

THE HERBACEOUS FLORA OF MATURE CHESTNUT OAK FORESTS, NORTHWESTERN HIGHLAND RIM, KENTUCKY AND TENNESSEE

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ABSTRACT—The herbaceous stratum was sampled in 180 plots taken from 10 mature chestnut oak (*Quercus prinus* L.) stands in Lyon (1 stand) and Trigg (7) counties, Kentucky, and Stewart (2) County, Tennessee. All stands are on xeric, rocky-gravelly, nutrient-poor convex ridges and upper slopes within the Land Between The Lakes National Recreation Area. Coverage is mostly by bryophytes-lichens (relative cover 53.80%), bare ground, including exposed rock and gravel (18.78%), and leaf litter-other organic debris (17.09%). Total relative cover for the 119 herbaceous species is only 10.35%. An importance value (IV, maximum 200) was determined for each species by summing relative frequency (the percent contributed by a species to total frequency, where frequency is the number of plots occurrence of a species/180), and relative cover (the percent contributed by a species to total, visually-estimated cover). Based on percent of IV-200, *Danthonia spicata* (11.4%) and *Carex artecta* (10.1%) are the dominant species. Dominant families (based on total of IV's for taxa comprising a family) are: Poaceae (19.3), Cyperaceae (13.8), Asteraceae (13.1), Fabaceae (12.8), and Vitaceae (7.7). These five families (13.2% of families, 46.6% of species) contribute 67% of IV. Dominant genera (based on total of IV's for taxa comprising a genus) are *Carex* (13.8), *Danthonia* (11.4), *Lespedeza* (18.1), *Panicum* (5.9), *Vitis* (5.1), *Smilax* (4.2), and *Solidago* (3.3). These seven genera (0.9% of genera, 21.8% of species) account for 52% of IV. This study provides the first analysis of the herbaceous stratum of this forest type on the Northwestern Highland Rim. Results indicate a sparse flora (119 species) dominated by grasses-sedges in spring, progressing to a grasses-mints-legumes-composites flora in late summer-autumn. The data will provide a benchmark for future monitoring as these chestnut oak forests mature in the absence of fire and anthropogenic influences.

Many xeric, rocky-gravelly, nutrient-poor ridges and upper slopes of the Northwestern Highland Rim, Interior Low Plateaus, are dominated by chestnut oak, *Quercus prinus* L. (*Q. montana* Wild.), often comprising more than two-thirds of density and basal area (Chester et al., 1998). These forests have been anthropogenically disturbed in various ways, e.g., pasturing, selective timber removal (especially by the iron industry for charcoal production in the 1800–early 1900s), and fires. However, these forests essentially have been ignored this century because: (1) the soil is too poor and the slopes too steep for agriculture, and (2) the slow-growing chestnut oaks are not as commercially desirable as other species. Franklin and Fralish (1994), based on research by Fralish et al. (1991) in southern Illinois, have suggested that mature oak stands on such xeric, nutrient-poor sites are the best representatives of pre-European settlement forest communities in the region.

The herbaceous layer is an important and dynamic forest stratum that is receiving increasing attention in the study of forest communities (Gilliam and Turrill, 1993, Gilliam et al., 1995, Meier et al., 1995). However, little quantitative information is available on the herbaceous stratum of mature Tennessee-Kentucky forests (Baskin et al., 1987, Bryant et al., 1993, Chester, 1989). In reference to chestnut oak forests, Braun (1950) noted the lack of herbaceous diversity, and low numbers for herbaceous species were reported by Caplenor (1965) from the Cumberland Plateau, and by Condeley (1984) from the Ridge and Valley. Ches-

ter et al. (1995), Franklin and Fralish (1994), and Wheat and Dimmick (1987) studied forests of the Northwestern Highland Rim, including those dominated by chestnut oak, but did not characterize the herbaceous flora.

The goal of this research was to document and quantitatively characterize the herbaceous stratum of xeric-site, mature chestnut oak forests of the Northwestern Highland Rim, Kentucky and Tennessee. Herbaceous plants are defined herein as vascular species that are not woody, with the exception of woody vines such as *Parthenocissus quinquefolia* and semi-shrubs such as *Hypericum stragulum*.

MATERIALS AND METHODS

Field studies—Ten sites were selected based on (1) topography and xeric conditions, (2) the presence of numerous and mature chestnut oaks in the canopy, and (3) few if any signs of human disturbance. Within each site, 3–6, 0.04 ha circular macroplots (total of 45) were established along mid-slope or ridge transects. Plots were permanently marked with plastic stakes and identified by witness trees and distances. Each macroplot was divided into four equal subplots (total of 180, hereafter referred to as plots), each encompassing 10 m², arranged, numbered, and identified by polar coordinates. Preliminary sampling showed that smaller plots did not adequately sample the sparse herbaceous flora.

TABLE 1. Presence-class data for herbaceous species from ten mature chestnut oak stands on xeric sites, Northwestern Highland Rim, Kentucky and Tennessee.

Presence classes/definitions	Normal percent of taxa (Oosting, 1956)	Data for this study
1. rare, found in 1-20% of stands	56.0	55 species, 48.2%
2. seldom present, found in 21-40% of stands	16.0	15 species, 13.2%
3. often present, found in 41-60% of stands	9.3	11 species, 9.6%
4. mostly present, found in 61-80% of stands	9.3	13 species, 11.4%
5. constantly present, found in 81-100% of stands	9.3	20 species, 17.5%

Sampling was conducted from 12 May-23 June, 1997. During each site visit, plots and non-sampled areas of the forest stand were surveyed for floristic composition. Gleason and Cronquist (1991) was the primary source used in identifications; nomenclature follows Wofford and Kral (1993). The percentage of each plot covered by (1) bryophytes and lichens; (2) bare ground, including exposed rock and gravel; (3) leaf litter and other organic debris; and (4) each herbaceous species, was visually estimated in accordance with the percentage coverage scale of Daubenmire (1959, 1968) as modified by Bailey and Poulton (1968). Coverage classes, range of percentage cover for each, and class midpoints were: class 1 (0-1%, 0.5); 2 (1-5%, 3.0); 3 (5-25%, 15.0); 4 (25-50%, 37.5); 5 (50-75%, 62.5); 6 (75-95%, 85.0); and 7 (95-100%, 97.5). Each site was revisited between 22 July-19 September, 1997, and the flora-coverage classes reevaluated to include taxa not present in the earlier sampling and to observe seasonal progression of the flora.

Data analysis—Total flora, number of exotics, and richness per site were determined from samples and overall floristic observations. The most important families and genera based on numbers of taxa and elements of concern in Tennessee and/or Kentucky were determined. Presence (percentage of the 10 stands in which a given species occurred) and presence classes were defined and compared with the normal distribution (Oosting, 1956). The Sorenson Index of Similarity based on presence [$IS_s = (2C/A + B) \times 100$, where A is the number of species in stand 1, B the number in stand 2, C the number in common], was used to determine floristic similarity between stands (Barbour et al., 1987).

Major sampling categories (i.e., bryophytes and lichens; bare ground, including exposed rock and gravel; leaf litter and other

organic debris; and all herbaceous taxa) were first considered for quantitative analyses. For each category, frequency (the percent of 180 plots in which the sampling category was found), total cover (based on midpoints of estimated cover classes), average cover per plot (total cover/180), and relative cover (the percent contributed by a sampling category to total cover) were determined. Then, for each herbaceous species, frequency (the percent of 180 plots in which a species was found), relative frequency (the percent contributed by a species to total frequency), total cover (based on midpoints of estimated coverage classes), average cover (total cover/180), and relative cover (the percent contributed by a species to total cover) were determined. Importance value (200) was obtained for each species by summing the two relative values (Barbour et al., 1987).

RESULTS AND DISCUSSION

Site descriptions—The sites are in the Land Between the Lakes National Recreation Area, and include Lyon (1 site) and Trigg (7) counties, Kentucky, and Stewart (2) County, Tennessee. Three of the sites are on west-facing slopes directly above the Tennessee River at elevations of 122 ± 6 m above sea level. The other sites are on narrow ridge crests (hogbacks) and adjacent slopes at an elevation of 152 ± 6 m above sea level, but not directly adjacent to the river.

The bedrock at all sites is mostly cherty limestones of the Mississippian System, but a variety of parent materials has contributed to present soils, including thin loess, gravel, and chert. Most soils of the sites are of the Baxter and Bodine series and are highly porous, infertile, and droughty (Harris, 1988). Patches of Tuscaloosa white chert gravels/McNairy Sand (Cretaceous)

TABLE 2. Number of plots occurrence (of 180) for each sampling category, frequency (percent of 180 plots in which a sampling category occurred), average percent cover per plot based on visual estimates, and relative cover (the percent contributed to total cover) for four sampling categories: (1) bryophytes and lichens, (2) bare ground, including exposed rock and gravel, (3) leaf litter and other organic debris, and (4) herbaceous taxa, in ten mature chestnut oak stands on xeric sites, Northwestern Highland Rim, Kentucky and Tennessee.

Category	No. plots	Frequency	Average cover (%)	Relative cover
Bryophytes and lichens	180	100.00	57.29	53.80
Bare ground, exposed rock and gravel	177	98.33	19.99	18.78
Leaf litter and other organic debris	179	99.44	18.19	17.09
Herbaceous taxa	180	100.00	11.02	10.35
Totals	—	—	106.49	100.02

TABLE 3. Frequency (percent of 180 plots in which a species occurred), relative frequency (the percent contributed by a species to total frequency), average percent cover per plot based on visual estimates, relative cover (the percent contributed by a species to total cover), importance value-200 (sum of the two relative values), and %IV (IV/2) for herbaceous taxa in ten mature chestnut oak stands on xeric sites, Northwestern Highland Rim, Kentucky and Tennessee.

Taxa	Frequency	Relative frequency	Average cover	Relative cover	IV 200	Percent IV
<i>Danthonia spicata</i>	77.78	5.82	1.86	16.91	22.73	11.37
<i>Carex artitecta</i>	99.44	7.44	1.40	12.68	20.12	10.06
<i>Toxicodendron radicans</i>	57.78	4.33	0.63	5.72	10.05	5.03
<i>Smilax glauca</i>	37.78	2.83	0.54	4.89	7.72	3.85
<i>Cunila origanoides</i>	51.67	3.87	0.41	3.70	7.57	3.79
<i>Lespedeza hirta</i>	56.11	4.20	0.34	3.07	7.27	3.64
<i>Panicum dichotomum</i>	55.56	4.16	0.33	3.02	7.18	3.59
<i>Hieracium gronovii</i>	45.00	3.37	0.25	2.29	5.66	2.83
<i>Triodanis perfoliata</i>	20.00	1.50	0.44	3.96	5.46	2.73
<i>Hypericum stragulum</i>	46.11	3.45	0.22	1.99	5.44	2.72
<i>Vitis rotundifolia</i>	40.56	3.04	0.25	2.29	5.33	2.67
<i>Parthenocissus quinquefolia</i>	42.78	3.20	0.21	1.94	5.14	2.57
<i>Aster linariifolius</i>	41.11	3.08	0.21	1.89	4.97	2.49
<i>Vitis aestivalis</i>	40.00	2.99	0.21	1.94	4.93	2.47
<i>Lespedeza intermedia</i>	37.22	2.79	0.20	1.81	4.60	2.30
<i>Carex picta</i>	4.44	0.33	0.36	3.30	3.63	1.82
<i>Solidago erecta</i>	22.78	1.71	0.19	1.76	3.47	1.74
<i>Panicum depauperatum</i>	27.78	2.08	0.14	1.26	3.34	1.67
<i>Coreopsis major</i>	27.22	2.04	0.14	1.23	3.27	1.64
<i>Tephrosia virginiana</i>	27.22	2.04	0.14	1.23	3.27	1.64
<i>Hedyotis caerulea</i>	25.56	1.91	0.14	1.26	3.17	1.59
<i>Clitoria mariana</i>	19.44	1.46	0.13	1.13	2.59	1.30
<i>Euphorbia corollata</i>	21.67	1.62	0.10	0.91	2.53	1.27
<i>Lespedeza procumbens</i>	20.00	1.50	0.10	0.91	2.41	1.21
<i>Carex cephalophora</i>	19.44	1.46	0.09	0.83	2.29	1.15
<i>Antennaria plantaginifolia</i>	18.89	1.41	0.10	0.88	2.29	1.15
<i>Pteridium aquilinum</i>	16.11	1.21	0.11	0.98	2.19	1.10
<i>Solidago ulmifolia</i>	13.89	1.04	0.11	1.01	2.05	1.03
<i>Hedyotis purpurea</i>	16.11	1.21	0.08	0.73	1.94	0.97
<i>Luzula echinata</i>	15.00	1.12	0.09	0.78	1.90	0.95
<i>Lespedeza repens</i>	14.44	1.08	0.07	0.66	1.74	0.87
<i>Krigia biflora</i>	13.89	1.04	0.07	0.63	1.67	0.84
<i>Polygonatum biflorum</i>	13.89	1.04	0.07	0.63	1.67	0.84
<i>Desmodium nudiflorum</i>	12.78	0.96	0.06	0.58	1.54	0.77
<i>Galium circaeazans</i>	12.78	0.96	0.06	0.58	1.54	0.77
<i>Rosa carolina</i>	11.67	0.87	0.06	0.53	1.40	0.70
<i>Sphenopholis obtusata</i>	10.56	0.79	0.07	0.60	1.39	0.70
<i>Oxalis violacea</i>	10.56	0.79	0.05	0.48	1.27	0.64
<i>Panicum commutatum</i>	10.56	0.79	0.05	0.48	1.27	0.64
Subtotal: (39 species):	1155.58	86.53	10.08	91.47	178.00	89.00
Other 75 species:	180.12	13.48	0.94	8.53	22.01	11.01
Total	1335.70	100.01	11.02	100.00	200.01	100.01

and brown gravels (Tertiary-Quaternary) (Harris, 1988), often covering several m², are exposed on many sites.

The woody strata of these stands were previously sampled using the same 45 0.04 ha (0.1 acre) plots, and described and characterized by Chester et al. (1998). Based on an importance value (IV) of 300 (sum of relative frequency, relative density, and relative basal area), the canopy was found to be dominated by *Quercus prinus* (chestnut oak, 59.2% of IV 300), followed by

Oxydendrum arboreum (sourwood, 8.1%), *Q. velutina* (black oak, 6.7%), *Carya glabra* (pignut hickory, 5.1%), *Q. marilandica* (blackjack oak, 4.5%), *Q. stellata* (post oak, 4.2%), and *Q. alba* (white oak, 3.6%).

Floristic analyses—Based on plot sampling (114 species sampled) and floristic surveys (an additional five species observed), the known herbaceous flora of these stands consists of 119 species within 81 genera and 38 families. Only three taxa

(2.5%) are not native, indicating a lack of recent disturbance in the sampled areas. An annotated list of taxa with author citations is included. Richness (species per site) ranged from 29–61 with an average of 44.1. The three sites adjacent to the Tennessee River averaged 44 species/site while the seven sites on slopes and hogbacks not adjacent to the river averaged 43.3 species/site.

Five families, Asteraceae (19 taxa), Fabaceae (17), Poaceae (14), Cyperaceae (6), and Rosaceae (6) include 52.1% of the flora. Other large families are the Brassicaceae, Lamiaceae, and Rubiaceae (4 taxa each), and the Clusiaceae, Scrophulariaceae, Violaceae, and Vitaceae (3 each). In addition, six families include two taxa each and 21 families are represented by only one. Large genera are *Carex* and *Lespedeza* (6 taxa each), *Solidago* (5), *Aster*, *Panicum* and *Desmodium* (4 each), and *Hypericum* and *Viola* (3 each). Genera with two taxa are *Andropogon*, *Arabis*, *Asclepias*, *Galium*, *Hedyotis*, *Helianthus*, *Krigia*, *Oxalis*, *Rubus*, *Smilax*, and *Vitis*; 62 genera are represented by only one species.

The flora includes four species of semi-shrubs (*Hypericum stragulum*, *Rosa carolina*, *Rubus argutus* and *R. flagellaris*) and nine species of woody vines (*Bignonia capreolata*, *Campsis radicans*, *Parthenocissus quinquefolia*, *Smilax bona-nox* and *S. glauca*, *Toxicodendron radicans*, *Vitis aestivalis* and *V. rotundifolia*, and *Wisteria frutescens*). Three pteridophyte species were found but only one (*Pteridium aquilinum*) contributed significantly to the flora. No listed taxa for Kentucky or Tennessee were found (Kentucky State Nature Preserves Commission 1997, Tennessee Natural Heritage Program 1998).

Presence classes and normal distributions (Oosting, 1956) and presence class percentages found in the stands are given in Table 1. The number of site and plot occurrences for each species is given in the list of taxa. These results show that there are more "mostly and constantly present" and fewer "rare or seldom present" species, indicating a more uniform herbaceous flora in these chestnut oak stands than normally encountered.

Sorenson's Index of Similarity (IS_s) based on presence may range from 0 for two stands completely different in floristic composition to 100 for two identical stands; values >50 indicate that stands belong to the same association (Barbour et al., 1987). IS_s values for the 45 pairwise comparisons ranged from 47.73 to 75.56 with an average of 63.14; only one comparison was $<50\%$. These data indicate a close floristic similarity between the stands.

Herbaceous community structure—The herbaceous stratum is sparse and coverage is mostly by bryophytes-lichens (relative cover 53.80%), bare ground, including exposed rock and gravel (relative cover 18.78%), and leaf litter-other organic debris (relative cover 17.09%). The herbaceous taxa contributed only 10.35% of relative cover (Table 2). The 39 species contributing $>0.5\%$ each to total IV (89% of total IV) are ranked in Table 3. Two species, *Danthonia spicata* (IV 22.73) and *Carex artitecta* (IV 20.12), clearly are the dominating elements but are most noticeable in the spring-early summer flora. Other spring-early summer dominants are *Triodanis perfoliata* (5.46), *Aster linariifolius* (4.97), *Carex picta* (3.63, southern stands only), *Panicum* spp. (extending into summer-fall: *P. dichotomum* 7.18; *P. depauperatum* 3.34), and *Coreopsis major* (3.27). The late summer-fall flora is dominated by *Cunila origanoides* (IV 7.57), *Lespedeza* spp. (*L. hirta* 7.27; *L. intermedia* 4.60; *L. procumbens* 2.41; *L. repens* 1.74), *Hieracium gronovii* (5.66), *Tephrosia virginiana* (3.27), *Clitoria mariana* (2.59), and *Solidago* spp. (*S. erecta* 3.47; *S. ulmifolia* 2.05). Several species of woody vines and semi-shrubs contribute significantly: *Toxicodendron radicans* (10.05), *Smilax glauca* (7.72), *Hypericum stragulum* (5.44), *Vitis*

rotundifolia (5.33), *V. aestivalis* (4.93), and *Parthenocissus quinquefolia* (5.14).

Dominant families, based on total IV of taxa within a family, include the Poaceae (IV 38.49), Cyperaceae (27.56), Asteraceae (26.11), Fabaceae (25.58), and Vitaceae (15.40). These five families (13.2% of families) contribute 46.6% of the species but 66.6% of IV. Dominant genera, based on total IV of taxa within a genus, are *Carex* (IV 27.56), *Danthonia* (22.73), *Lespedeza* (16.23), *Panicum* (11.86), *Vitis* (10.26), *Smilax* (8.46), and *Solidago* (6.66). These seven genera (0.9% of genera, 21.8% of total species) account for 51.9% of IV.

Summary—This study shows that the herbaceous stratum of mature chestnut oak stands on xeric, rocky-gravelly, nutrient-poor ridges of the Northwestern Highland Rim, Kentucky and Tennessee, is sparse and not diverse (119 species within 81 genera and 38 families). Surface coverage is mostly by bryophytes-lichens (53.80% of relative cover), bare ground, including exposed rock and gravel (18.78%), and litter-organic debris (17.09%). Herbaceous taxa contribute 10.35% of total cover. Dominant herbs are *Danthonia spicata* and *Carex artitecta*, both most noticeable in April–June. *Cunila origanoides*, other sedges (*Carex* spp.), panic grasses (*Panicum* spp.), legumes (*Clitoria mariana*, *Lespedeza* spp., *Tephrosia virginiana*), and composites (*Aster* spp., *Coreopsis major*, *Hieracium gronovii*, *Solidago* spp.) become important in July–October. Woody vines, e.g., *Parthenocissus quinquefolia*, *Smilax glauca*, *Toxicodendron radicans*, *Vitis* spp., and semi-shrubs, e.g., *Hypericum stragulum*, are important throughout the growing season. The stands surveyed appear to be compositionally stable in all strata (Chester et al., 1998) and are in public ownership. Our permanent plots will allow for long-term monitoring and assessment of change in all strata.

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LITERATURE CITED

- BAILEY, A. W., AND C. E. POULTON. 1968. Plant communities and environmental relationships in a portion of the Tillamook burn, northwestern Oregon. *Ecology* 49:1–13.
- BASKIN, J. M., C. C. BASKIN, AND R. M. JONES (eds.). 1987. The vegetation and flora of Kentucky: a symposium sponsored by the Kentucky Academy of Science. Eastern Kentucky University, Richmond, Kentucky.
- BARBOUR, M. G., J. H. BURK, AND W. D. PITTS. 1987. Terrestrial plant ecology, 2nd ed. Benjamin/Cummings Publishing, Menlo Park, California.
- BRAUN, E. L. 1950. Deciduous forests of eastern North America. Hafner Publishing Company, New York.
- BRYANT, W. S., W. C. MCCOMB, AND J. S. FRALISH. 1993. Oak-Hickory Forests (Western Mesophytic/Oak-Hickory Forests). Pp. 143–201 in *Biodiversity of the southeastern United States: upland terrestrial communities* (W. H. Martin, S. B. Boyce, and A. C. Echternacht, eds.). John Wiley & Sons New York.
- CAPLENOR, D. 1965. The vegetation of the gorges of the Fall Creek Falls State Park in Tennessee. *J. Tennessee Acad. Sci.* 40:27–39.

- CHESTER, E. W. (ed.) 1989. The vegetation and flora of Tennessee: proceedings of the invited papers session of the second annual symposium on the natural history of Lower Tennessee and Cumberland River Valleys. *J. Tennessee Acad. Sci.* 64:57–207.
- CHESTER, E. W., R. J. JENSEN, AND J. SCHIBIG. 1995. Forest communities of Montgomery and Stewart counties, northwestern Middle Tennessee. *J. Tennessee Acad. Sci.* 70:82–91.
- CHESTER, E. W., C. E. HARRIS, S. GONZALEZ, AND K. K. DENLEY. 1998. Characterization of the woody strata in the xeric-site chestnut oak forest community, Northwestern Highland Rim, Kentucky and Tennessee. *J. Kentucky Acad. Sci.* 59: 178–184.
- CONDLEY, B. C. 1984. The ridge top chestnut oak forest community of the Ridge and Valley Physiographic Province and adjacent areas. MS Thesis, Univ. Tennessee, Knoxville, Tennessee.
- DAUBENMIRE, R. 1959. Canopy coverage method of vegetation analysis. *Northwest Sci.* 33:43–64.
- . 1968. Plant communities: a textbook of plant synecology. Harper and Row, Publishers, New York.
- FRALISH, J. S., F. B. CROOKS, J. L. CHAMBERS, AND F. M. HARTY. 1991. Comparison of presettlement, second-growth and old-growth forest on six site types in the Illinois Shawnee Hills. *Amer. Midland Naturalist* 125:294–309.
- FRANKLIN, S. B., AND J. S. FRALISH. 1994. The chestnut oak and post oak woodland communities of Land Between The Lakes, Kentucky and Tennessee. Pp. 341–346 in *Proceedings of the North American conference on barrens and savannas* (J. S. Fralish, R. C. Anderson, J. E. Ebinger, and R. Szafoni, eds.). Illinois State University, Normal, Illinois.
- GILLIAM, F. S., AND N. L. TURRILL. 1993. Herbaceous layer cover and biomass in a young versus a mature stand of a central Appalachian hardwood forest. *Bull. Torrey Bot. Club* 120:445–450.
- GILLIAM, F. S., N. L. TURRILL, AND M. B. ADAMS. 1995. Herbaceous-layer and overstory species in clear-cut and mature central Appalachian hardwood forests. *Ecological Applications* 5:947–955.
- GLEASON, H. A., AND A. CRONQUIST. 1991. *Manual of vascular plants of Northeastern United States and adjacent Canada*, 2nd ed. The New York Botanical Garden, Bronx, New York.
- HARRIS, S. E., JR. 1988. Summary review of geology of Land Between The Lakes, Kentucky and Tennessee. Pp. 26–83 in *Proceedings of the first annual symposium on the natural history of lower Tennessee and Cumberland River valleys* (D. Snyder, ed.). The Center for Field Biology, Austin Peay State Univ., Clarksville, Tennessee.
- KENTUCKY STATE NATURE PRESERVES COMMISSION. 1997. Endangered, threatened, special concern, and historic plants and animals of Kentucky. Revised list, KSNPC, Frankfort, Kentucky.
- MEIER, A. J., S. P. BRATTON, AND D. C. DUFFY. 1995. Possible ecological mechanisms for loss of vernal-herb diversity in logged eastern deciduous forests. *Ecological Applications* 5: 935–946.
- OOSTING, H. J. 1956. *The study of plant communities*, 2nd ed. W. H. Freeman, San Francisco, California.
- TENNESSEE NATURAL HERITAGE PROGRAM. 1998. Tennessee rare plant list. Tennessee Dept. Environment and Conservation, Nashville, Tennessee.
- WHEAT, R. M. JR., AND R. DIMMICK. 1987. Forest communities

- and their relationships with landtypes on the Western Highland Rim of Tennessee. Pp. 377–383 in *Central hardwood Forest Conference VI* (R. L. Hay, F. W. Woods, and H. DeSelm, eds.). The Univ. Tennessee, Knoxville, Tennessee.
- WOFFORD, B. E., AND R. KRAL. 1993. Checklist of the vascular plants of Tennessee. Sida; Botanical Miscellany. Number 10. Botanical Research Institute of Texas, Fort Worth, Texas.

APPENDIX I

List of taxa—The arrangement, nomenclature, and designation of non-native taxa (indicated by an asterisk) follow Wofford and Kral (1993). Annotations are: the number of sites occurrence of 10 and the number of plots occurrence of 180; taxa observed but not sampled are so indicated.

Pteridophyta

Aspleniaceae

Asplenium platyneuron (L.) Britton, Sterns & Poggenb. [2, 5]

Dennstaedtiaceae

Pteridium aquilinum (L.) Kuhn [7, 29]

Polypodiaceae

Polypodium polypodioides (L.) Watt [1, 1]

Angiosperms—Monocots

Cyperaceae

Carex artitecta Mack. [10, 179]

Carex blanda Dewey [3, 6]

Carex cephalophora Willd. [9, 35]

Carex complanata Torr. & Hook. [6, 10]

Carex muhlenbergii Schkuhr [4, 6]

Carex picta Steud. [1, 8]

Dioscoreaceae

Dioscorea villosa L. [1, 1]

Juncaceae

Luzula echinata (Small) E.J. Herm. [6, 27]

Liliaceae

Polygonatum biflorum (Walter) Elliott [7, 25]

Orchidaceae

Spiranthes tuberosa Raf. [3, 12]

Poaceae

Agrostis perennans (Walter) Tuck. [3, 5]

Andropogon gyrans Ashe [2, 2]

Andropogon virginicus L. [5, 9]

Danthonia spicata (L.) P. Beauv. ex Roem. & Schult. [10, 140]

Elymus virginicus L. [3, 6]

Eragrostis hirsuta (Michx.) Nees [1, 1]

Muhlenbergia sobolifera (Muhl.) Trin. [1, 3]

Panicum boscii Poir. [1, 1]

Panicum commutatum Schult. [7, 19]

Panicum depauperatum Muhl. [10, 50]

Panicum dichotomum L. [10, 100]

Schizachyrium scoparium (Michx.) Nash [1, 3]

Sphenopholis obtusata (Michx.) Scribn. [6, 19]

Vulpia octoflora (Walter) Rydb. [4, 9]

Smilacaceae

- Smilax bona-nox* L. [4, 11]
Smilax glauca Walter [9, 68]

Angiosperms—Dicots

Acanthaceae

- Ruellia caroliniensis* (J.F. Gmel.) Steud. [observed but not sampled]

Anacardiaceae

- Toxicodendron radicans* (L.) Kuntze [10, 104]

Apiaceae

- Sanicula canadensis* L. [1, 1]

Apocynaceae

- Apocynum cannabinum* L. [1, 1]

Aristolochiaceae

- Aristolochia serpentaria* L. [1, 1]

Asclepiadaceae

- Asclepias amplexicaulis* Sm. [1, 1]
Asclepias verticillata L. [observed but not sampled]

Asteraceae

- Ambrosia artemisiifolia* L. [2, 2]
Antennaria plantaginifolia (L.) Richardson [10, 34]
Aster lateriflorus (L.) Britton [1, 1]
Aster linariifolius L. [9, 74]
Aster patens Aiton [2, 4]
Aster shortii Lindl. [observed but not sampled]
Coreopsis major Walter [7, 49]
Erigeron annuus (L.) Pers. [1, 1]
Eupatorium serotinum Michx. [1, 2]
Helianthus divaricatus L. [2, 3]
Helianthus hirsutus Raf. [1, 1]
Hieracium gronovii L. [10, 81]
Krigia biflora (Walter) S.F. Blake [6, 25]
Krigia dandelion (L.) Nutt. [3, 8]
Solidago caesia L. [2, 5]
Solidago erecta Pursh [8, 41]
Solidago hispida Muhl. [1, 2]
Solidago nemoralis Aiton [5, 10]
Solidago ulmifolia Muhl. [9, 25]

Bignoniaceae

- Bignonia capreolata* L. [1, 8]
Campsis radicans (L.) Seem. ex Bureau [1, 2]

Boraginaceae

- Myosotis verna* Nutt. [3, 9]

Brassicaceae

- Arabis canadensis* L. [1, 6]
Arabis laevigata (Muhl.) Poir. [2, 5]
Cardamine hirsuta L.* [2, 8]
Dentaria laciniata Muhl. ex Willd. [1, 1]

Cactaceae

- Opuntia humifusa* (Raf.) Raf. [2, 7]

Campanulaceae

- Lobelia inflata* L. [observed but not sampled]
Triodanis perfoliata (L.) Nieuwl. [8, 36]

Caryophyllaceae

- Silene antirrhina* L. [1, 1]

Cistaceae

- Lechea tenuifolia* Michx. [2, 5]

Clusiaceae

- Hypericum denticulatum* Walter [2, 2]
Hypericum gentianoides (L.) Britton, Sterns & Poggenb. [1, 1]
Hypericum stragulum W.P. Adams & N. Robson [10, 83]

Ericaceae

- Monotropa hypopithys* L. [2, 3]

Euphorbiaceae

- Acalypha virginica* L. [2, 3]
Euphorbia corollata L. [10, 39]

Fabaceae

- Baptisia bracteata* Muhl. ex Elliott var. *glabrescens* (Lairsey) Isley [2, 6]
Chamaecrista fasciculata (Michx.) Greene [1, 1]
Clitoria mariana L. [7, 35]
Desmodium canescens (L.) DC. [7, 12]
Desmodium nudiflorum (L.) DC. [4, 23]
Desmodium paniculatum (L.) DC. [1, 2]
Desmodium rotundifolium DC. [1, 1]
Lespedeza cuneata (Dum. Cours.) G. Don* [observed but not sampled]
Lespedeza hirta (L.) Hornem. [10, 101]
Lespedeza intermedia (S. Watson) Britton [10, 67]
Lespedeza procumbens Michx. [8, 36]
Lespedeza repens (L.) Barton [7, 26]
Lespedeza virginica (L.) Britton [2, 3]
Melilotus officinalis (L.) Pall.* [1, 1]
Stylosanthes biflora (L.) Britton, Sterns & Poggenb. [2, 5]
Tephrosia virginiana (L.) Pers. [9, 42]
Wisteria frutescens (L.) Poir. [1, 1]

Lamiaceae

- Cunila origanoides* (L.) Britton [10, 93]
Hedeoma pulegioides (L.) Pers. [2, 3]
Monarda fistulosa L. [2, 2]
Scutellaria parvula Michx. [2, 5]

Linaceae

- Linum virginianum* L. [1, 1]

Oxalidaceae

- Oxalis stricta* L. [5, 12]
Oxalis violacea L. [6, 19]

Passifloraceae

- Passiflora lutea* L. [2, 3]

Polygonaceae

- Polygonum scandens* L. [1, 1]

Rosaceae

- Agrimonia rostellata* Wallr. [1, 1]
Porteranthus stipulatus (Muhl. ex Willd.) Britton [4, 13]
Potentilla simplex Michx. [4, 11]
Rosa carolina L. [5, 21]
Rubus argutus Link [4, 8]
Rubus flagellaris Willd [3, 4].

Rubiaceae

- Galium aparine* L. [2, 3]

Galium circaezans Michx. [8, 23]

Hedyotis caerulea L. [8, 46]

Hedyotis purpurea (L.) Torr. & A. Gray [8, 29]

Saxifragaceae

Heuchera villosa Michx. [5, 9]

Scrophulariaceae

Agalinis tenuifolia (Vahl) Raf. [1, 3]

Aureolaria pectinata (Nutt.) Pennell [2, 3]

Dasytoma macrophylla (Nutt.) Raf. [6, 9]

Violaceae

Viola palmata L. [1, 1]

Viola pedata L. [2, 2]

Viola sororia Willd. [1, 3]

Vitaceae

Parthenocissus quinquefolia (L.) Planch. [10, 17]

Vitis aestivalis Michx. [9, 72]

Vitis rotundifolia Michx. [10, 73]