

FLORISTIC COMPOSITION AND POTENTIAL COMPETITORS IN *LINDERA MELISSIFOLIA* (LAURACEAE) COLONIES IN MISSISSIPPI WITH REFERENCE TO HYDROLOGIC REGIME

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ABSTRACT

Lindera melissifolia is a federally endangered shrub endemic to the southeastern United States. Hydrologic regime and floristic composition within individual *L. melissifolia* colonies in three disjunct populations in Mississippi were monitored for three years. Sixty-nine vascular plant species were identified growing within *L. melissifolia* colonies. Although number of flooding events and flood duration varied among the three populations, floristic composition and the ratio of *L. melissifolia* to other plants in the colonies remained relatively constant during the study period. In Mississippi, *Smilax* spp. and *Vitis* spp. have the greatest potential to become strong competitors of *L. melissifolia*.

RESUMEN

Lindera melissifolia es un arbusto en peligro a nivel federal, endémico del sureste de los Estados Unidos. Se monitorizó durante tres años el régimen hidrológico y la composición florística en colonias individuales de *L. melissifolia* en tres poblaciones disjuntas en Mississippi. Se identificaron sesenta y nueve especies de plantas vasculares creciendo en las colonias de *L. melissifolia*. Aunque el número de episodios de inundación y la duración de las inundaciones varió entre las tres poblaciones, la composición florística y la proporción de *L. melissifolia* con otras plantas de las colonias permaneció relativamente constante durante el periodo de estudio. En Mississippi, *Smilax* spp. y *Vitis* spp. tienen el mayor potencial para ser fuertes competidores de *L. melissifolia*.

INTRODUCTION

The Species

Lindera melissifolia (Walter) Blume is a dioecious shrub endemic to the southeastern United States. This member of Lauraceae, commonly called pondberry, was collected in South Carolina and described by Walter (1788) as *Laurus melissaefolia*. By the mid-20th century, Steyermark (1949) found that few herbarium specimens had been collected subsequent to Walter's (1788) description, with only three collections having been made in the first half of the twentieth century. Herbarium studies by Steyermark (1949) throughout the United States confirmed the historical presence of *L. melissifolia* in Alabama, Florida, Georgia, Louisiana, Missouri, North Carolina, and South Carolina. Although Gattinger (1901) made reference to *L. melissifolia* in Tennessee, Steyermark (1949) believed this report probably referred "...to misidentified pubescent *Lindera Benzoin*, since no authentic material of *L. melissaefolia* has been found in the herbarium of the University of Tennessee..." Similarly, Deam (1924) excluded *L. melissifolia* from "Shrubs of Indiana" citing only one historic report with no voucher specimen. Based on the number of preserved *L. melissifolia*, Steyermark (1949) concluded that this species may be one of the rarest shrubs in the United States.

Currently, extant populations of *L. melissifolia* are present in Alabama, Arkansas, Georgia, Mississippi, Missouri, North Carolina, and South Carolina. It is believed to be extirpated in Louisiana and Florida. In the southeastern Coastal Plain (South Carolina and Georgia), *L. melissifolia* grows along the margin of seasonally flooded depressional wetlands dominated by *Nyssa biflora* Walter and *Taxodium ascendens* Brongn. (Aleric & Kirkman 2005). The only population known to occur in Alabama grows along the edge of a forested depres-

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sion under a partially open canopy of *N. biflora*, *Ilex myrtifolia* Walter, and *Quercus laurifolia* Michx. (Shotz 2005). In the Lower Mississippi Alluvial Valley (LMAV), *L. melissifolia* populations in Mississippi, Arkansas, and Missouri grow in periodically flooded, bottomland hardwood forests underlain by hydric soils. Forest canopy composition among the sites in the LMAV is similar, composed primarily of trees designated as facultative wetland or obligate wetland species (Hawkins et al. 2009a). *Liquidambar styraciflua*, *Acer rubrum*, *Q. lyrata*, *Q. nuttallii*, and *Q. phellos* are important canopy components; however, the relative importance of these and other canopy species varies between sites (Hawkins et al. 2009a).

Lindera melissifolia populations consist of spatially segregated, unisexual colonies (Hawkins et al. 2009b). Colony sizes range from approximately 20 stems to >1,000 stems (Morris 1987; Devall et al. 2001; Hawkins pers. obs.). In the LMAV, populations are strongly male-biased, with male to female colony ratios ranging from 7:1 (Wright 1994) to 19:1 (Hawkins et al. 2009b).

In both male (pollen-bearing) and female (seed/fruit-bearing) *L. melissifolia*, anthesis occurs in late spring, often during flooded conditions, and precedes leafing out. Small, yellow flowers are produced on axillary inflorescences (Fig. 1A), followed by production of green drupes on female plants. Approximately 90 days following anthesis, drupes contain a single, fully developed seed (Connor et al. 2007) and upon maturation drupes are bright red (Fig. 1B, 1C). Drupes are dispersed from fall to early winter (Smith et al. 2004) and fruit pedicels may remain on the plant until the following spring. Female *L. melissifolia* appear to invest heavily in sexual reproduction (Connor et al. 2007); however, seedlings are rarely observed in naturally occurring populations (Wright 1990). Vegetative propagation of ramets from rhizomes appears to be the predominant form of reproduction (Wright 1990, 1994).

During the first one to three years following seedling and/or ramet emergence, *L. melissifolia* plants are morphologically very similar to *L. benzoin* (L.) Blume. In fact, during Steyermark's (1949) investigation of the species, he noted numerous misidentified herbarium specimens of *L. melissifolia* resulting from this close similarity. Although leaf pubescence and leaf size sometimes differ between the two species, these characteristics may be dependent on season and locality. On the other hand, the angle of the lateral veins in the leaf blade may be used to distinguish the congeners. In *L. melissifolia*, the lowest two pairs of lateral veins of the leaf blade diverge at a 45°–50° angle from the midrib, and distal to this, successive veins diverge at approximately 35° (Steyermark, 1949). In other words, the lower two lateral veins are not parallel to the successive upper veins. In contrast, all lateral veins of *L. benzoin* leaves diverge from the midrib at the same angle (35°–45°); therefore, are parallel (Steyermark 1949). Both Nuttall (1818) and Steyermark (1949) described the fruits of *L. melissifolia* as "larger" than those of *L. benzoin*. The senior author has found the seeds of the congeners to be consistently reliable for definitive identification of fruiting plants. While seeds of *L. melissifolia* are spherical and light brown to yellowish brown, those of *L. benzoin* are oval and dark brown (Fig. 1D).

In 1986, *L. melissifolia* was listed under the Federal Endangered Species Act of 1973 (U.S. Fish and Wildlife Service 1986). Recent research has provided some insight into the ecophysiology (Hawkins et al. 2009b; Aleric & Kirkman 2005) of this species, and forest types and forest structure associated with *L. melissifolia* in the LMAV have been reported (Hawkins et al. 2009a). Wright (1990) suggested species of *Brunnichia*, *Rubus*, and *Smilax* as main competitors of *L. melissifolia* in northeast Arkansas, and that periodic flooding served to minimize competitive interactions. Beyond Wright's (1990) initial report, very little is known about the microhabitat or biotic interactions in *L. melissifolia* colonies. In an effort to provide concise information regarding the microhabitat and general ecology of *L. melissifolia*, three native, disjunct populations in Mississippi were monitored for three years. The objectives of our study were to 1) assemble a vascular plant checklist of groundcover species growing within *L. melissifolia* colonies, 2) identify potential competitors of *L. melissifolia*, and 3) monitor hydrologic regime for *L. melissifolia* colonies.

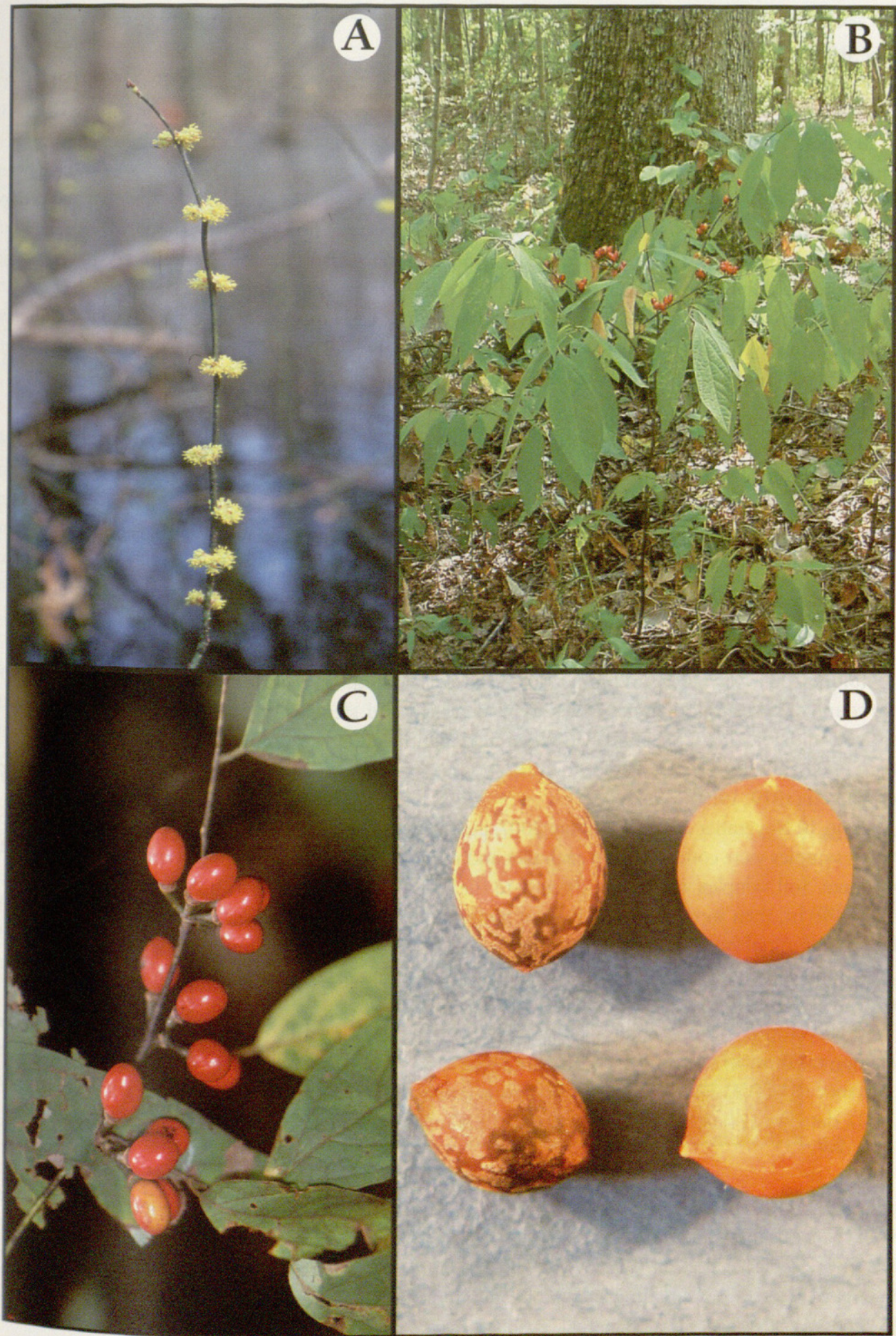


FIG. 1. (A) flowering *Lindera melissifolia* stem, (B) reproductively mature *L. melissifolia* plant, (C) mature drupes on female *L. melissifolia*, and (D) seeds of *L. benzoin* (left) and *L. melissifolia* (right).

METHODS

Study Sites

Two of the study sites are in Sharkey County, Mississippi. The North Delta National Forest site (NDNF) is a 25-ha tract of Delta National Forest that has been under management by the U. S. Forest Service since 1938 (Devall & Ramp 1992). The South Delta National Forest (SDNF) site is a 10-ha tract of forest approximately 9 km southeast of NDNF. The third study site (BC) is in Bolivar County, Mississippi, and is a privately owned 30-ha forest fragment surrounded by agricultural fields (see Hawkins et al. 2009a for map and detailed descriptions). Soil association for the three sites is Dowling (very fine, smectitic, nonacid, thermic Vertic Endoaquepts)-Alligator (very-fine, smectitic, thermic Chromic Dystraquerts)-Sharkey (very-fine, smectitic, thermic Chromic Epiaquerts), an association characterized by poorly drained, fine-textured clayey surface soils and subsoils formed from Mississippi River alluvium (Rogers 1958, Scott & Carter 1962). Mean annual temperature for Sharkey and Bolivar counties is approximately 18.0°C, and total annual precipitation ranges from 1228 mm to 1319 mm (Rogers 1958, Scott & Carter 1962).

Data Collection and Analysis

In autumn 2003, rectangular plots were established for selected *L. melissifolia* colonies at BC ($N_{\text{colony}} = 6$), NDNF ($N_{\text{colony}} = 10$), and SDNF ($N_{\text{colony}} = 1$). In 2000, SDNF was habitat for numerous *L. melissifolia* colonies, many with >200 stems (GSRC 2000). However, during reconnaissance of this area we found only one remaining colony and were able to establish only one study plot. The perimeter of each plot was positioned 1m beyond the outermost *L. melissifolia* stems of a colony. A 1.2 m wooden stake (5 cm x 5 cm) was established at each of the four corners of the rectangular plot. Colony sizes were variable, and thus plot areas varied with colony size. Within each plot, 1m x 1m quadrats were marked with pin flags along the diagonals of the rectangular plot; therefore, the percent of plot area sampled was the same among plots.

In June 2004, May 2005, and June 2007, *L. melissifolia* stems in each 1m x 1m quadrat within the plots were counted, and groundcover species were identified and stems were counted. Common plants were identified in the field by TSH and DAS. When field identification was problematic, plants in question were top-cropped and taken to the lab for identification using Radford et al. (1968), supplemented by Godfrey and Wooten (1979, 1981).

From 10 November 2004 to 22 May 2007, plots were visited bi-weekly. When plots were not flooded, two soil samples were collected from each plot and placed in individual 141 cm³, hermetically sealed, metal containers. Soil samples were taken directly to the lab, weighed to the nearest 0.01 g, dried in an oven at 70°C for 48 hr, then weighed again. Percent moisture for each soil sample was calculated by dividing the difference of initial (wet) and final (dry) weights by the initial weight and multiplying the quotient by 100. During flooded conditions, water depth was measured to the nearest 0.1 cm at each plot corner post and the mean ($\pm$ SE) used to represent water depth for the plot.

At NDNF, there were substantial differences in water depth among some of the *L. melissifolia* colonies; therefore, mean water levels for each sampling date at each colony were compared using a one-way analysis of variance (ANOVA; SAS 2001). For colonies where mean water level was not significantly different ($p \geq 0.2421$), data were pooled producing one mean $\pm$ standard error for each of three groups of colonies.

RESULTS AND DISCUSSION

Hydrologic regime for forests with *Lindera melissifolia* populations is often described within the broad definition of "periodically flooded". For populations in Mississippi, flooding generally occurred in late-winter to late-spring. However, flooding events and flood duration were found to vary among sites. The BC population experienced annual flooding events of comparable depth and duration in 2005, 2006, and 2007 (Fig 2A). Flooding at this site is artificially controlled by the landowner; therefore, hydrologic regime remains consistent from year to year.

Flood duration and initial time of flooding varied with year at NDNF. Flooding occurred in 2005 and 2006, but not in 2007 (Fig. 2B). Although water depth differed among some of the ten monitored colonies at

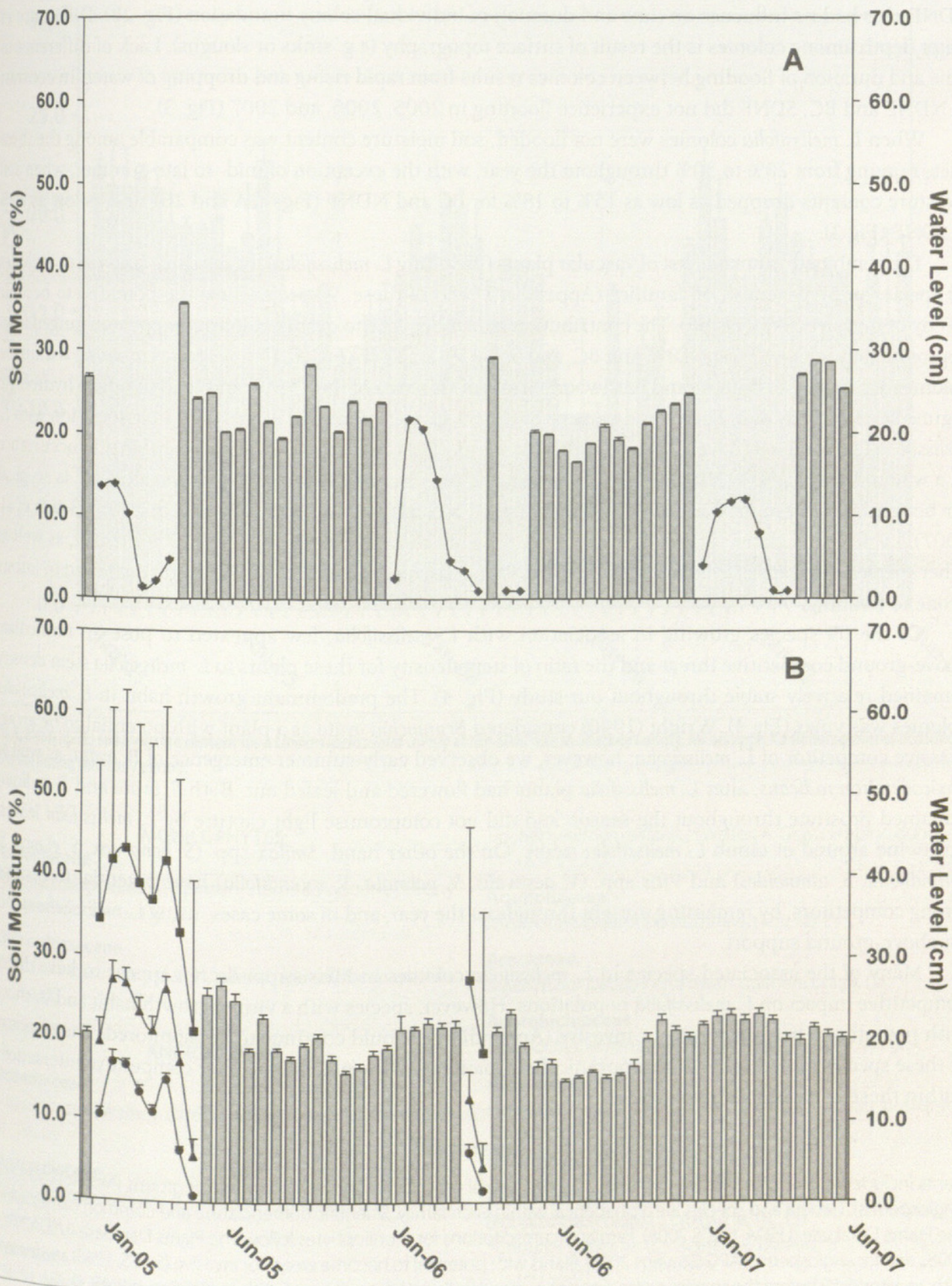


FIG. 2. Mean ($\pm$ SE) soil moisture content (bars) and water level (lines) for *Lindera melissifolia* colonies, at the (A) BC site ($N_{\text{colony}} = 6$) in Bolivar County, Mississippi and (B) NDNF site ($N_{\text{colony}} = 10$) in Sharkey County, Mississippi. For NDNF site, $\blacksquare$ = plot 1, $\blacktriangle$ = plots 2, 3, 5, 8, and $\bullet$ = plots 4, 6, 7, 9, 10 as segregated by ANOVA.

NDNF, this had no influence on time and duration of individual colony inundation (Fig. 2B). Difference in water depth among colonies is the result of surface topography (e.g. sinks or sloughs). Lack of difference in time and duration of flooding between colonies results from rapid rising and dropping of water. In contrast to NDNF and BC, SDNF did not experience flooding in 2005, 2006, and 2007 (Fig. 3).

When *L. melissifolia* colonies were not flooded, soil moisture content was comparable among the three sites, ranging from 20% to 30% throughout the year, with the exception of mid- to late-summer, when soil moisture contents dropped as low as 15% to 18% for BC and NDNF (Figs. 2A and 2B); and as low as 10% at SDNF (Fig 3).

The combined annotated list of vascular plants (including *L. melissifolia*) for the three study sites includes 70 species in 57 genera in 45 families (Appendix 1) and of these, 9 species have the potential to become weedy or invasive (SWSS 1998). The contribution of *L. melissifolia* to overall colony composition ranged from approximately 20%–40% at NDNF and BC, and 5%–15% at SDNF (Fig. 4). Other species growing within the colonies are typical of bottomland hardwood forests in this area of the LMAV, and tend to reflect hydrologic regime at each study site. Forty-nine percent of the 69 species identified as growing in association with *L. melissifolia* (Appendix 1) have a wetland indicator status of FACW and a 67%–99% probability of occurrence in a wetland area (USDA, NRCS 2008). However, the presence of *Callicarpa americana* at SDNF is atypical for bottomland forests in the LMAV and represented a county record first reported in 2007 (Skojac et al. 2007). Lack of inundation at SDNF (Fig. 3) has possibly allowed establishment of *C. americana*, as well as other species, such as *Asplenium platyneuron* and *Phytolacca americana*, that generally are not found in forests prone to flooding.

Of the 69 species growing in association with *L. melissifolia*, few appeared to pose an immediate above-ground competitive threat and the ratio of stem density for these plants to *L. melissifolia* stem density remained relatively stable throughout our study (Fig. 4). The predominant growth habit in *L. melissifolia* colonies was vines (Fig 4). Wright (1990) considered *Brunnichia ovata* as a plant with potential to be an aggressive competitor of *L. melissifolia*; however, we observed early-summer emergence of *B. ovata*, as well as *Toxicodendron radicans*, after *L. melissifolia* plants had flowered and leafed out. Both *B. ovata* and *T. radicans* remained prostrate throughout the season and did not compromise light capture by *L. melissifolia* leaves, nor twine around or climb *L. melissifolia* stems. On the other hand, *Smilax* spp. (*S. bona-nox*, *S. glauca*, *S. rotundifolia*, *S. tamnoides*) and *Vitis* spp. (*V. aestivalis*, *V. palmata*, *V. rotundifolia*) have potential to become strong competitors, by remaining upright throughout the year, and in some cases, using *L. melissifolia* stems for above-ground support.

Many of the associated species in *L. melissifolia* colonies in Mississippi do not appear to have direct competitive impact on *L. melissifolia* populations. However, species with a vining growth habit and/or those with potential to become weedy or invasive (Appendix 1), should continue to be monitored. The response of these species to natural or anthropogenic disturbances has the potential to alter competitive interactions within these *L. melissifolia* populations.

APPENDIX 1

Plants included in this checklist are compiled in alphabetical order by family within two major groups (Monilophytes and Angiosperms). Genera and species are alphabetical within each family. Scientific nomenclature and common names follow The Plants Database (USDA, NRCS 2008). Family circumscriptions for monilophytes follow The Plants Database (USDA, NRCS 2008), and for angiosperms, APG (Stevens 2008). Plants with potential to become weedy or invasive (SWSS, 1998) are denoted with an asterisk (*) before the species name. Species wetland indicator status for the Southeast Region (AL, AR, FL, GA, LA, MS, NC, SC, TN) is noted as: **OBL** = obligate (99% probability of occurrence in wetlands); **FACW** = facultative wetland (67% - 99% probability of occurrence in wetlands, but occasionally found in non-wetlands); **FAC** = facultative (equal probability of occurrence in wetlands or non-wetlands); **FACU** = facultative upland (occurrence usually in non-wetlands, occasional wetland occurrence); and **NI** = unable to determine wetland indicator status based solely on genus. Locality data are noted as: **(1)** = Bolivar County, MS; **(2)** = North Delta National Forest, Sharkey County, MS; and **(3)** = South Delta National Forest, Sharkey County, MS.

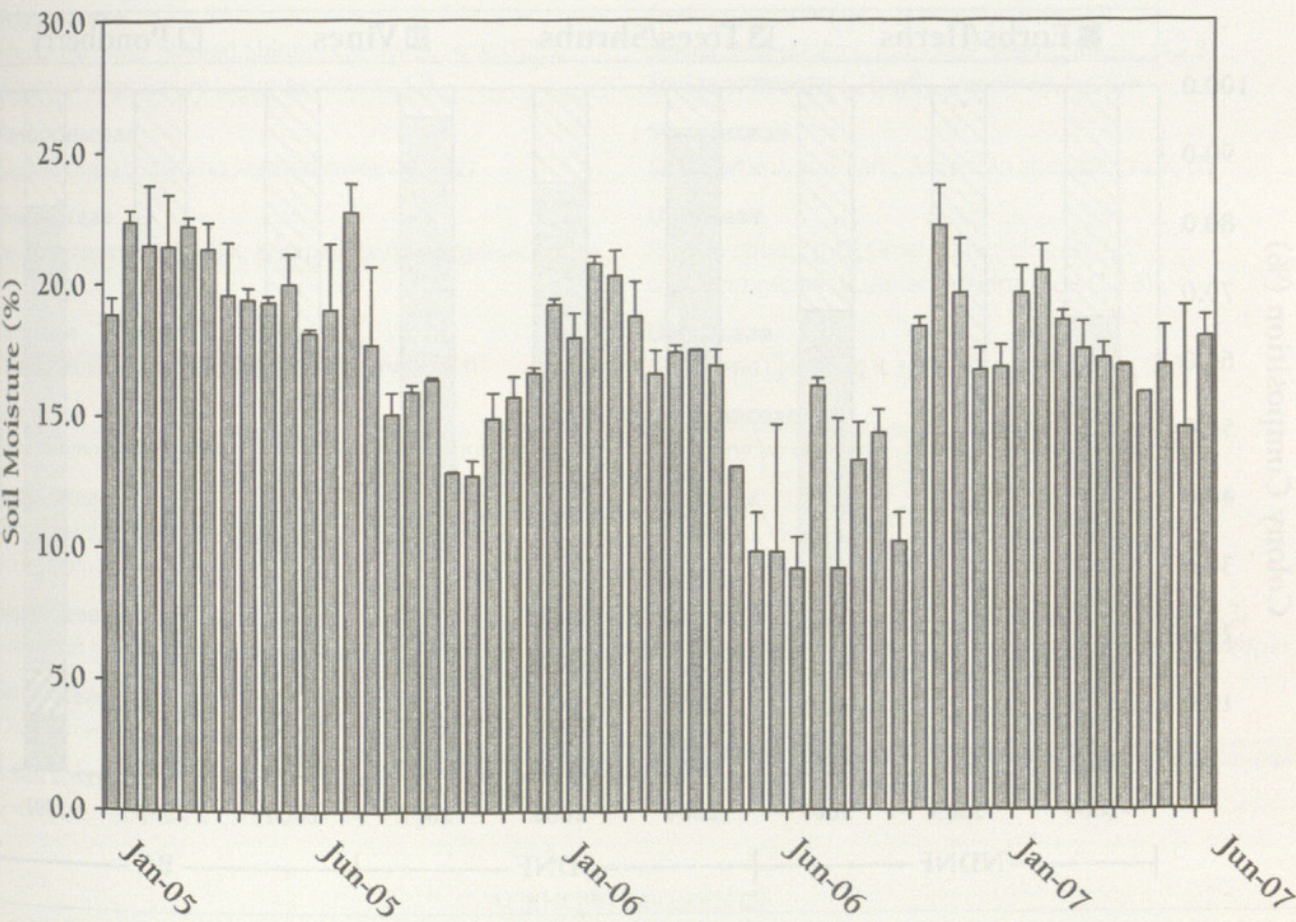


FIG. 3. Mean ($\pm$ SE) soil moisture content for a *Lindera melissifolia* colony at the SDNF site in Sharkey County, Mississippi. No flooding events occurred at this site during the study period.

MONILOPHYTES

- Aspleniaceae**
Asplenium platyneuron (L.) Britton, Sterns & Poggenb., ebony spleenwort, FACU, (3)
- Ophioglossaceae**
Botrychium bitermatum (Sav.) Underw., sparselobe grapefern, FAC, (3)

ANGIOSPERMS

- Acanthaceae**
Justicia ovata (Walter) Lindau, looseflower water-willow, OBL, (2)
- Anacardiaceae**
**Toxicodendron radicans* (L.) Kuntze, eastern poison ivy, FAC, (1,2,3)
- Apiaceae**
Cynoscadium digitatum DC., finger dogshade, FACW, (1)
Sanicula canadensis L., Canadian black snakeroot, FACU, (3)
Sanicula odorata (Raf.) K.M. Pryer & L.R. Phillippe, clustered black snakeroot, FAC, (2,3)
- Apocynaceae**
Matelea gonocarpus (Walter) Shinnars, angularfruit milkvine, FACW, (1)

- Trachelospermum difforme* (Walter) A. Gray, climbing dogbane, FACW, (1,2,3)
- Aquifoliaceae**
Ilex decidua Walter., possumhaw, FACW, (2)
- Arecaceae**
Sabal minor (Jacq.) Pers., dwarf palmetto, FACW, (2)
- Aristolochiaceae**
Aristolochia serpentaria L., Virginia snakeroot, FACU, (2)
- Asteraceae**
Erechtites hieracifolia (L.) Raf ex DC., American burnweed, FAC, (1,3)
Eupatorium sp. L., thoroughwort, NI, (3)
- Bignoniaceae**
Bignonia capreolata L., crossvine, FAC, (3)
**Campsis radicans* (L.) Seem ex Bureau, trumpet creeper, FAC, (2,3)
- Cannabaceae**
Celtis laevigata Willd., sugarberry, FACW, (1,2)
- Commelinaceae**
Commelina virginica L., Virginia dayflower, FACW, (2)
- Cornaceae**
Cornus foemina Mill., stiff dogwood, FACW, (2)

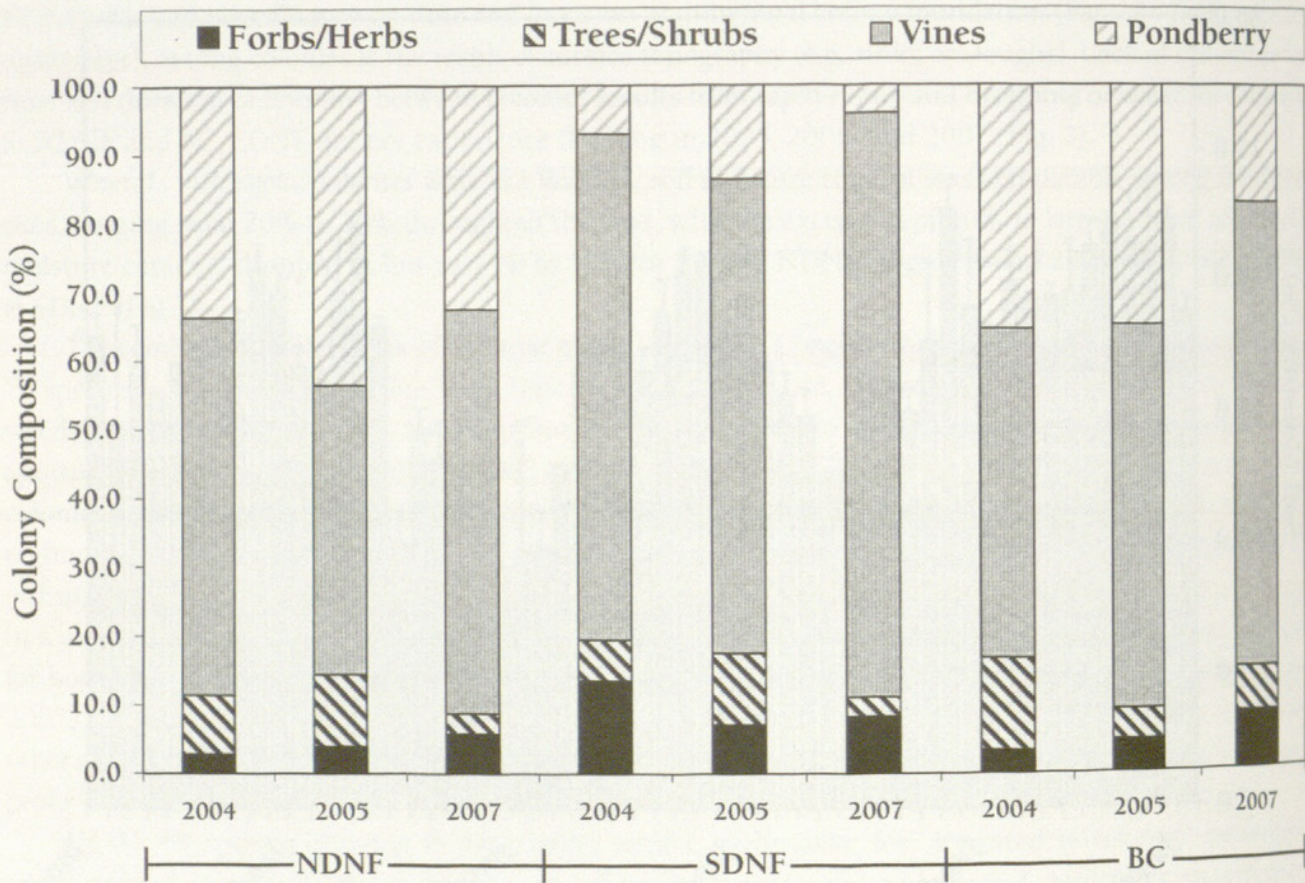


FIG. 4. Percent contribution of *Lindera melissifolia* (Pondberry), vines, trees/shrubs, and forbs/herbs to *Lindera melissifolia* colony composition in three populations in Sharkey (NDNF & SDNF) and Bolivar (BC) counties, Mississippi. Percentages calculated from the number of stems of each growth habit per unit area (stems/m²).

Cucurbitaceae

Melothria pendula L., Guadeloupe cucumber, FACW, (3)

Cyperaceae

Carex crus-corvi, Shuttlw. ex Kunze, ravenfoot sedge, OBL, (1)

Carex louisianica L.H. Bailey, Louisiana sedge, OBL, (2)

Carex tribuloides Wahlenb., blunt broom sedge, FACW, (1,2)

Ebenaceae

Diospyros virginiana L., common persimmon, FAC, (2)

Fabaceae

Desmodium sp. Desv., ticktrefoil, NI, (3)

Dioclea multiflora (Torr. & A. Gray) C. Mohr, Boykin's clusterpea, FAC, (2,3)

Gleditsia triacanthos L., honeylocust, FAC, (1,3)

Fagaceae

Quercus lyrata Walter, overcup oak, OBL, (1,2)

Quercus nigra L., water oak, FAC, (3)

Quercus phellos L., willow oak, FACW, (1,2,3)

Quercus texana Buckley, Texas red oak, OBL, (1,2)

Hamamelidaceae

Liquidambar styraciflua L., sweetgum, FAC, (1,2)

Juglandaceae

Carya aquatica (Michx. f) Nutt., water hickory, OBL, (2)

Lauraceae

Lindera melissifolia (Walt.) Blume, OBL, (1,2,3)

Sassafras albidum (Nutt.) Nees., sassafras, FACU, (2)

Menispermaceae

**Cocculus carolinus* (L.) DC., Carolina coralbead, FAC, (2,3)

Moraceae

Morus rubra L., red mulberry, FAC, (2)

Oleaceae

Forestiera acuminata (Michx.) Poir., swamp privet, OBL, (2)

Fraxinus pennsylvanica Marsh., green ash, FACW, (1,2,3)

Fraxinus profunda (Bush) Bush, pumpkin ash, OBL, (1)

Onagraceae

Ludwigia glandulosa Walter, cylindricfruit primrose-willow, OBL, (1)

Orchidaceae

Spiranthes ovalis Lindl., October lady's tresses, FAC, (2)

Passifloraceae

**Passiflora lutea* L., yellow passionflower, FAC, (2)

Phytolaccaceae

**Phytolacca americana* L., American pokeweed, FACU, (3)

Poaceae

Leersia virginica Willd., whitegrass, FACW, (1,2)

Polygonaceae

**Brunnichia ovata* (Walter) Shinnars, redberry, FACW, (1,2,3)

Polygonum virginianum L., jumpseed, FAC, (2)

Ranunculaceae

Clematis crispa L., swamp leatherflower, FACW, (2)

Rhamnaceae

Berchemia scandens (Hill) K. Koch, Alabama supplejack, FACW, (1,2,3)

Rosaceae

Rubus trivialis Michx., southern dewberry, FAC, (3)

Rubiaceae

Cephalanthus occidentalis L., common buttonbush, OBL, (2)

Sapindaceae

Acer negundo L., boxelder, FACW, (3)

Acer rubrum L., red maple, FAC, (1,2)

Sapotaceae

Sideroxylon lycioides L., buckthorn, FACW, (1,2)

Saururaceae

**Saururus cernuus* L., lizard's tail, OBL, (2)

Smilacaceae

Smilax bona-nox L., saw greenbrier, FAC, (1,2,3)

Smilax glauca Walter, cat greenbrier, FAC, (2)

Smilax rotundifolia L. roundleaf greenbrier, FAC, (1,2,3)

Smilax tamnoides L., bristly greenbrier, FAC, (2)

Styracaceae

Styrax americanus Lam., American snowbell, FACW, (2)

Ulmaceae

Planera aquatica J.F. Gmel., water elm, OBL, (2)

Ulmus americana L., American elm, FACW, (1,2,3)

Urticaceae

Boehmeria cylindrica (L.) Sw., false nettle, FACW, (2,3)

Verbenaceae

Callicarpa americana L., American beautyberry, FACU, (3)

Violaceae

Viola sp. L., violet, NI, (3)

Vitaceae

**Ampelopsis arborea* (L.) Koehne, peppervine, FAC, (1,2,3)

**Parthenocissus quinquefolia* (L.) Planch., Virginia creeper, FAC, (1,2,3)

Vitis aestivalis Michx. summer grape, FAC, (2)

Vitis palmata Vahl., catbird grape, FACW, (1,2)

Vitis rotundifolia Michx., muscadine, FAC, (2,3)

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