 90-285.

Nyssa sylvatica Marsh. Blackgum. Tree; 1 a, b, c, f; 2 a, b, c; 3 a=F. 89-914.

Crassulaceae (Stonecrop Family)

Sedum ternatum Michx. Wild Stonecrop. Perennial; 3 a=O. 90-244.

Cyperaceae (Sedge Family)

Carex digitalis Willd. Digitate Sedge. Perennial; 2 a, c=I. 89-980.

C. laxiflora Lam. Lax-flowered Sedge. Perennial; 1 a; 2 a=I. 90-321.

†*C. prasina* Wahlenb. Leek-green Sedge. Perennial; 1 h=R. 89-978.

C. purpurifera Mack. Purple-leaf Sedge. Perennial; 1 a, c=I. 90-322.

†*C. scoparia* Willd. Broom-like Sedge. Perennial; 1 h=R. 90-313.

C. virescens Willd. Green Sedge. Perennial; 2 a=R. 89-1586.

C. vulpinoidea Michx. Fox Sedge. Perennial; 1 h=I. 89-872.

Eleocharis ovata (Roth) R. & S. Blunt Spike-rush. Annual; 1 h=I. 89-1275.

Scirpus atrovirens Willd. Black-green Sedge. Perennial; 1 h=I. 89-1319.

S. cyperinus (L.) Kunth. Wool Grass. Perennial; 1 h=I. 89-2012.
†o*S. fluviatilis* (Torr.) A. Gray. River Bulrush. Perennial; 1 h=R. 89-1273.

Dioscoreaceae (Yam Family)

Dioscorea villosa L. Wild Yam. Perennial; 1 a; 2 a=O. 89-873.

Ebenaceae (Persimmon Family)

Diospyros virginiana L. Persimmon. Tree; 1 b, d, f=R. 89-874.

Ericaceae (Heath Family)

Kalmia latifolia L. Mountain Laurel. Shrub; 1 a, b, c; 2 b; 3 a, b=O. 89-875.
Oxydendrum arboreum (L.) DC. Sourwood. Tree; 1 a, b, c, d, e, f; 2 a, b, c; 3 a=A. 89-1280.
Vaccinium pallidum Ait. Hillside Blueberry. Shrub; 1 b, g; 2 b; 3 a, b=I. 90-279.

Euphorbiaceae (Spurge Family)

Acalypha rhomboidea Raf. Rhombic Copperleaf. Annual; 1 i=R. 89-2077.
Euphorbia maculata L. Spotted Spurge. Annual; 1 i=R. 89-1962.

Fabaceae (Pea Family)

Cercis canadensis L. Eastern Redbud. Tree; 2 a, b, c, d; 2 a, b; 3 a=O. 90-262.
Chamaecrista nictitans (L.) Moench. Wild Sensitive Plant. Annual; 1 d, f=I. 89-1978.
Desmodium glabellum (Michx.) DC. Smooth Sticktights. Perennial; 1 d, i=I. 89-1617.
D. paniculatum (L.) DC. Sticktights. Perennial; 1 a, d=O. 89-2026.
+**Lespedeza bicolor* Turcz. Shrub Lespedeza. Shrub; 1 a, b, c, e; 2 a, d, e; 3 a=A. 89-2004.
+**L. cuneata* (Dum.-Cours.) G. Don. Sericea Lespedeza. Perennial; 1 a, b, c, d, f=O. 89-2043.
L. hirta (L.) Hornem. Hairy Lespedeza. Perennial; 1 d=I. 89-2074.
L. repens (L.) Bart. Smooth Trailing Lespedeza. Perennial; 1 b, g, j=I. 89-2068.
+**L. stipulacea* Maxim. Korean Lespedeza. Annual; 1 d, e, f=O. 89-2032.
**L. striata* (Thunb.) Hook. & Arnott. Japanese Lespedeza. Annual; 1 d, e=I. 89-2080.
+**Melilotus alba* Medic. White Sweet Clover. Biennial; 1 e, i=R. 89-1563.
o*Robinia pseudoacacia* L. Black Locust. Tree; 1 a, b, c, d, e; 2 a, b, c; 3 a=F. 89-880.
**Trifolium campestre* Schreb. Pinnate Hop Clover. Annual; 1 i=R. 89-881.
+**T. repens* L. White Clover. Perennial; 1 d, f, i=I. 89-1341.

Fagaceae (Beech Family)

Fagus grandifolia Ehrh. American Beech. Tree; 1 a, b, c, d, e; 2 a, c; 3 a=F. 89-882.
o*Quercus alba* L. White Oak. Tree; 1 a, b, c, f; 2 a, b, c=I. 89-883.
Q. coccinea Muench. Scarlet Oak. Tree; 1 a; 2 a=R. 89-1605.
Q. prinus L. Chestnut Oak. Tree; 1 a, b, c, f; 2 a, b; 3 a=I 89-886.
o*Q. rubra* L. Northern Red Oak. Tree; 1 a, b, c, d; 2 a, b=O. 89-884.
Q. velutina Lam. Black Oak. Tree; 1 a, b, c, d, e; 2 a, b, c; 3 a=O. 89-887.

Geraniaceae (Geranium Family)

Geranium carolinianum L. Carolina Crane's-bill. Annual; 1 i=R. 90-322.
G. maculatum L. Wild Geranium. Perennial; 2 a; 3 a=I. 90-265.

Hamameliaceae (Witch Hazel Family)

Liquidambar styraciflua L. Sweet Gum. Tree; 1 b, c, d; 2 a; 3 a=O. 89-889.

Hippocastanaceae (Buckeye Family)

Aesculus flava Soland. Yellow Buckeye. Tree; 1 a; 2 a=R. 89-890.

Hydrangeaceae (Hydrangea Family)

Hydrangea arborescens L. Wild Hydrangea. Shrub; 1 a, c, d, g; 2 a, d; 3 a=O. 89-1305.

Iridaceae (Iris Family)

Sisyrinchium angustifolium P. Mill. Blue-eye Grass. Perennial; 1 f=R. 90-308.

Juglandaceae (Walnut Family)

Carya cordiformis (Wang.) K. Koch. Bitternut Hickory. Tree; 1 a, c; 2 a, c=I. 89-1310.

C. glabra (P. Mill.) Sweet. Smooth Pignut Hickory. Tree; 1 a, b, c, d, g; 2 a, b, c=O. 89-1308.

C. ovalis (Wang.) Sarg. Sweet Pignut Hickory. Tree; 1 a, b; 2 a=R. 89-1266.

C. ovata (P. Mill.) K. Koch. Shagbark Hickory. Tree; 1 a, b, c, 2 a=I. 89-902.

Juglans nigra L. Black Walnut. Tree; 1 a, c; 2 a, c, f=R. 89-1619.

Juncaceae (Rush Family)

Juncus diffusissimus Buckl. Slimpod Rush. Perennial; 1 h=I. 89-1269.

J. effusus L. var. *solutus* Fern. & Wieg. Soft Rush. Perennial; 1 h=R. 89-1309.

J. tenuis Willd. var. *tenuis*. Slender Path Rush. Perennial; 1 h, i=I. 89-1285.

Lamiaceae (Mint Family)

Lycopus virginicus L. Virginia Bugle-weed. Perennial; 1 h=R. 89-1983.

Monarda clinopodia L. Basil Bee-balm. Perennial; 3 a=I. 89-1608.

Prunella vulgaris L. Self Heal. Perennial; 1 h, i=R. 89-1953.

Stachys nuttallii Shuttlew. Nuttall's Hedge-nettle. Perennial; 1 h=R. 89-1290.

Lauraceae (Laurel Family)

Sassafras albidum (Nutt.) Nees. White Sassafras. Tree; 1 a, b, c, f; 2 a, c; 3 a=O. 90-274.

Liliaceae (Lily Family)

Diosporum maculatum (Buckl.) Britt. Spotted Fairy-bells. Perennial; 3 a=R. 90-278.

Hypoxis hirsuta (L.) Cov. Yellow Star-grass. Perennial; 2 c=R. 89-845.

Polygonatum biflorum (Walt.) Ell. True Solomon's-seal. Perennial; 2 a, b, f; 3 a=I. 89-907.

Smilacina racemosa (L.) Desf. False Solomon's-seal. Perennial; 2 a, d, f=I. 89-908.

Trillium grandiflorum (Michx.) Salisb. Large White Trillium. Perennial; 3 a=R. 90-277.

Uvularia grandiflora J. E. Smith. Large-flowered Bellwort. Perennial; 3 a=R. 90-257.

Linaceae (Flax Family)

Linum striatum Walt. Ridge-stemmed Yellow Flax. Perennial; 1 b, c=R. 89-1559.

Magnoliaceae (Magnolia Family)

o*Liriodendron tulipifera* L. Yellow Poplar. Tree; 1 a, b, c, d, e; 2 a, b, c; 3 a=F. 89-911.

o*Magnolia acuminata* (L.) L. Cucumber-tree. Tree; 1 a=R. 89-912.

Malvaceae (Mallow Family)

Sida spinosa L. Prickly Sida. Annual; 1 i=R. 89-2064.

Menispermaceae (Moonseed Family)

Menispermum canadense L. Canada Moonseed. Woody vine; 1 a; 2 a, f=I. 89-913.

Monotropaceae (Indian Pipe Family)

Monotropa hypopithys L. Pinesap. Perennial; 1 b=R. 90-320.

Oleaceae (Olive Family)

Fraxinus americana L. White Ash. Tree; 1 a, b, c, g; 2 a, c; 3 a=O. 89-915.

†o*F. pensylvanica* Marsh. Green Ash. Tree; 1 a, c; 2 a=I. 89-916.

†+**Ligustrum sinense* Lour. Chinese Privet. Shrub; 2 f=R. 90-329.

Onagraceae (Evening Primrose Family)

Circaea lutetiana L. var. *canadensis* L. Enchanter's Nightshade. Perennial; 2 a=I. 89-1282.

Epilobium coloratum Biehler. Eastern Willow-herb. Perennial; 1 h=I. 89-2065.

Ludwigia alternifolia L. Square-pod Water-primrose. Perennial; 1 h=I. 89-1950.

Orchidaceae (Orchid Family)

Corallorhiza odontorhiza (Willd.) Nutt. Fall Coral-root. Perennial; 1 a=R. 89-2340.

Goodyera pubescens (Willd.) R. Br. Rattlesnake Plantain. Perennial; 1 b, g; 2 b; 3 b=I. 89-1320.

Spiranthes cernua (L.) Rich. Nodding Ladies' Tresses. Perennial; 1 h=R. 89-2343.

Oxalidaceae (Wood Sorrel Family)

Oxalis grandis Small. Great Yellow Wood Sorrel. Perennial; 1 a; 3 a=R. 89-920.

Papaveraceae (Poppy Family)

Sanguinaria canadensis L. Bloodroot. Perennial; 1 a, 3 a=R. 90-280.

Passifloraceae (Passion Flower Family)

†*Passiflora lutea* L. var. *glabriflora* Fern. Small Passion Flower. Perennial; 3 a=R. 89-1574.

Phytolaccaceae (Poke Family)

Phytolacca americana L. Common Pokeweed. Perennial; 1 a, b, c; 2 a, b, f=I. 89-1340.

Plantaginaceae (Plantain Family)

†*Plantago aristata* Michx. Bracted Plantain. Annual; 1 d, j=I. 89-1284.

**P. lanceolata* L. English Plantain. Perennial; 1 i=R. 89-926.

P. rugelii Decne. Rugel's Plantain. Perennial; 1 h=I. 89-1323.

P. virginica L. Virginia Plantain. Annual; 1 j, 2 a=I. 89-927.

Platanaceae (Sycamore Family)

oPlatanus occidentalis L. American Sycamore. Tree; 1 a, b, c, d, f; 2 a, b, c=O. 89-933.

Poaceae (Grass Family)

+**Agrostis gigantea* Roth. Redtop. Perennial; 1 e, h=I. 89-1336.

A. perennans (Walt.) Tuckerm. Autumn Bentgrass. Perennial; 1 b; 3 a, b=O. 89-2085.

†*Andropogon gerardii* Vitman. Big Bluestem. Perennial; 1 d, e=I. 89-1589.

A. virginicus L. Broom-sedge. Perennial; 1 b, c, d, f, j=F. 89-2067.

†**Anthoxanthum odoratum* L. Sweet Vernalgrass. Perennial; 1 i=R. 90-306.

†*Aristida dichotoma* Michx. Three-awn Grass. Annual; 1 b, d, j; 2 b=F. 89-2376.

**Bromus japonicus* Thunb. Japanese Chess. Annual; 1 h, i=I. 89-1335.

Cinna arundinacea L. Woodreed Grass. Perennial; 1 a=R. 89-1958.

+**Dactylis glomerata* L. Orchard Grass. Perennial; 1 d, e, i; 3 b=I. 89-928.

Danthonia compressa Austin. Mountain Oatgrass. Perennial; 1 a, b, c, f, j; 3 a=O. 89-974.

**Digitaria ischaemum* (Schreb.) Muhl. Smooth Crab-grass. Annual; 1 i=R. 89-2063.

†**D. sanguinalis* (L.) Scop. Northern Crab-grass. Annual; 1 i=R. 89-1971.

**Echinochloa crusgalli* (L.) Beauv. Barnyard Grass. Annual; 1 h=I. 89-1317.

**Eleusine indica* (L.) Gaertn. Yardgrass. Annual; 1 i=R. 89-1960.

†**Eragrostis pectinacea* (Michx,) Nees. Pectinate Lovegrass. Annual; 1 i=R. 89-1557.

+**Festuca elatior* L. Tall Fescue. Perennial; 1 d, e, i; j; 3 a, b=O. 89-929.

†*F. subverticillata* (Pers.) E. Alexeev. Nodding Fescue. Perennial; 3 a=R. 89-1283.

* *Microstegium vimineum* (Trin.) A. Camus. Eulalia. Annual; 1 a, b, c; 2 a, b, c; 3 a=A. 89-2372.

Panicum capillare L. Annual Witchgrass. Annual; 1 h=R. 89-2087.

P. clandestinum L. Deer-tongue Panicum. Perennial; 2 a, b, c; 3 a=I. 89-2331.

P. dichotomiflorum Michx. Spreading Witchgrass. Annual; 1 h=R. 89-2086.
P. dichotomum L. Forked Panicum. Perennial; 1 b, c, h; 3 a=O. 89-1528.
P. lanuginosum Ell. Hairy Panicum. Perennial; 3 a=O. 89-982.
P. laxiflorum Lam. Lax Panicum. Perennial; 3 a, b=I. 90-304.
†*P. liniarifolium* Scribn. Low Panicum. Perennial; 1 b, j; 3 a=O. 89-930.
P. polyanthes Schult.. Many-flowered Panicum. Perennial; 2 a, d, 3 a=I. 89-1271.
†*P. verrucosum* Muhl. Warty Panicum. Annual; 3 b=R. 89-1951.
†o*P. virgatum L*. Switchgrass. Perennial; 1 d, e=I. 89-1982.
**Phleum pratense* L. Timothy. Perennial; 1 h=R. 89-1307.
Poa alsodes Gray. Woodland Bluegrass. Perennial; 1 a; 2 a=R. 90-333.
†**P. annua* L. Annual Bluegrass. Annual; 1 h=R. 90-334.
P. cuspidata Nutt. Short-leaf Bluegrass. Perennial; 3 a=O. 90-245.
**P. pratensis* L. Kentucky Bluegrass. Perennial; 1 d, f=I. 89-985.
Sphenopholis nitida (Biehler) Scribn. Slender Wedge-grass. Perennial; 1 a; 2 a=I. 90-326.
†*S. obtusata* (Michx.) Scribn. Prairie Wedge-grass. Perennial; 2 a=R. 89-984.
†*Vulpia octoflora* (Walt.) Rydb. Six-week Fescue. Annual; 1 d, f=I. 89-932.

Polygonaceae (Smartweed Family)

**Polygonum caespitosum* Blume var. *longisetum* (DeBruyn) Stewart. Asiatic Smartweed. Annual; 1 d, h, I=I. 89-1953.
†**P. orientale* L. Prince's Feather. Annual; 1 h=R. 89-1955.
P. pensylvanicum L. Pennsylvania Smartweed. Annual; 1 h, i=R. 89-1988.
**P. persicaria* L. Lady's Thumb. Annual; 1 i=I. 89-1612.
P punctatum Ell. Dotted Smartweed. Perennial; 1 h=I. 89-2047.
†*P. sagittatum* L. Arrow-leaf Tear-thumb. Annual; 1 h=R. 89-2082.
P. scandens L. False Buckwheat. Perennial; 1 h; 3 a=O. 89-2071.
†**Rumex acetosella* L. Red Sorrel. Perennial; 1 b, i, j=R. 89-934.
**R. crispus* L. Curly Dock. Perennial; 1 h, i=I. 89-1303.
**R. obtusifolius* L. Bitter Dock. Perennial; 1 i=R. 89-1313.

Portulacaceae (Purslane Family)

Claytonia caroliniana Michx. Carolina Spring Beauty. Perennial; 1 a; 2 a=I. 90-242.

Primulaceae (Primrose Family)

Lysimachia quadrifolia L. Whorled Loosestrife. Perennial; 1 a, d, e; 2 c; 3 a=O. 89-945.
L. tonsa. Southern Loosestrife. Perennial; 3 a=R. 89-1272.

Pyrolaceae (Wintergreen Family)

Chimaphila maculata (L.) Pursh. Spotted Wintergreen. Suffrutescent shrub; 1 a, b, f, g; 2 b=I. 89-1286.

Ranunculaceae (Buttercup Family)

Actaea alba (L.) Miller. White Baneberry. Perennial; 1 a; 2 a, 3 a=I. 89-946.
Anemone virginiana L. Tall Thimbleweed. Perennial; 2 a=I. 89-2050.
Anemonella thalictroides (L.) Spach. Rue Anemone. Perennial; 1 a; 2 a=R. 90-230.
Clematis virginiana L. Virgin's Bower. Woody vine; 1 a, c, e, g, f; 3 a=I. 89-1968.
Hepatica acutiloba DC. Sharp-lobed Hepatica. Perennial; 1 a; 3 a=R. 90-225.
Ranunculus abortivus L. Small-flowered Crowfoot. Biennial; 2 a; 3 a=I. 90-255.

R. hispidus Michx. Bristly Buttercup. Perennial; 1 h; 3 a=I. 90-258.
R. recurvatus Poir. Hooked Crowfoot. Perennial; 1 a; 2 a=R. 90-253.

Rhamnaceae (Buckthorn Family)

†*Rhamnus caroliniana* Walt. Carolina Buckthorn. Tree; 1 a; 2 a=R. 89-904.

Rosaceae (Rose Family)

Amelanchier laevis Wieg. Smooth Serviceberry. Tree; 1 a, c; 2 a, c; 3 a=I. 89-951.
Aruncus dioicus (Walt.) Fern. Goat's Beard. Perennial; 3 a=R. 89-952.
Fragaria virginiana Duchesne. Wild Strawberry. Perennial; 1 a, b, d, f; 3 a=O. 90-256.
Geum canadense Jacq. White Avens. Perennial; 1 a, c, d; 3 a=O. 89-1573.
Potentilla canadensis L. Running Cinquefoil. Perennial; 1 b, d, j ; 3 a=O. 90-337.
**P. norvegica* L. Rough Cinquefoil. Perennial; 1 h=R. 89-1337.
P. simplex Michx. Old-field Cinquefoil. Perennial; 1 c, d; 2 a, c; 3 a=I. 90-250.
Prunus serotina Ehrh. Wild Black Cherry. Tree; 1 a, b, c, g; 2 a, c; 3 a=O. 89-955.
+**Rosa multiflora* Thunb. Multiflora Rose. Shrub; 1 c, d, e, f, g; 2 a, c; 3 a=O. 89-2081.
Rubus allegheniensis Porter. Allegheny Blackberry. Perennial; 1 a, b, c, d, h; 2 a, d, f; 3 a=A. 89-1316.
R. flagellaris Willd. Dewberry. Perennial; 1 b, c, d, j=F. 89-957.
R. occidentalis L. Black Raspberry. Perennial; 1 b, c, d, h; 2 a, c, d=F. 89-958.
Spiraea tomentosa L. Pink Hardtack. Shrub; 1 e; 3 a=I. 89-1986.

Rubiaceae (Madder Family)

Galium aparine L. Common Cleavers. Annual; 1 a, b, d, g; 2 a=O. 90-259.
G. circaezans Michx. Wild Licorice. Perennial; 1 a; 2 a=O. 90-332.
G. triflorum L. Fragrant Bedstraw. Perennial; 1 a; 2 a, b, f; 3 a=O. 89-1572.
Hedyotis purpurea (L.) Torr. & Gray. Summer Bluets. Perennial; 1 a; 3 a=I. 89-1324.
Mitchella repens L. Partridge-berry. Suffrutescent Shrub; 1 a, b; 2 b=O. 89-1569.

Salicaceae (Willow Family)

†o*Populus deltoides* Marsh. Eastern Cottonwood. Tree; 1 a; 3 a=I. 89-961.
†o*P. grandidentata* Michx. Big-tooth Aspen. Tree; 1 a; 3 a=I. 89-962.

Saxifragaceae (Saxifrage Family)

Heuchera americana L. American Alum-root. Perennial; 2 a; 3 a=I. 89-964.

Scrophulariaceae (Figwort Family)

**Veronica arvensis* L. Corn Speedwell. Annual; 1 i=R. 90-231.
†**V. peregrina* L. Purslane Speedwell. Annual; 1 i=R. 89-967.
†**V. serpyllifolia* L. Thyme-leaved Speedwell. Perennial; 1 i=R. 89-1576.

Simaroubaceae (Quassia Family)

**Ailanthus altissima* (P. Mill.) Swingle. Tree of Heaven. Tree; 1 a, b, e, f; 3 a=I. 89-968.

Smilacaceae (Greenbrier Family)

Smilax glauca Walt. Glaucous Greenbrier. Woody vine; 1 a, b, c, d; 2 a, b, c; 3 a=F. 90-312.
S. rotundifolia L. Common Greenbrier. Woody vine; 1 a, b, c, d, g; 2 a, b, c; 3 a, b=F. 89-969.

Solanaceae (Nightshade Family)

Datura stramonium L. Jimson Weed. Annual; 1 i=R. 89-1567.
†*Physalis longifolia* Nutt. Longleaf Ground Cherry. Perennial; 1 i=R. 89-2093.

Tiliaceae (Basswood Family)

Tilia americana L. American Basswood. Tree. 1 a; 2 d; 3 a=R. 89-1276.

Ulmaceae (Elm Family)

Ulmus alata Michx. Winged Elm. Tree; 2 b; 3 a, b=R. 89-2007.

U. rubra Muhl. Red Elm. Tree; 1 a, b, d, f; 2 a, c=O. 89-1270.

Urticaceae (Nettle Family)

Boehmeria cylindrica (L.) Sw. False Nettle. Perennial; 1 h; 3 a=I. 89-2048.

Verbenaceae (Vervain Family)

†*Phryma leptostachya* L. Lopseed. Perennial; 1 a=R. 89-1602.

Verbena urticifolia L. White Vervain. Perennial; 1 h=I. 89-1575.

Violaceae (Violet Family)

Viola blanda Willd. Sweet White Violet. Perennial; 3 a=R. 90-240.

V. canadensis L. Tall White Violet. Perennial; 1 a; 2 a, b, 3 a=O. 90-264.

V. palmata L. Three-lobed Violet. Perennial; 1 a; 2 a=O. 90-232.

V. pubescens Ait. Smooth Yellow Violet. Perennial; 1 a=I. 90-269.

V. sororia Willd. Downy Wood Violet. Perennial; 1 a, b; 2 a, b, c, d=O. 90-272.

Vitaceae (Grape family)

Parthenocissus quinquefolia (L.) Planch. Virginia Creeper. Woody vine; 1 a, b, c, d, f, g; 2 a, b, c; 3 a=F. 89-1276.

Vitis aestivalis Michx. Summer Grape. Woody vine; 1 a, b, c, d, f; 2 a, b, c, d; 3 a=O. 89-973.

Code: (†) Bell County records; (+) Introduced, planted taxa; (o) Native planted taxa; (*) Naturalized taxa.

Life Form: Annual; Biennial; Perennial; Suffrutescent shrub; Shrub; Woody vine; Tree.

Relative Abundance Values: R=rare; I=Infrequent; O=occasional; F=frequent; A=abundant.

Habitats:

1=Bench
- a) Mixed hardwoods,
- b) Virginia pine
- c) Black locust
- d) European alder and grass mix
- e) Shrub lespedeza
- f) Wildlife plantings
- g) Loblolly pine
- h) Wetland (siltation pond shoreline, spillway, and drains)
- i) Ruderal (coal haul road and hemp plots
- j) Acid non-planted acid areas

2=Outslope
- a) Mixed hardwoods
- b) Virginia pine
- c) Black locust
- d) European alder and grass mix
- e) Shrub lespedeza
- f) Wildlife plantings

3=Highwall
- a) Non-planted highwall
- b) Virginia pine and grass mix

Table 4. Taxonomic summary for the Fonde Surface Mine Demonstration Area, Bell Co., KY

		Largest Families in Species:		Largest Genera:	
Families:	86	Asteraceae	43	*Panicum*	10
Genera:	189	Poaceae	34	*Carex*	7
Species:	299	Fabaceae	14	*Aster*	7
(*) Naturalized	53	Rosaceae	13	*Solidago*	7
Woody species:	70	Cyperaceae	11	*Polygonum*	7
Trees	46	Polygonaceae	10	*Eupatorium*	6
Shrubs	17	Herbaceous:	228		
Vines	7				
Planted Species:	27				
Native	16				
Exotic	11				

A total of 33 Bell County distributional records were found. Of the 31 species planted, 26 still persisted and 273 had successfully invaded and become established in the mine flora. The five planted taxa that did not persist were all exotic herbaceous species.

Fifty-two taxa (17.4 percent) in the Fonde flora are annuals and seven (2.3 percent) are biennials. Brynes and Miller (1973) found that the proportion of annuals in mine floras in southern Indiana decreased from 30-60 percent in the first decade after mining to less than 10 percent at age 45 years. The proportion of annuals in the Fonde flora is close to what they observed on 25-year-old cast overburden spoils.

The majority of the Fonde mine taxa fell into abundance classes rated infrequent (38.1 percent) or rare (35.5 percent)(Table 5). Such a distribution is to be expected among a developing flora, and it is not unusual for more natural, mature areas. Ugland and Gray (1982) noted that among data sets of 50 or more species lognormally distributed, approximately 10 percent will be very abundant, 25 percent will be ranked intermediate, and 65 percent of the total will be rare. We used five abundance classes instead of three and it is difficult to directly compare our distributions to that

suggested by Ugland and Gray. The distribution of taxa among abundance classes is generally similar for both native and exotic taxa.

Planted and persisting species comprised half of the taxa rated as abundant 24 years later, but they were lesser fractions of the lower abundance classes (Table 5). Seventeen (22.5 percent) of the 31 planted species were classified abundant or frequent. While they dominated the mine flora at its inception, the planted herbaceous species have, for the most part, yielded to native taxa.

The 53 exotic taxa comprised 17.7 percent of the flora, and of these, 12 species (22.6 percent of the exotics) were planted. The planted shrub *Lespedeza bicolor* remained abundant after 24 years, but only one invading exotic taxon, *Microstegium vimineum*, achieved a rating of abundant. Some of the exotic taxa such as *Lespedeza hirta* and *Trifolium campestre* may have reached the mine as contaminants in the reclamation species seed mixes applied to Fonde or other nearby mines. Most of the exotic taxa are well-established, naturalized members of the Kentucky flora.

One wetland species on the Fonde site, *Scirpus fluviatilis*, is on the Kentucky Threatened plant species list (Warren at al. 1986). Complete inventories of other mines have also yielded one or more species listed as threatened or endangered (Drake 1991, Thompson et al. 1984 and 1996, Thompson and Rafaill in press, Thompson and Wade 1991).

Table 5. The distribution of taxa among abundance classes on the Fonde mine. Numbers in parentheses indicate how many taxa in each abundance class were planted.

	Abundant	Frequent	Occasional	Infrequent	Rare
Number					
Native taxa	4 (2)	16 (4)	50 (3)	94 (4)	82 (1)
Exotic taxa	2 (1)	1 (0)	6 (5)	20 (4)	24 (2)
All taxa	6 (3)	17 (4)	56 (8)	114 (8)	106 (3)
Percent					
Native taxa	1.3 (0.7)	5.4 (1.3)	16.7 (1.0)	31.4 (1.3)	27.4 (0.3)
Exotic taxa	0.7 (0.3)	0.3 (0.0)	2.0 (1.7)	6.7 (1.3)	8.0 (0.7)
All Taxa	2.0 (1.0)	5.7 (1.3)	18.7 (2.7)	38.1 (2.7)	35.5 (1.0)

We used a regional species-area curve of regional floras to provide a benchmark for relative richness of this mine (Wade and Thompson 1991 and 1993). Species richness of the Fonde mine is comparable to that found by complete botanical inventories of other mines in this region (Thompson et al. 1984 and 1996, Thompson and Rafaill in press, Thompson and Wade 1991). The species richness of 299 in this 7.3 ha mine is 87.5 percent of that to be expected in Braun's (1950) Mixed and Western Mesophytic Forest Regions based upon the species-area curve.

As we have in previous mine floristic studies, we ask the question, "Why does the Fonde mine flora now have so many species on formerly devastated land?" The answer seems to be that surface mining and reclamation under pre-SMCRA conditions produced a high diversity of environments with soil and water chemistry ranging from medium to extremely acid, site conditions ranging from hydric to xeric, soil depths ranging from bare rock to several meters, a variety of slope aspects, and limited initial plant competition but with some site moderation by initial plantings. This high diversity of environments promotes high diversity of species, given that they are able to reach the site via wind, water, bird, or mammal transport or in mud on motor vehicles, colluviation of upslope soil material, or seed banks contained in original soils mixed into mine spoils. Most of these

mechanisms were probably operative on the Fonde mine site.

Other studies of mined areas in Appalachia have returned much lower relative species richness but those were sample-based vegetation studies (Brynes and Miller1973, Skousen et al. 1988, Holl and Cairns 1994). Sampling studies tend to miss many occasional species and the large majority of species rated infrequent or rare, especially if sampling is usually conducted only once or twice in a growing season.

At the same time that we inventoried this mine, we conducted an intensive sampling study of vegetation in the plantations of mixed hardwoods, pine, black locust and the ruderal area (Wade and Thompson 1999). Of 221 taxa present in the sampled plantations and the unplanted area, the plots captured 86 taxa (38.9 percent). The plots captured 100 percent of the abundant taxa but only 9.9 percent of those rated rare on the mine (Fig. 3). Plot studies provide data that allow calculation of many measures of diversity, but plot studies miss much of the *bio*diversity.

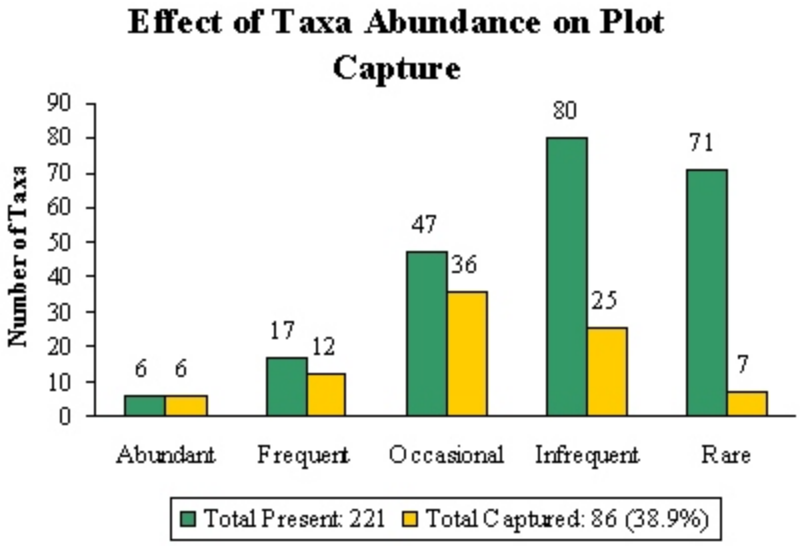

Figure 3. Effects of taxa abundance on plot capture. Mixed hardwoods, pine, and black locust plantations and an unplanted area contained 221 taxa. A sampling study in those areas captured only 38.9 percent of those taxa. Less abundant taxa are more likely to be missed by sampling studies.

Sampling studies of mined lands have not found threatened or endangered species. While sampling studies are best for numerically characterizing communities, they obtain a limited view of what is occurring in development of a flora in an area. Sampling studies generally have a stratified design, and plots in mine studies are usually uniform in aspect and slope position(s). Small, unusual habitats and ecotones are usually avoided. Much of the variation on the mine that might be revealed is thus omitted by study design. When the rare and the unusual habitats are not surveyed; the rare and the unusual species within them are not captured.

Complete inventories also have disadvantages. They require several visits to each site per growing season in order to find species in flower when they are most visible and when similar taxa are most easily distinguished. Areas up to 10 ha can take a day for complete coverage, that is, walking the area so that all of it is seen. The required time increases greatly during phenologically active periods if voucher specimens are being collected. Brushy areas and dense thickets also increase survey time. As the inventoried area increases more time is required, and by 100 ha the botanist may switch to intensively searching several examples of each habitat type and spending less effort in other replicate habitat areas where additional efforts would be expected to return few

additional species.

Given the advantages and disadvantages associated with inventories and sampling studies, it seems reasonable to suggest that a combination of both – sampling studies to characterize vegetation and inventories to define the flora – is most desirable for future studies of succession and biodiversity on reclaimed surface mines.

Conclusions

The pre-SMCRA, 7.3-ha Fonde Surface Mine Demonstration Area supported a vascular plant flora of 299 taxa after 25 years of succession. Native taxa comprised 82.2 percent of the flora. Out of 31 taxa that were planted for reclamation and research purposes, 26 still remained. The abundances of 73 percent of all taxa were rated as infrequent or rare on this site. This abundance distribution is similar to that obtained when lognormally distributed species are assigned to abundance categories. Relative richness of this mine is 87.5 percent of that to be expected in an unmined area of this size in the Mixed and Western Mesophytic Forest Regions, and this relative richness is similar to that found in other completely inventoried pre-SMCRA mined areas in Appalachia. One wetland species on the Fonde site, *Scirpus fluviatilis*, is on the Kentucky Threatened plant species list (Warren at al. 1986). A contemporaneous sampling study captured 38.9 percent of the plant species in the study area. Despite their shortcomings in relation to floras, sampling studies provide fine-grained data on community organization and structure that inventories do not provide. Given the inherent advantages and disadvantages of inventories and sampling studies, we suggest that a combination of both methods is most desirable for future studies of succession and biodiversity on reclaimed surface mines and in other areas.

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