

NATURAL AND PLANTED FLORA OF THE LOG MOUNTAIN SURFACE-MINED DEMONSTRATION AREA, BELL COUNTY, KENTUCKY¹

by

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Abstract. A descriptive study of the naturally invading and planted flora was conducted during 1984-1985 on a 14- and 21-year-old contour surface mine, the 14.2 ha Log Mountain Demonstration Area (LMDA), in Bell County, Kentucky. Six habitats are designated from areas created from coal mining; the 1963 bench, 1970 bench, bench highwalls, mine outcrops, mine seeps, and coal haul-telephone microwave tower road. Twenty-four of 25 woody and herbaceous species (11 indigenous, 13 non-indigenous) have persisted from plantings by personnel of the Northeastern Forest Experiment Station, USDA Forest Service. We recommend 11 native and exotic woody and herbaceous species for planting on coal surface-mined areas. An annotated list of vascular plants comprises 360 taxa (286 indigenous, 74 non-indigenous) in 224 genera from 82 families. Taxa consist of 1 Lycopodiophyta, 1 Equisetophyta, 8 Polypodiophyta, 7 Pinophyta, and 343 Magnoliophyta. The most species-rich families are the Asteraceae (64), Poaceae (39), Fabaceae (20), Cyperaceae (16), Rosaceae (13), and Lamiaceae (11). A total of 155 Bell County distribution records were documented. Three threatened Kentucky species (*Gentiana decora*, *Liparis loeselii*, *Silene ovata*) were present in refugial habitats created by surface mining. The high species richness has resulted from native and naturalized invading species from the environs, native and exotic planted species, and species from the remnant seed bank. Forest vegetation is a complex mosaic of natural and semi-natural plant communities on the unplanted and planted areas of LMDA.

Additional Key Words: biodiversity, plant invasion, plant succession, reclamation, refugium.

Introduction

Coal mine operators have been required to reclaim and revegetate surface-mined spoils even before the passage of Public Law 95-87, the Surface-Mining Control and Reclamation Act of 1977 (SMCRA). From 1963-1971, the Northeastern Forest Experiment Station, USDA Forest Service, Berea, Kentucky, cooperated with several private coal companies in the planting of native and exotic

reclamation species on five surface-mined sites in eastern Kentucky. Four of these surface-mined areas were selected as pre-SMCRA demonstration or research sites by the Federal-State Interagency Research Coordinating Committee (FSIRCC). Reclamation goals were to prevent erosion and siltation, foster soil development and forest succession, provide suitable wildlife habitat, determine potential species for forest products, and contribute to landscape aesthetics.

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We inventoried the entire flora of the Log Mountain Demonstration Area (LMDA), a 14- and 21-year-old pre-SMCRA contour surface-mined site in Bell County, Kentucky, during 1984-1985. The LMDA constitutes 14.2 ha; a 9.1 ha area mined in 1963 and an additional 5.1 ha area mined in 1970. The original 9.1 ha area was selected by the FSIRCC in 1965 for reclamation plantings toward forestry postmining land use.

Our study objectives at LMDA were to: 1) report the success of planted native and exotic species after 14 and 21 years; 2) describe the establishment of native and exotic volunteer species; 3) describe the plant communities and plant succession in the different surface-mined habitats; and, 4) compile an annotated list of vascular plants.

Complete floristic inventories, vegetation development studies, and success of natural and planted species observations have also been made on an 18-year-old area-type mine in Laurel County (Thompson et al. 1984), and on a 12-year-old contour surface-mined area in Rockcastle County (Thompson and Wade 1991). Assessments of experimental plantings at the Laurel County site and at a 20-year-old mined site in Bell County have revealed the potential of those sites for forestry, wildlife habitat, soil building, and site stabilization (Wade et al. 1985, 1986).

Methods

We collected representative vascular plant specimens approximately every two weeks during the growing season from March 1984 through October 1985. Voucher specimens were processed according to standard herbarium procedures and deposited in the Berea College Herbarium (BEREA). Manuals used for plant identification were Gleason and Cronquist (1963) and Strausbaugh and Core (1978). Plant classification and nomenclature follow Gleason and Cronquist (1991).

The LMDA is divided into two contour-mined sites; "Site A" which was mined in 1963, and "Site B" which was mined in 1970. Reclamation woody plantations within these two sites are designated as "Areas 1-10." The physical environments which have developed on LMDA are designated as "habitats." In some cases, these "habitats" may cross the boundaries of both site A and B, and different area designations may overlap, e.g., mine highwalls, outcrops, and seeps.

Table 1 shows the pH of 30 soil samples from the surface layer (0-17 cm) in nine plantation areas in July 1985 at LMDA. Soil samples were analyzed from seven plantation areas on the 1963 site A bench, the mixed pine plantation above the 1963 highwall, and the 1970 site B bench (Dan Childress, NRCS Scientist, unpublished data 1985).

Table 2 reports the complete inventory of the entire 1963 site A bench in August 1985 for total seedlings, saplings, and trees by diameter at breast height (dbh). This census includes planted Areas 1-9. Percentage composition or relative density was calculated from the tree population results according to Brower and Zar (1977).

Table 3, the annotated list of vascular plants, is arranged alphabetically by division, family, and species. All non-indigenous taxa, naturalized or introduced, are preceded by an asterisk (*). Those

non-indigenous taxa planted as reclamation species are preceded by a (+). Native reclamation species planted on LMDA are coded by a circle (o). Bell County distribution records are indicated with a dagger (†). These county records are based on herbarium specimens on deposit at (BEREA), the University of Tennessee Herbarium (TENN), and the University of Kentucky Herbarium (UK), and on literature citations (Braun 1943, Ettman 1976, Cranfill 1980, Hinkle 1975, Beal and Thieret 1986, Pounds et al. 1987). Vernacular or common names follow Strausbaugh and Core (1978), Gleason and Cronquist (1991), and Swink and Wilhelm (1994).

From field reconnaissance, we identified six different habitats on LMDA based on the effects of 1963 and 1970 mining procedures, reclamation processes, topographic terrain features, and present plant communities. In Table 3, these six habitats are designated as: 1=1963 mine bench, 2=1970 mine bench, 3=mine highwalls, 4=mine outcrops, 5=mine seeps, and 6=coal haul-telephone microwave tower road.

Relative abundance for each taxon was determined by field observations from each habitat. Each taxon was compared with numbers of individuals or colonies from other taxa of similar growth habit and duration. In Table 3, the abundance scale values are: Rare (R)=1-5 individuals or isolated colonies, Infrequent (I)=6-25 individuals or colonies; Occasional (O)=26-100 individuals or colonies; Frequent (F)=100s of individuals or colonies; and Abundant (A)=1000s of individuals or colonies.

The evaluation of native and planted species and plant successional trends are based upon our personal observation, tree sampling data, and unpublished planting documentation from the USDA Forest Service Northeastern Forest Experiment Station, Berea, Kentucky.

Log Mountain Demonstration Area

The Environmental Site

The LMDA, is a WNW-trending, 14.2-ha contour surface-mined area, which is located 18 km west of Middlesboro off Kentucky Highway 74 in southwestern Bell County. The mine lies within the Log Mountains at Maiden Ridge at latitude 36° 37' 05" N and longitude 85° 51' 01" W. Elevation of the study site ranges from 850 m on the 1963 lower outcrop to 908 m at the ridge crest bordered by the coal haul-telephone microwave tower road (Fig. 1).

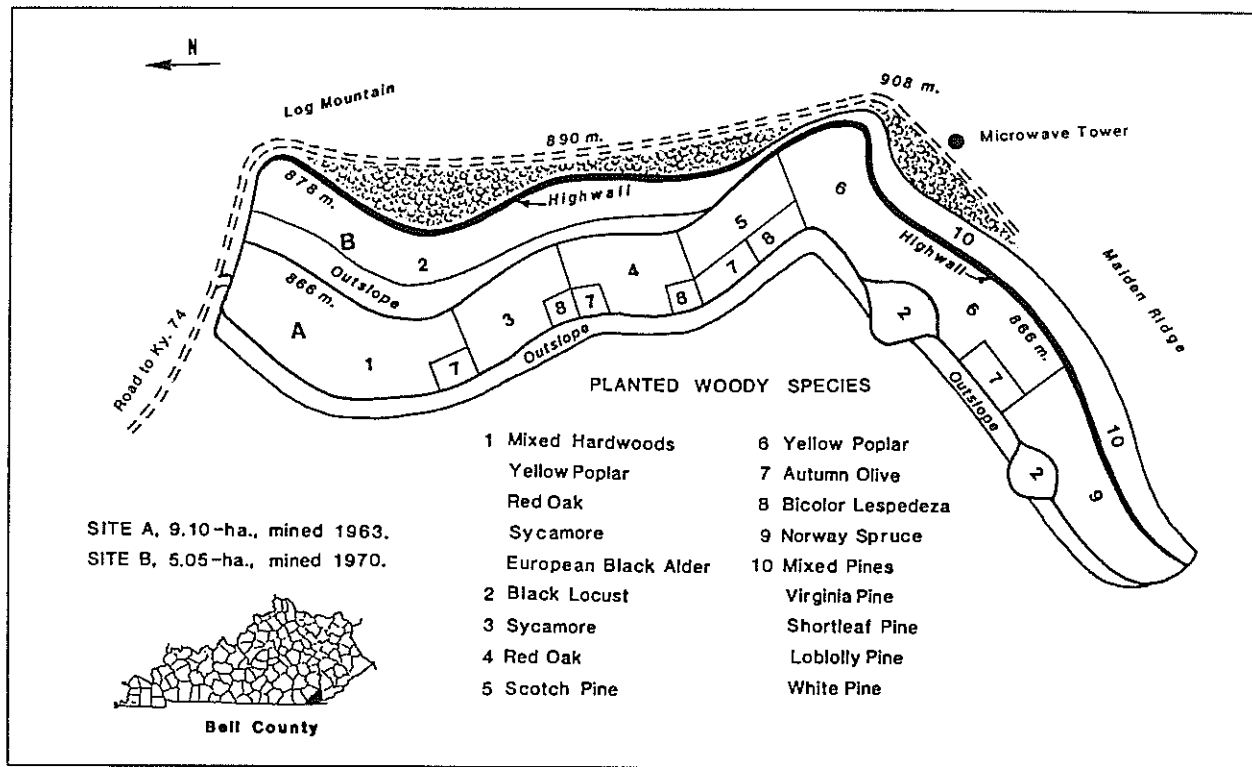


Figure 1. Log Mountain Demonstration Area, Bell County, Kentucky

Physiography and Vegetation. Fenneman (1938) described the Log Mountains as a small mountain range near the middle of the broad syncline between the Cumberland Mountains and Pine Mountains of the Appalachian Plateaus Province. The upper slope and ridgetop forest of the Log Mountains are described as the All Deciduous Mixed Mesophytic Community Type of the Mixed Mesophytic Forest Region by Braun (1950). The Cumberland Mountains have been described as the richest center of the Mixed Mesophytic Forest where several important canopy trees characteristically share dominance (Braun 1950).

Geology. Bedrock of Log Mountain and Maiden Ridge belongs to the Bryson Formation of the Lower to Middle Pennsylvanian Series of the Pennsylvanian System. The lithology of the 112 m thick Bryson Formation consists of siltstones, claystones, sandstones, and four coal beds. The Red Springs coal bed, the major coal seam of 1.0-2.0 m, forms the basement layer of the formation. A thin, unnamed coal rider in sandstone-filled channels lies above the Red Springs coal bed (Rice and Maughan 1978).

Soils. The surface-mined soils in the Log Mountain region have been classified as part of the Fairpoint soils series, a loamy-skeletal, mixed, nonacid, mesic

Typic Udorthents. These soils are nonacid (pH 6.6-7.3) very deep (>60 inches), well-drained, and moderately permeable. They are found in coal-mined mountain ridges and slopes within the Cumberland Mountains (Childress 1992).

Climate. The nearest United States Weather Bureau station is located at Middlesboro at 358 m elevation. During the 1961-1990 period, the mean annual precipitation was 130 cm including a mean of 37 cm snowfall. Mean annual temperature was 13.3°C with the mean winter minimum -4°C and the mean summer maximum 23°C. The mean growing season (based on 0°C) was 170 days (University of Kentucky Agricultural Weather Center 1995).

LMDA Mined Sites

Surface-mining was done at two different time periods at LMDA. In 1963, Site A, an area of 9.1 ha was created by the contour mining of the Red Springs coal bed. A 16 m WNW vertical highwall was formed by the final mining cuts. The nearly level bench extends from the highwall to a steep 35-50 percent outslope at 866 m elevation. This outslope was produced from excess overburden spoils pushed over unmined forest soils.

In 1970, Site B, a tract of 5.1 ha, was formed by the contour mining of a thin, unnamed rider coal seam above the Red Springs coal bed. Part of the 1963 highwall was included in this mining. A second vertical W-trending 4 m highwall and a 2-6 percent sloping bench were created. Elevation varied from 878 m on the bench to 882 m at the top of the highwall. Additional mine spoils were displaced over the 1963 highwall area to form a steep 20-35 percent outslope down to the 1963 mine bench.

A continuous highwall was formed from the 1970 mining and 1963 mining of Log Mountain at the junction of the forested ridge top at Maiden Ridge. A compacted gravel-stone road initially used as a coal haul road presently serves as an access road from the telephone microwave tower to Kentucky Highway 74. This access road forms the eastern boundary of the LMDA and lies on the ridgetop of Log Mountain and Maiden Ridge (Fig. 1).

A 4.7 ha stand of mixed mesophytic hardwood forest lies above the highwall habitat between the access road. This forest has been disturbed from the mining processes by soil scraping, coal haul road construction, and past timbering practices. Wet seep pools have formed on the 1963 site A bench from the highwall in two planted areas, and on the 1970 site B bench at the highwall base.

From LMDA, we have designated six habitats from the 1963 and 1970 mining procedures, topographic features, reclamation processes, and existing plant communities: the 1963 mine bench, 1971 mine bench, mine highwalls, mine out slopes, mine seeps, and coal haul-telephone tower road.

LMDA Revegetation Efforts

Twenty-five species were planted during 1964, 1965, 1971, and 1984 on the LMDA. These species consisted of 11 native trees, four non-indigenous trees, two non-indigenous shrubs, and eight non-indigenous perennial herbs. All 25 species have been recommended for revegetation of surface-mined lands in the eastern United States (Vogel 1981).

In the spring of 1964, the 1963 site A mined area was seeded with Korean lespedeza (*Lespedeza stipulacea*) and tall fescue (*Festuca elatior*) for initial ground cover. In 1965, 10 demonstration areas were established and 13 woody species were planted to promote postmining forestry land use (Fig. 1). Four nitrogen-fixing tree and shrub species were planted on the bench; black locust (*Robinia pseudoacacia*), European black alder (*Alnus glutinosa*), bicolor lespedeza (*Lespedeza bicolor*), and autumn olive (*Elaeagnus umbellata*).

Nine native and non-indigenous tree species of potential forestry value were also planted in mixed hardwood, mixed pine, and individual hardwood and conifer plantations on the 1963 mined area. Yellow poplar (*Liriodendron tulipifera*), American sycamore (*Platanus occidentalis*), northern red oak (*Quercus rubra*), were planted in mixed hardwood blocks and on individual areas on the bench.

Table 1. LMDA soil pH from the surface layer (0-17 cm) at nine areas (Fig. 1).

Area	Mean pH Value	pH Range
1963 Bench Site A		
Area 1: Mixed hardwoods	5.3	4.9-6.6
Area 4: Northern red oak	6.4	6.1-6.6
Area 5: Scotch pine	6.1	6.0-6.1
Area 6: Yellow poplar	7.3	6.1-7.7*
Area 7: Autumn olive	7.4	7.2-7.6*
Area 8: Bicolor lespedeza	7.1	6.9-7.2*
Area 9: Norway spruce	4.9	4.8-5.1
1963 Highwall		
Area 10: Mixed Pine	4.3	4.0-4.9
1970 Bench Site B		
Area 2: Black locust	5.7	5.6-5.9

Code: Three samples from each area except six samples from Area 2; (*) carbonates present.

The non-native Scotch pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*) were planted in individual bench areas. A mixed block of Virginia pine (*Pinus virginiana*), shortleaf pine (*P. echinata*), loblolly pine (*P. taeda*), and eastern white pine (*P. strobus*) was established above the highwall rim adjacent to the disturbed mixed mesophytic hardwood forest. In 1965, two perennial non-indigenous herbs, crown-vetch (*Coronilla varia*) and creeping foxtail (*Alopecurus arundinaceus*) were also seeded in two areas on the bench.

The 1970 site B was hydroseeded in 1971 on the bench and outslope with a grass-legume herbaceous mixture of tall fescue and nitrogen-fixing

species; sericea lespedeza (*Lespedeza cuneata*), red clover (*Trifolium pratense*), yellow sweet clover (*Melilotus officinalis*), white sweet clover (*M. alba*), and black locust. In 1984, seven tree species were interplanted in 48 plots with 24 seedlings each on the 1970 site B bench after herbiciding the herbaceous ground cover. These planted species were white ash (*Fraxinus americana*), northern red oak, saw-tooth oak (*Quercus acutissima*), black walnut (*Juglans nigra*), sugar maple (*Acer saccharum*), yellow poplar, and eastern white pine.

LMDA Minesoils

Minesoils are representative of the Fairpoint soil series derived from siltstone, sandstone, claystone, and coal intermixed with original forest soils. From the soil analysis of the 30 samples at LMDA, the mean pH value of the 1963 bench, 1970 bench, and 1963 highwall was 6.1 with a range from 4.0 to 7.7 pH. The mean pH value on the site A bench was 6.4 and varied from 4.9 to 7.7 with some free carbonates present. On the site B bench, the mean pH value was 5.7. The mean pH of the 1963 highwall mixed pine plantation was 4.3 and a range from 4.0-4.9 (Table 1). In general, the LMDA minesoils are less acid than unmined contiguous areas because of the basic nature of the carbonates contained in some of the Fairpoint soils (Dan Childress, NRCS Scientist, unpublished data 1995).

Results

LMDA Habitats

In 14 and 21 years after coal mining, a complex vegetational mosaic of natural and semi-natural plant communities is developing in the seven habitats from the mining effects and reclamation processes. Plant communities are progressing through various seral stages of secondary succession toward a young mixed hardwood forest throughout the planted and unplanted mine habitats.

1963 Site A Bench. Environments range from seasonally hydric sites near the highwall and open grassy xeric areas near the outslope to mixed mesic forested areas. A tree population analysis of 7,320 individuals reveals the development of a young mesophytic hardwood-dominated forest. Different degrees of canopy closure occur from volunteer native and exotic woody and herbaceous species from the contiguous forest environs, the nine woody plantations, and the existing spoil seed bank (Table 2). The highest species richness, 223 taxa, is found on this habitat (Table 3).

The most significant native trees colonizing the 1963 bench are white ash, yellow poplar, sugar maple, black locust, red maple (*Acer rubrum*), and Virginia pine (Table 2). Important nitrogen-fixing woody species spreading from the 1963 bench plantings are black locust, autumn olive, and European black alder. Shade-intolerant, mid-successional trees, sourwood (*Oxydendrum arboreum*), wild black cherry (*Prunus serotina*), eastern redbud (*Cercis canadensis*), white sassafras (*Sassafras albidum*), red elm (*Ulmus rubra*), blackgum (*Nyssa sylvatica*), and eastern red cedar (*Juniperus virginiana*), are volunteering on the bench (Table 2).

Shrubs present are American elderberry (*Sambucus canadensis*), wild hydrangea (*Hydrangea arborescens*), winged sumac (*Rhus copallina*), smooth sumac (*R. glabra*), and bicolor lespedeza. Characteristic woody vines on the bench are virgin's bower (*Clematis virginiana*), poison ivy (*Toxicodendron radicans*), moonseed (*Menispermum canadense*), Japanese honeysuckle (*Lonicera japonica*), glaucous greenbrier (*Smilax glauca*), common greenbrier (*S. rotundifolia*), summer grape (*Vitis aestivalis*), and Virginia creeper (*Parthenocissus quinquefolia*).

The numerically most important herbs are members of the Asteraceae, Poaceae, Fabaceae, Cyperaceae, and Rosaceae. Representative mesic woodland herbs include eulalia (*Microstegium vimineum*), pale jewelweed (*Impatiens pallida*), white snakeroot (*Eupatorium rugosum*), joe-pye weed (*E. fistulosum*), late boneset (*E. serotinum*), crownbeard (*Verbesina alternifolia*), sweet cicely (*Osmorhiza claytonii*), honewort (*Cryptotaenia canadensis*), black raspberry (*Rubus occidentalis*), wood nettle (*Laportea canadensis*), climbing buckwheat (*Polygonum scandens*), pokeweed (*Phytolacca americana*), Indian hemp (*Apocynum cannabinum*), cinnamon vine (*Dioscorea batatas*), deer-tongue panicum (*Panicum clandestinum*), cleavers (*Galium aparine*), spring beauty (*Claytonia virginica*), and violets (*Viola* spp.).

In drier exposed bench areas, herbs include tall fescue, broomsedge (*Andropogon virginicus*), hairy panic grass (*Panicum lanuginosum*), Kentucky bluegrass (*Poa pratensis*), Canadian goldenrod (*Solidago canadensis*), old-field goldenrod (*S. nemoralis*), rough goldenrod (*S. rugosa*), hairy white aster (*Aster pilosus*), ox-eye daisy (*Chrysanthemum leucanthemum*), wild carrot (*Daucus carota*), Allegheny blackberry (*Rubus allegheniensis*), northern dewberry (*R. flagellaris*), common cinquefoil (*Potentilla simplex*), wild strawberry (*Fragaria virginiana*), Japanese knotweed (*Polygonum cuspidatum*), sericea lespedeza, and Korean lespedeza.

Table 2. Tree population analysis on the 1963 bench, Log Mountain Demonstration Area, Kentucky.

Species	Decimeter Size Classes (dbh)						Species Total	Percentage Composition
	Seedlings <1.0 m tall	Saplings <0.5	0.5-1.0	1.0-2.0	2.0-3.0	3.0-4.0		
<i>Fraxinus americana</i>	286	1118	151	27	3	1	1586	21.67
o <i>Liriodendron tulipifera</i>	311	301	180	214	55	6	1067	14.58
<i>Acer saccharum</i>	453	528	57	2	0	0	1040	14.21
o <i>Robinia pseudoacacia</i>	203	325	130	89	51	14	812	11.09
<i>Acer rubrum</i>	317	377	54	4	1	0	753	10.29
+ <i>Alnus glutinosa</i>	165	229	53	35	19	7	508	6.94
o <i>Pinus virginiana</i>	95	171	33	7	0	0	306	4.18
o <i>Platanus occidentalis</i>	52	125	37	21	1	0	236	3.22
+ <i>Pinus sylvestris</i>	0	12	63	92	9	0	176	2.40
o <i>Quercus rubra</i>	31	86	31	9	1	0	158	2.16
<i>Oxydendrum arboreum</i>	58	97	2	0	0	0	157	2.14
+ <i>Picea abies</i>	0	13	45	90	8	0	156	2.13
<i>Prunus serotina</i>	38	43	12	5	4	3	105	1.43
<i>Salix nigra</i>	24	45	5	3	0	0	77	1.05
<i>Sassafras albidum</i>	28	25	5	3	0	0	61	0.83
<i>Cornus florida</i>	2	30	4	0	0	0	36	0.49
<i>Tilia americana</i>	2	7	3	5	0	0	17	0.23
<i>Nyssa sylvatica</i>	7	5	1	3	0	0	16	0.22
<i>Juniperus virginiana</i>	1	11	2	0	0	0	14	0.19
<i>Cercis canadensis</i>	6	5	0	0	0	0	11	0.15
<i>Ulmus rubra</i>	1	5	0	0	0	0	6	0.08
<i>Carya cordiformis</i>	1	3	1	0	0	0	5	0.07
<i>Liquidambar styraciflua</i>	1	1	2	1	0	0	5	0.07
<i>Quercus velutina</i>	3	1	0	0	0	0	4	0.06
<i>Aesculus flava</i>	2	2	0	0	0	0	4	0.06
<i>Betula lenta</i>	1	1	0	0	0	0	2	0.03
<i>Magnolia acuminata</i>	1	1	0	0	0	0	2	0.03
Total Species: 27	2089	3567	871	610	152	31	7320	100.00

Code: (*) Percentage Composition=Relative Density (Brower and Zar 1977).
 (+) Planted nonindigenous trees on bench.
 (o) Planted native trees on bench.

The nine woody demonstration areas are discussed regarding the success of the planted species and the influence of native and exotic species. Three Kentucky endangered species are present on the 1963 bench habitat that were not encountered in the unmined environs.

Area 1: Mixed Hardwoods. The four tree species planted in blocks are yellow poplar, American sycamore, northern red oak, and European black alder. Yellow poplar is volunteering and reproducing on the bench while exhibiting excellent growth. American sycamore has persisted with only fair to good success and is not volunteering on the site. Northern red oak has rather poor growth and appears stunted. European black alder, an actinomycete nitrogen-fixing tree, is

spreading vegetatively and by seed although some older trees are senescent. Crown-vetch plantings have spread but are suppressed by the lush, dense growth of mesic woodland herbs. Two endangered species for Kentucky, ovate-leaved catchfly (*Silene ovata*) and Appalachian showy gentian (*Gentiana decora*), are growing in the mixed hardwoods plantation at the base of the 1970 outslope.

Area 2: Black Locust. The stand has good growth in height, 6-8 m, and is present in all size classes from 1-5 dm dbh on the bench (Table 2). Planted and volunteer trees have reproduced vegetatively and from seed. Black locust is especially important where bench soils have slumped onto the 1963 outslope.

Area 3: American sycamore. Sycamore ranges from 4-7 m in height and 1-2 dm dbh, but only had fair growth success. Area 3 appears to have droughty, shallow soil with a good stand of tall fescue, sericea lespedeza, Korean lespedeza, and white sweet clover.

Area 4: Northern red oak. Most red oak has rather poor growth with most trees less than 3 m tall and only a few trees 1-2 dm dbh.

Area 5: Scotch pine. This introduced pine has exhibited good growth with 9-11 m height and several trees in the 2-3 dm dbh size class. Although ovulate cones are produced, Scotch pine is not reproducing from seeds in cones (Table 2). Tall fescue dominates under trees, and several woodland herbs are present near the outslope. A wet seep depression near the highwall contains several wetland species. Creeping foxtail has locally become established and expanded its area from the Scotch pine plantation into the yellow poplar plantation (Thompson and Thieret 1986a).

Area 6: Yellow poplar. Some trees of yellow poplar have excellent growth with some 8-14 m tall and 3-4 dm dbh. It is also an important invading species. Several mesic woodland herbs are present along the outslope as well as wetland herbs from the highwall seep habitats, the yellow poplar plantation, and the Scotch pine plantation.

Area 7: Autumn olive. This actinomycete nitrogen-fixing species has migrated from its plantation and spread into adjacent Areas 3, 6, and 9. Autumn olive characteristically has some dieback, but is readily reproducing vegetatively and from seed.

Area 8: Bicolor lespedeza. Nitrogen-fixing bicolor lespedeza has migrated from subplots 3, 4, and 5 and spread into Areas 1 and 6. As it has spread, considerable root sprouting has occurred from old decadent stems.

Area 9: Norway spruce. This introduced spruce has growth comparable to the Scotch pine. Some taller trees are 12-13 m high and several are in the 2-3 dm dbh class. Although Norway spruce is producing ovulate cones, it is not reproducing from seeds.

1970 Site B Bench. The 1970 bench is rather open, dry, and grassy with numerous dense black locust and blackberry thickets near the outslope and highwall. A good ground cover has developed from the hydroseeded tall fescue, sericea lespedeza, Korean lespedeza, red clover, and black locust. The

annual white and yellow sweet clovers have thinned out, but are still persisting. Black locust developed dense seedling thickets within six to eight years and has currently formed a partially closed canopy. The seven tree species interplanted in the 1984 plots have not had enough time to influence the bench vegetation. In one year, white ash, yellow poplar, and sugar maple are growing well; but, northern red oak, black walnut, and eastern white pine are barely persisting. Saw-tooth oak did not survive in any of the one-year-old tree plots.

Plant communities are composed mostly of volunteering, mid-successional, native woody plants and invading native and exotic herbaceous species. Successional trees invading the 1970 bench include red maple, white ash, yellow poplar, sugar maple, wild black cherry, and sourwood. Allegheny blackberry is the pre-eminent perennial forming dense thickets with glaucous greenbrier, northern dewberry, black raspberry, and multiflora rose (*Rosa multiflora*).

Several important herbs include tall fescue, broomsedge, oat poverty grass (*Danthonia compressa*), orchard grass (*Dactylis glomerata*), sericea lespedeza, cinquefoil (*Potentilla simplex*), wild strawberry (*Fragaria virginiana*), and stickights. Hairy white aster, Canadian goldenrod, and slender goldenrod are the most important members of the Asteraceae. The site B bench has the second highest species richness with 160 taxa (Table 3).

Highwalls. Characteristic shade-intolerant woody invaders on the open highwall rim crest and in talus areas include Virginia pine, black locust, red maple, blackgum, sourwood, sassafras, and some shortleaf pine. Seral shrubs in open, grassy areas are poison ivy, winged sumac, smooth sumac, glaucous greenbrier, lowbush blueberry (*Vaccinium pallidum*), and St. Andrews-cross (*Hypericum stragulum*). Perennial herbs on the steep highwall slope and upper rim include oat poverty grass, broomsedge, hairy panicum, Allegheny blackberry, old-field goldenrod, tickseed sunflower (*Coreopsis major*), and Small's ragwort (*Senecio anonymus*). Steep highwall talus and crevices are colonized by patches of the naturalized common dandelion (*Taraxacum officinale*), coltsfoot (*Tussilago farfara*), and Japanese knotweed. Ninety-eight taxa were recorded from the highwalls (Table 3).

Area 10: Mixed pines. The only plantation that was not established on the 1963 site A bench was a block plantation of Virginia pine, shortleaf pine, loblolly pine, and eastern white pine. This mixed pine area was planted above the site A highwall adjacent to the disturbed mixed mesophytic hardwood forest. The forest soils are mostly unmined. The mean pH value is 4.3 and ranges from

Table 3. Annotated Vascular Plant List, Log Mountain Demonstration Area, Bell County, Kentucky.

Family	Species	Common Name	Habitats	1	2	3	4	5	6
POLYPODIOPHYTA (True Ferns)									
Aspleniaceae (Spleenwort Family)									
	<i>Asplenium platyneuron</i> (L.)	Oakes. Ebony Spleenwort.		R	R	-	-	-	-
	<i>Polystichum acrostichoides</i> (Michx.) Schott.	Christmas Fern.		I	-	R	-	-	-
	<i>Thelypteris hexagonoptera</i> (Michx.) Weath.	Broad Beech Fern.		R	-	-	-	-	-
	<i>T. noveboracensis</i> (L.) Nieuwl.	New York Fern.		R	I	-	-	-	-
Ophioglossaceae (Adder's Tongue Family)									
	<i>Botrychium dissectum</i> Spreng.	Cut-leaved Grape Fern.		R	-	-	-	-	-
	<i>B. virginianum</i> (L.) Sw.	Rattlesnake Fern.		-	-	-	R	-	-
Osmundaceae (Royal Fern Family)									
	<i>Osmunda cinnamomea</i> L.	Cinnamon Fern.		-	-	-	-	R	-
Polypodiaceae (Polypody Family)									
	<i>Polypodium virginianum</i> L.	Common Polypody.		-	-	-	R	-	-
EQUISETOPHYTA (Horsetails)									
Equisetaceae (Horsetail Family)									
	† <i>Equisetum arvense</i> L.	Common Horsetail.		-	-	-	-	I	-
LYCOPODIOPHYTA (Lycopods)									
Lycopodiaceae (Clubmoss Family)									
	† <i>Lycopodium digitatum</i> Dillen.	Southern Ground-cedar.		I	-	I	-	-	-
PINOPHYTA (Conifers)									
Cupressaceae (Cypress Family)									
	† <i>Juniperus virginiana</i> L.	Eastern Redcedar.		I	R	R	-	-	-
Pinaceae (Pine Family)									
	†+* <i>Picea abies</i> (L.) Karst.	Norway Spruce.		O	-	-	-	-	-
	†o <i>Pinus echinata</i> P. Mill.	Shortleaf Pine.		-	I	I	-	-	-
	†o <i>P. strobus</i> L.	Eastern White Pine.		-	R	I	-	-	-
	†+* <i>P. sylvestris</i> L.	Scotch Pine.		O	-	-	-	-	-
	†o <i>P. taeda</i> L.	Loblolly Pine.		-	-	R	-	-	-
	o <i>P. virginiana</i> L.	Virginia Pine		F	O	I	O	-	-
MAGNOLIOPHYTA (Flowering Plants)									
Aceraceae (Maple Family)									
	<i>Acer negundo</i> L.	Boxelder.		R	-	-	-	-	-
	<i>A. rubrum</i> L.	Red Maple.		A	A	A	O	-	-
	o <i>A. saccharum</i> Marsh.	Sugar Maple.		A	F	F	O	-	-
Anacardiaceae (Sumac Family)									
	† <i>Rhus copallina</i> L.	Winged Sumac.		R	O	I	I	-	-
	† <i>R. glabra</i> L.	Smooth Sumac.		-	I	I	-	-	-
	<i>Toxicodendron radicans</i> (L.) Kuntze.	Poison Ivy.		I	I	I	I	-	I
Apiaceae (Parsley Family)									
	<i>Cryptotaenia canadensis</i> (L.) DC.	Honewort.		I	-	-	-	-	-
	* <i>Daucus carota</i> L.	Wild Carrot.		O	O	O	-	-	I
	<i>Osmorhiza claytonii</i> (Michx.) Clarke.	Hairy Sweet Cicely.		I	-	-	-	-	-
	† <i>Sanicula canadensis</i> L.	Black Snakeroot.		R	-	-	-	-	-
	† <i>Thaspium barbinode</i> (Michx.) Nutt.	Hairy Meadow Parsnip.		I	-	-	-	-	-
	<i>Zizia aptera</i> (Gray) Fern.	Heart-leaved Meadow Parsnip.		-	R	R	-	-	-
Apocynaceae (Dogbane Family)									
	<i>Apocynum cannabinum</i> L.	Indian Hemp.		O	O	I	-	R	-
Araceae (Arum Family)									
	<i>Arisaema triphyllum</i> (L.) Schott.	Jack-in-the-Pulpit.		R	-	-	-	-	-
Aristolochiaceae (Birthwort Family)									
	<i>Asarum canadense</i> L.	Wild Ginger.		R	-	R	-	-	-
Asclepiadaceae (Milkweed Family)									
	† <i>Asclepias exaltata</i> L.	Poke Milkweed.		-	R	-	-	-	R
	<i>A. quadrifolia</i> Jacq.	Whorled Milkweed.		R	-	-	-	-	-

† <i>A. syriaca</i> L. Common Milkweed.	I	I	I	-	-	-
Asteraceae (Aster Family)						
†* <i>Achillea millefolium</i> L. Yarrow.	I	R	-	-	-	I
<i>Ambrosia artemisiifolia</i> L. Common Ragweed.	O	O	-	-	-	F
<i>A. trifida</i> L. Giant Ragweed.	O	O	-	-	-	O
<i>Antennaria plantaginifolia</i> (L.) Rich. Pussy-toes.	-	-	I	-	-	-
†* <i>Arctium minus</i> Schk. Common Burdock.	-	-	-	-	-	R
†* <i>Artemisia vulgaris</i> L. Mugwort.	-	-	-	-	-	R
<i>Aster cordifolius</i> L. Heart-leaved Aster.	R	-	-	-	-	-
<i>A. divaricatus</i> L. White Wood Aster.	R	-	-	-	-	-
<i>A. dumosus</i> L. Bushy Aster.	-	R	R	-	-	-
<i>A. lowrieanus</i> Porter Smooth Heart-leaved Aster.	-	-	R	-	-	-
<i>A. lateriflorus</i> (L.) Britt. Calico Aster.	-	-	I	-	-	I
† <i>A. phlogifolius</i> Muhl. Phlox-leaved Aster.	-	-	R	-	-	-
† <i>A. pilosus</i> Willd. White Heath Aster.	O	O	O	I	-	I
<i>A. undulatus</i> L. Wavy-leaved Aster.	-	O	I	-	-	-
<i>Bidens polylepis</i> S. F. Blake. Bur Marigold.	O	O	O	-	I	-
<i>Cacalia atriplicifolia</i> L. Pale Indian Plantain.	-	-	-	-	R	-
* <i>Chrysanthemum leucanthemum</i> L. Ox-eye Daisy.	O	O	I	I	-	-
* <i>Cichorium intybus</i> L. Chicory.	-	-	-	-	-	R
†* <i>Cirsium arvense</i> (L.) Scop. Field Thistle.	-	O	-	-	-	R
† <i>C. discolor</i> (Muhl.) Spreng. Pasture Thistle.	-	I	-	-	-	O
†* <i>C. vulgare</i> (Savi) Tenore. Bull Thistle.	-	-	-	-	-	R
† <i>Conyza canadensis</i> (L.) Cronq. Horseweed.	-	O	-	-	-	O
<i>Coreopsis major</i> Walt. Forest Tickseed.	-	-	O	I	-	-
† <i>Erechtites hieracifolia</i> (L.) Raf. Fireweed.	-	R	-	-	-	I
<i>Erigeron annuus</i> (L.) Pers. Annual Fleabane.	O	O	O	-	-	O
<i>E. philadelphicus</i> L. Philadelphia Fleabane.	I	-	-	I	-	-
<i>E. strigosus</i> Muhl. Daisy Fleabane.	I	O	I	-	-	O
<i>Eupatorium fistulosum</i> Barratt. Hollow Joe-pye Weed.	O	O	-	-	-	O
<i>E. purpureum</i> L. Purple Joe-pye Weed.	-	-	-	R	-	-
<i>E. rugosum</i> Houtt. White Snakeroot.	F	O	O	A	-	-
<i>E. serotinum</i> Michx. Late Boneset.	O	-	-	-	O	-
† <i>E. sessilifolium</i> L. Upland Boneset.	R	-	-	-	-	-
<i>Gnaphalium obtusifolium</i> L. Old-field Balsam.	I	I	-	-	-	-
<i>Helianthus microcephalus</i> T. & G. Small-headed Sunflower.	I	I	R	O	-	-
† <i>H. tuberosus</i> L. Jerusalem Artichoke.	R	-	I	-	-	I
<i>Hieracium gronovii</i> L. Hairy Hawkweed.	R	-	I	-	-	-
<i>H. paniculatum</i> L. Panicked Hawkweed.	-	-	I	-	-	-
<i>H. scabrum</i> Michx. Rough Hawkweed.	-	R	R	-	-	-
<i>H. venosum</i> L. Rattlesnake Hawkweed.	-	-	I	-	-	-
<i>Krigia biflora</i> (Walt.) S. F. Blake. False Dandelion.	R	-	-	I	-	R
† <i>Lactuca biennis</i> (Moench) Fern. Tall Blue Lettuce.	-	-	-	-	-	R
<i>L. canadensis</i> L. Canadian Wild Lettuce.	-	-	-	I	-	O
<i>L. floridana</i> (L.) Gaertn. Florida Blue Lettuce.	-	-	I	I	-	-
†* <i>L. saligna</i> L. Willow Lettuce.	-	-	-	-	-	R
†* <i>L. serriola</i> L. Prickly Lettuce.	-	R	-	-	-	I
† <i>Polymnia uvedalia</i> L. Bear's Foot.	-	-	-	I	-	-
<i>Rudbeckia hirta</i> L. Black-eyed Susan.	I	R	-	-	-	R
† <i>Senecio anonymus</i> Wood. Appalachian Groundsel.	O	O	O	O	-	-
† <i>Silphium trifoliatum</i> L. Whorled Rosin-weed.	R	-	-	R	-	-
<i>Solidago arguta</i> Ait. Cut-leaved Goldenrod.	O	O	O	I	-	-
<i>S. bicolor</i> L. Silver-rod.	R	-	I	-	-	-
<i>S. caesia</i> L. Blue-stemmed Goldenrod.	R	-	-	-	-	-
† <i>S. canadensis</i> L. Canada Goldenrod.	F	O	F	I	-	I
<i>S. erecta</i> Pursh. Slender Goldenrod.	-	R	-	-	-	-
† <i>S. flexicaulis</i> L. Broad-leaved Goldenrod.	O	I	-	O	-	-
† <i>S. gigantea</i> Ait. Late Goldenrod.	-	-	-	-	I	-
<i>S. nemoralis</i> Ait. Old-field Goldenrod.	O	O	O	O	-	-

<i>S. rugosa</i> Mill. Rough Goldenrod.	I	I	I	O	-	-
† <i>S. sphacelata</i> Raf. Short-pappus Goldenrod.	R	-	-	-	-	-
* <i>Sonchus asper</i> (L.) Hill. Spiny Sow Thistle.	-	-	-	-	-	I
* <i>Taraxacum officinale</i> Weber. Common Dandelion.	-	-	-	I	-	I
†* <i>Tussilago farfara</i> L. Coltsfoot.	-	-	I	-	-	-
<i>Verbesina alternifolia</i> (L.) Britt. Wingstem.	O	R	-	O	O	O
<i>Vernonia gigantea</i> (Walter) Trel. Tall Ironweed.	O	I	O	-	-	-
Balsaminaceae (Touch-Me-Not-Family)						
<i>Impatiens capensis</i> Meerb. Spotted Jewelweed.	I	-	-	F	-	-
<i>I. pallida</i> Nutt. Pale Jewelweed.	F	R	F	F	-	-
Berberidaceae (Barberry Family)						
<i>Caulophyllum thalictroides</i> (L.) Michx. Blue Cohosh.	-	-	-	R	-	-
<i>Podophyllum peltatum</i> L. May Apple.	R	-	-	I	-	-
Betulaceae (Birch Family)						
†+* <i>Alnus glutinosa</i> (L.) Gaertn. European Black Alder.	F	-	-	-	-	-
<i>Betula lenta</i> L. Sweet Birch.	R	-	-	R	-	-
Brassicaceae (Mustard Family)						
* <i>Barbarea vulgaris</i> R. Br. Yellow Rocket.	I	I	-	-	-	R
† <i>Cardamine concatenata</i> (Michx.) Schwartz. Slender Toothwort.	I	-	-	R	-	-
* <i>C. hirsuta</i> L. Hairy Bittercress.	O	O	-	-	-	O
†* <i>Lepidium campestre</i> (L.) R. Br. Field Cress.	-	-	-	-	-	R
† <i>L. virginicum</i> L. Common Peppergrass.	-	-	-	-	-	I
Campanulaceae (Bellflower Family)						
† <i>Campanula americana</i> L. Tall Bellflower.	O	-	-	O	-	-
<i>C. divaricata</i> Michx. Appalachian Bellflower.	-	-	R	-	-	-
<i>Lobelia inflata</i> L. Indian Tobacco.	I	-	-	-	-	O
† <i>L. siphilitica</i> L. Great Blue Lobelia.	I	-	-	-	I	-
Caprifoliaceae (Honeysuckle Family)						
* <i>Lonicera japonica</i> Thunb. Japanese Honeysuckle.	I	I	-	O	-	-
<i>Sambucus canadensis</i> L. American Elderberry.	O	I	I	O	I	-
<i>Triosteum perfoliatum</i> L. Late Horse Gentian.	-	R	-	-	-	-
Caryophyllaceae (Pink Family)						
* <i>Cerastium vulgatum</i> L. Mouse-ear Chickweed.	R	O	-	-	-	O
* <i>Dianthus armeria</i> L. Deptford Pink.	-	-	-	-	-	R
† <i>Paronychia canadensis</i> (L.) Wood. Tall Forked Chickweed.	-	-	-	R	-	-
<i>Silene ovata</i> Pursh. Ovate-leaved Catchfly.	R	-	-	-	-	-
† <i>S. virginica</i> L. Fire Pink.	-	-	R	-	-	-
†* <i>Stellaria media</i> (L.) Vill. Common Chickweed.	R	O	-	-	-	O
<i>S. pubera</i> Michx. Great Chickweed.	-	-	-	R	-	-
Celasteraceae (Staff Tree Family)						
†* <i>Euonymus fortunei</i> (Turcz.) Hand. & Maz. Winter Creeper.	-	-	-	R	-	-
Chenopodiaceae (Goosefoot Family)						
<i>Chenopodium album</i> L. Lamb's Quarters.	-	R	-	-	-	R
Clusiaceae (Mangosteen Family)						
† <i>Hypericum canadense</i> L. Canadian St. John's Wort.	-	-	-	-	O	-
<i>H. stragulum</i> P. Adams & Robson. St. Andrew's Cross.	I	-	I	-	-	-
† <i>H. mutilum</i> L. Weak St. John's Wort.	R	-	-	-	O	-
<i>H. punctatum</i> Lam. Spotted St. John's Wort.	O	I	-	-	-	-
Commelinaceae (Spiderwort Family)						
* <i>Commelina communis</i> L. Asiatic Dayflower.	I	-	-	-	-	-
† <i>Tradescantia subaspera</i> Ker-Gawl. Broad-leaved Spiderwort.	-	-	I	R	-	-
Convolvulaceae (Morning Glory Family)						
<i>Calystegia sepium</i> (L.) R. Br. Hedge Bindweed.	-	-	-	-	-	I
Cornaceae (Dogwood Family)						
<i>Cornus florida</i> L. Flowering Dogwood.	O	O	I	O	-	-
<i>Nyssa sylvatica</i> Marsh. Black Gum.	O	O	F	F	-	-
Crassulaceae (Stonecrop Family)						
<i>Sedum ternatum</i> Michx. Wild Stonecrop.	-	-	-	R	-	-

Cuscutaceae (Dodder Family)									
† <i>Cuscuta pentagona</i> Engelm. Prairie Dodder.	I	-	-	-	I	-			
Cyperaceae (Sedge Family)									
† <i>Carex atlantica</i> L.H. Bailey. Atlantic Star Sedge.	-	-	-	-	O	-			
† <i>C. blanda</i> Dewey. Common Wood Sedge.	R	-	I	-	-	-			
<i>C. digitalis</i> Willd. Narrow-leaved Wood Sedge.	R	-	I	-	-	-			
<i>C. frankii</i> Kunth. Frank's Sedge.	R	-	-	-	O	-			
<i>C. laxiflora</i> Lam. Beech Wood Sedge.	-	-	R	-	-	-			
<i>C. lurida</i> Wahl. Yellow-green Sedge.	O	-	-	-	F	-			
† <i>C. purpurifera</i> Mack. Purple-leaved Sedge.	-	-	-	R	-	-			
<i>C. virescens</i> Muhl. Slender Green Sedge.	-	-	R	-	-	-			
<i>C. vulpinoidea</i> Michx. Brown Fox Sedge.	O	-	-	-	F	-			
<i>Cyperus strigosus</i> L. Long-scaled Nut Sedge.	-	-	-	-	R	-			
<i>Eleocharis ovata</i> (Roth) R. & S. Oval Spike Rush.	-	-	-	-	O	-			
<i>Fimbristylis autumnalis</i> (L.) R. & S. Autumn Sedge.	-	-	-	-	O	-			
<i>Rhynchospora capitellata</i> (Michx.) Vahl. Brown Beakrush.	-	-	-	-	O	-			
† <i>Scirpus atrovirens</i> Willd. Dark Green Bulrush.	-	-	-	-	I	-			
<i>S. cyperinus</i> (L.) Kunth. Woolgrass.	-	-	-	-	F	-			
Dioscoreaceae (Yam Family)									
* <i>Dioscorea batatas</i> Decne. Cinnamon Vine.	O	O	-	O	-	-			
<i>D. villosa</i> L. Wild Yam.	R	-	-	I	-	-			
Elaeagnaceae (Oleaster Family)									
†+* <i>Elaeagnus umbellata</i> Thunb. Autumn Olive.	F	-	-	-	-	-			
Ericaceae (Heath Family)									
<i>Chimaphila maculata</i> (L.) Pursh. Spotted Wintergreen.	-	-	I	-	-	-			
<i>Oxydendrum arboreum</i> (L.) DC. Sourwood.	F	O	O	O	-	-			
<i>Vaccinium pallidum</i> Ait. Lowbush Blueberry.	R	-	I	-	-	-			
Euphorbiaceae (Spurge family)									
† <i>Acalypha rhomboidea</i> Raf. Three-seeded Mercury.	-	I	-	-	-	I			
<i>Euphorbia corollata</i> L. Flowering Spurge.	-	R	-	-	-	-			
<i>E. maculata</i> L. Spotted Spurge.	-	I	-	-	-	I			
<i>E. nutans</i> Lagasca. Eyebane.	-	-	-	-	-	I			
Fabaceae (Pea Family)									
<i>Amphicarpea bracteata</i> (L.) Fern. Hog Peanut.	I	-	-	I	-	-			
<i>Cercis canadensis</i> L. Eastern Redbud.	I	I	-	R	-	-			
<i>Chamaecrista nictitans</i> (L.) Moench. Wild Sensitive Plant.	-	-	-	-	-	I			
†+* <i>Coronilla varia</i> L. Crown-vetch.	O	-	-	-	-	-			
† <i>Desmodium glabellum</i> (Michx.) DC. Smooth Tick Trefoil.	I	O	-	-	-	-			
<i>D. glutinosum</i> (Muhl.) Wood. Pointed Tick Trefoil.	-	-	-	R	-	-			
<i>D. paniculatum</i> (L.) DC. Panicked Tick Trefoil.	O	F	-	-	-	-			
†+* <i>Lespedeza bicolor</i> Turcz. Bicolor Lespedeza.	F	-	-	-	-	-			
†+* <i>L. cuneata</i> (Dum.-Cours.) G. Don. Sericea Lespedeza.	F	A	-	I	-	I			
†+* <i>L. stipulacea</i> Maxim. Korean Lespedeza.	F	A	-	-	-	-			
†* <i>Medicago lupulina</i> L. Black Medick.	-	R	-	-	-	I			
†+* <i>Melilotus alba</i> Medic. White Sweet Clover.	I	O	-	-	-	-			
†+* <i>M. officinalis</i> (L.) Pallas. Yellow Sweet Clover.	I	I	-	-	-	-			
†o <i>Robinia pseudoacacia</i> L. Black Locust.	A	A	O	A	-	-			
* <i>Trifolium campestre</i> Schreb. Low Hop Clover.	R	O	-	-	-	R			
* <i>T. hybridum</i> L. Alsike Clover.	R	I	-	-	-	-			
+* <i>T. pratense</i> L. Red Clover.	O	O	-	-	-	-			
†* <i>T. repens</i> L. White Clover.	O	O	-	-	-	R			
<i>Vicia caroliniana</i> Walt. Carolina Wood-vetch.	-	R	-	-	-	-			
†* <i>V. sativa</i> L. Common Vetch.	R	I	-	-	-	-			
Fagaceae (Beech Family)									
<i>Fagus grandifolia</i> Ehrh. American Beech.	R	-	-	-	-	-			
<i>Quercus alba</i> L. White Oak.	R	R	-	-	-	-			
<i>Q. prinus</i> L. Chestnut Oak.	R	-	-	-	-	-			
o <i>Q. rubra</i> L. Northern Red Oak.	O	R	-	-	-	-			
<i>Q. velutina</i> Lam. Black Oak.	R	-	-	-	-	-			

Gentianaceae (Gentian Family)						
<i>Gentiana decora</i> Pollard. Appalachian Gentian.	R	-	-	-	-	-
Geraniaceae (Geranium Family)						
<i>Geranium maculatum</i> L. Wild Geranium.	I	-	-	R	-	-
Hamamelidaceae (Witch Hazel Family)						
<i>Liquidambar styraciflua</i> L. Sweetgum.	R	-	-	-	R	-
Hippocastanaceae (Buckeye Family)						
<i>Aesculus flava</i> Ait. Yellow Buckeye.	R	-	-	-	-	-
Hydrangeaceae (Hydrangea Family)						
<i>Hydrangea arborescens</i> L. Wild Hydrangea.	O	I	I	O	-	-
Iridaceae (Iris Family)						
† <i>Sisyrinchium angustifolium</i> P. Mill. Narrow Blue-eyed Grass.	I	-	R	-	-	-
Juglandaceae (Walnut Family)						
† <i>Carya cordiformis</i> (Wang.) K. Koch. Bitternut Hickory.	R	-	-	-	-	-
<i>C. ovalis</i> (Wang.) Sarg. Sweet Pignut Hickory.	R	-	-	-	-	-
† <i>Juglans nigra</i> L. Black Walnut.	R	R	-	-	-	-
Juncaceae (Rush Family)						
<i>Juncus acuminatus</i> Michx. Sharp-fruited Rush.	-	-	-	-	O	-
<i>J. effusus</i> L. var. <i>solutus</i> Fern. & Wieg. Soft Rush.	-	-	-	-	F	-
<i>J. marginatus</i> Rostk. Grass-leaved Rush.	-	-	-	-	O	-
<i>J. tenuis</i> Willd. Path Rush.	R	-	-	-	I	I
† <i>Luzula multiflora</i> (Retz.) Lejeune. Common Wood Rush.	R	-	-	-	-	-
Lamiaceae (Mint Family)						
<i>Collinsonia canadensis</i> L. Richweed.	I	-	-	-	-	-
† <i>Hedeoma pulegioides</i> (L.) Pers. American Pennyroyal.	-	-	R	-	-	-
* <i>Lamium purpureum</i> L. Purple Dead Nettle.	-	-	-	-	-	R
<i>Lycopus virginicus</i> L. Bugleweed.	-	-	-	-	O	-
<i>Monarda clinopodia</i> L. Basil Bee Balm.	-	-	-	R	-	R
† <i>M. fistulosa</i> L. Wild Bergamot.	R	-	-	I	-	-
†* <i>Prunella vulgaris</i> L. Selfheal.	O	O	-	-	-	R
† <i>Pycnanthemum incanum</i> (L.) Michx. Hoary Mountain Mint.	-	R	I	-	-	I
<i>Salvia lyrata</i> L. Lyre-leaved Sage.	I	-	-	-	I	-
<i>Scutellaria elliptica</i> Muhl. Hairy Skullcap.	R	-	-	R	-	-
† <i>Stachys nuttallii</i> Shuttlw. ex Benth. Nuttall's Hedge Nettle.	I	-	-	I	-	-
Lauraceae (Laurel Family)						
<i>Sassafras albidum</i> (Nutt.) Nees. White Sassafras.	O	O	O	O	-	-
Liliaceae (Lily Family)						
†* <i>Allium vineale</i> L. Field Garlic.	I	R	-	-	-	-
† <i>Erythronium americanum</i> Ker-Gawl. Yellow Trout Lily.	I	-	-	-	-	-
†* <i>Hemerocallis fulva</i> L. Orange Day-lily.	-	-	-	R	-	-
†* <i>Narcissus pseudonarcissus</i> L. Daffodil.	-	-	-	R	-	-
† <i>Polygonatum biflorum</i> (Walt.) Eil. True Solomon's Seal.	R	-	-	I	-	-
<i>Smilacina racemosa</i> (L.) Desf. False Solomon's Seal.	I	-	-	I	-	-
<i>Trillium grandiflorum</i> (Michx.) Salisb. Large White Trillium.	R	-	-	-	-	-
<i>Uvularia grandiflora</i> Smith. Bellwort.	R	-	-	-	-	-
Linaceae (Flax Family)						
† <i>Linum striatum</i> Walt. Stiff Yellow Flax.	-	R	-	-	-	-
<i>L. virginianum</i> L. Slender Yellow Flax.	-	R	-	-	R	-
Magnoliaceae (Magnolia Family)						
o <i>Liriodendron tulipifera</i> L. Yellow Poplar.	F	F	O	O	-	-
† <i>Magnolia acuminata</i> L. Cucumber-tree.	I	-	-	I	-	-
Menispermaceae (Moonseed Family)						
† <i>Menispermum canadense</i> L. Canadian Moonseed.	R	-	-	-	-	-
Oleaceae (Olive Family)						
o <i>Fraxinus americana</i> L. White Ash.	A	F	O	A	-	-
Onagraceae (Evening Primrose Family)						
<i>Circaea lutetiana</i> L. var. <i>canadensis</i> L. Enchanter's Nightshade.	I	-	-	-	-	-
† <i>Epilobium coloratum</i> Biechler. Cinnamon Willow Herb.	-	-	-	-	I	-
† <i>Ludwigia alternifolia</i> L. Seedbox.	-	-	-	-	I	-

<i>Oenothera biennis</i> L. Evening Primrose.	-	R	-	-	-	R
Orchidaceae (Orchid Family)						
<i>Aplectrum hyemale</i> (Muhl.) Torr. Crane-fly Orchid.	R	-	-	-	-	-
<i>Goodyera pubescens</i> (Willd.) R. Br. Rattlesnake Plantain.	R	-	-	-	-	-
<i>Habenaria lacera</i> (Michx.) Lodd. Ragged Fringed Orchid.	R	-	-	-	-	-
† <i>Liparis loeselii</i> (L.) L. Rich. Green Twayblade.	-	-	-	-	O	-
<i>Spiranthes lacera</i> (Raf.) Raf. Slender Ladies' Tresses.	-	-	R	-	-	-
Oxalidaceae (Wood Sorrel Family)						
* <i>Oxalis comiculata</i> L. Creeping Wood Sorrel.	-	-	-	-	-	R
† <i>O. grandis</i> Small. Large Yellow Wood Sorrel.	I	-	-	-	-	-
<i>O. stricta</i> L. Common Wood Sorrel.	-	-	-	-	-	I
Paeoniaceae (Peony Family)						
†* <i>Paeonia officinalis</i> L. Common Peony.	-	-	-	R	-	-
Papaveraceae (Poppy Family)						
<i>Sanguinaria canadensis</i> L. Bloodroot.	R	-	-	-	-	-
Phytolaccaceae (Poke Family)						
† <i>Phytolacca americana</i> L. American Pokeweed.	-	O	I	O	-	I
Plantaginaceae (Plantain Family)						
* <i>Plantago lanceolata</i> L. English Plantain.	I	O	-	-	-	O
<i>P. rugelii</i> Decne. Rugel's Plantain.	I	I	-	-	-	O
Platanaceae (Plane Tree Family)						
† <i>Platanus occidentalis</i> L. American Sycamore.	F	O	I	O	O	-
Poaceae (Grass Family)						
* <i>Agrostis gigantea</i> Roth. Redtop.	O	I	-	-	O	-
<i>A. perennans</i> (Walt.) Tuckerm. Autumn Bentgrass.	-	-	O	-	-	R
†+ <i>Alopecurus arundinaceus</i> Poir. Creeping Foxtail.	O	-	-	-	I	-
<i>Andropogon virginicus</i> L. Broomsedge.	F	F	O	-	-	I
<i>Brachyelytrum erectum</i> (Schreb.) Beauv. Awned Woodgrass.	-	-	-	R	-	-
†* <i>Bromus japonica</i> Thunb. Japanese Chess.	I	O	-	-	-	I
<i>B. pubescens</i> Muhl. Woodland Brome.	-	-	-	R	-	-
†* <i>Dactylis glomerata</i> L. Orchard Grass.	O	O	-	-	-	R
† <i>Danthonia compressa</i> Aust. Mountain Oatgrass.	O	I	F	R	-	-
†* <i>Digitaria ischaemum</i> Schreb. Smooth Crabgrass.	I	I	-	-	-	O
†* <i>Echinochloa crusgalli</i> (L.) Beauv. Barnyard Grass.	I	-	-	-	O	-
† <i>Elymus hystrix</i> L. Bottlebrush Grass.	R	-	-	-	-	-
† <i>E. virginicus</i> L. Virginia Wild Rye.	I	-	-	-	-	-
†* <i>Elytrigia repens</i> (L.) Nevski. Quackgrass.	-	R	-	-	-	R
† <i>Eragrostis capillaris</i> (L.) Nees. Lacegrass.	-	-	-	-	-	I
† <i>E. frankii</i> C. A. Mey. Sandbar Lovegrass.	-	-	-	-	-	R
†+* <i>Festuca elatior</i> L. Tall Fescue.	A	A	I	O	-	I
<i>Leersia virginica</i> Willd. White Grass.	-	-	-	-	O	-
* <i>Microstegium vimineum</i> (Trin.) Camas. Eulalia.	A	A	O	A	-	I
† <i>Muhlenbergia frondosa</i> (Poir.) Fem. Satin Grass.	-	-	-	-	I	-
† <i>M. schreberi</i> J. F. Gmel. Nimblewill.	-	R	-	-	-	-
† <i>Panicum boscii</i> Poir. Wide-leaved Panic Grass.	O	O	-	I	-	-
† <i>P. capillare</i> L. Old Witch Grass.	-	R	-	-	-	R
† <i>P. clandestinum</i> L. Deer-tongue Panic Grass.	F	O	-	O	O	-
† <i>P. commutatum</i> Schultes. Ashe's Panic Grass.	O	I	-	O	-	-
<i>P. dichotomiflorum</i> Michx. Spreading Witch Grass.	-	-	-	-	I	I
<i>P. dichotomum</i> L. Forked Panic Grass.	-	-	-	-	F	-
† <i>P. lanuginosum</i> Ell. Hairy Panic Grass.	F	O	I	F	-	-
<i>P. polyanthes</i> Schultes. Small-fruited Panic Grass.	O	O	-	O	-	-
* <i>Phleum pratense</i> L. Timothy.	I	O	-	-	-	-
† <i>Poa alsodes</i> A. Gray. Grove Bluegrass.	-	-	-	R	-	-
†* <i>P. compressa</i> L. Canada Bluegrass.	I	I	-	-	-	I
† <i>P. cuspidata</i> Nutt. Short-leaved Bluegrass.	-	-	-	R	-	-
* <i>P. pratensis</i> L. Kentucky Bluegrass.	O	O	-	-	-	I
†* <i>Setaria faberii</i> Herrm. Nodding Foxtail.	O	-	I	-	-	I
* <i>S. glauca</i> (L.) Beauv. Yellow Foxtail.	R	-	-	-	-	R

† <i>Sphenopholis obtusata</i> (Michx.) Scribn. Prairie Wedgegrass.	I	I	R	-	-	-
† <i>Sporobolus vaginiflorus</i> (Torr.) Wood. Dropseed.	-	-	R	-	-	O
†* <i>Triticum aestivum</i> L. Wheat.	-	R	-	-	-	-
Polemoniaceae (Phlox Family)						
<i>Phlox amplifolia</i> Britt. Wide-leaved Phlox.	I	-	-	-	-	-
Polygalaceae (Milkwort Family)						
† <i>Polygala senega</i> L. Seneca Snakeroot.	I	I	-	-	-	-
Polygonaceae (Smartweed Family)						
* <i>Polygonum aviculare</i> L. Common Knotweed.	-	-	-	-	-	R
+* <i>Polygonum cuspidatum</i> Sieb. & Zucc. Japanese Knotweed.	O	O	O	O	-	-
<i>P. pensylvanicum</i> L. Pennsylvania Pinkweed.	-	I	-	-	-	I
* <i>P. persicaria</i> L. Lady's Thumb.	-	-	-	-	-	I
† <i>P. punctatum</i> Ell. Dotted Smartweed.	-	-	-	-	R	I
<i>P. sagittatum</i> L. Arrow-leaved Tearthumb.	-	-	-	-	I	-
<i>P. scandens</i> L. Climbing False Buckwheat.	F	I	-	F	-	O
<i>P. virginianum</i> L. Virginia Knotweed.	R	I	-	-	-	-
†* <i>Rumex crispus</i> L. Curly Dock.	I	I	-	-	R	I
* <i>R. obtusifolius</i> L. Bitter Dock.	I	I	-	-	-	I
Portulacaceae (Purslane Family)						
<i>Claytonia virginica</i> L. Spring Beauty.	I	-	-	-	-	-
Primulaceae (Primrose Family)						
† <i>Lysimachia quadrifolia</i> L. Whorled Loosestrife.	-	-	I	-	-	I
<i>L. tonsa</i> (Wood) Kunth. Appalachian Loosestrife.	-	I	I	-	-	I
Ranunculaceae (Buttercup Family)						
† <i>Anemone virginiana</i> L. Thimbleweed.	I	O	-	I	-	-
† <i>Anemonella thalictroides</i> (L.) Spach. Rue Anemone.	I	I	-	-	-	-
† <i>Clematis glaucophylla</i> Small. Glaucous-leaved Clematis.	-	-	-	-	-	I
<i>C. virginiana</i> L. Virgin's Bower.	A	A	-	A	-	I
† <i>Delphinium tricorne</i> Michx. Dwarf Larkspur.	R	-	-	-	-	-
<i>Ranunculus abortivus</i> L. Small-flowered Buttercup.	O	O	-	-	-	I
† <i>R. hispidus</i> Michx. Hispid Buttercup.	I	I	-	O	-	-
<i>R. recurvatus</i> Poir. Hooked Crowfoot.	I	I	-	-	-	-
<i>Thalictrum dioicum</i> L. Early Meadow-rue.	I	I	-	O	-	-
Rosaceae (Rose Family)						
† <i>Agrimonia rostellata</i> Wallr. Beaked Agrimony.	O	I	-	O	-	I
<i>Fragaria virginiana</i> Duchesne. Virginia Strawberry.	F	F	O	-	-	I
<i>Geum canadense</i> Jacq. White Avena.	O	-	-	O	-	-
<i>Potentilla canadensis</i> L. Canada Cinquefoil.	I	O	O	-	-	I
†* <i>P. norvegica</i> L. Rough Cinquefoil.	-	I	-	-	-	I
* <i>P. recta</i> (L.) Raeusch. Upright Cinquefoil.	I	-	-	-	-	-
† <i>P. simplex</i> Michx. Common Cinquefoil.	O	O	I	-	-	I
<i>Prunus serotina</i> Ehrh. Wild Black Cherry.	I	I	-	-	-	-
†* <i>Rosa multiflora</i> Thunb. Multiflora Rose.	I	I	-	I	-	-
<i>Rubus allegheniensis</i> Porter. Allegheny Blackberry.	A	A	I	F	O	I
† <i>R. flagellaris</i> Willd. Common Dewberry.	O	F	I	O	-	I
† <i>R. occidentalis</i> L. Black Raspberry.	O	O	I	O	-	-
† <i>Spiraea tomentosa</i> L. Pink Steeplebush.	-	-	-	-	O	-
Rubiaceae (Madder Family)						
<i>Galium aparine</i> L. Annual Cleavers.	F	F	-	A	-	I
<i>G. latifolium</i> Michx. Wide-leaved Bedstraw.	-	-	-	I	-	-
† <i>G. triflorum</i> Michx. Sweet-scented Bedstraw.	O	-	-	O	-	-
<i>Hedyotis caerulea</i> (L.) Hook. Spring Bluets.	O	O	O	-	-	R
<i>H. purpurea</i> (L.) T. & G. Large Summer Bluets.	I	I	-	-	-	-
Salicaceae (Willow Family)						
† <i>Salix nigra</i> Marsh. Black Willow.	F	-	-	-	F	-
† <i>S. sericea</i> Marsh. Silky Willow.	F	-	-	-	F	-
Saxifragaceae (Saxifrage Family)						
<i>Heuchera americana</i> L. Common Alum-root.	-	-	R	-	-	-

Scrophulariaceae (Figwort Family)						
<i>Aureolaria laevigata</i> (Raf.) Raf. Smooth False Foxglove.	-	-	-	R	-	-
† <i>Mimulus ringens</i> L. Common Monkey-flower.	-	-	-	-	I	-
<i>Pedicularis canadensis</i> L. Wood Betony.	R	-	-	-	-	-
† <i>Penstemon brevisepalis</i> Pennell. Appalachian Beard-tongue.	-	R	I	-	-	R
* <i>Verbascus thapsus</i> L. Common Mullein.	-	-	-	-	-	R
†* <i>Veronica arvensis</i> L. Corn Speedwell.	-	O	-	-	-	I
†* <i>V. hederifolia</i> L. Ivy-leaved Speedwell.	R	R	-	-	-	-
* <i>V. officinalis</i> L. Common Speedwell.	I	I	-	-	-	-
Simaroubaceae (Quassia Family)						
* <i>Ailanthus altissima</i> (Mill.) Swingle. Tree-of-heaven.	-	-	R	-	-	-
Smilacaceae (Greenbrier Family)						
† <i>S. glauca</i> Walt. Glauous Greenbrier.	F	F	I	O	-	I
<i>S. herbacea</i> L. Herbaceous Carrion Flower.	R	-	-	-	-	-
† <i>S. rotundifolia</i> L. Common Greenbrier.	F	F	O	I	-	-
Solanaceae (Nightshade Family)						
† <i>Datura stramonium</i> L. Jimson Weed.	-	-	-	-	-	R
† <i>Solanum americanum</i> Mill. Black Nightshade.	-	-	-	-	-	R
<i>S. carolinense</i> L. Horse Nettle.	-	I	-	-	-	I
Tiliaceae (Linden Family)						
<i>Tilia americana</i> L. American Basswood.	I	-	-	I	-	-
Typhaceae (Cattail Family)						
† <i>Typha latifolia</i> L. Common Cattail.	-	-	-	-	A	-
Ulmaceae (Elm Family)						
† <i>Ulmus rubra</i> Muhl. Red Elm.	I	R	-	I	-	-
Urticaceae (Nettle Family)						
† <i>Laportea canadensis</i> (L.) Wedd. True Nettle.	O	-	-	F	-	-
<i>Pilea pumila</i> (L.) A. Gray. Clearweed.	O	O	-	O	-	-
Verbenaceae (Vervain Family)						
<i>Verbena urticifolia</i> L. Hairy White Vervain.	I	-	-	-	R	-
Violaceae (Violet Family)						
† <i>Hybanthus concolor</i> (Forster) Spreng. Green Violet.	R	-	-	-	-	-
† <i>Viola canadensis</i> L. Canada Violet.	O	I	-	F	-	-
† <i>V. eriocarpa</i> Schwein. Smooth Yellow Violet.	I	I	-	I	-	-
† <i>V. hirsutula</i> Brainerd. Southern Woolly Violet.	-	R	I	-	-	-
† <i>V. rostrata</i> Pursh. Long-spurred Violet.	I	-	-	-	-	-
<i>V. rotundifolia</i> Michx. Round-leaved Yellow Violet.	R	-	-	-	-	-
† <i>V. sororia</i> Willd. Common Blue Violet.	F	O	R	O	-	-
† <i>V. palmata</i> L. Lobed Violet.	-	I	I	I	-	-
Vitaceae (Grape Family)						
<i>Parthenocissus quinquefolia</i> (L.) Planch. Virginia Creeper.	I	R	I	O	-	-
<i>Vitis aestivalis</i> Michx. Summer Grape.	I	R	-	O	-	-

Habitat Total Species:

223 160 98 109 53 104

Code: (†) Bell County records; (+) Introduced planted taxa; (o) Native planted taxa; (*) Non-indigenous taxa.
 Relative abundance values: R=rare; I=infrequent; O=occasional; F=frequent; A=abundant.
 Habitats: 1=1963 bench; 2=1970 bench; 3=highwalls; 4=outslopes; 5=seeps, 6=access road.
 [Note: Methods section].

4.0-4.9 which is the overall lowest pH sampled (Table 1). Virginia pine exhibits vigorous reproduction and growth. It has spread by seed to the outslopes, highwalls, the 1963 bench (Table 2), the 1970 bench and into the mixed hardwood forest. Nearly all the loblolly pine and eastern white pine and most of the shortleaf pine were destroyed by the mining of the

1970 area. Only three loblolly pines and 10 eastern white pine have persisted on this highwall plantation. Shortleaf pine has some seedling and sapling reproduction evident on the highwall and on the 1970 bench. Shrubs and herbs in this dry exposed area are representative of the species of the general highwall habitat.

Outslopes. The 1964 outslope plantings of tall fescue and Korean lespedeza have exhibited fair to good success. Black locust was heavily seeded in 1965 on the steep 1963 outslope after slumping of the bench occurred in 1964. Bench plantings of European black alder, autumn olive, and bicolor lespedeza have spread onto the outslope as have yellow poplar, white ash, sugar maple, and red maple. Shrubs and vines include wild hydrangea, poison ivy, common elderberry, virgin's bower, multiflora rose, and Japanese honeysuckle. The herbaceous layer is dominated by pioneer planted and volunteer species in the Poaceae, Asteraceae, Fabaceae, and Rosaceae. A total of 109 taxa were recorded from the outslopes (Table 3).

The black locust stand on the 1970 site B outslope at LMDA was one of several sites in the black locust provenance studies by Ashby et al. (1985). Black locust was initially hydroseeded in 1971 on the 1970 outslope and bench. By 1977, black locust seedlings had grown through the tall fescue and sericea lespedeza to form dense seedling thickets. This black locust stand had a density of 716 trees per hectare with a third of the trees dead in 1982. Most of the 482 live black locust trees per hectare were less than 1.0 dm dbh. The shade-tolerant tall fescue dominated about one-third of the open areas. A rich cover of white snakeroot, orange jewelweed (*Impatiens capensis*), pokeweed, eulalia, and other woodland herbs covered the remainder of the area (Ashby et al. 1985).

Sugar maple, red maple, white ash, and other more shade-tolerant volunteers, were replacing black locust. However, invasion was meager partly because of the vigorous herbaceous cover and scarcity of seed sources (Ashby et al. 1985). Other invading trees documented in the stand were yellow poplar, wild black cherry, sourwood, blackgum, sassafras, autumn olive, red elm, and Virginia pine. Vines and shrubs included virgin's bower, American elderberry, wild hydrangea, summer grape, Virginia creeper, poison ivy, and common greenbrier (Ashby and Vogel, USDA, unpublished data 1992).

LMDA Seeps. Wet seep pools are found on the 1963 site A bench in Scotch pine plantations of Area 5, yellow poplar plantations of Area 6, and on the 1970 site B bench at the highwall base. These wet depressions retain water throughout most of the growing season and support wetland vegetation. We collected 53 species from the seeps (Table 3). The woody plant zone is dominated by black willow (*Salix nigra*), silky willow (*S. sericea*), and pink steplebush (*Spiraea tomentosa*). At the border of the woody zone is a common cattail (*Typha latifolia*)-woolgrass (*Scirpus cyperinus*) emergent zone. Other emergent species are soft rush (*Juncus effusus*), blunt

spikerush (*Eleocharis ovata*), and blue-green bulrush (*Scirpus atrovirens*).

Wet meadow species adjacent to the tree and emergent zones comprise the sedge (*Carex*)-rush (*Juncus*) zone. Wetland indicator herbs include yellow-green sedge (*Carex lurida*), Frank's sedge (*C. frankii*), fox sedge (*C. vulpinoidea*), beakrush (*Rhynchospora capitellata*), sharp-pointed rush (*Juncus acuminatus*), seedbox (*Ludwigia alternifolia*), great blue lobelia (*Lobelia siphilitica*), marsh St. John's-wort (*Hypericum mutilum*), bugleweed (*Lycopus virginicus*), deer-tongue panicum, and common horsetail (*Equisetum arvense*).

Two unique plants for Kentucky are present in the sedge-rush zone. Creeping foxtail (*Alopecurus arundinaceus*), recorded only from North Dakota and Newfoundland, is becoming naturalized at LMDA (Thompson and Thieret 1986a). The rare green twayblade (*Liparis loeselii*), is a new distribution record which was previously known from only a single county in Kentucky (Thompson and MacGregor 1986b).

Coal Haul-Telephone Microwave Tower Road. This highly compacted access road is maintained in an early, pioneer seral stages from the continual disturbance by vehicles. Indicator herbs are mainly composed of many weedy native and exotic annuals, biennials, and perennials of the Asteraceae, Poaceae, Fabaceae, Rosaceae, and Polygonaceae. A few herbs found are common ragweed (*Ambrosia artemisiifolia*), daisy fleabane (*Erigeron annuus*), horseweed (*Conyza canadensis*), Korean lespedeza, sericea lespedeza, wild carrot, English plantain (*Plantago lanceolata*), milk spurge (*Euphorbia nutans*), smooth crabgrass (*Digitaria ischaemum*), nodding foxtail (*Setaria faberii*), and tall fescue. This ruderal habitat had 104 taxa recorded (Table 3).

LMDA Flora Summary

The annotated list is composed of 360 specific and infraspecific taxa in 224 genera from 82 families. A total of 74 species (20.6%) were non-indigenous introduced or naturalized (Table 3). Vascular plants consist of 1 Lycopodiophyta, 1 Equisetophyta, 8 Polypodiophyta, 7 Pinophyta, and 343 Magnoliophyta (82 Liliopsida, 261 Magnoliopsida). The largest plant families numerically are the Asteraceae (64), Poaceae (39), Fabaceae (20), Cyperaceae (16), Rosaceae (13), Lamiaceae (11), and Polygonaceae (10). Three threatened Kentucky species, Appalachian showy gentian, green twayblade, and ovate-leaved catchfly, are found in habitats created by surface mining. A total of 155 (43.1%) were Bell County distribution records (Table 3).

Discussion

Planted Species Evaluation

Twenty-four of 25 reclamation species (96.0%) originally planted during 1964, 1965, 1971, and 1984, are persisting at the LMDA through 1985. Several legumes are contributing to soil enrichment and community development. Several hardwoods and conifers are important to plant community structure and for potential forestry products. Woody and herbaceous exotic species are becoming locally naturalized and important in revegetation and plant succession on LMDA.

We recommend eleven successful planted species at LMDA for other contour surface-mined areas or similarly disturbed areas in the Cumberland Mountains. The plantings of tall fescue, sericea lespedeza, and Korean lespedeza, have been important for initial plant cover and site development throughout the LMDA habitats. Crown-vetch, red clover, white sweet clover, and yellow sweet clover, have enhanced overall cover, but to a lesser degree than tall fescue, sericea lespedeza, and Korean lespedeza. European black alder, autumn olive, and bicolor lespedeza are important soil enrichment species spreading on outslopes and benches. Black locust has significantly influenced the development of the young hardwood forest. This important early pioneering species contributes to soil nitrogen-fixation processes, litter production from dead trees, and serves as a nurse tree for other species.

Sugar maple, yellow poplar, and white ash are important volunteers in secondary succession throughout the LMDA habitats. Virginia pine is an important invader in other mine habitats. Shortleaf pine has been less successful in survival and migration. Eastern white pine and loblolly pine have not survived well partly because of destruction during remining in 1970. Scotch pine and Norway spruce on the 1963 bench have potential for forest products although these introduced trees are not reproducing from their own seed sources.

We do not highly recommend some woody plantings that have persisted at LMDA until more experimental planting research has been done or other potential choices have been tried. American sycamore and northern red oak have not grown as well as several other planted hardwood trees on the 1963 bench. American sycamore, northern red oak, and black walnut are not growing well on the 1984 block plots on the 1970 bench, although it is too early for final evaluation. The only planted species not recommended for planting is saw-tooth oak which did not survive at LMDA.

LMDA as a Refugium for Rare Species

The Log Mountain Demonstration Area has provided new habitats for at least three Kentucky "endangered" plant species. The second Kentucky documentation of the green twayblade (*Liparis loeselii*) was recorded in the sedge-rush 1963 bench seeps (Thompson and MacGregor 1986b). The ovate-leaved catchfly (*Silene ovata*) and the Appalachian showy gentian (*Gentiana decora*), were found on the 1963 bench (Table 3).

Wade and Thompson (1993) reported that five pre-SMCRA surface-mined sites in Kentucky have provided important habitats for certain rare plant species not found in the undisturbed or non-mined environs. All five revegetated pre-SMCRA coal-mined sites in the Cumberland Mountains and Cumberland Plateau have provided habitats for one or more Kentucky endangered or threatened species listed by Warren et al. (1986). None of these rare Kentucky species were found in the adjacent non-mined environs of these coal mined sites during the initial or subsequent reconnaissances. While presence of these rare species outside of the immediate environs is unreported or unknown, the establishment of rare species has occurred in habitats created on the pre-SMCRA coal mined areas in the Cumberland Mountains and Cumberland Plateau. The potential status of these rare species is not predictable because of continual vegetation development, potential environmental changes, or anthropogenical effects in the future (Thompson and Wade 1991).

We classify these restricted habitats created by pre-law surface mining in Kentucky as "refugia" where rare species have become established. These unique habitats have served as suitable refuges for certain rare plants that might otherwise have become more rare or even extirpated from the region. In Europe, abandoned rock quarries (Usher 1979, Wartner 1983), and surface-mined lands (Bruns 1986, Dahl and Juering 1982, Sanderson 1992) have served as refugia for many rare species not found elsewhere.

LMDA Floristic Richness

Species richness is a measure of success in the reclamation process in conjunction with natural plant succession. At the LMDA, the 360 species are comparable to two other pre-law coal mined sites in the Cumberland Plateau of Kentucky. A total of 350 species were found on an 18-year-old area-type surface mine of 14.0 ha in Laurel County (Thompson et al. 1984); 272 species were present on a 12-year-old contour surface-mined area of 2.5 ha in

Rockcastle County (Thompson and Wade 1991). The Asteraceae, Poaceae, Fabaceae, Cyperaceae, and Rosaceae, were also the largest families on the other four pre-SMCRA mines sites in eastern Kentucky (Wade and Thompson 1993). The 360 species at LMDA represent 11.5% of the total flora for Kentucky based on Browne and Athey (1992).

A species-area curve was derived to compare species that were "found" with those "expected" in different-sized areas within the Western and Mixed Mesophytic Forest Region (Wade and Thompson 1991, 1993). We found that the actual species richness at the LMDA is only two percent less than species richness expected. At four other pre-SMCRA Kentucky surface-mined sites, species richness ranged from only three to 12 percent less than predicted. The 155 distribution records indicate the sparseness of plant collections and botanical exploration in Bell County.

LMDA Vegetation and Secondary Succession

The contour-mining and reclamation efforts have created six physical habitats with mine soils significantly different from the non-mined contiguous ridgetops of the disturbed mixed mesophytic hardwood forest. While contour-mining disturbance at LMDA removed most of the original soils with the geologic substrate, seed bank diaspores or propagules were intermixed with surface minespoils. Planted nitrogen-fixing trees and herbs helped ameliorate the rapidly weathering mine soils. Planted exotics and native invaders have influenced the species composition during the early secondary successional stages. Shade-intolerant, pine and hardwood seedlings have become established from wind-transported seeds and fruits.

The disturbed mixed mesophytic hardwood forest above the highwall is important as diaspore or propagule source for overall high species richness and natural successional trends at the LMDA. This forest has a well-developed canopy with seedlings and saplings evident, a sparse subcanopy and shrub layers, and a rich herbaceous layer. Important trees are sugar maple, red maple, yellow poplar, American basswood (*Tilia americana*), yellow buckeye (*Aesculus flava*), white ash, sourwood, red pignut hickory (*Carya ovalis*), white oak (*Quercus alba*), chestnut oak (*Q. prinus*), and northern red oak. Flowering dogwood (*Cornus florida*) and eastern redbud are two important subcanopy trees. Shrubs and vines are common greenbrier, glaucous greenbrier, Virginia creeper, summer grape, and wild hydrangea.

The forest vegetation at LMDA is a complex mosaic of natural and semi-natural plant communities in various of secondary seral stages in the LMDA habitats. Plant communities are the result of habitat diversity created by surface-mining, reclamation, and mine soil characteristics. High species richness is a function of volunteering species from the environs, planted reclamation species, and the remnant seed bank of the pre-mining habitats at LMDA. Species richness, vegetation development, and habitat diversity at LMDA are comparable to other pre-SMCRA surface-mined area in the Cumberland Plateau of Kentucky (Thompson et al. 1984, 1986c, Thompson and Wade 1991, Wade and Thompson 1993).

Conclusions

Several interrelated factors have been ascertained from descriptive research data of the pre-SMCRA Log Mountain Demonstration Area:

1. Habitat diversity created by pre-law coal surface mining supports a high species richness comparable to the contiguous non-mined environs.
2. Habitats from pre-SMCRA mining serve as refugia for certain rare plants that are not present in the unmined contiguous habitats or environs.
3. The entire flora is derived from the remnant seed bank, native and exotic invaders from the environs, and the planted native and exotic reclamation species.
4. Plant communities are developing mainly through seral stages of secondary succession with the strong influence of the natural invading and planted native and exotic flora.
5. Vegetation is a complex mosaic of natural and semi-natural plant communities progressing toward a young mixed hardwood forest on the planted and unplanted surface-mined habitats.
6. Twenty-four of 25 native and exotic species have persisted from plantings by personnel of the USDA Forest Service.
7. Nitrogen-fixing species important for soil and site enrichment are black locust, European black alder, autumn olive, bicolor lespedeza, sericea lespedeza, Korean lespedeza, and red clover.
8. Native trees recommended as reclamation plantings for vegetational development are black locust, white ash, yellow poplar, sugar maple, and Virginia pine.
9. Naturalized herbaceous taxa recommended for reclamation ground cover and pioneer species are tall fescue, sericea lespedeza, Korean lespedeza, and red clover.
10. Introduced woody trees recommended for potential forestry products are Norway spruce and Scotch pine.

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Literature Cited

- Ashby, W. C., W. G. Vogel, and N. F. Rogers. 1985. Black locust in the reclamation equation. USDA For. Ser. NE For. Exp. Stat., Gen. Tech. Rep. NE-105, Broomall, PA. 12 p.
- Beal, E. O. and J. W. Thieret. 1986. Aquatic and wetland plants of Kentucky. Kentucky Nature Preserves Commission, Sci. and Tech. Ser., No. 5. 314 p.
- Braun, E. L. 1943. An annotated catalogue of spermatophytes of Kentucky. John W. Swift Co., Cincinnati, OH. 161 p.
- Braun, E. L. 1950. Deciduous forests of eastern North America. Hafner Publ. Co., NY. 596 p.
- Brower, J. E. and J. H. Zar. 1977. Field and laboratory methods for general ecology. Wm. C. Brown Publishers, Dubuque, IA. 197 p.
- Browne, Jr., E. T. and R. Athey. 1992. Vascular plants of Kentucky. The University Press of Kentucky. Lexington, KY. 180 p.
- Bruns, D. 1986. Does "reclamation by natural colonization" produce desirable environments? Pp. 45-49 in J. Harper and B. Plass, eds., "New Horizons for Mined Land Reclamation," Proceedings, ASSMR National Meeting, March 17-20, 1986, Jackson, MS.
<https://doi.org/10.21000/JASMR86010045>
- Childress, J. D. 1992. Soil survey of Bell and Harlan Counties, Kentucky. USDA Soil Cons. Serv., Washington, DC. 181 p. + 15 maps.
- Cranfill, R. 1980. Ferns and fern allies of Kentucky. Kentucky Nature Preserves Commission, Sci. and Tech. Ser., No. 1. 284 p.
- Dahl, H. J. and P. Juerging. 1982. Abgrabungen als sukzessionslaeche fuer flora und fauna. Jahrbuch fuer naturschutz und landschaftspflege 32:55-88.
- Ettman, J. K. 1976. An annotated checklist of the orchidaceae of Bell County, Kentucky. Annals Ky. Nat. Hist. 3:1-7.
- Fenneman, N. M. 1938. Physiography of eastern United States. McGraw-Hill Book Co., Inc. NY. 714 p.
- Gleason, H. A. and A. Cronquist. 1963. Manual of vascular plants of the northeastern United States and adjacent Canada. D. Van Nostrand Co., NY. 810 p.
- Gleason, H. A. and A. Cronquist. 1991. Manual of vascular plants of the northeastern United States and adjacent Canada, second edition. New York Botanical Garden, NY. 910 p.
- Hinkle, C. R. 1975. A preliminary study of the flora and vegetation of Cumberland Gap National Historic Park, Middlesboro, Kentucky. M.S. Thesis, University of Tennessee, Knoxville. 236 p.
- Pounds, L., T. S. Patrick, and R. Hinkle. 1987. Rare plant assessment and revised park checklist for Cumberland Gap National Historic Park, U.S. Dept. Interior, Nat. Park Serv., Middlesboro, KY. 75 p.
- Rice, C. L. and E. K. Maughan. 1978. Geologic map of the Kayjay Quadrangle and part of the Fork Ridge Quadrangle, GQ1505, Bell and Knox Counties, Kentucky. U. S. Geological Survey, Reston, VA.
- Sanderson, R. A. 1992. Hemiptera of naturally vegetated derelict land in north-west England. Entomologist's Gazette 43:221-226.
- Strausbaugh, P. D. and E. L. Core. 1978. Flora of West Virginia, Second Edition. Seneca Books, Inc. Grantsville, WV. 1079 p.
- Swink, F. and G. Wilhelm. 1994. Plants of the Chicago region, 4th edition. Indiana Academy of Science, Indianapolis, IN. 921 p.
- Thompson, R. L., W. G. Vogel, and D. D. Taylor. 1984. Vegetation and flora of a coal surface-mined area in Laurel County, Kentucky. Castanea 49:111-126.

- Thompson, R. L. and J. W. Thieret. 1986a. *Alopecurus arundinaceus* (Poaceae) established in Kentucky. *Trans. Ky. Acad. Sci.* 47:138.
- Thompson, R. L. and J. R. MacGregor. 1986b. *Liparis loeselii* (Orchidaceae) documented in Kentucky. *Trans. Ky. Acad. Sci.* 47:138-139.
- Thompson, R. L., W. G. Vogel, G. L. Wade, and B. L. Rafail. 1986c. Development of natural and planted vegetation on surface mines in southeastern Kentucky. Pp. 145-153 in: J. Harper and B. Plass, eds., "New Horizons for Mined Land Reclamation," Proceedings, ASSMR National Meeting, March 17-20, 1986, Jackson, MS.
<https://doi.org/10.21000/JASMR86010145>
- Thompson, R. L. and G. L. Wade. 1991. Flora and vegetation of a 12-year-old coal surface-mined area in Rockcastle County, Kentucky. *Castanea* 56:99-116.
- University of Kentucky Agricultural Weather Center, Lexington, Kentucky. 1995. Interactive map for Kentucky climate data, 1960-1990. <<http://www.ca.uky.edu/agcollege/agweather/analysis2/middlesboro.htm./>>.
- Usher, M. B. 1979. Natural communities of plants and animals in disused quarries. *J. Environ. Manage.* 8:223-236.
- Vogel, W. G. 1981. A guide for revegetating coal minesoils in the eastern United States. USDA For. Serv. Tech. Rep. NE-68, Broomall, PA. 190 p.
- Wade, G. L., R. L. Thompson, and W. G. Vogel. 1985. Success of trees and shrubs in an 18-year-old planting on mine spoil. USDA For. Serv. NE For. Exp. Stat., Res. Pap. NE-567, Broomall, PA. 10 p.
- Wade, G. L., J. T. Crews, and W. G. Vogel. 1986. Development and productivity of forest plantations on a surface mine in south-eastern Kentucky. Pp. 184-193 in: C. A. Kolar, ed., "Better Reclamation with Trees," Proceedings, Fifth Annual Central Hardwoods Forest Conference, June 5-7, 1985, Carbondale, IL.
- Wade, G. L. and R. L. Thompson. 1991. The species-area curve and regional floras. *Trans. Ky. Acad. Sci.* 52:21-26.
- Wade, G. L. and R. L. Thompson. 1993. Species richness on five partially reclaimed Kentucky Surface Mines. Pp. 307-314 in: B. A. Zamora and R. E. Connolly, eds., "The Challenge of Integrating Diverse Perspectives in Reclamation," Proceedings, ASSMR National Meeting, May 16-19, 1993, Spokane, WA.
<https://doi.org/10.21000/JASMR93010307>
- Warren, M. L., W. H. Davis, R. R. Hannan, M. Evans, D. L. Batch, B. D. Anderson, B. Palmer-Ball, Jr., J. R. MacGregor, R. R. Cicerello, R. Athey, B. A. Branson, G. J. Fallo, B. M. Burr, M. E. Medley, and J. M. Baskin. 1986. Endangered, threatened, and rare plants and animals of Kentucky. *Trans. Ky. Acad. Sci.* 47:83-98.
- Wartner, H. 1983. Steinbrueche vom Menschen geschaffene lebensraeme. *Landschafts-oekologie weihenstephan*, Vol 4.