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FLORA OF NORTHERN ALABAMA, PART 4. BASAL MONOCOTS: ACORALES AND ALISMATALES SWEETFLAG TO PONDWEEDS

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ABSTRACT

This paper is a floristic guide to native and naturalized monocots in the orders Acorales and Alismatales found within the Interior Plains and Appalachian Highlands of northern Alabama. Families included in this treatment are: Acoraceae, Araceae, Alismataceae, Tofieldiaceae, Hydrocharitaceae, and Potamogetonaceae. Identification keys, photographs, maps of occurrence in northern Alabama, habitats, flowering and fruiting times, distributional data, pertinent synonymy, and comments are provided for each taxon.

Flowering plants (angiosperms) have historically been separated into two distinct groups, distinguished by characteristic differences such as leaf venation, organization of floral structures, and the number of cotyledons (embryonic seed leaves). Dicots or dicotyledons are plants having leaves with netted venation, tetramerous or pentamerous (four or five-parted) flowers, and two cotyledons. Monocots or monocotyledons are plants having parallel venation, grass-like leaves, trimerous (three-parted) flowers, and a single cotyledon. These two assemblages, once believed to represent natural groups have been recognized as Class Magnoliopsida (dicots) and Class Liliopsida (monocots) (Takhtajan 1980; Cronquist 1981).

Angiosperms clearly are monophyletic, but their traditional classification into monocots and dicots is not phylogenetically supported (Soltis et al. 2018). One problem associated with this binary classification is the existence of plants displaying a mixture of both dicot- and monocot-like features. Phylogenetic studies revealed that these “hard to classify, primitive dicots" are in reality a disparate assemblage of early-divergent species and that their unusual traits are plesiomorphic (primitive)

features that arose early in angiosperm evolution. Specifically, plants classified as dicots are not monophyletic but actually a paraphyletic grade from which monocots evolved (Soltis et al. 2018).

While dicots as traditionally recognized have been shown to be polyphyletic, recent phylogenetic studies utilizing both molecular and morphological data have found strong support for monophyly of the monocots (Soltis et al. 2018). Morphological synapomorphies (shared advanced traits) uniting the monocots include the presence of a single cotyledon, parallel-veined leaves, adventitious root systems, and scattered vascular bundles within the stem (Soltis et al. 2018). Despite agreement on the group's monophyly, phylogenetic studies differ in their placement of monocots relative to other major angiosperm clades; a comprehensive understanding of early angiosperm relationships is lacking (Soltis et al. 2018).

With a recent estimate of 74,273 species globally, monocots comprise approximately 25% of all flowering plants (Christenhusz & Byng 2016). Of the approximately 4,200 vascular plant species in Alabama, about 27% are monocots (Keener et al. 2019). The current paper treats 45 species of monocots (Fig. 1) within the orders Acorales (Acoraceae) and Alismatales, which include the following families: Alismataceae, Araceae, Hydrocharitaceae, Potamogetonaceae, and Tofieldiaceae (Table 1). The families treated in this paper are often referred to as basal monocots because the fossil record of Acorales and Alismatales extends back to the Cretaceous (Stockey 2006). Igersheim et al. (2001) states that "*Acorus* (Acoraceae) is the basalmost clade among extant monocots, followed by Araceae and Alismatales."

Table 1. Taxonomic classification of basal monocots used for the flora of north Alabama.

ORDER ACORALES	
Family Acoraceae	*Acorus* (1 species)
ORDER ALISMATALES	
Family Araceae	*Arisaema* (4 species) *Arum* (1 species) *Colocasia* (1 species) *Landoltia* (1 species) *Lemna* (3 species) *Orontium* (1 species) *Peltandra* (1 species) *Pistia* (1 species) *Spirodela* (1 species) *Wolffia* (2 species) *Wolffiella* (1 species)
Family Tofieldiaceae	*Triantha* (1 species)
Family Alismataceae	*Alisma* (1 species) *Echinodorus* (1 species) *Sagittaria* (6 species)
Family Hydrocharitaceae	*Egeria* (1 species) *Elodea* (1 species) *Hydrilla* (1 species) *Limnobium* (1 species) *Najas* (3 species) *Vallisneria* (1 species)
Family Potamogetonaceae	*Potamogeton* (9 species) *Stuckenia* (1 species) *Zannichellia* (1 species)

Numerous taxonomic systems are available for the classification of plants into orders and families. Early treatises relied almost entirely on morphological evidence to show relationships of the angiosperms, including the monocots. Two widely used works are Cronquist's *An integrated System of Classification of Flowering Plants* (1981), which divided the monocots (Class Liliopsida) into 19 orders and 65 families, and Takhtajan's *Diversity and Classification of Flowering Plants* (1997), which recognized 58 orders and 133 families. A discussion of the taxonomic concepts used here is detailed below, along with a comparison of alternative treatments of orders and families.

With the benefit of modern phylogenetic techniques and molecular data, it is now understood that early classifications contained paraphyletic groups, which are no longer accepted. Modern classifications have greatly clarified the evolutionary relationships of the monocots. The widely-used Angiosperm Phylogeny Group (APG 2016) recognizes 78 families of monocots within 11 orders globally. An alternative treatment presented by Reveal (2012) incorporates a narrower circumscription, placing the monocots into 22 orders with 93 families. Table 2 provides a comparison of the two classification schemes (Reveal 2012; APG 2016) for the basal monocots covered in this flora.

Table 2. Comparison of APG (2016) and Reveal (2012) in their classifications of basal monocots treated in the flora of northern Alabama.

FAMILY	APG (2016)	Reveal (2012)
Acoraceae	Acorales	Acorales
Araceae	Alismatales	Arales
Tofieldiaceae	Alismatales	Tofieldiales
Alismataceae	Alismatales	Alismatales
Hydrocharitaceae	Alismatales	Alismatales
Zannichelliaceae*	Alismatales	Potamogetonales
Potamogetonaceae	Alismatales	Potamogetonales

* included in Potamogetonaceae by APG (2016)

For the purpose of this paper we follow APG's (2016) classification of orders and families. However, there has been a recent trend by some botanists (e.g., Reveal 2012, Weakley 2015, Keener et al. 2019) to recognize smaller, more narrowly defined families. While the family concepts used in this paper do not differ from APG (2016), subsequent treatments in the series are anticipated to deviate from their concepts; especially in the recognition of numerous segregate lilioid families (e.g., Weakley et al. 2015), which are broadly lumped in the most current version of APG (2016).

The order Acorales is represented by the monotypic family Acoraceae, with *Acorus* being the sole genus (APG 2016; Soltis et al. 2018) and *A. calamus* the only species in Alabama. The genus *Acorus* was traditionally classified as a member of the Araceae, but this was prior to the development of modern molecular and DNA sequencing techniques (Engler 1920; Cronquist 1981; Dahlgren et al. 1985). The taxonomy was based on a widespread assumption that the morphologically similar spadix and accompanying spathe-like leaf of *Acorus* were homologous to those same structures uniting the aroid plants (Grayum 1987; Thompson 1995, 2000a). However, despite the striking similarity in inflorescence types, *Acorus* was also believed to be highly aberrant in the Araceae (Grayum 1987).

Anatomical and embryological research on *Acorus* uncovered a wealth of data suggesting that its placement within the Arum family was incorrect. These early efforts discovered a number of unusual traits in *Acorus* that were atypical of the Araceae or completely absent from it, such as the

presence of a perisperm (a diploid food storage tissue in its seeds), ensiform (sword-shaped), unifacial (iris-like) leaves, and a lack of needle-like calcium-oxalate crystals, or raphides (Nicolson 1959; Kaplan 1970). Although the sheath-like bract of *Acorus* was previously interpreted to be equivalent to the spathe in Araceae, it has been shown to be independently derived (Ray 1987).

Morphological synapomorphies (shared derived traits) that might unite *Acorus* with some other group are ambiguous and its phylogenetic relationships remained unclear (Weakley 2015; Soltis et al. 2018). Despite its unresolved position, accumulating evidence from anatomical studies ultimately led to removing *Acorus* from Araceae and placing it into its own family, Acoraceae, and separate order, Acorales (Grayum 1987; Bogner & Nicolson 1991; Reveal 1995; Mayo et al. 1997; Takhtajan 1997; APG 1998; Reveal 2012). DNA analyses using multiple markers showed that *Acorus* is not only distinct from other members of the Araceae, but is a sister group to all other monocots (French & Kessler 1989; Duvall et al. 1993; Chase 2004; Graham et al. 2006).

APG (2016) divides the order Alismatales into 14 monophyletic families (Fig. 1). An alternative classification by Reveal (2012) employs smaller taxonomic entities, recognizing the following orders: Arales (Araceae), Tofieldiales (Tofieldiaceae), Alismatales (Alismataceae, Hydrocharitaceae), and Potamogetonales (Potamogetonaceae, Zannichelliaceae). Prior to DNA analyses, most authors, including Cronquist (1981), Dahlgren et al. (1985), and Takhtajan (1997), accepted a similarly coherent group of Alismatid-like monocots at some level. These botanists, however, consistently excluded aroid plants (i.e., Araceae, Lemnaceae, and Acoraceae), as well as the Tofieldiaceae, which was frequently included within Liliaceae.

Phylogenetic studies utilizing multiple DNA markers have shown that recognition of an expanded Alismatales including both Araceae and Tofieldiaceae, is phylogenetically warranted (Petersen et al. 2015; Luo et al. 2016; Soltis et al. 2018), with the latter family representing the order's most basal lineage (Luo et al. 2016). Alismatales is now viewed as sister to all other remaining monocots (excluding *Acorus*) (Ross et al. 2016; Soltis et al. 2018).

Families included within Alismatales share scales or glandular hairs at the nodes within their sheathing leaf bases, and their embryos are uniquely green (Soltis et al. 2018). The order contains one of the largest lineages of aquatic angiosperms — a clade of 12 exclusively aquatic families including free-floating, floating-leaved, submersed, and emergent taxa (Ross et al. 2016).

METHODS AND FORMAT OF FLORA

Northern Alabama (Fig. 2) includes all of the counties occurring within the Interior Plains and Appalachian Highlands. The two divisions encompass four physiographic provinces (Fenneman 1938): Interior Low Plateaus (Highland Rim section), Appalachian Plateaus (Cumberland Plateau section), Ridge & Valley (Tennessee section), and Piedmont Plateau (Piedmont Upland section).

County distribution maps with physiographic regions are provided for each species occurring within northern Alabama (Fig. 3). A symbol is used to document county-level occurrences within the physiographic province. In some cases more than one symbol per county is used. Specimens were examined from various herbaria and searches for collections were made online from the following sites: Alabama Plant Atlas (Keener et al. 2019), Floristic Synthesis of North America (Kartesz 2018), iNaturalist (2019), and the Southeast Regional Network of Expertise and Collections Data Portal (SERNEC 2018). All vouchered specimens were assessed from the following herbaria: ALNHS, AMAL, APSC, AUA, BRIT, CM, GA, F, FLAS, FSU, HTTU, IBE, JSU, KE, LSU, MICH, MUR, NCSC, NCU, NO, NY, SAMF, TENN, TROY, UCHT, UNA, UNAF, UWAL, and VDB. Herbarium acronyms follow those found in *Index Herbariorum* (Thiers 2016).

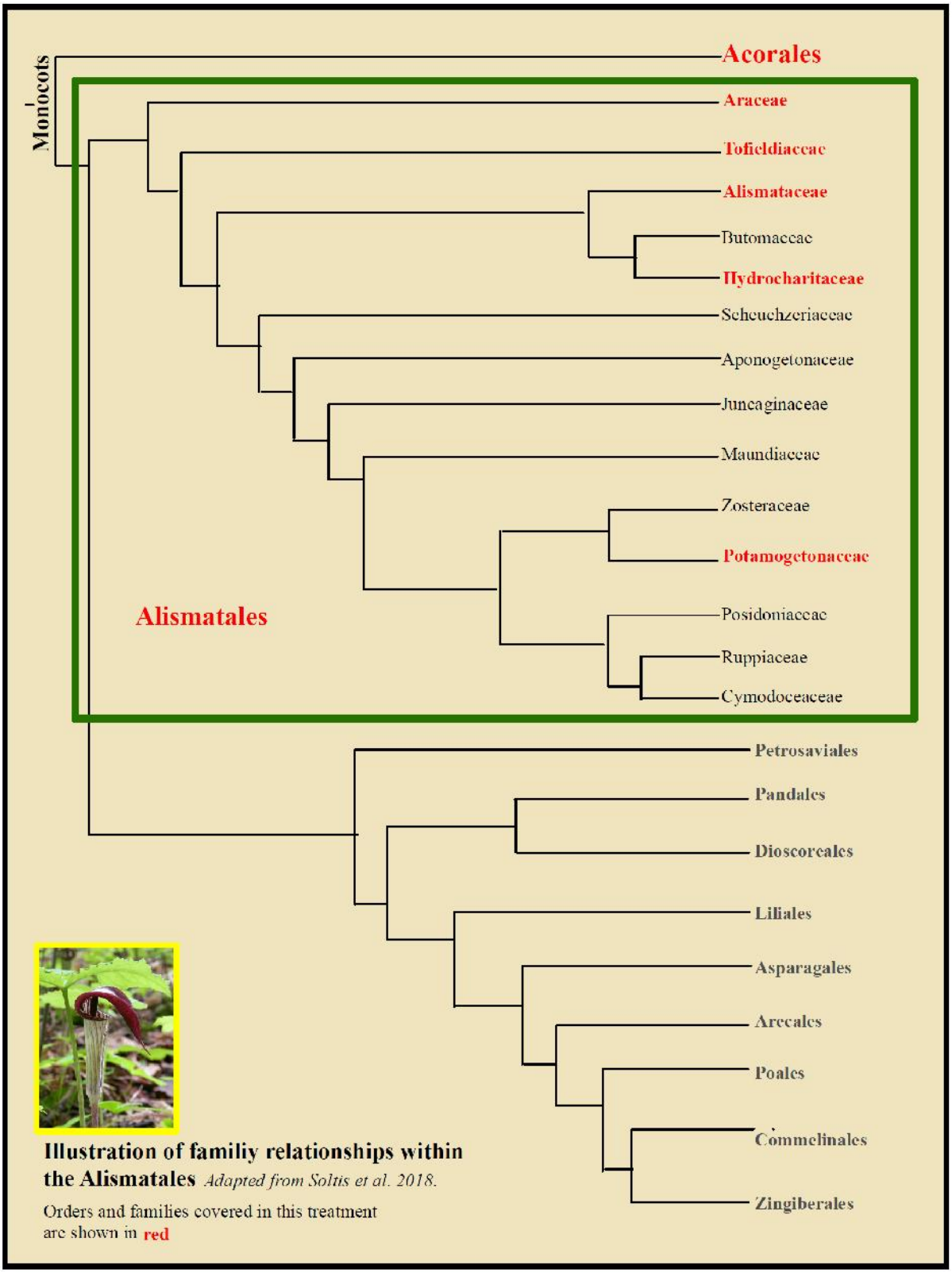


Figure 1. Phylogeny of the monocots showing the placement of Acorales and Alismatales.

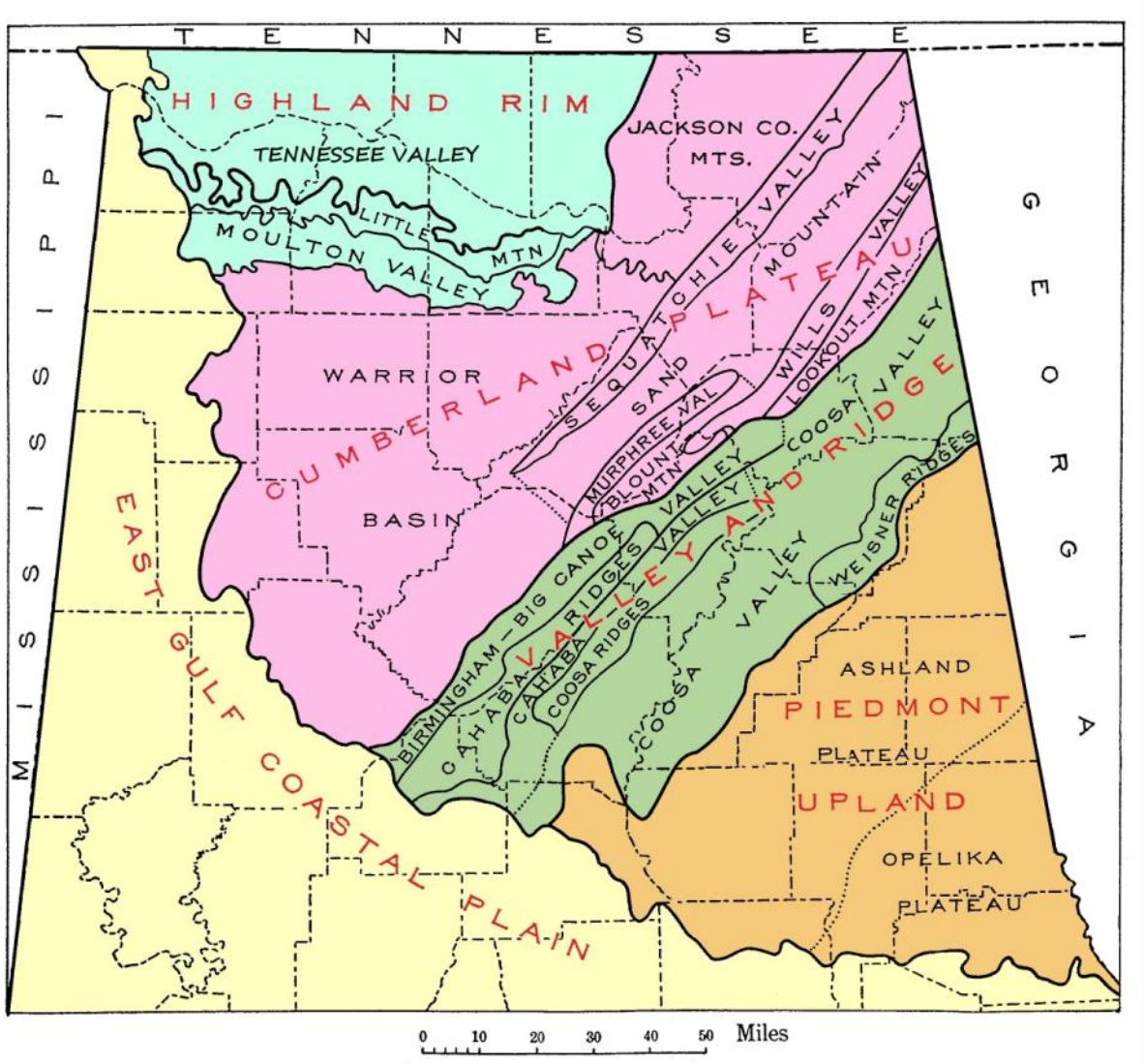
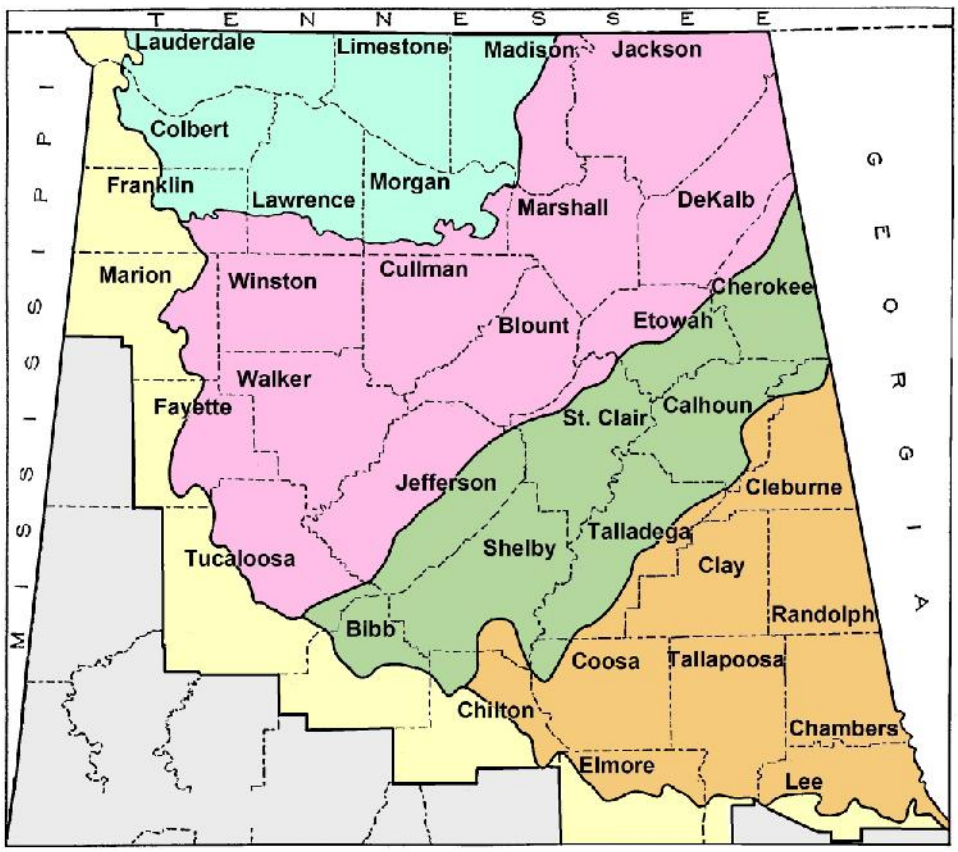


Figure 2. Map of physical divisions of northern Alabama (adapted and modified from Johnston 1930).

Family and generic sequences follow Weakley (2015) and are arranged phylogenetically, while species are arranged alphabetically. Generic names include authors and date of publication. The format for common names follows Kartesz (2018) and Kartesz & Thieret (1991). Within a given description of taxa the following sequence is followed: Scientific name, authority citation for specific and infraspecific taxa. Vernacular name(s). Synonyms. Habit/duration. Habitat. Flowering dates; fruiting dates (listed only if significantly different from flowering times). Frequency of occurrence in Alabama provinces. Overall range and distribution. Comments.

Frequency of occurrence is defined as follows, ranging in descending order: *Common* (occurring in abundance throughout a province); *frequent* (occurring throughout a province, but not abundant); *uncommon* (occurring in scattered localities in a province); *rare* (known only from a small number of populations, 6 to 20 occurrences, often restricted to specific localities or habitats); and *very rare* (known only from a few populations, 5 or fewer occurrences, often narrow endemics, disjuncts, or peripheral taxa, at the edges of their ranges).



MAP KEY	
●	Native taxon, present in physiographic area of county
✪	Sensitive species, listed as imperiled or rare in Alabama
▼	Exotic taxon, adventive or naturalized in Alabama

Figure 3. Counties of study area and map key to symbols

The following publications were utilized in creating keys: Abbott 2017; Armstrong 2001; Beal 1960; Clewell 1985; Cronquist 1981; Davenport & Haynes 1981; Diggs et al. 2006; Fassett 1940; Fernald 1950; Flora of North America Committee 2000; Godfrey & Wooton 1979; Haines 2011; Haynes 1977, 1978, 1979, 1980; Haynes & Holm-Nielsen 1987, 2001; Jones 2005; Landolt 1992; Meriläinen 1968; Mohlenbrock 1970; Radford et al. 1968; Rogers 1983; Small 1933; Smith 1994; Tennessee Flora Committee 2015; Wang et al. 2010; Weakley 2015; Wofford 1989; and Yatskievych 1999. Specimens were also examined from various southeastern herbaria, as well as recent collections in the field, to assist in construction of the keys.

KEY TO FAMILIES

1. Free-floating aquatic plants not rooted in substrate (occasionally stranded at low water.)

    2. Plants small thalloid bodies; leaves not distinct, reduced to fronds (< 2 cm long); roots present or absent .....**2. Araceae** (*Landoltia*, *Lemna*, *Spirodela*, *Wolffia*, *Wolffiella*)
    2. Plants much larger; leaves distinct in rosettes (> 2 cm long); roots present.

3. Leaves with petioles; leaf blades mostly cordate at base obtuse at apex; floating leaves with inflated cells (spongy tissue) underneath ..... **5. Hydrocharitaceae** (*Limnobium*)
3. Leaves sessile; leaf blades cuneate (wedge-shaped) at base, truncate at apex; floating leaves lacking inflated cells..... **2. Araceae** (*Pistia*)

1. Rooted terrestrial, amphibious, or submersed aquatic plants (unless uprooted or pieces broken off), a few species may have some floating leaves.

4. Plants submersed aquatics, though some leaves or stems may float on surface (sometimes stranded in substrate if water level is low); flowers emersed or submersed.

5. Leaves basally clustered.

6. Leaves flaccid and ribbon-like (of varying lengths, the longer ones often floating); pistillate flowers floating on long peduncles, staminate flowers submersed then later detach; carpels united ..... **5. Hydrocharitaceae** (*Vallisneria*)
6. Leaves firm, not ribbon-like (all roughly the same length, some with an expanded blade); flowers emersed or occasionally floating, but in 2 or more pedicelled whorls; carpels separate..... **4. Alismataceae** (*Sagittaria*)

5. Leaves scattered along stem.

7. Leaves opposite or alternate; carpels separate..... **6. Potamogetonaceae**
7. Leaves whorled; carpels united ..... **5. Hydrocharitaceae** (*Egeria*, *Elodea*, *Hydrilla*)

4. Plants terrestrial, amphibious, or an emersed aquatic, all or some of plant parts above water surface (base sometimes permanently submerged and some leaves occasionally floating); flowers emersed (aerial).

8. Leaves sessile, broadly linear, iris-like (leaves basally folded and partly enclosing the next leaf above).

9. Leaves >35 cm long and 5–18 mm wide; inflorescence lateral and sessile at base of leaf-like bract, 4–9 cm long (appearing to be an extension of the leaf) ..... **1. Acoraceae**
9. Leaves < 35 cm long and 1–6 mm wide; inflorescence racemose (with obvious glandular-pubescent peduncle), bracts minute, not leaf-like ..... **3. Tofieldiaceae**

8. Leaves petioled with expanded leaf blades, not iris-like.

10. Leaves compound, with 3 or more leaflets..... **2. Araceae** (*Arisaema*)
10. Leaves simple, not divided into leaflets.

11. Plants connected by stolons that are suspended in water; floating leaves suborbicular with a central disk of spongy, inflated cells underneath; flowers solitary in leaf axils. ..... **5. Hydrocharitaceae** (*Limnobium*)
11. Plant with or without stolons, if present, occurring at plant base, mostly in substrate, not suspended in water; floating leaves, if present, not suborbicular and lacking a central disk of spongy tissue (though some may be spongy throughout); flowers not solitary in leaf axils.

12. Leaf bases hastate, sagittate, or cordate, with distinct basal lobes.

13. Leaf blades with 3 prominent veins extending from the base to the tips of apex and lobes, smaller nerves branching off the main veins; apex and lobes of leaf broadly rounded or tapering to a rounded or obtuse tip; inflorescence a spadix subtended by a spathe (a sheathing bract); perianth absent ..... **2. Araceae** (*Arum*, *Colocasia*, *Peltandra*)
13. Leaf blades with numerous thick veins (more than 3) extending from base of blade to sides of lobes and apex; leaf apex and lobes sharply acute; inflorescence a raceme or panicle (with widely-spaced flowers on pedicels and in whorls); perianth consisting of white petals and green sepals ..... **4. Alismataceae** (*Echinodorus*, *Sagittaria*)

12. Leaf bases acute, obtuse, cuneate, truncate, rounded, or shallowly cordate, lacking obvious basal lobes.

14. Leaves blue-green with a velvety sheen and a water-repellent surface (water beading due to thick layer of short hairs); inflorescence a fleshy, elongated, bright golden-yellow to orange spadix; flowers crowded, sessile; perianth with yellow tepals..... **2. Araceae** (*Orontium*)
14. Leaves green, not water-repellent; inflorescence a diffuse raceme or panicle; flowers in widely spaced whorls; perianth with white petals and green sepals..... **4. Alismataceae** (*Alisma*, *Echinodorus*, *Sagittaria*)

FAMILY 1. ACORACEAE (Calamus Family)

1. ACORUS Linnaeus 1753

[Latin form of Greek *akoron*; ancient name of an aromatic plant]

1. Acorus calamus L. {old name for a reed} — COMMON SWEETFLAG; EUROPEAN CALAMUS; SWEETROOT; DRUG SWEETFLAG; FLAGROOT; CALAMUS-ROOT; SWEET-RUSH; SWEET-GRASS; SWEET-CANE; SINGLE-VEIN SWEETFLAG (Fig. 4). [*Acorus aromaticus* Gilib.; *Acorus calamus* var. *verus* L.; *Acorus calamus* var. *vulgaris* L.]

Figure 4. *Acorus calamus.* A. Inflorescence, Preble Co., Ohio, 28 May 2007. Photo: Daniel Nickrent. B. Population in ditch along margin of swamp, Cleburne Co., Alabama, 3 Apr 2019. Photo: Dan Spaulding.

Amphibious, perennial herb with rhizomes. Margins of springs, lakes, rivers, swamps, and marshes; flowers April–early August (sometimes populations produce none); rare in the Highland Rim, northeastern Cumberland Plateau, and lower Coastal Plain; very rare in the Ridge & Valley and Piedmont (Fig. 5). Early European settlers introduced a sterile triploid cytotype of *Acorus calamus* into North America (Thompson 2000a), which now occurs throughout the USA and adjacent Canada. Most populations are concentrated in the central and northeastern portions of the USA (Kartesz 2018). Common Sweetflag has been introduced world-wide in temperate regions (Grayum 1987).

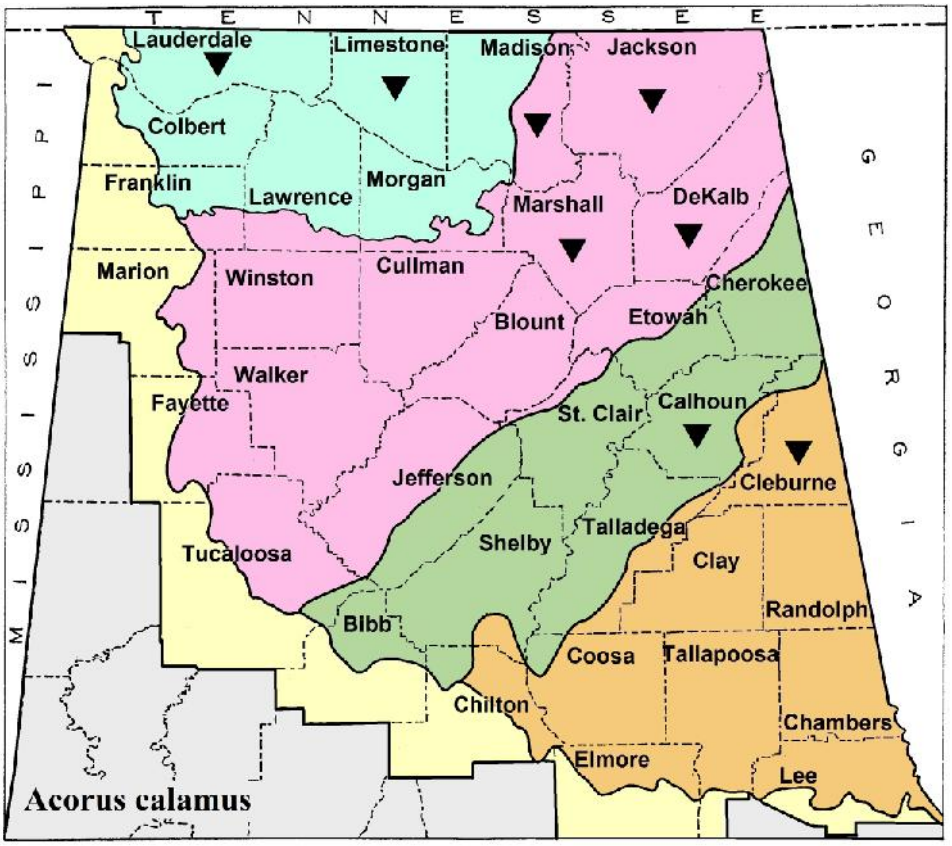


Figure 5. Distribution of *Acorus calamus* in northern Alabama.

According to Li et al. (2010), the triploid cytotype of *Acorus calamus* was created from a cross between diploid and tetraploid cytotypes that occur naturally in Asia. The authors asserted the triploid form may have originated in the Himalayan region and "then probably dispersed naturally or with humans to Sakhalin [large Russian Island] and with humans to Turkey, then to Europe, and finally to E North America as a medicinal plant."

Acorus is a small genus of two to six species (Grayum 1987). Li et al. (2010) concluded that only two species occurred worldwide: *A. calamus* and *A. gramineus* Sol. ex Ait. *Acorus gramineus*, Japanese Sweetflag, is native to eastern Asia and is commonly planted in the USA, but it is not known to escape. Japanese Sweetflag is easily recognized by its narrow (< 10 mm wide), non-aromatic leaves that lack a distinct midrib (Li et al. 2010).

Thompson (2000a) offered an alternative interpretation to the two-species concept. She recognized *Acorus americanus* (Raf.) Raf., a fertile diploid species restricted to the northern USA and adjacent Canada, as well as the sterile triploid plants *A. calamus*, introduced from the Old World.

Davenport and Haynes (1981) reported *A. americanus* from Alabama based on Wilson's (1960) assumption that *A. americanus* was the species represented in the southeastern USA. Wilson stated that "whether or not the European sterile triploid has been introduced into North America still remains to be shown." Thompson (1995) claimed that both taxa were present in North America and that our native plant was distinct from the Eurasian introduction. Thompson (2000a) concluded that *A. americanus* differs from *A. calamus* by having lateral veins as prominent as the midvein and its flowers produce fertile fruits, whereas *A. calamus* has only one prominent mid-vein and its flowers are sterile. However, Abbott (2016) suggested that *A. americanus* cannot be reliably separated morphologically on venation differences from *A. calamus* and said, "It is not yet clear that this global complex can be split into meaningful entities worthy of formal taxonomic recognition, or if it is just a complex based on ploidy-level differences."

(6a) Iris-like leaves, one prominent vein.

(6b) Rhizome of *Acorus*.

Figure 6. *Acorus calamus,* Salem Springs, Limestone Co., Alabama, 18 Jul 2018. Photos: Dan Spaulding.

Sweetflag has been used by various cultures for millennia. Its rhizomes produce essential oils that were utilized historically for numerous medicinal purposes. *Acorus* was found in Tutankhamen's tomb in Egypt and is mentioned in the Old Testament of the Bible (van Wyk & Wink 2004). Its aromatic leaves were also used by humans for other purposes. Dwyer et al. (1986) wrote that "settlers who knew the plant in Europe, where it was widely grown by the 17th century, scattered the lemony-smelling leaves on floors of their homes to mask the stench of poor sanitation and ventilation." The rhizome was candied (Coffey 1993) and reported to have been smoked or chewed to rid the taste of tobacco or to help break the habit (Dwyer et al. 1986). Caution is advised, however, since *Acorus* leaves (Fig. 6a) resemble some *Iris* species, which have poisonous rhizomes (Kingsbury 1964). In the New World, American Indians not only used the aromatic rhizomes (Fig. 6b) for medicinal purposes, but some tribes utilized the rootstalk as a medium of exchange (Dwyer et al. 1986). Native Americans may also have played a role in the distribution of the diploid form (Thompson 2000a).

FAMILY 2. ARACEAE (Arum Family)

The Araceae represent one of the most diverse flowering plant families in the world (Mayo et al. 1997; Christenhusz & Byng 2016). Members of the family have an inflorescence called a spadix, which consists of tightly packed, sessile flowers on a fleshy axis. The spadix is usually subtended or

enclosed by a leaf-like bract called a spathe. Plants in this family typically contain needle-like, calcium oxalate crystals within their tissues, which can cause an intense burning and are likely to inhibit consumption by herbivores (Wilson 1960).

As currently recognized (Reveal 2012; APG 2016), the Arum family is circumscribed to include the duckweed family (Lemnaceae). Previous recognition of duckweeds as a separate family was based on the group's diminutive size and accompanying reduction in reproductive structures, with flowers containing only simple pistils and anthers (Godfrey & Wooten 1979). Attesting to the extent of miniaturization, the duckweeds are known as the world's smallest angiosperms, with some individuals attaining a maximum width of only 0.3 mm at maturity (Landolt 1986).

Historically, Lemnaceae were suspected to be closely related to aroid plants (Cronquist 1981; Takhtajan 1997; Cabrera et al. 2008). Early anatomical and developmental studies were used to associate it with Araceae, in particular with the floating aroid genus *Pistia* (Grayum 1991; Cabrera et al. 2008). Modern molecular phylogenetic research has consistently shown that the Lemnaceae are clearly nested within Araceae and should be included within that family (French et al. 1995; Cabrera et al. 2008). Studies by Cabrera et al. (2008) revealed a more distant relationship between the duckweeds and *Pistia*. Their morphological similarities represent independent evolutionary origins that arose from adaption to an aquatic lifestyle.

1. Plants tiny, free-floating (rarely submersed), thalloid bodies (called fronds) < 2 cm long, (sometimes stranded in mud or on wet debris); leaves and stems reduced and cannot be differentiated; roots present or absent.

    2. Fronds lacking roots; veins absent.

        3. Fronds tiny (pinhead-sized), < 2 mm long, thick (at least below), globoid, ellipsoid, or ovoid, and a little longer than wide ..... **5. Wolffia**
        3. Fronds distinctly larger, > 3.5 mm long, flat, narrowly lanceolate, often falcate (sickle-shaped), and much longer than wide ..... **6. Wolffiella**

    2. Fronds with at least one root; veins one or more (though sometimes difficult to see).

        4. Frond with only 1 root; lower surface green or slightly reddish; upper surface entirely green; veins 1–3, but often obscure ..... **3. Lemna**
        4. Frond usually with 2 or more roots (a few fronds rarely with one); lower surface often solid reddish-purple; upper surface completely green or green with a purple margin; veins 3 or more, some often easily discernable.

            5. Roots (6-) 7–18 (-21); fronds nearly as wide as long, usually broadly obovate, or orbicular-ovate with main frond 5–10 mm long (daughter fronds smaller); upper surface often with a red or purple dot near end of frond, where roots attach; veins of frond mostly 5–16 ..... **2. Spirodela**
            5. Roots usually (1-) 2–5 (-7); fronds typically longer than wide, usually obovate, narrowly obovate, or oblong-ovate, with main fronds 2–5 mm long; upper surface lacking a single, conspicuous red dot, but can punctate with scattered reddish-brown pigment cells; veins mostly 3–5 ..... **4. Landoltia**

1. Plants much larger, either emergent or free-floating aquatics; leaves and stems distinct (except *Pistia*, which lacks a discernible stem); roots present.

6. Floating aquatic plants; leaves in cabbage-like rosettes; blades densely pubescent and obovate, with a cuneate base and truncate apex; roots conspicuously feathery and clustered beneath the rosette of leaves; stems absent..... **8. Pistia**
6. Rooted terrestrial or aquatic plants; leaves and roots not as described above; stems present.

    7. Leaves compound, with 3 or more leaflets; plant arising from a corm (swollen bulbous base) that lacks stolons ..... **10. Arisaema**
    7. Leaves simple, undivided; plant with rhizomes, tubers, or stoloniferous corms.

        8. Leaf bases tapering (acute or cuneate); blades oblong-elliptic or lanceolate; spadix golden yellow and not enclosed in a spathe; perianth consisting of 6 yellow tepals; main veins of leaves parallel.....**1. Orontium**
        8. Leaf bases cordate, hastate, or sagittate; blades cordate-hastate, ovate-triangular, hastate, or sagittate; spadix greenish or whitish and enclosed in a spathe; perianth absent; main veins of leaves palmate or pinnate, not parallel.

            9. Leaves peltate (petiole attached on the undersurface of leaf, not at margin of blade); basal leaf lobes obtuse or broadly rounded ..... **9. Colocasia**
            9. Leaves not peltate (petiole attached on the margin of leaf at base of blade); basal leaf lobes acute or tapering to an obtuse apex.

                10. Leaves green throughout; base of spadix not sessile; terminal portion of spadix lacking a sterile appendix or reduced to only a few millimeters in length; berries green at maturity, remaining enclosed within spathe; leaves present when fruiting; native wetland plant lacking tubers.....**7. Peltandra**
                10. Leaves variegated with conspicuous whitish veins; base of spadix narrowed below forming a stalk; terminal portion of spadix with a conspicuous sterile appendix; berries red at maturity, not enclosed within the spathe (it withers away); leaves die back during fruiting; alien terrestrial plant with tubers..... **11. Arum**

1. ORONTIUM Linnaeus 1753

[Ancient name of a plant said to have grown in the Syrian river Orontes]

1. Orontium aquaticum L. {aquatic} — GOLDEN-CLUB; BOG-TORCH; NEVER-WET (Fig. 7).

Amphibious to emersed, perennial herb with rhizomes. Marshes, swamps, bogs, lakes, streams, and rivers; flowers February–May, fruits May–July; rare in the Highland Rim (Little Mountain district); uncommon in the Cumberland Plateau, Ridge & Valley, and Piedmont; frequent in the Coastal Plain (Fig. 8). *Orontium* is a monotypic genus, endemic to the eastern USA and occurs primarily on the southeastern Coastal Plain (Wilson 1960), but it extends inland into the other physiographic provinces within suitable habitats (Grear 1966). The species is native from New York and Massachusetts south to Florida, west to Kentucky and eastern Texas (Kartesz 2018).

Orontium aquaticum prefers acidic sandy, muddy, or peaty soils (Klotz 1992). It frequently inhabits shallow waters (Fig. 9a), but if water is low it can grow in wet substrates (Fig. 9b). When water levels are high, its leaves will often float, due to large intercellular air spaces in the leaves (Thompson 2000b). Populations of *Orontium* can be dense and expansive (Fig. 10a), especially on the Coastal Plain, but in the Appalachians individuals may occur lodged within cracks in sandstone bedrock of streams (Fig. 10b).

Figure 7. *Orontium aquaticum*, Perry Co., Alabama, 7 Apr 2015. Photo: Brian Finzel.

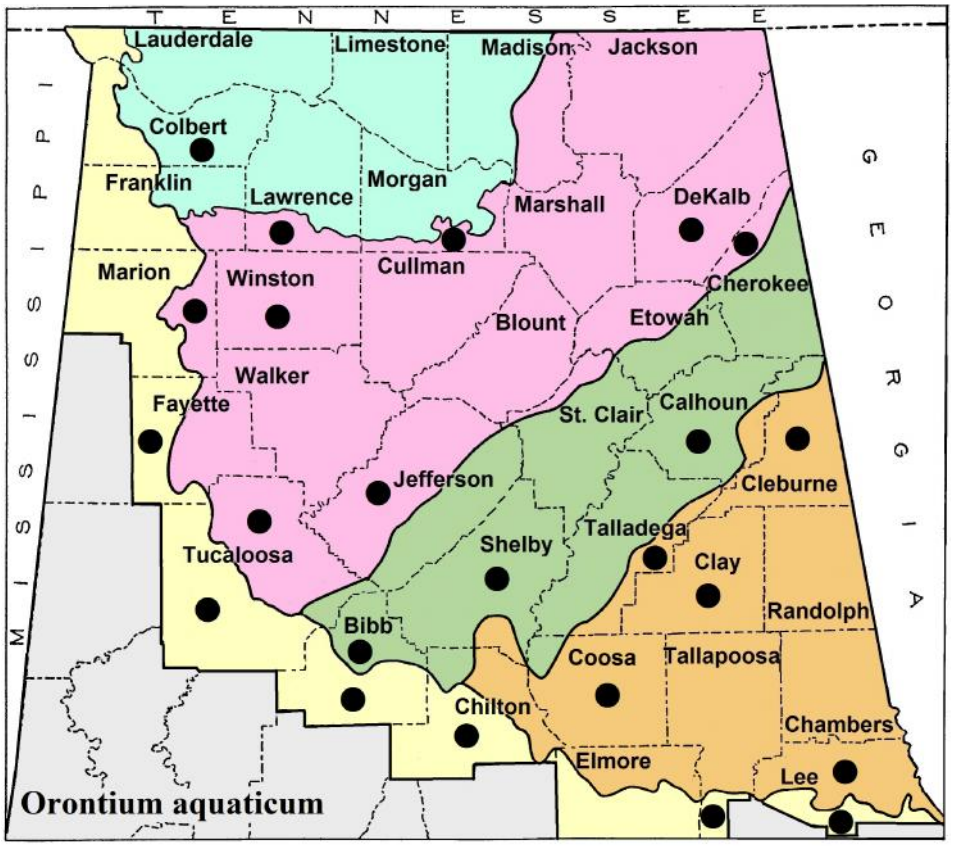
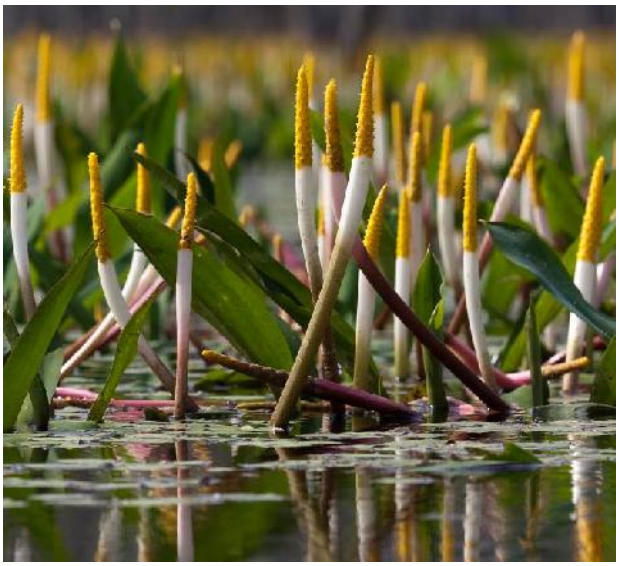


Figure 8. Distribution of *Orontium aquaticum* in northern Alabama.

Golden-Club is a very distinct species with a golden yellow-orange spadix that is not enclosed by a spathe (a leaf-like bract). The spadix is a fleshy spike of crowded flowers, initially green, turning brilliant yellow at maturity, then becoming green again following pollination. The flower stalk (scape) grows downward following pollination, with most fruits (Fig. 10c) maturing underwater. When the berry-like fruits ripen, they detach from the spadix and float. Buoyancy is due to air spaces within the seed coat (the pericarp). The fruit will float on the surface for about a week, then sinks after becoming water-logged. The seeds are dispersed by water or animals (Klotz 1992).



(9a) High water in marsh. Photo: Eric Soehren.

(9b) Ebenezer Swamp. Photo: Brian Finzel.

Figure 9. *Orontium aquaticum*. A. Mobile Co., Alabama, 7 Apr 2010. B. Shelby Co., Alabama, 28 Mar 2016.

(10a) Photo: Eric Soehren.

(10b) Photo: Dan Spaulding.

(10c) Photo: Brian Finzel.

Figure 10. *Orontium aquaticum*. A. Backwaters of Escatawpa River, Mobile Co., Alabama, 7 Apr 2010. B. Little River, Cherokee Co., Alabama, 14 Oct 2018. C. Unripe fruits, Perry Co., Alabama, 27 May 2013.

This species is easily identified by its unlobed, blue-green, elliptical leaves that have a velvety sheen. The blades are protected by a waxy epidermal cell layer and covered by short hairs, which in combination makes their surfaces appear to be "unwettable" (Thompson 2000b). Davenport

and Haynes (1981) reported "that water will run off or bead up rather than wet the leaves." When fresh foliage is submersed, it becomes silvery iridescent but once removed appears to be completely dry, hence the name "Never-Wet" (Grimm 1968). In autumn, the leaves wither and the plant becomes dormant until the following spring. Native Americans used the starchy seeds and rhizomes for food, but they first had to boil and dry them to remove irritating calcium oxalate crystals (Klotz 1992). The rhizome was ground into a nutritious, mealy flour and the seeds were eaten as a pea-like vegetable (Peterson 1977).

2. **SPIRODELA** Schleiden 1839

[Evident cord; possibly alluding to the roots]

1. Spirodela polyrrhiza (L.) Schleid. {many-rooted} — GREATER DUCKWEED; MINNOW-FOLE; COMMON DUCKMEAT (Fig. 11).

Figure 11. *Spirodela polyrrhiza*, swamp in Bullock Co., Alabama, 18 May 2018. Photo: Dan Spaulding.

Floating aquatic, perennial herb. Marshes, swamps, inlets, lakes, sloughs, ponds, and still waters of streams, rivers, and creeks; rarely flowers and fruits in early summer–early fall (Landolt 2000); uncommon in the Highland Rim and Cumberland Plateau; rare in the Ridge & Valley and Piedmont; frequent in the Coastal Plain (Fig. 12). Inhabiting eutrophic, quiet waters in temperate and tropical regions nearly worldwide (Landolt 2000).

Spirodela polyrrhiza is the largest duckweed in Alabama, with more roots than any other species. Its fronds are broadly obovate to suborbicular, purplish underneath, green above, with usually 7–16 palmately arranged veins. The upper surface is typically red-dotted near the apex where roots attach below. This character is due to the accumulation of reddish pigments (anthocyanin) caused by the reduction of nutrients (Bog et al. 2015). When waters are nutrient dense (e.g., agricultural ponds) the colored spot is frequently lacking (Fig. 13).

Flowers of *Spirodela* are enclosed within a membranous spathe within a reproductive pouch along the margin of the frond. Reproduction, however, is mostly vegetative because it rarely flowers (Wilson 1960). Populations emerge via production of new fronds that emerge through slits in the sides of parent fronds. *Landoltia* is a similar duckweed but has smaller, narrowly obovate fronds (Fig. 14a). *Spirodela* has more numerous roots (Fig. 14b) and produces turions (Fig. 14c), disk-

shaped “resting fronds” loaded with starch that sink to the bottom and remain dormant throughout winter (Dölger 1997). Turions are absent in *Landoltia punctata* (Les & Crawford 1999).

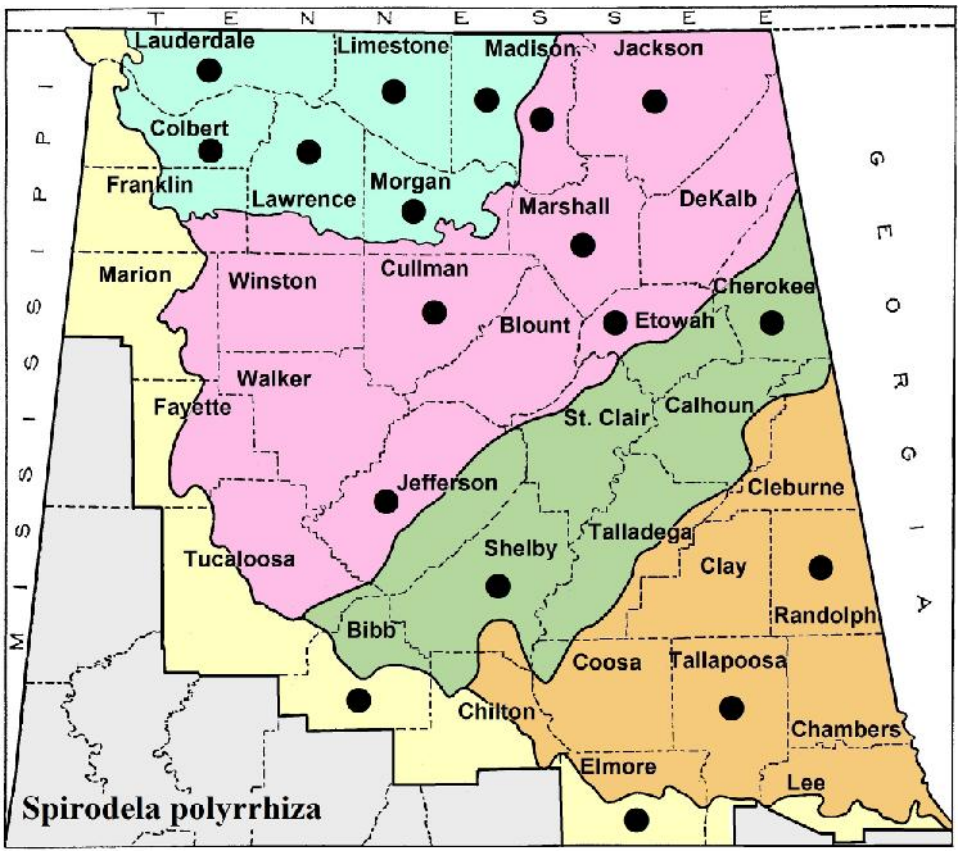


Figure 12. Distribution of *Spirodela polyrrhiza* in northern Alabama.

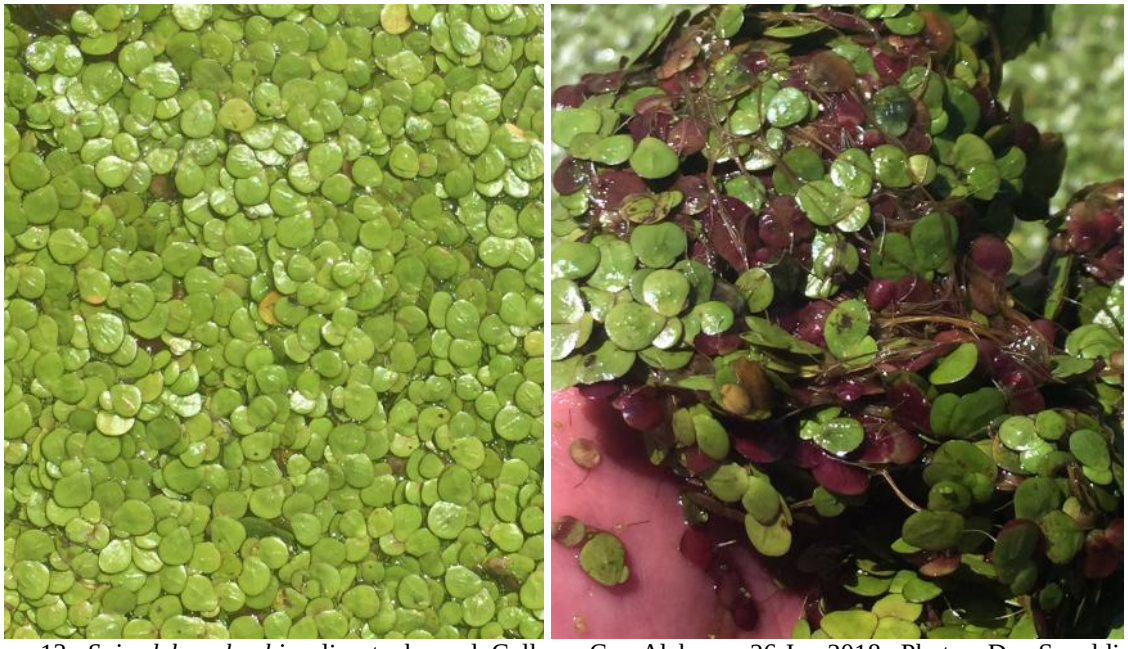


Figure 13. *Spirodela polyrrhiza*, livestock pond, Cullman Co., Alabama, 26 Jun 2018. Photos: Dan Spaulding.


(14a) *Spirodela* and *Landoltia*.


(14b) *Spirodela* roots.


(14c) *Spirodela* turion.

Figure 14. A. Weiss Lake, Cherokee Co., Alabama, 20 Jun 2018. B. Swamp, Bullock Co., Alabama, 18 May 2018. C. Farm pond, Cullman Co., Alabama, 26 Jun 2018. Photos: Dan Spaulding.

3. LEMNA Linnaeus 1753
[Ancient name of an aquatic plant]

Duckweeds are much easier to key when fresh. Once dried, fronds may need to be rehydrated to make an accurate determination. Armstrong (2001) recommends that "herbarium specimens of duckweeds be soaked (hydrated) in a small container of water. This allows the tissues to absorb (imbibe) water, enabling certain characteristics discernible under a dissecting microscope. It is also preferable to examine them using background lighting or a white background to observe the number of veins and other diagnostic features." Staining the fruits with a red dye and placing them on a transparent slides is also helpful (Yatskievych 1999). Due of the difficulty in discerning veins and minute surface features on the fronds, these characters should not be solely relied upon in order to make determinations.

1. Fronds narrowly elliptic, oblong, narrowly ovate, linear, or lanceolate; sides of fronds are typically asymmetric or basally oblique; both surfaces green; veins 1 ..... **3. *Lemna valdiviana***
1. Fronds oval to broadly elliptic; sides of fronds mostly symmetrical and base not oblique; surfaces green or lowers surface sometimes with reddish pigmentation; veins 3–5 (often very obscure).

    2. Roots not longer than 3 cm long; root tip usually sharply pointed; sheath of root winged basally (best seen when fresh under high magnification); frond lacking any reddish pigmentation ..... **1. Lemna aequinoctialis**
    2. Roots > 3 cm (up to 15 cm long); root tip mostly rounded; sheath of root not winged basally; fronds occasionally with reddish pigmentation (especially on the lower surface where the root attaches) ..... **2. Lemna obscura**

1. Lemna aequinoctialis Welw. {of equatorial regions} — LESSER DUCKWEED; THREE-NERVE DUCKWEED (Fig. 15). [*Lemna trinervis* (Austin) Small]

Floating aquatic, perennial herb. Still or slow moving water of ponds, swamps, streams, inlets, creeks, lakes, ditches, and man-made tanks or containers. Flowers and fruits generally develop in early summer–early fall (Landolt 2000). Frequent in the Highland Rim, Cumberland Plateau,

Ridge & Valley, and Coastal Plain; infrequent in the Piedmont (Fig. 16). Widespread worldwide, except in northern regions of North America and Eurasia (Weakley 2015).

Figure 15. *Lemna aequinoctialis*, small tributary to Choccolocco Creek, below a beaver dam, Talladega Co., Alabama, 22 Apr 2019. Photo: Dan Spaulding.

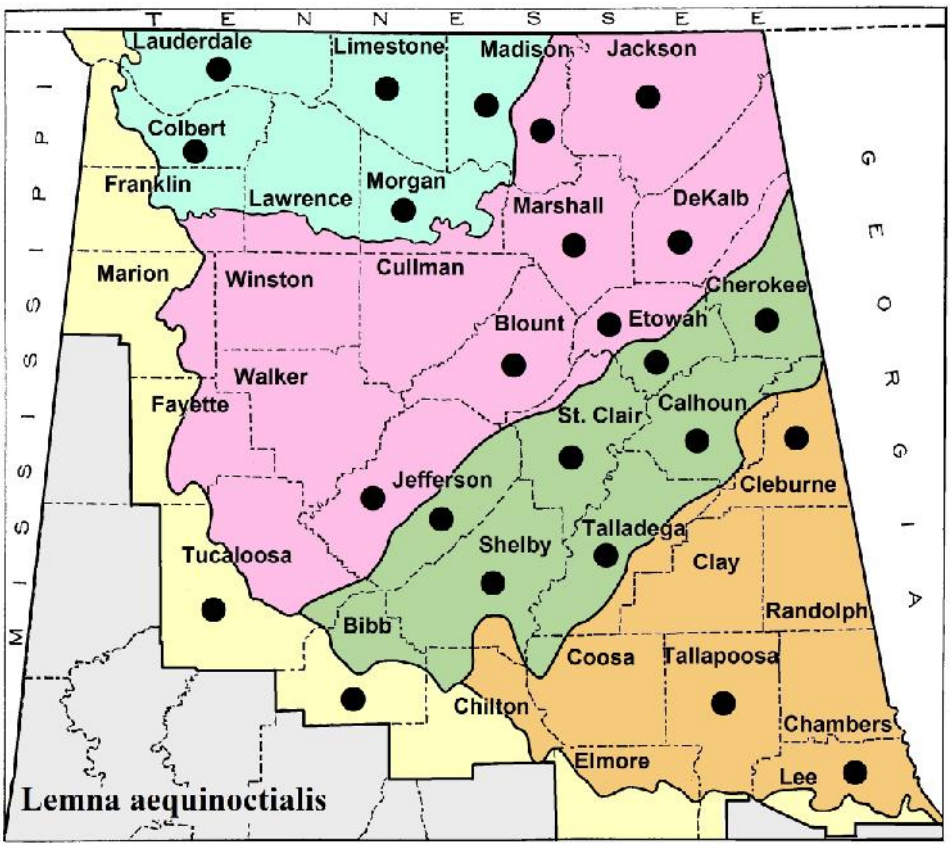
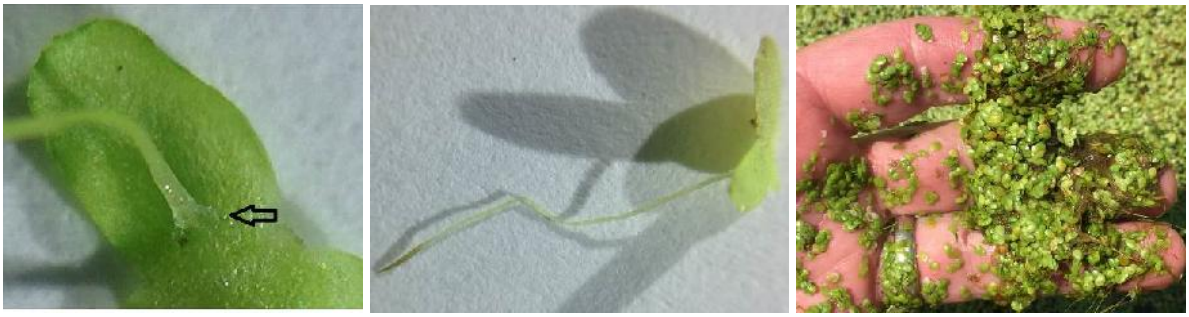


Figure 16. Distribution of *Lemna aequinoctialis* in northern Alabama.

Lemna aequinoctialis is similar to *L. obscura* but has a winged root sheath (Fig. 17a) and shorter roots (< 3 cm long) with sharp-pointed tips (Fig. 17b–c). *Lemna aequinoctialis* is the only annual duckweed known from Alabama. Viable, fertile fruits help to spread the species into new locations. Davenport and Haynes (1981) reported another annual, *L. perpusilla* Torr. (Minute Duckweed) for Alabama, but no specimens were seen in our study. Some authors place *L. aequinoctialis* into synonymy under *L. perpusilla* (Daubs 1965), but these two species can be identified by their seeds and surface features of their fronds (Weakley 2015). *Lemna perpusilla* has whitish seeds with 35–70 obscure ribs and its fronds have 2–3 papillae above the node, which are larger than the papule at the apex. *Lemna aequinoctialis* has brownish seeds with 8–26 prominent ribs and its fronds have only 1 papilla above the node, which is smaller than the papule at the apex.



(17a) Winged root sheath. (17b) Root < 3cm with pointed tip. (17c) Fronds with shorter roots.

Figure 17. A–B. Fronds growing in swamp by Choccolocco Creek in Talladega Co., Alabama, 13 May 2018. C. Crystal Springs, Calhoun Co., Alabama, 8 Jun 2018. Photos: Dan Spaulding.

2. Lemna obscura (Austin) Daubs {hidden} — LITTLE DUCKWEED (Fig. 18). [*Lemna minor* L. var. *obscura* Austin]

Figure 18. *Lemna obscura*, Salem Springs, Limestone Co., Alabama, 15 Jul 2018. Photo: Dan Spaulding.

Floating aquatic, perennial herb. Still or slow moving water of rivers, lakes, marshes, swamps, ponds, springs, and man-made ponds; occasionally flowers and fruits spring–fall (Landolt 2000); frequent in the Highland Rim, Cumberland Plateau, Ridge & Valley, and Coastal Plain;

infrequent in the Piedmont (Fig. 19). Native to the New World in temperate and subtropical regions with mild winters, from the USA south to Columbia and Ecuador (Landolt 2000).

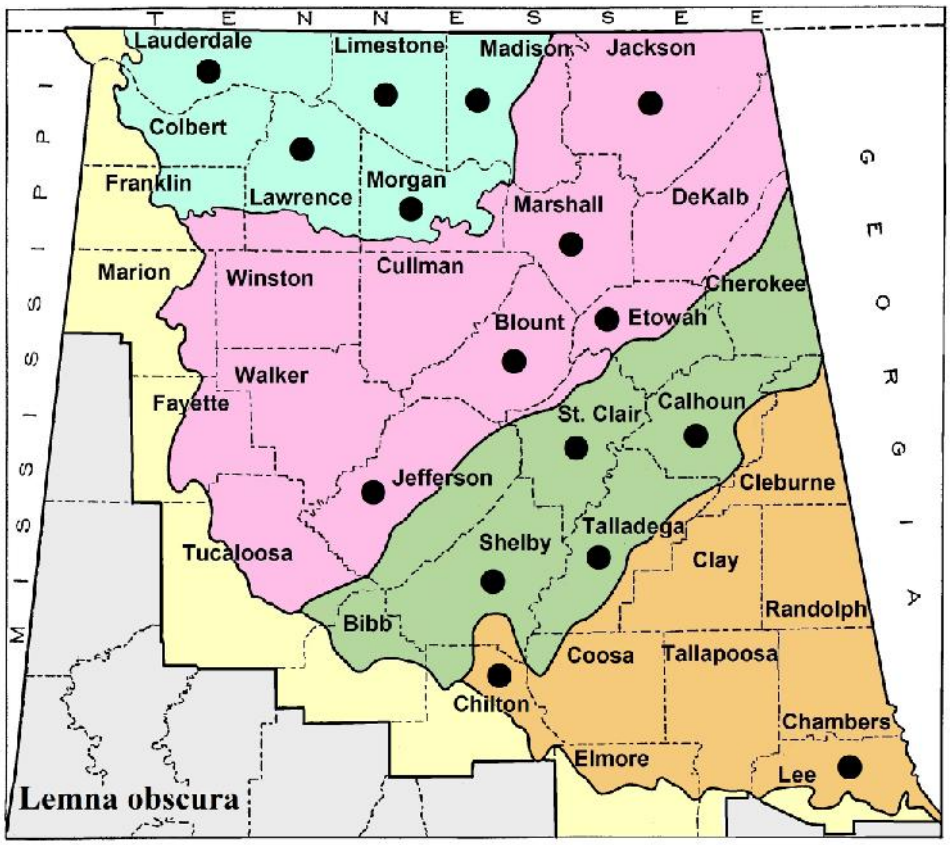


Figure 19. Distribution of *Lemna obscura* in northern Alabama.

Lemna obscura is similar to *L. aequinoctialis* but has longer roots (up to 15 cm), which often form a tangled hair-like mass (Fig. 18). Other distinguishing characters include the root tip being rounded rather than sharply pointed (Fig. 20a), a root sheath that is not winged, and lower surface of fronds being reddish or sometimes green (Fig. 20b–c).

(20a) Round root tip.

(20b) Fronds red or green beneath.

(20c) Fronds sometimes blotched with red.

Figure 20. *Lemna obscura*. A. Pond, Calhoun Co. Alabama, 29 Mar 2018. B. Tennessee River, Lawrence Co., Alabama, 20 Aug 2018. C. Lay Lake, Chilton Co., Alabama, 19 Jul 2018. Photos: Dan Spaulding.

Lemna turionifera Landolt [Turion Duckweed] was reported from Jackson County in northeast Alabama (Kartesz 2018; Landolt 2000), but no specimens were seen. This species has small, flat olive-brown fronds with papillae on midline of the upper surface. Turion Duckweed often produces small, rootless turions (0.8–1.6 mm in diameter) that sink to the bottom in the fall (Fig. 21). *Lemna obscura* differs by lacking turions and having mostly gibbous ("hump-backed") fronds with papillae above the node, near the apex of the upper surface (Weakley 2015).

Figure 21. *Lemna turionifera*, backwaters of Danube River, Austria, 3 Oct 2016. Photo: Stefan Lefnaer.

Lemna minor (Fig. 22) is also similar to *L. obscura*, but no valid specimens were observed in this study. Landolt (2000) listed it for Alabama, with collections reported from several counties (Kartesz 2018; SERNEC 2018). Davenport and Haynes (1981) said *L. minor* was "common in ponds and logjams throughout the State." It is possible that many reports of *L. minor* have been misapplied to *L. obscura* in Alabama. Austin (1867) first described this taxon as *L. minor* var. *obscura*, but Thompson (1898), in his revision of American Lemnaceae, did not recognize it. However, Daubs (1965) justified elevating Austin's variety to species rank, because of its larger, gibbous fronds that are often more pigmented than those of *L. minor*. Additionally, the upper surface of *L. obscura* fronds have a prominent papule near the apex with a row of distinct papules along the midvein, whereas the fronds of *L. minor* have papules that are all relatively small (Yatskievych 1999). Turions are absent in both these species, but daughter fronds can be confused for turions, but they are the same color or lighter than parent fronds and also develop roots when mature.

Figure 22. *Lemna minor*, pond in Austria, 28 Aug 2018. Photo: Stefan Lefnaer.

3. Lemna valdiviana Phil. {of Valdivia, Chile} — VALDIVIA DUCKWEED; PALE DUCKWEED; SMALL DUCKWEED (Fig. 23).

Figure 23. *Lemna valdiviana*, Borden Springs, Cleburne Co., Alabama, 9 Jun 2018. Photos: Dan Spaulding.

Floating aquatic, perennial herb. Still or very slow moving water of swamps, marshes, ponds, rivers, inlets, lakes, streams, creeks, and springs; rarely flowers and fruits in spring–fall (Landolt 2000); infrequent in the Highland Rim, Cumberland Plateau, and Coastal Plain; rare in the Ridge & Valley (Fig. 24). Native to temperate and tropical regions of the USA south to South America (Landolt 2000).

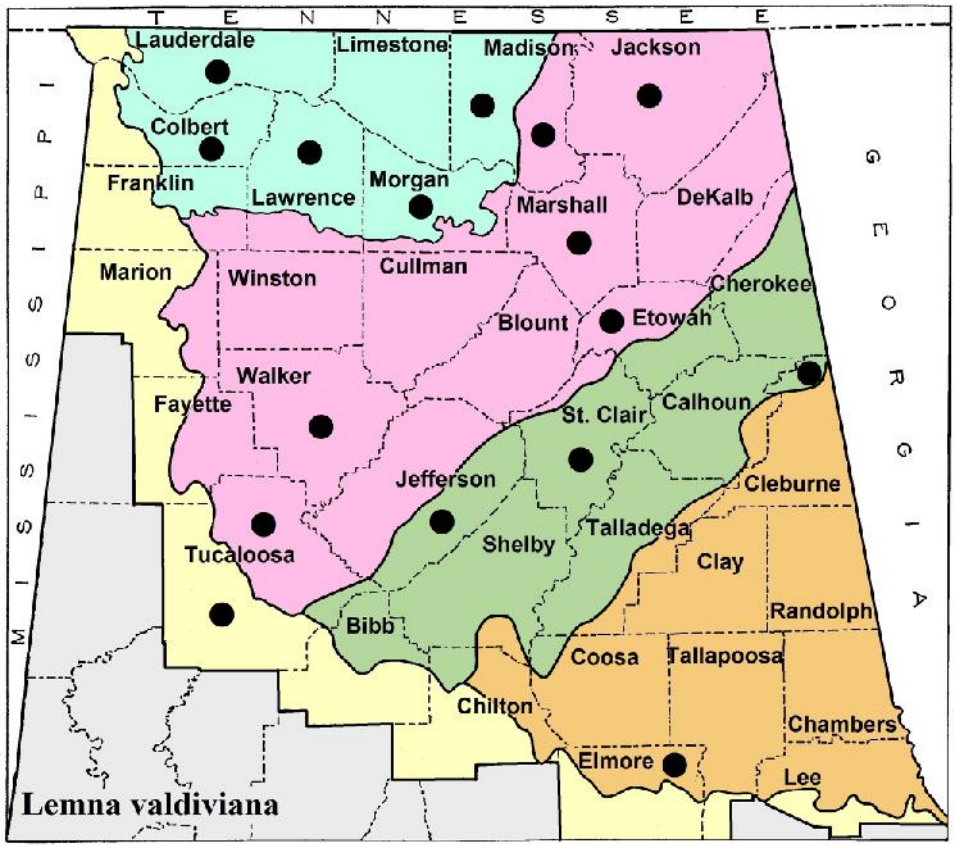


Figure 24. Distribution of *Lemna valdiviana* in northern Alabama.

Lemna valdiviana is very distinctive, its fronds are asymmetrical basally, up to 3 times longer than wide, mostly 2.5–5 mm long, and either floating or occasionally submersed. When this duckweed's fronds are connected in 4s they often resemble a butterfly (Fig. 25).

Figure 25. *Lemna valdiviana* fronds, Cleburne Co., Alabama, 9 Jun 2018. Photo: Dan Spaulding.

Lemna valdiviana is similar to *L. minuta* Kunth [Least Duckweed] because both have single veined fronds. *Lemna minuta* has been reported for Alabama (Kral et al. 2011) from Colbert, Houston, and Jackson counties (Keener et al. 2019). Northern Alabama collections have been annotated to *L. valdiviana* and visits to the site in Houston County found only *Landoltia punctata*. The fronds of *L. minuta* (Fig. 26) are nearly symmetrical basally, 1–2 times longer than wide, mostly 1–3 mm long, and are always found floating (Diggs et al. 2006).

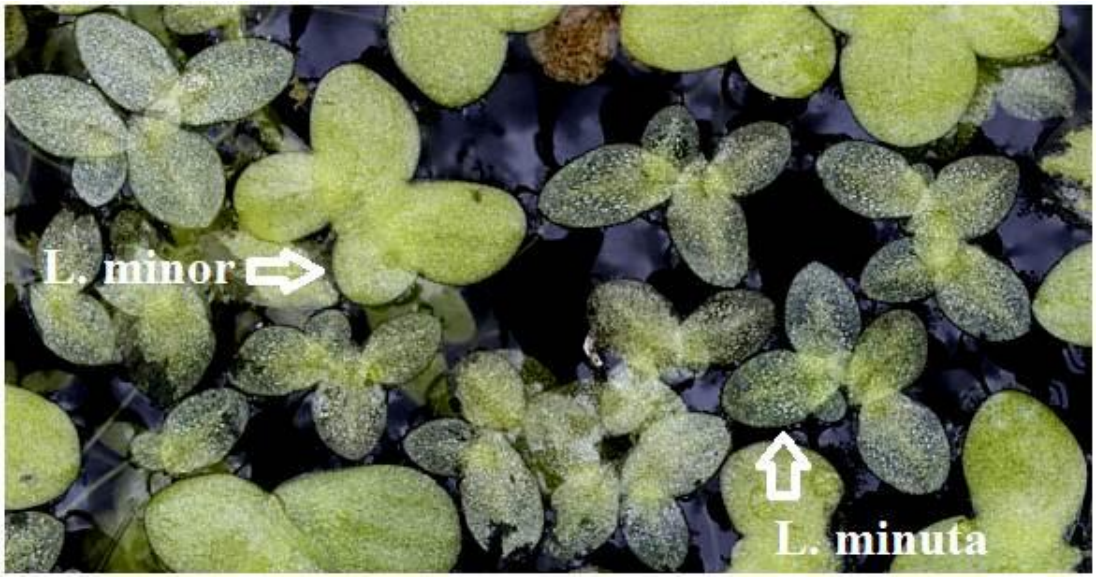


Figure 26. *Lemna minuta* with *L. minor*, France, 30 Apr 2016. Photo: Pascale Guinchard.

4. LANDOLTIA D.H. Les & D.J. Crawford 1999
[Named for Elias Landolt, 1926–2013, a duckweed expert from Zurich, Switzerland]

1. Landoltia punctata (G.F.W. Mey.) D.H. Les & D.J. Crawford {dotted} — DOTTED DUCKMEAT; DOTTED DUCKWEED; LESSER GREATER DUCKWEED (Fig. 27). [*Lemna punctata* G.F.W. Mey.; *Spirodela oligorrhiza* (Kurz) Hegelm.; *Spirodela punctata* (G.F.W. Mey.) Thomps.]


Figure 27. *Landoltia punctata*, marsh in Lee Co., Alabama, 29 May 2018. Photo: Dan Spaulding.

Floating aquatic, perennial herb. Still or slow moving water of ponds, lakes, swamps, springs, marshes, inlets, rivers, streams, livestock watering holes, man-made water tanks, and water treatment lagoons; rarely flowers and fruits in summer–early fall (Landolt 2000); uncommon in the Highland Rim, Cumberland Plateau, Ridge & Valley, and Piedmont; frequent in the Coastal Plain (Fig. 28).

Landoltia is believed to have originated from South Asia or Australia (Landolt 1986) but is now widespread in warm-temperate to subtropical regions (Landolt 2000). It was first discovered from North America in Kansas City, Missouri, by Albert Saeger in 1934 (Ward 2011). *Landoltia* was possibly introduced via aquarium plant trade (Daubs 1965) and is becoming a noxious weed in the southeastern USA (Fig. 29a).

Landoltia was first described as a member of the genus *Lemna* but later placed into the genus *Spirodela*, along with other species that had more than one root per frond (Landolt 1986). Ward (2011) disputed the application of the basionym of *Lemma punctata*, believing that Thompson (1898) erroneously selected a collection of a different species (*Lemma oligorrhiza*) when transferring the species to his new combination, *Spirodela punctata*. Most modern authors disagree with Ward's conclusions and continue to recognize *Lemma punctata* as the correct basionym (Les & Crawford 1999; Wiersema 2015). Les and Crawford (1999) stated that is was "transitional between, but not a member of either *Lemna* or *Spirodela*" and placed *S. punctata* into a new genus, *Landoltia*. They also said that this monotypic genus "is very polymorphic in relation to size, pigmentation, number of roots, and veins." Since populations often contain individuals with only one root, it is best to examine a number of fronds in a population before making a determination. Daubs (1965) separated the two smaller species of *Spirodela* (now *Landoltia*) based on fronds being noticeably punctate with reddish-brown pigmented cells and having fewer roots.

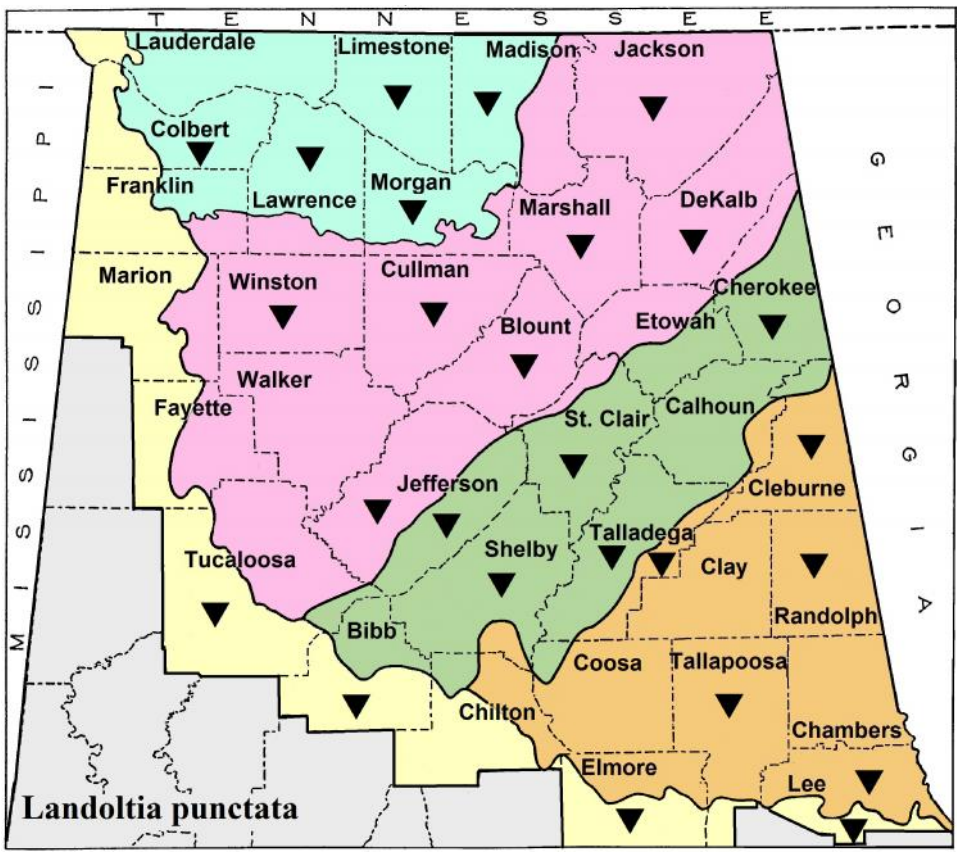


Figure 28. Distribution of *Landoltia punctata* in northern Alabama.

Although *Spirodela polyrrhiza* is similar to *Landoltia*, the latter has smaller, elongate-obovate fronds that lack a red spot (although fronds are sometimes dotted with reddish pigmentation). *Landoltia* also has fewer roots (Fig. 29b) than *Spirodela*, all of them perforating the scale-like leaflet. Moreover, turions are present in *S. polyrrhiza* but absent in *Landoltia* (Les & Crawford 1999). New fronds growing from the sides of the main fronds of *Landoltia* can mimic turions (Fig. 29c). These daughter fronds differ from turions by being the same color as the parent frond, remaining attached, and producing roots. True duckweed turions separate from parent fronds, sink, and later break dormancy after a period of cold temperatures (Kuehdorf et al. 2014).

(29a) Population on edge of pond.

(29b) Frond roots.

(29c) Daughter fronds similar in color.

Figure 29. *Landoltia punctata*. A. Cleburne Co., Alabama, 4 Aug 2019. B. Bankhead Lake, Jefferson Co. Alabama, 2 Jun 2018. C. Fronds from a pond in Cullman Co., Alabama, 27 Feb 2019. Photos: Dan Spaulding.

5. WOLFFIA Horkel ex Schleiden 1844

[Named for Johann F. Wolff, 1778–1806, German botanist who wrote about *Lemna*]

Wolffia is the smallest flowering plant in the world with fronds the size of a pinhead (Daubs 1965). All the duckweeds (*Landoltia, Lemna, Spirodela*, *Wolffia*, and *Wolffiella*) are used as food by wildlife, especially ducks, marsh birds, and shorebirds (Martin et al. 1951). Two species of *Wolffia* are known from Alabama and they sometimes grow intermixed.

1. Upper surface of frond with a distinct, single cone-shaped papule in the center; fronds often brown-punctate when dying, dead, or dried; cells inflated in lower portion of frond becoming progressively smaller and compact toward the upper surface; thus fronds are darker green in the top portion and lighter green or whitish in the lower section; all fronds floating no matter how crowded.....**1. Wolffia brasiliensis**
1. Upper surface of frond with a median row of smaller papules, but lacking a single nipple-like papule; fronds never brown-punctate; cells of frond all the same size, appearing uniformly green from the side; some fronds may occur under water in dense populations.....**2. Wolffia columbiana**

1. Wolffia brasiliensis Wedd. {of Brazil} — BRAZILIAN WATERMEAL (Fig. 30). [*Wolffia papulifera* C.H. Thomps.; *Wolffia punctata* Griseb.]

Figure 30. *Wolffia brasiliensis*, Snake Lake, Cleburne Co., Alabama, 8 Jun 2018. Photos: Dan Spaulding.

Floating aquatic, perennial herb. Still or very slow moving water of ponds, creeks, streams, impoundments, sloughs, swamps, and springs; rarely flowers and fruits in late spring–early fall (Landolt 2000); uncommon in the Highland Rim and Ridge & Valley; rare in the Cumberland Plateau and Piedmont; frequent in the Coastal Plain (Fig. 31). This species is native throughout the Americas. In the USA, it occurs mostly in eastern to midwestern states, and is disjunct on the west coast (Kartesz 2018).

Even though fronds of *Wolffia brasiliensis* are almost the size of a pinhead (Fig. 32a), populations often cover the entire water surface (Fig. 32b). Fronds are nutshell-like or boat-shaped (ellipsoid or broadly ovoid) and the upper surface is flat, except for a single, conical papule (nipple-like projection) in the center (Fig. 32c). Cells in the lower portion are inflated, becoming

progressively smaller and more compact toward the upper surface, which makes the frond appear darker at the top (Fig. 32c). These characters are detectable only under magnification and are easier to see in fresh specimens viewed from the side. Identification is also facilitated by brownish pigmented cells (dark dots) that appear in dead, dying, or dried fronds (Fig. 32d).

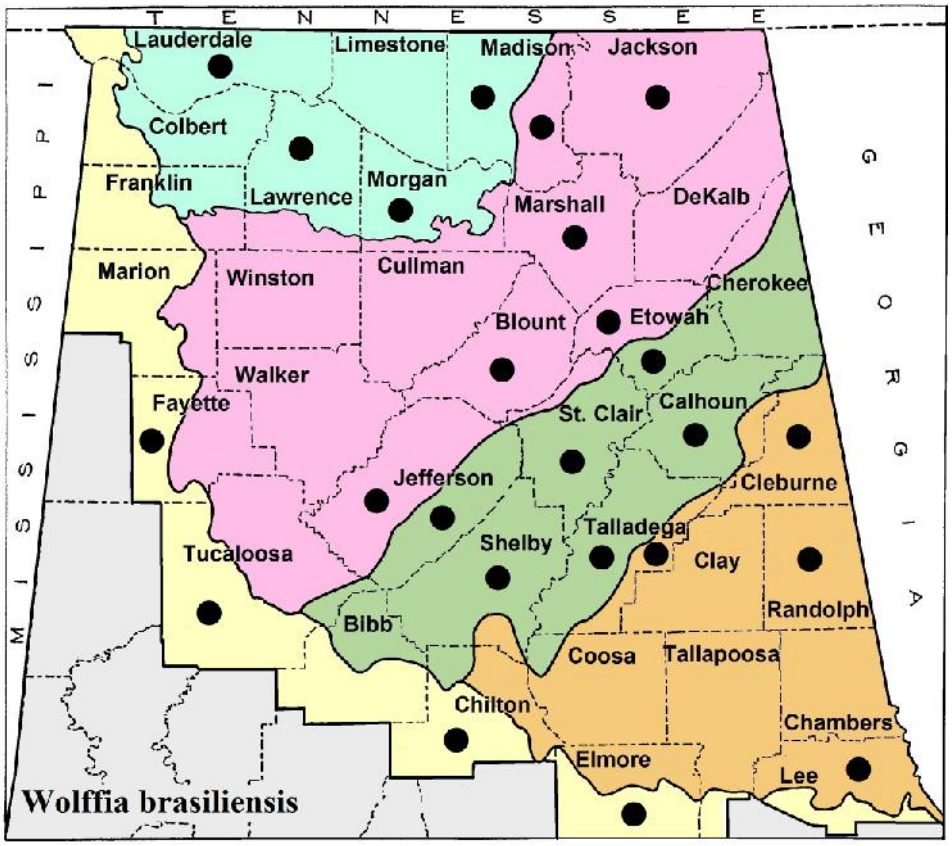
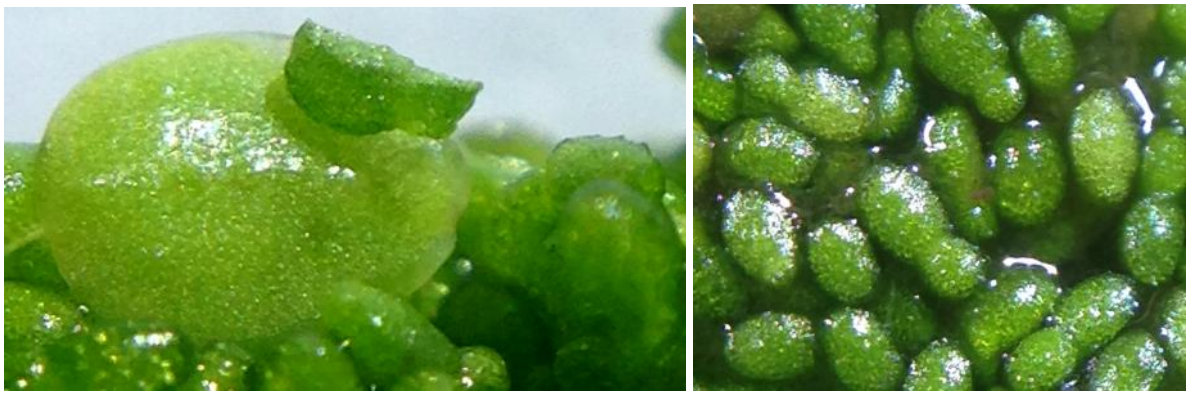


Figure 31. Distribution of *Wolffia brasiliensis* in northern Alabama.

(32a) Pinhead-sized fronds. (32a) Population on pond. (32c) Darker on top. (32d) Brown punctate frond.

Figure 32. *Wolffia brasiliensis*. A–B. Cleburne Co. Alabama, 20 Jun 2018. C. Lake Wedowee, Randolph Co., Alabama, 30 Jul 2018. D. Snake Lake, Cleburne Co., Alabama, 8 Jun 2018. Photos: Dan Spaulding.

2. Wolffia columbiana H. Karst. {of Colombia} — COLUMBIAN WATERMEAL (Fig. 33). [*Bruniera columbiana* (H. Karst.) Nieuwl.]



(33a) Frond (on *Landoltia*) lacking larger central papule. (33b) Fronds floating and some submersed.

Figure 33. *Wolffia columbiana*. A. Marsh, Limestone Co., Alabama, 15 Jul 2018. B. Pond, Tallapoosa Co., Alabama, 10 Jul 2018. Photos: Dan Spaulding.

Floating aquatic, perennial herb. Still or very slow moving water of ponds, ditches, marshes, lakes, sloughs, oxbows, inlets, swamps, and rivers; very rarely flowers and fruits in summer–early fall (Landolt 2000); uncommon in the Highland Rim and Ridge & Valley; rare in the Cumberland Plateau and Piedmont; frequent in the Coastal Plain (Fig. 34). *Wolffia columbiana* is native to the Americas, from Canada south to Colombia and Venezuela (Daubs 1965).

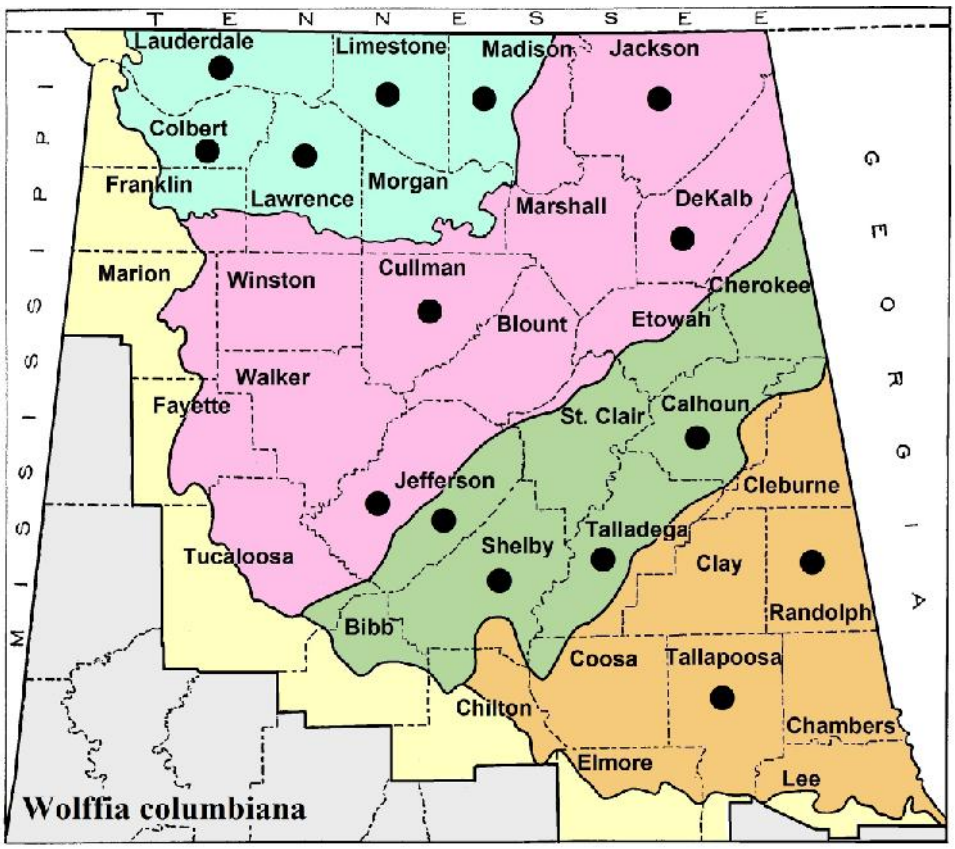


Figure 34. Distribution of *Wolffia columbiana* in northern Alabama.

Fronds of *Wolffia columbiana* are ovoid to globose and rounded (convex) on the upper surface. They typically have a median row of small papules, but lack a prominent, central papule (Fig. 33a). Fronds are never brown punctate (lack dots), and appear uniformly green from the side, since the cells are similar in size throughout. When crowded, individual fronds will often be forced under water (Fig. 33b), which is never the case in *W. brasiliensis*. Columbian Watermeal commonly occurs in mixed populations with other duckweed genera, such as *Landoltia* (Fig. 35).

Figure 35. *Wolffia brasiliensis* with *Landoltia punctata* on surface of a wastewater treatment pond in Wedowee, Randolph Co., Alabama, 13 Jun 2018. Photos: Dan Spaulding.

6. **WOLFFIELLA** Hegelmaier 1895

[Diminutive of *Wolffia*, named for Johann Friedrich Wolff, 1778–1806]

1. Wolffiella gladiata (Hegelm.) Hegelm. — MUD-MIDGETS; SWORD BOGMAT (Fig. 36).

Figure 36. *Wolffiella gladiata* at Summit Metro Parks in Triangle Lake Bog, Portage Co., Ohio, 23 May 2016. Photos: Rob Curtis.

Floating aquatic, perennial herb. In quiet waters of swamps, reservoirs, marshes, ponds, and sloughs; rarely flowering and fruiting in spring–fall (Landolt 2000); very rare in the Highland Rim and Cumberland Plateau (Fig. 37); infrequent in the Coastal Plain. This species is found primarily on the Coastal Plain from Massachusetts to east Texas, but scattered northward to southeast Oklahoma, west through the Ohio River Valley to Pennsylvania (Kartesz 2018).

Wolffiella is a monophyletic genus containing 10 species and is restricted to tropical to warm temperate areas of Africa and the Americas. This limited distribution is biogeographically unique

among the widespread temperate duckweed genera (Kimball et al. 2003). Allozyme and molecular phylogenetic studies suggest that the genus likely originated in Africa (Kimball et al. 2003; Crawford et al. 1997) with an early movement and subsequent radiation into the Americas (Kimball et al. 2003).

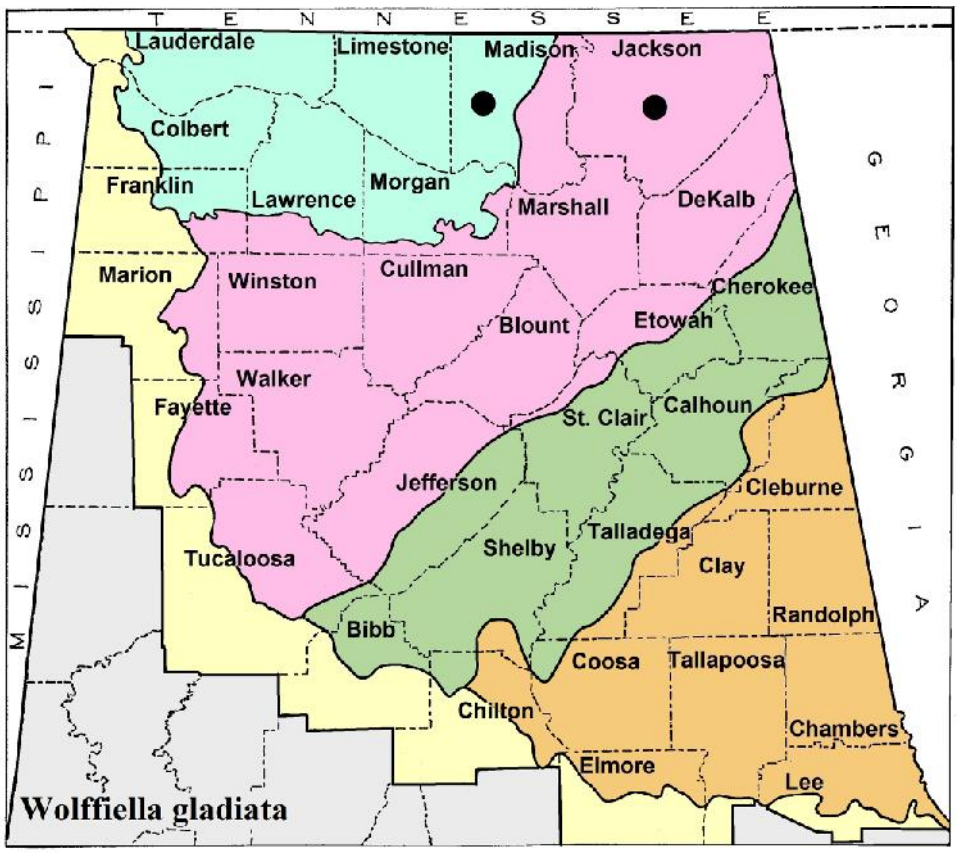


Figure 37. Distribution of *Wolffiella gladiata* in northern Alabama.

Wolffiella gladiata was recently discovered in northern Alabama by David Webb in Jackson County and later by Wayne Barger in Madison County. Like *Wolffia*, this genus lacks roots and veins, but differs by its flat, narrow, elongated fronds. When their sword-like fronds are connected, they can form a star-like structure (Fig. 38).

Figure 38. *Wolffiella gladiata*, Blackwell Swamp, Madison Co., Alabama, 15 Jun 2018. Photos: Wayne Barger.

7. **PELTANDRA** Rafinesque 1819

[Greek, *pelt* a small shield, and *andros*, male; referring to shape of tops of staminate flowers]

1. Peltandra virginica (L.) Schott {Virginian} — GREEN ARROW-ARUM; TUCKAHOE (Fig. 39). [*Peltandra luteospadix* Fern.; *Peltandra virginica* ssp. *luteospadix* (Fern.) W.H. & K.P. Blackw.]

Figure 39. *Peltandra virginica*, Autauga Co., Alabama, 27 May 2013. Photos: Brian Finzel.

Amphibious, perennial herb. Swamps, marshes, bogs, seeps, margins of lakes and ponds; flowers and fruits May–June; frequent throughout Alabama (Fig. 40). Native to eastern North America from southern Ontario and Quebec, south to Texas and Florida, and introduced in California, Oregon, and Washington (Kartesz 2018). Its original range has been expanding due to the dispersal of seeds by wildlife (Thompson 2000b).

Peltandra virginica generally has a green, succulent spathe, which occasionally has a whitish border. Its fruits are green to dark purple when ripe (Fig. 41a). A similar species, *P. sagittifolia* (Michx.) Morong [White Arrow-Arum], which is restricted to the southeastern Coastal Plain, differs by having a two-tone spathe that is solid white above and green at the base (Fig. 41b). Its fruits are red when ripe (Fig. 41c). Sterile material of these two species can be separated by their leaf venation. Leaves of both species have thick midveins, but the lateral veins of *P. sagittifolia* are all finely textured (Fig. 42a), while the lateral veins of *P. virginica* are thicker than the other veins (Fig. 42b).

Thompson (2000b) recognized only two species, *Peltandra virginica* and *P. sagittifolia*, stating that *P. virginica* is highly variable and that "different forms have been recognized taxonomically, both at the specific and infraspecific levels." Fernald (1948) named a third species *P. luteospadix* (Fig. 43), which he claimed differed from typical *P. virginica* because the upper portion of the spathe was flared and had a white border. The spathe of typical *P. virginica* is often tightly inrolled around the spadix and green throughout. Fernald's *P. luteospadix* is now considered to represent a form of *P. virginica*, which can be mistaken for *P. sagittifolia* due to its flaring white-margined spathe. Reports of *P. sagittifolia* from northern Alabama are most likely this form of *P. virginica*.

Blackwell and Blackwell (1974) reorganized the genus into a single species with two subspecies, *Peltandra virginica* subsp. *virginica* and *P. virginica* subsp. *luteospadix*. They

synonymized *P. sagittifolia* with subspecies *luteospadix*. Their taxonomic decision was based on the false assumption that "berries of all *Peltandreae* are in fact more or less green" and that spathes were "always somewhat greenish… In none we observed were the spathes entirely white… This is apparently an artifact of the drying process." The authors believed that *P. sagittifolia* was "a bit of fiction" and said "there is no such plant," which led them to an incorrect conclusion that "*Peltandra sagittifolia* was to be regarded as myth."

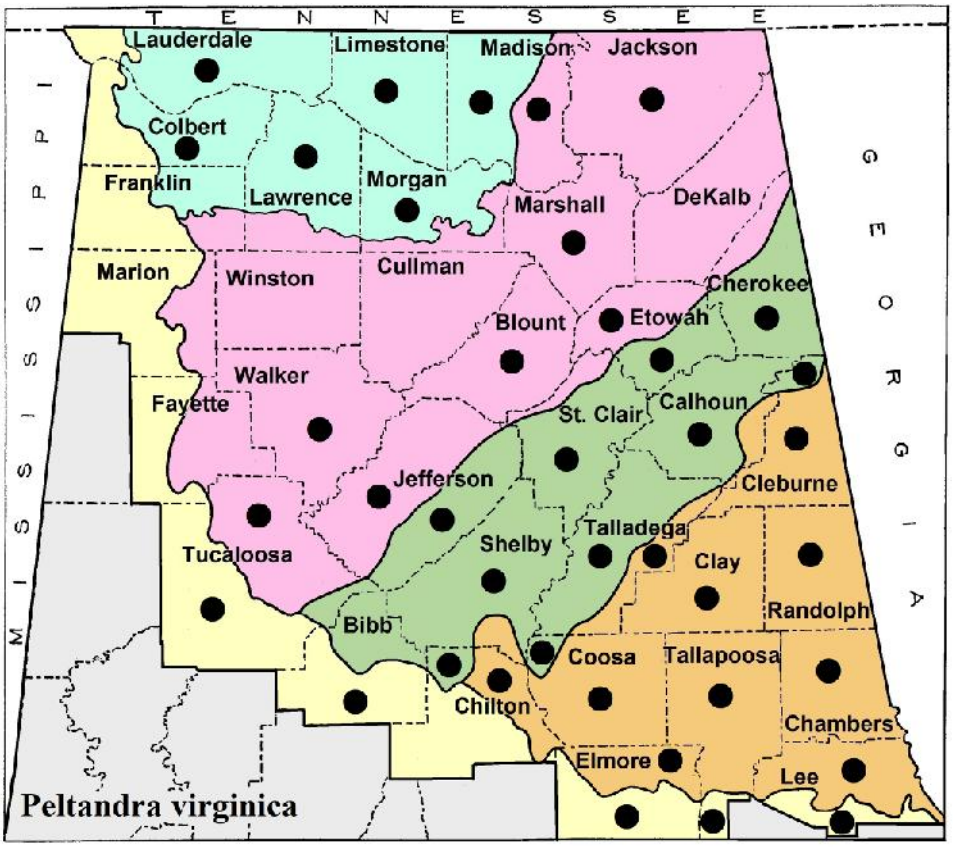


Figure 40. Distribution of *Peltandra virginica* in northern Alabama.

(41a) *Peltandra virginica* fruits. (41b) *Peltandra sagittifolia* in flower. (41c) *Peltandra sagittifolia* fruits.

Figure 41. A. Photo: Josef Bogner. <http://araceae.e-monocot.org/file/1271> B. Baldwin Co. Alabama, 19 Jun 2008. Photo: Wayne Barger. C. Perry Co. Mississippi, 14 Aug 2008. Photo: John Gwaltney. <http://www.southeasternflora.com>

(42a) *Peltandra sagittifolia* leaf.

(42b) *Peltandra virginica* leaf.

Figure 42. A. Perry Co. Mississippi, 14 Aug 2008. Photo: John Gwaltney. <http://www.southeasternflora.com> B. Madison Co., Alabama, 8 Jun 2013. Photo: Brian Finzel.

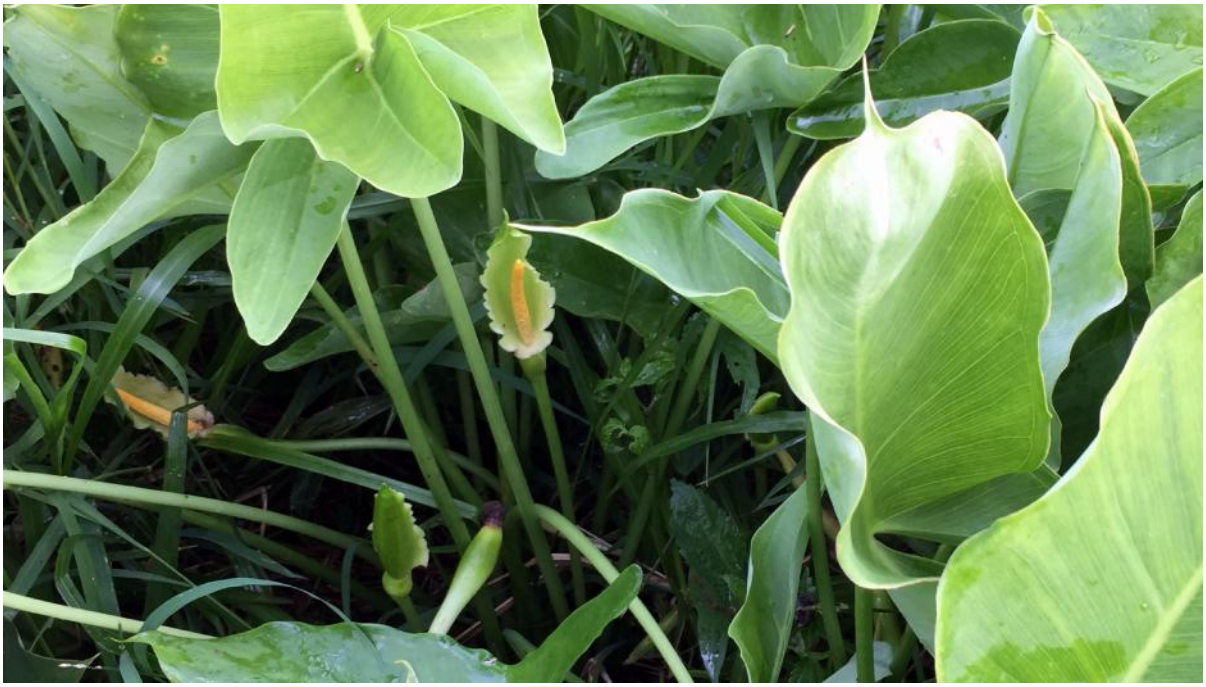


Figure 43. *Peltandra virginica* "*luteospadix*" along margin of lake in Delta, Clay Co., Alabama, 13 Jun 2018. Photo: Dan Spaulding.

Pollination studies of *Peltandra virginica* revealed that the unusual odor of the flowers attracts small flies (Patt et al. 1995). A species of chloropid fly (*Elachiptera formosa*) uses the inflorescence as a mating area and later as a food source for its larvae. The chloropid fly deposits its eggs on the spadix, enabling the emerging larvae to feed on the upper male portion, which is usually rotting when they hatch.

Coffey (1993) wrote that *Peltandra* was used historically as food by various Native American tribes of eastern North America. They ate the fruits, which allegedly sweeten after boiling, and utilized seeds from the berries to make bread. The starchy rhizomes have a potato-like flavor but need to be properly cooked prior to eating due to poisonous alkaloids. The vernacular name "tuckahoe" is actually an Algonquin Indian word, meaning edible roots.

8. **PISTIA** Linnaeus 1753
[Greek, *pistos*, liquid; referring to its aquatic habitat]

1. Pistia stratiotes L. {Greek for soldier; possibly referring to rows of leaves} — WATER-LETTUCE; WATER-CABBAGE; RIVER-LETTUCE; WATER-BONNET; SHELL-FLOWER (Fig. 44).

Figure 44. *Pistia stratiotes*, Lay Lake/Coosa River, Chilton Co., Alabama, 19 Jul 2018. Photo: Wayne Barger.

Floating aquatic, perennial herb with stolons. Slow or stagnant water along margins of rivers, lakes and inlets; very rarely flowers in late summer–early winter (Thompson 2000b); rare in the Cumberland Plateau, Ridge & Valley, Piedmont, and Coastal Plain (Fig. 45), but locally abundant. The center of origin of *Pistia stratiotes* is uncertain, but the species occurs worldwide mostly in tropical to subtropical regions (Adebayo et al. 2011). Some authors believe that *Pistia* may have originated in Africa since it is depicted in Ancient Egyptian hieroglyphs (Stoddard 1989). Center et al. (2002) suggested a South American origin because a large number of insects in Brazil and Argentina specialize on *Pistia*.

Water-Lettuce is the sole extant member of the ancient genus *Pistia* (Wilson 1960). It had long been thought to be in the evolutionary line to the duckweeds (Arber 1919). *Pistia stratiotes* flowers (Fig. 46a) are thought to be insect pollinated, but most plants in North America rarely set seed, possibly due to lack of pollinators (Haynes 1988). In northern Alabama, no flowers were observed in any populations. New plants are produced at the ends of stolons and spread by fragmentation (Fig. 46b). Water-Lettuce is a free-floating, stoloniferous aquatic with a rosette of velvety leaves and feathery roots that hang underneath (Fig. 46c). Its seeds are small and typically dispersed by water or occasionally transported on the feet of wading birds (Bown 2000).

Pistia was first observed in North America by John and William Bartram along the St. Johns River in Florida in the 18th Century (Stuckey & Les 1984). Based on the paleo-botanical, historical, and ecological evidence, Evans (2013) argued that *Pistia* is native to Florida. It is considered nonindigenous to all other states and was first documented from Alabama in 2002 (Thayer et al. 2018). New introductions, especially in the USA, are probably from the disposal or escape of

ornamental pond plants (Adebayo et al. 2011). Water-Lettuce listed as an extremely noxious weed because it clogs waterways and is perhaps one of the most invasive aquatic plants in the world (Dray & Center 2018). Kartesz (pers. comm. 2019) reported that from 6 individuals introduced into a private pond in Chapel Hill, North Carolina, produced about 1,600 plants in just over a 60-day period.

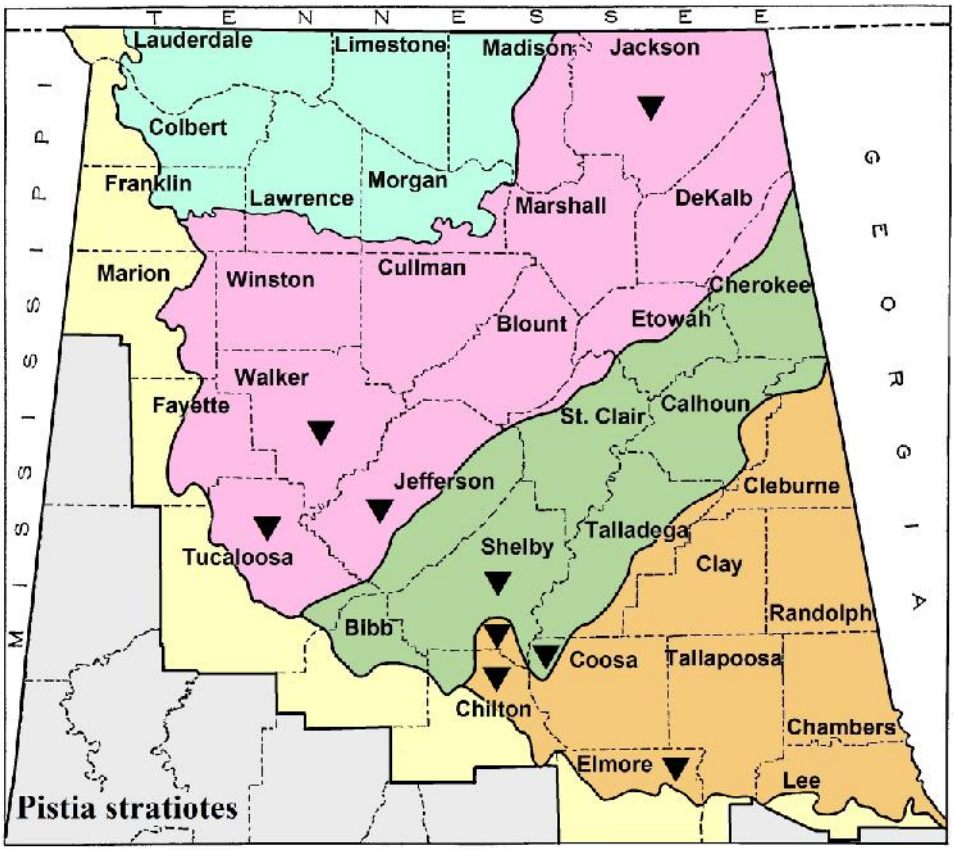


Figure 45. Distribution of *Pistia stratiotes* in northern Alabama.

(46a) *Pistia stratiotes* flowers resemble shells.

(46b) Dense population on lake.

(46c) Feathery roots.

Figure 46. *Pistia stratiotes.* A. Osaka Japan, 3 Nov 2005. Photo: Keisotyo. <https://commons.wikimedia.org> B. Lake Jordan Marina, Elmore Co., Alabama, 3 Sep 2018. Photo: Dan Spaulding. C. Maui, Hawaii. 20 Feb 2008. Photo: Forest & Kim Starr. <http://www.starrenvironmental.com>

9. COLOCASIA Schott 1832

[Greek name derived from an old Middle Eastern Arabic name of the plant, *colcus* or *culcas*]

1. Colocasia esculenta (L.) Schott {edible} — WILD TARO; COCO-YAM; ELEPHANT'S-EAR; DASHEEN; EDDO (Fig. 47). [*Colocasia antiquorum* Schott; *Colocasia esculenta* var. *antiquorum* (Schott) Hubb. & Rehder; *Colocasia esculenta* var. *aquatilis* Hassk.; *Colocasia esculenta* var. *nymphaeifolia* (Vent.) A.F. Hill]

Figure 47. *Colocasia esculenta* along banks of Choccolocco Creek, Talladega Co., Alabama, 21 Sep 2018. Photo: Dan Spaulding.

Amphibious, perennial herb with tuberous rhizomes. Along rivers, lakes, inlets, marshes, floodplains, canals, ditches, and wet disturbed areas; occasionally flowers and fruits June–October; uncommon in the Highland Rim, Cumberland Plateau, Ridge & Valley, and Piedmont; frequent in the Coastal Plain (Fig. 48). Native to Asia and naturalized in the southeastern USA from North Carolina to Texas (Kartesz 2018), as well as Mexico, Central America, South America, Africa, Australia, Pacific Islands, and other tropical areas (Thompson 2000b).

Colocasia esculenta is widely cultivated in the tropics and subtropics for its starchy, edible tubers, making it one of the oldest crops in the world (Bown 2000). The tuber (corm), however, must be properly cooked prior to eating because it contains calcium oxalate crystals, which can severely irritate the tissues of the mouth (Wilson 1960). Taro is a staple food in the Pacific Islands, especially Hawaii, where they make poi (a fermented paste) from crushed, cooked corms (Thompson 2000b).

Because of Taro's long history of cultivation, many varieties and cultivars have been named. *Colocasia esculenta* is thought to have been introduced into the Caribbean and the southeastern USA by slaves who brought it from Africa (Thompson 2000b). Taro is widely planted in the Southeast and has escaped cultivation into areas beyond the southeastern Coastal Plain. It is locally abundant and can become an aggressive, invasive weed. Plants flower and fruit sporadically (Fig. 49a–d).

Colocasia mostly spreads vegetatively by stolons and rhizomes (Fig. 50a–b), forming large clonal colonies, especially along rivers and lakes. A key characteristic of *Colocasia* is its large, peltate leaves with a leaf stalk (petiole) that is attached on the underside of leaf blade (Fig. 50c).

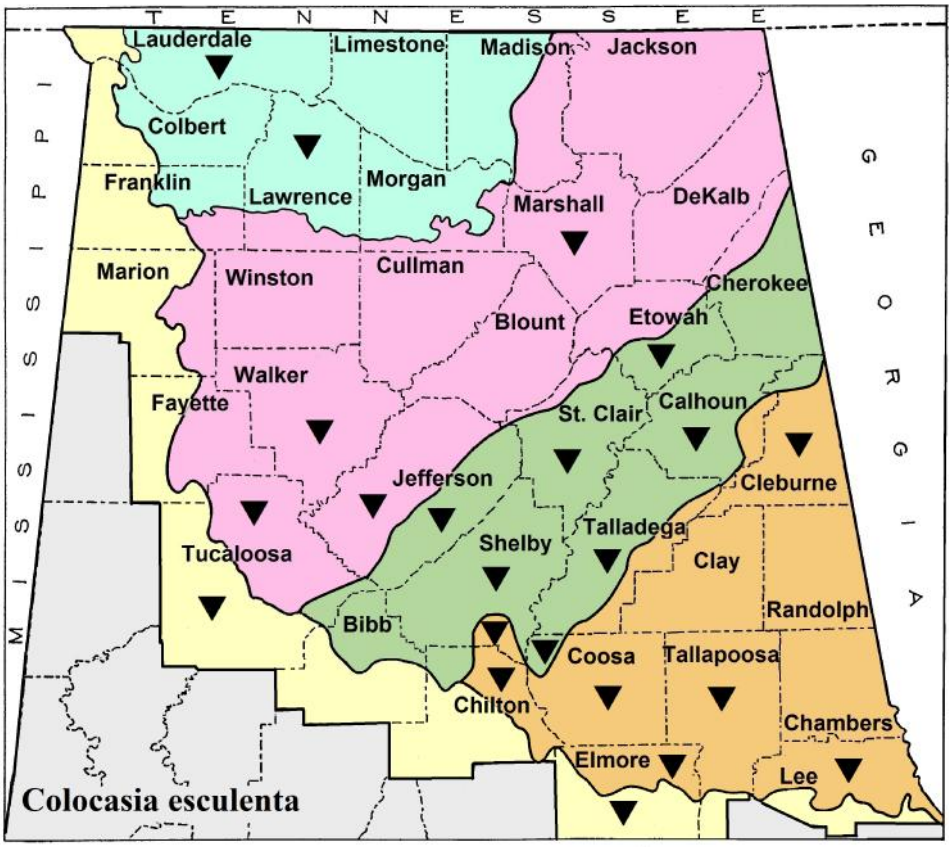


Figure 48. Distribution of *Colocasia esculenta* in northern Alabama.

(49a) Young inflorescence. (49b) Mature inflorescence. (49c) Close-up of spadix. (49d) Maturing fruits.

Figure 49. *Colocasia esculenta*. A–D. Margins of Black Warrior River, Jefferson Co., Alabama, 12 Oct 2018. D. Mulberry Fork of the Black Warrior River, Walker Co., Alabama, 22 Sep 2018. Photos: Dan Spaulding.

(50a) Base of plant with stolons. (50b) Plantlet at end of stolon. (50c) Peltate leaves.

Figure 50. *Colocasia esculenta*. A–C. Inlet into the Tennessee River, Lawrence Co., Alabama, 19 Aug 2018. C. Locust Fork of the Black Warrior River, Jefferson Co., Alabama, 2 Jun 2018. Photos: Dan Spaulding.

Serviss et al. (2000) listed three varieties of *Colocasia esculenta* (var. *antiquorum*, var. *aquatilis*, var. *nymphaeifolia*) occurring in the southeastern USA. The taxa are separated by lengths of rhizomes and size of tubers. Thompson (2000b) did not recognize any varieties and stated that "the species is extremely variable" and plants "are essentially all one morphologic form."

10. ARISAEMA Martius 1831

[Greek, *aris*, a kind of arum, and *haima*, blood; referring to red-spotted leaves of some species]

Taxa in the *Arisaema triphyllum* complex has been variously treated as species, subspecies, varieties, or forms. Small (1933) recognized them as species, Huttleston (1949, 1981) as subspecies, but Thompson (2000b) treated the complex as one highly variable species with multiple morphological forms. Weakley (2015) recognizes three distinct species and notes that the taxa "sometimes occur together in mixed populations with little sign of introgression or hybridization and seem to behave as biological species."

The distinguishing characteristics separating the members of the complex are often lost when specimens are pressed and dried, but they are easily identified in the field. *Arisaema dracontium* is distinct from the *A. triphyllum* complex but produces sterile hybrids with *A. stewardsonii* Britt., a species of the complex in the northeastern USA (Sanders & Burk 1992). *Arisaema* is considered poisonous because of needle-like, calcium oxalate crystals (concentrated in the corm) that can cause intense burning sensation if chewed (Gibbons et al. 1990).

1. Leaves pedately divided into (5-) 7–15 (21) unequal leaflets arranged on a semicircular axis (some divisions do not separate completely); spadix long-exserted from the spathe, 9–20 cm long, attenuate; summit of spathe hood with inrolled (involute) margins; fruit cluster conical to oblong ..... **1. Arisaema dracontium**
1. Leaves palmately divided into 3–5 subequal leaflets; spadix included within spathe, 3.5–8 cm long, club-shaped (clavate) or cylindrical and blunt; summit of spathe hood flat; fruit cluster ovoid or subglobose.

2. Leaves 5-foliolate, with all leaflets the same size (primary leaf has 5 leaflets, but secondary leaves sometimes 3-foliate); leaflets strongly glaucous beneath; spathe hood solid green; apex of spathe obtuse to abruptly pointed (apiculate); terminal portion of spadix (sterile appendix) curved or bent outward and often slender, but sometimes cylindrical.....**3. Arisaema quinatum**
2. Leaves primarily 3-foliolate (some plants occasionally have lobes on one or both lateral leaflets, but these are smaller than the primary leaflets); leaflets glaucous or green beneath; spathe hood solid green, solid purple or striped with white or purple; apex of hood long-acuminate or short-acute; terminal portion of spadix straight and cylindrical or club-shaped (clavate).

    3. Leaves glaucous (chalky-white) beneath at maturity; spathe hood up to 6 cm broad, green, green striped, or striped with purple (sometimes only on the underside of hood); spathe flange 4–9 mm wide; fruit cluster 2.5–6 cm long.....**4. Arisaema triphyllum**
    3. Leaves lustrous, light green beneath, not chalky-white; spathe hood up to 3.5 cm wide, solid green, green with white stripes, or occasionally uniformly purple (often just on the underside of hood), not purple-striped (although tube can be striped with purple); spathe flange 1–3 mm wide; fruit cluster 1.5–2.5 cm long..... **2. Arisaema pusillum**

1. Arisaema dracontium (L.) Schott {Greek name for a type of arum} — GREEN-DRAGON; DRAGON-ROOT; DRAGON-TAIL (Fig. 51). [*Muricauda dracontium* (L.) Small]

Figure 51. *Arisaema dracontium*, Tishomingo Co., Mississippi, 27 May 2007. Photo: Brian Finzel.

Perennial herb from corms. Rich woods, low woods, bottomland forests and floodplains; flowers April–June, fruits July–August; frequent in the Highland Rim, Cumberland Plateau, and Coastal Plain; uncommon in the Ridge & Valley and Piedmont (Fig. 52). Native to eastern North America from Canada south to eastern Mexico (Thompson 2000b).

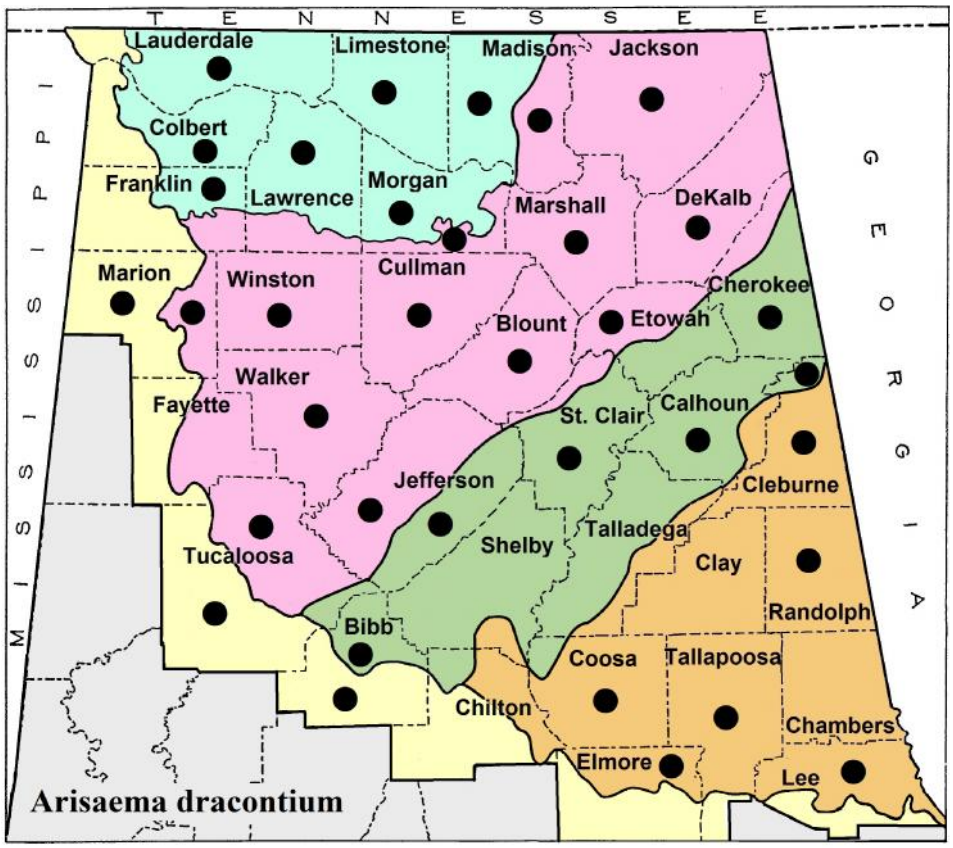


Figure 52. Distribution of *Arisaema dracontium* in northern Alabama.

(53a) Leaflet arrangement (plant with immature fruits). (53b) Inflorescence. (53c) Ripe fruits.

Figure 53. *Arisaema dracontium.* A. Colbert Co., Alabama, 16 Jun 2011. B. Madison Co., Alabama, 15 May 2012. C. Lawrence Co., Alabama, 27 Aug 2011. Photos: Brian Finzel.

Leaves and flowers of *Arisaema dracontium* are strikingly different from those of other species in the genus. Its leaflets are arranged on a semicircular axis, held out horizontally (Fig. 53a).

Its elongated spadix (Fig. 53b) possibly gave rise to the common names “dragon-flower” because it somewhat resembles a flickering lizard’s tongue or tail (Shosteck 1974). In Florida, Ward (2012) recognized *A. dracontium* var. *macrospathum* (Benth.) Huttl. ex D.B. Ward, which has a flared blade-like spathe rather than a tightly inrolled spathe.

Clay (1993) stated that *Arisaema dracontium* is able to switch genders annually. Younger plants produce only male flowers, but as they mature, they become monoecious, producing both male and female flowers on the same plant. Green-Dragon’s bright red berries resemble those of Jack-in-the-Pulpit, but occur in conical, rather than globose clusters (Fig. 53c).

The exotic Chinese Green Dragon, *Pinellia pedatisecta* Schott (Fig. 54), resembles our native species and it is not recommended for cultivation because it has the potential of becoming an invasive weed (Xu & Chang 2017). *Pinellia pedatisecta* differs by the following characteristics: the female portion of the spadix is fused (adnate) to the spathe, its berries are pale to greenish-white when ripe, and its fruits are single-seeded (Li & Bogner 2010).

Figure 54. *Pinellia pedatisecta*, St. Louis Co. Missouri, 31 Aug 2018. Photos: Adam Rembert.

2. Arisaema pusillum (Peck) Nash {very small} — SMALL-FLOWER JACK-IN-THE-PULPIT; PECK'S JACK-IN-THE-PULPIT (Fig. 55). [*Arisaema triphyllum* (L.) Schott ssp. *pusillum* (Peck) Huttl.; *Arisaema triphyllum* var. *pusillum* Peck]

Figure 55. *Arisaema pusillum*, Ebenezer Swamp, Shelby Co., Alabama, 22 Apr 2017. Photos: Brian Finzel.

Perennial herb from corms. Seeps, bogs, floodplains, and margins of swamps; flowers late March–May, fruits July–September; frequent throughout Alabama (Fig. 56). Native to the eastern USA from Connecticut and New York south to Florida and west to eastern Texas (Huddleston 1949).

Arisaema pusillum is similar to *A. triphyllum* in appearance. Both species usually have only three leaflets, but rarely one or two lateral leaflets produce smaller lobes (Fig. 57a). *Arisaema pusillum* has lateral leaflets that are only slightly asymmetrical (Fig. 57b); its leaflets are lustrous, light green beneath (Fig. 57c); spathe hood is green, green striped (Fig. 58a), or sometimes nearly solid purple on the underside (Fig. 58b); the flange (collar-like fold along spathe margin) is not prominent, only 1–3 mm wide; and its fruit cluster is small, up to 2.5 cm long (Fig. 58c–d). *Arisaema triphyllum* has lateral leaflets that are strongly asymmetrical and chalky white beneath; its spathe hood can be purple-striped but not blotched purple; its spathe has a conspicuous wider flange (up to 9 mm wide); and its fruit cluster is larger, usually greater than 2.5 cm long.

Arisaema pusillum is sometimes called Small Jack-in-the-Pulpit, but older individuals often become quite large, so this common name is a misnomer. The specific epithet likely refers to the spathes of *A. pusillum*, which are typically smaller than those of *A. triphyllum*. The senior author often refers to *A. pusillum* as “Swamp Jack” because it is more often found in wetter habitats than *A. triphyllum*.

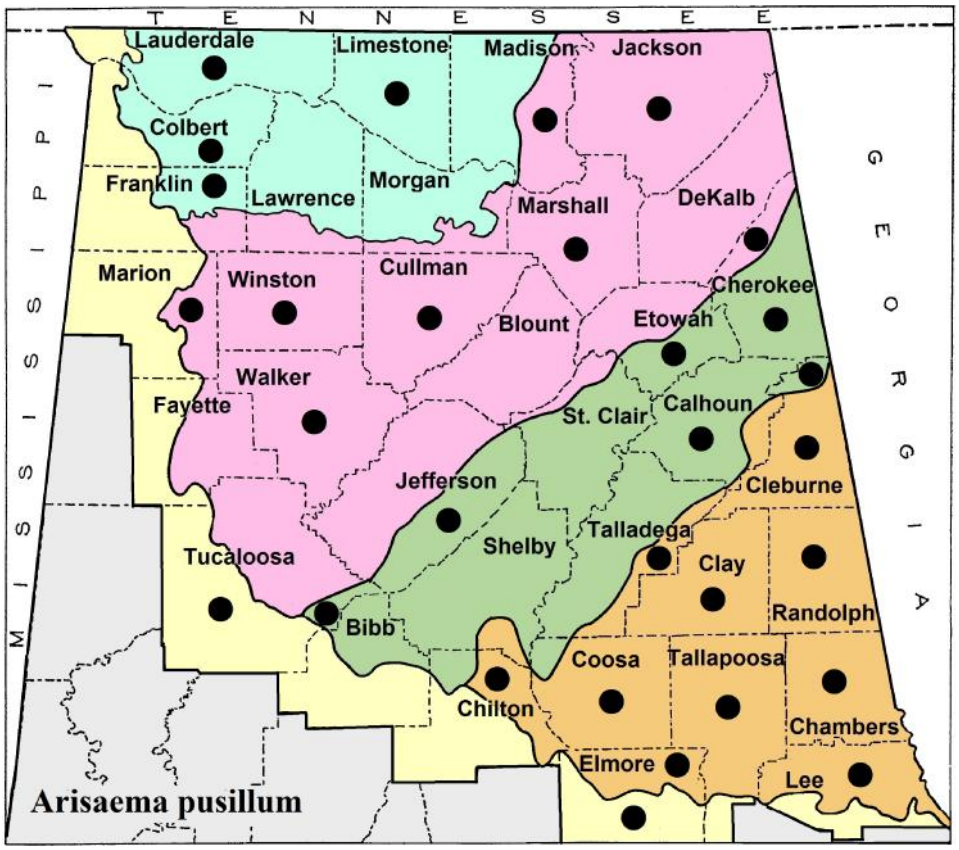


Figure 56. Distribution of *Arisaema pusillum* in northern Alabama.

(57a) Lateral leaflets rarely lobed. (57b) Slightly asymmetrical laterals. (57c) Undersurface not white.

Figure 57. *Arisaema pusillum.* A. Boggy woods, Etowah Co. Alabama, 18 Jun 2019. Photo: Dan Spaulding. C–B. Ebenezer Swamp, Shelby Co., Alabama, 7 May 2016. Photos: Brian Finzel.

(58a) Spathe often green striped. (58b) Solid purple hood below. (58c) Maturing fruits. (58d) Smaller fruit cluster.

Figure 58. *Arisaema pusillum.* A. Shelby Co., Alabama, 7 May 2016. Photo: Brian Finzel. B. Cleburne Co., Alabama, 12 May 2018. Photo: Dan Spaulding. C. Wake Co., North Carolina, 11 May 2018. Photo: Julie Tuttle. D. Randolph Co., Alabama 25 Aug 2019. Photo: Dan Spaulding. E. Randolph Co., Alabama 22 Sep 2018. Photo: Noah Yawn.

3. Arisaema quinatum (Nutt.) Schott {in fives} — FIVE-LEAF JACK-IN-THE-PULPIT; SOUTHERN JACK-IN-THE-PULPIT; PRESTER-JOHN; PREACHER-JOHN (Fig. 59). [*Arisaema triphyllum* (L.) Schott ssp. *quinatum* (Nutt.) Huttl.]

Figure 59. *Arisaema quinatum*, rich woods, Blount Co., Alabama, 20 Apr 2017. Photos: Brian Finzel.

Perennial herb from corms. Rich woods, mesic slopes, calcareous woods, and bottomlands; flowers late March–June, fruits July–September; uncommon in the Highland Rim and Coastal Plain; frequent in the Cumberland Plateau, Ridge & Valley, and Piedmont (Fig. 60). Endemic to the southeastern USA, ranging from North Carolina and Tennessee south to north Florida and eastern Texas (Godfrey & Wooten 1979).

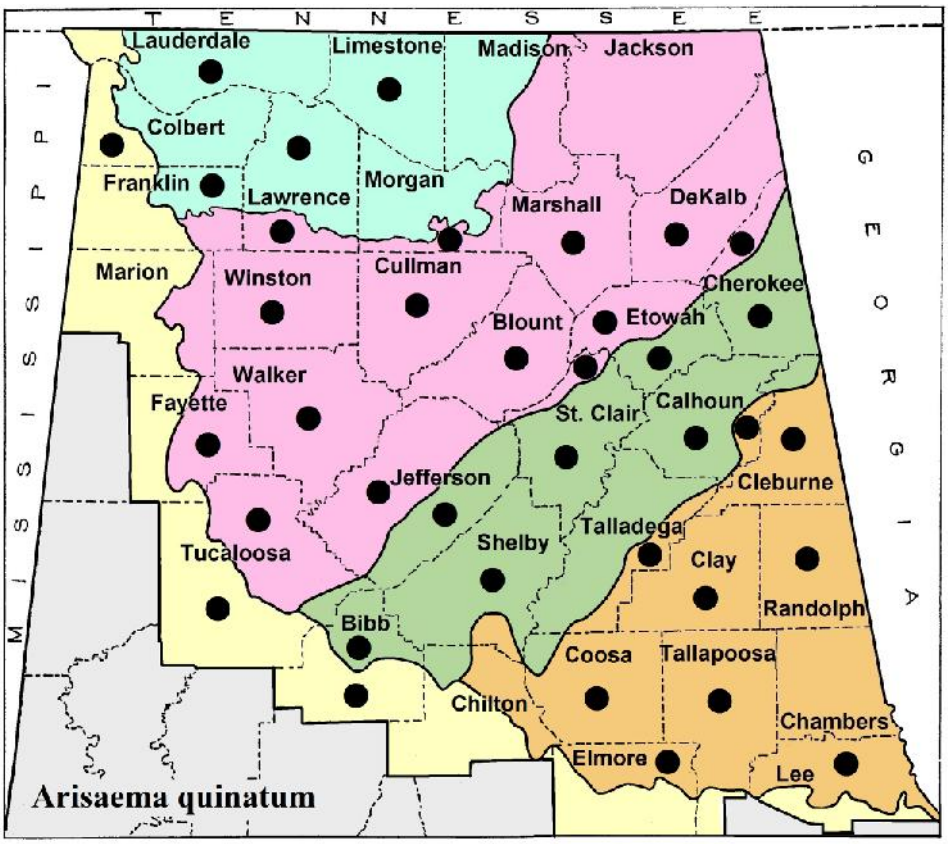


Figure 60. Distribution of *Arisaema quinatum* in northern Alabama.

(61a) Leaflets strongly glaucous underneath.

(61b) Spadix often bent.

Figure 61. *Arisaema quinatum*, hardwood forest, Fayette Co., Alabama, 15 Apr 2018. Photos: Dan Spaulding.

Arisaema quinatum differs from other members of the *A. triphyllum* complex by having five leaflets, rather than three (the secondary leaf can have three or five leaflets). Immature plants and seedlings are often trifoliate but are usually found growing next to mature plants. Like *A. triphyllum*, the leaves of *A. quinatum* are glaucous beneath (Fig. 61a), but its spadix is sometimes bent (Fig. 61b), somewhat resembling the spadix of *A. dracontium*, but much shorter.

4. Arisaema triphyllum (L.) Schott {three-leaved} — COMMON JACK-IN-THE-PULPIT; INDIAN-TURNIP; BROWN-DRAGON (Fig. 62). [*Arum triphyllum* L.; *Arisaema atrorubens* (Ait.) Blume]

Figure 62. *Arisaema triphyllum*, rich woods, Blount Co., Alabama, 19 Apr 2007. Photo: Brian Finzel.

Perennial herb from corms. Rich woods, mesic slopes, streambanks, low woods, and bottomland forests; flowers late March–June (peaks in April), fruits June–September; frequent throughout Alabama (Fig. 63). Native to eastern North America and Canada, from Nova Scotia to southeast Manitoba south to eastern Texas and northern Florida (Weakley 2015).

Arisaema triphyllum is the most common and widespread species in the genus (Treiber 1980). Its distinguishing characters are: trifoliate leaves that are chalky-white beneath; strongly asymmetrical lateral leaflets (Fig. 64); green to purple-striped spathes (Fig. 65a–b); and larger globose fruit clusters (Fig. 65c).

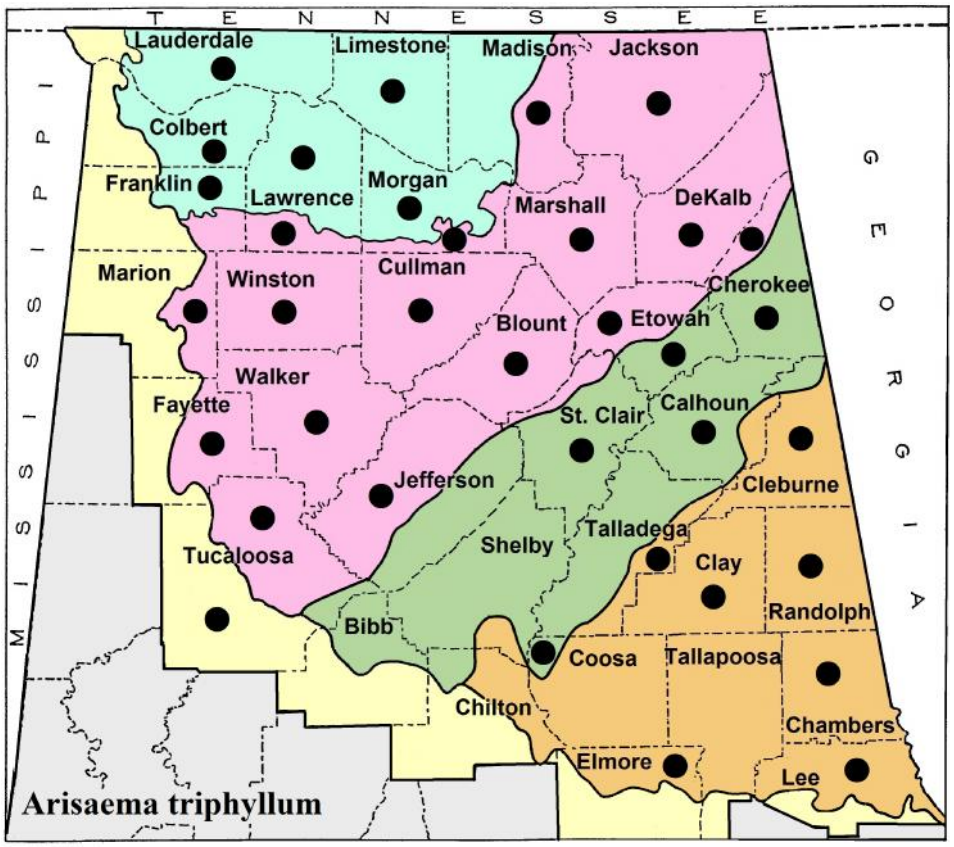


Figure 63. Distribution of *Arisaema triphyllum* in northern Alabama.

Figure 64. *Arisaema triphyllum* with strongly asymmetrical lateral leaflets that are chalky white beneath. Plant with immature globose fruit cluster (red when ripe). Fayette Co., Alabama, 2 Jun 2018. Photo: Dan Spaulding.

(65a) Green spathe. (65b) Purple-striped spathe. (65c) Immature fruit cluster with green berries.

Figure 65. *Arisaema triphyllum.* A. Cullman Co., Alabama, 2 Apr 2017. B. Sevier Co., Tennessee, 20 Apr 2015. C. Madison Co., Alabama, 15 Aug 2009. Photos: Brian Finzel.

Immature single-leaved plants are commonly found near mature plants, which appear to be vegetative off-shoots or seedlings. Camp (1932) noted that vegetative reproduction by “bud corms” is more common than reproduction by seeds. According to Rust (1980), Jack-in-the-Pulpit flowers are insect pollinated, primarily by thrips (Heterothripidae), springtails (Collembola), midges or fungus gnats (Mycetophilidae). In late summer and fall, plants produce a cluster of red berries, which are relished by Wild Turkey and Wood Thrush (Martin 1951).

Through maturation, Jack-in-the-Pulpit can change gender from male to female with varying degrees of bisexuality. In the first few years of life, plants are non-flowering but later produce male (staminate) flowers. Over time they develop female (pistillate) flowers at the base of the spadix, just below the male flowers. This hermaphroditic or monoecious stage usually lasts for several years, but at maturity, it transitions to being female (Camp 1932). However, if environmental conditions are poor or an individual expends too much energy producing fruit, it can revert back to a male or even become asexual again (Bown 2000). Historically, it has been thought that plants with green hoods were males and those with purple, females (Dana 1899), but there is no objective basis to this claim.

Jack-in-the-Pulpit gets its fanciful common name from the spadix appearing to represent a “preacher Jack” standing and surrounded by his pulpit with a sounding board, the spathe (Shosteck 1974). The whole plant, especially the corm, contains calcium oxalate crystals, which can cause a burning sensation if eaten raw. The colloquial name “memory-root" relates to a schoolboy trick of tempting others to bite into the tuber (Dana 1899). The name “Indian-Turnip” was derived from Native Americans use of the corms as food, but only after being properly prepared (Martin 1989). The peppery, tuberous root, as well as cooked berries, were important foods of Indians and early settlers (Coffey 1993).

11. ARUM Linnaeus 1753
[Latinized form of the Greek, *aron*, old name for these plants]

1. Arum italicum P. Mill. {Italian} — LORDS-AND-LADIES; ITALIAN ARUM; CUCKOO'S-PINT; ITALIAN-LILY (Fig. 66).

Figure 66. *Arum italicum*, disturbed woods, Calhoun Co., Alabama, 25 Apr 2018. Photos: Dan Spaulding.

Perennial herb with tubers. Suburban woodlands; flowers April–May, fruits July–September; very rare in the Ridge & Valley (Fig. 67). Native to Western Europe and North Africa around the Mediterranean region, where it inhabits woodlands and hedgerows (Tutin et al. 1980). *Arum italicum* is naturalizing from horticultural plantings in eastern and western coastal states of the USA (Kartesz 2018).

Arum italicum can spread quickly by tubers (Fig. 68a) and has the potential of becoming an invasive species (Randall 2001). Only the typical subspecies has been found to escape cultivation in the USA. The plant can be easily distinguished by the conspicuous whitish veins on its arrow-shaped leaves (Tutin et al. 1980). Scot Duncan, of Birmingham-Southern College, was the first to discover this species in Alabama in a disturbed forest on campus.

Lords-and-Ladies blooms in spring producing inflorescences of small, white monoecious (male and female) flowers borne at the base of a finger-like, green to greenish spadix. The spadix is surrounded by a green to greenish-white spathe (sheath-like bract). The flowers emit a foul, dung-like odor that attracts pollinators, such as dung beetles and flies (Linz et al. 2010). Following pollination, the spathe withers, leaving only a stalk of green berries, which turn bright orange-red at maturity (Fig. 68b). The glossy, variegated leaves also die back after flowering, but emerge in autumn and remain evergreen through winters in Alabama (Fig. 68c).

Like many plants within the Araceae, *Arum italicum* is toxic because of the needle-like calcium oxalate crystals (raphides), which cause intense burning when ingested (Bown 2000). Despite its toxicity, *Arum* has been used for food and medicinal purposes for centuries, especially as a treatment for warts and hemorrhoids (Azab 2017).

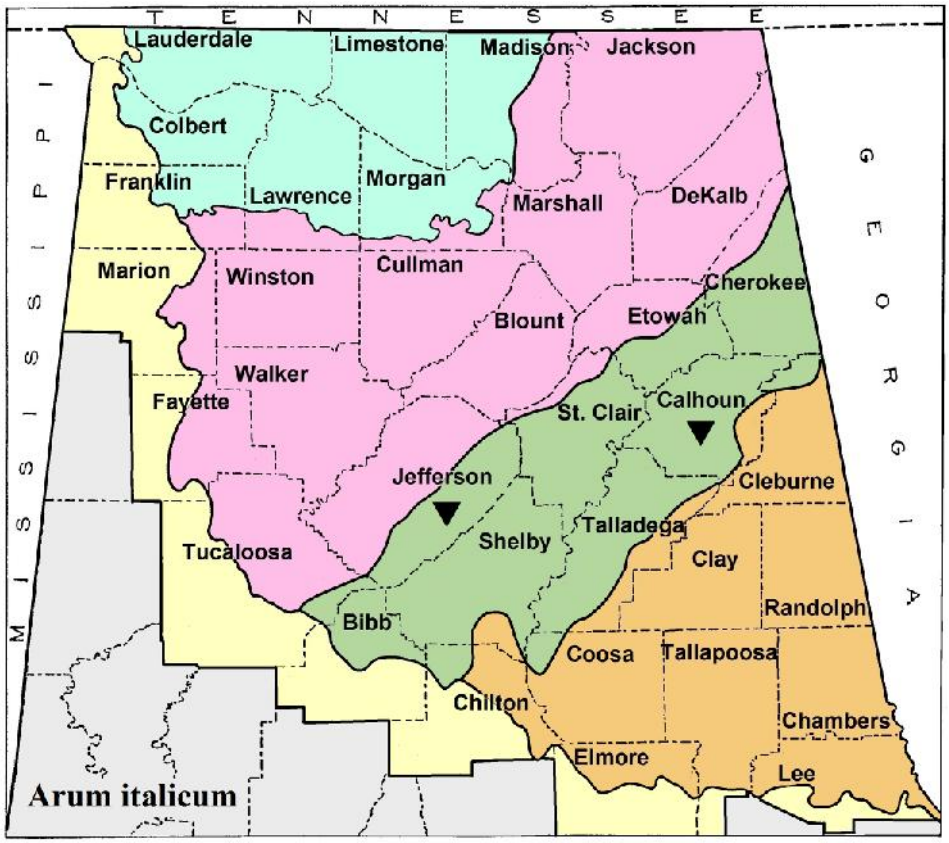


Figure 67. Distribution of *Arum italicum* in northern Alabama.

(68a) Tubers. (68b) Ripe fruits. (68c) Leaves in winter (coldest night).

Figure 68. *Arum italicum* in disturbed woods. A. Calhoun Co., Alabama, 30 Jan 2019. B. Calhoun Co., Alabama, 12 Jul 2018. C. Calhoun Co., Alabama, 30 Jan 2019. Photos: Dan Spaulding.

FAMILY 3. TOFIELDIACEAE (False-Asphodel Family)

Historically, members of this family were placed within the Liliaceae (Cronquist 1981; Utech 2002), but it is now shown to represent the most basal lineage within the order Alismatales and this family does not belong in the Liliales (Luo 2016). Tofieldiaceae consists of four genera: *Harperocallis*, *Pleea*, *Tofieldia*, and *Triantha*. Zomlefer (1997) included the last three genera within a broadly circumscribed *Tofieldia*, but Packer (2002) recognized them as distinct. Only two species, *Triantha racemosa* (Walt.) Small and *Pleea tenuifolia* Michx. [Rush-Featherling] are known from Alabama. *Pleea* is endemic to the southeastern Coastal Plain and differs from other genera within the family by its larger bracts and flowers. *Triantha* is distinguished from *Tofieldia* by its glandular-pubescent scapes with flowers in clusters of 2 or more (versus glabrous scapes with solitary flowers).

1. TRIANTHA (Nuttall) Baker 1879

[Greek, *tri*, three, and *anthos*, flower; in reference to flowers often clustered in threes]

1. Triantha racemosa (Walt.) Small {racemose} — SOUTHERN BOG-ASPHODEL; COASTAL-PLAIN BOG-ASPHODEL; COASTAL FALSE ASPHODEL; WOOD-FEATHERLING (Fig. 69). [*Tofieldia racemosa* (Walt.) B.S.P.]

Figure 69. *Triantha racemosa*, bog in Cherokee Co., Alabama, 30 Jun 2018. Photos: Brian Finzel.

Perennial herb with short rhizomes. Bogs, seepage slopes, and wet pine savannas; flowers June–August, fruits August–October; very rare in the Ridge & Valley and Piedmont; rare in the upper Coastal Plain, but frequent in the lower portions (Fig. 70). Chiefly found on the Coastal Plain from New Jersey south to northern Florida, west to east Texas. It is disjunct further inland in Maryland, Virginia, Georgia, Alabama, and central Tennessee (Kartesz 2018).

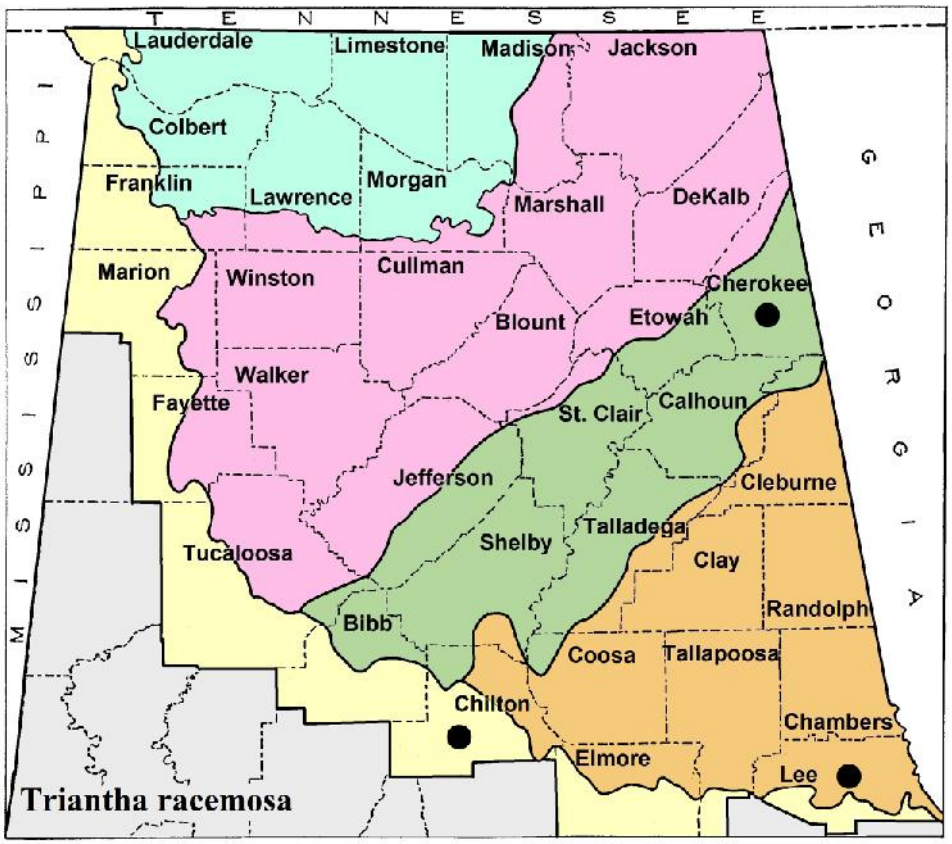


Figure 70. Distribution of *Triantha racemosa* in northern Alabama.

The population of *Triantha racemosa* in Cherokee County occurs in a seepage bog with the Green Pitcher-Plant, *Sarracenia oreophila* (Kearney) Wherry. This site is located in the Coosa Valley district of the Ridge & Valley province portion of the county. There is a historical collection from Lee County (*Baker s.n.*, July 1897) with only "Auburn" on the label, which is in the lower piedmont, but no population has ever been confirmed. This species has been documented from Chilton and Russell counties, which are in the Fall Line Hills district of the upper Coastal Plain. Southern Bog-Asphodel is much more common in southern Alabama in wet sandy-peaty soils of flatwoods, pine savannas, seeps, and bogs. It fruits in late summer to fall (Fig. 71a) and produces capsules, which are slightly longer than or equal to the length of the sepals (Fig. 71b).

(71a) fruiting raceme.

(71b) Close-up of fruit.

Figure 71. *Triantha racemosa*, AMAL, *Spaulding14087a*, Cherokee Co., Alabama, 23 Aug 2018. Photos: Dan Spaulding.

FAMILY 4. ALISMATACEAE (Water-Plantain Family)

1. Inflorescence paniculate, highly branched (compound with many of the primary nodes bearing whorled branches, which are also whorled); pistils in a single ring on a flat receptacle; stamens 6 .....**1. Alisma**
1. Inflorescence racemose, unbranched (nodes with one whorl of flowers); pistils densely crowded over the entire surface of a globose receptacle, forming a ball-like head; stamens more than 6.

    2. Scapes arching at maturity, becoming prostrate and rooting at nodes, forming plantlets (scapes erect when immature); inflorescences with more than 3 flowers per node; whorls subtended by 3 bracts and several smaller bracteoles; all flowers bisexual; fruiting heads (aggregate of achenes) bur-like due to long, persistent styles; achenes plump (turgid) and longitudinally ribbed, not winged.....**2. Echinodorus**
    2. Scapes erect; fruiting heads not bur-like; inflorescences with 3 flowers per node; whorls subtended by 3 bracts, lacking additional smaller bracteoles; flowers mostly unisexual (lower flowers bisexual in *Sagittaria calycina*); achenes flattened with a lateral wing, not ribbed .....**3. Sagittaria**

1. ALISMA Linnaeus 1753
[Ancient Greek name of a water plant]

1. Alisma subcordatum Raf. {somewhat heart-shaped} — AMERICAN WATER-PLANTAIN; SOUTHERN WATER-PLANTAIN (Fig. 72). [*Alisma plantago-aquatica* L. ssp. *subcordatum* (Raf.) Hultén; *Alisma plantago-aquatica* var. *parviflorum* (Pursh) Torr.]

Amphibious or emersed aquatic, perennial herb from bulbous corms. Marshes, ditches, wet disturbed areas, shores of ponds, lakes, and streams; flowers and fruits June–October; frequent in the Highland Rim; uncommon in the Cumberland Plateau, Ridge & Valley, and Piedmont; rare in the Coastal Plain (Fig. 73). Endemic to eastern North America, from southern Canada south to Texas and Georgia, excluding Louisiana and Florida (Haynes & Hellquist 2000a).

Figure 72. *Alisma subcordatum*, Benton Co., Tennessee, 5 Jul 2010. Photos: Brian Finzel.

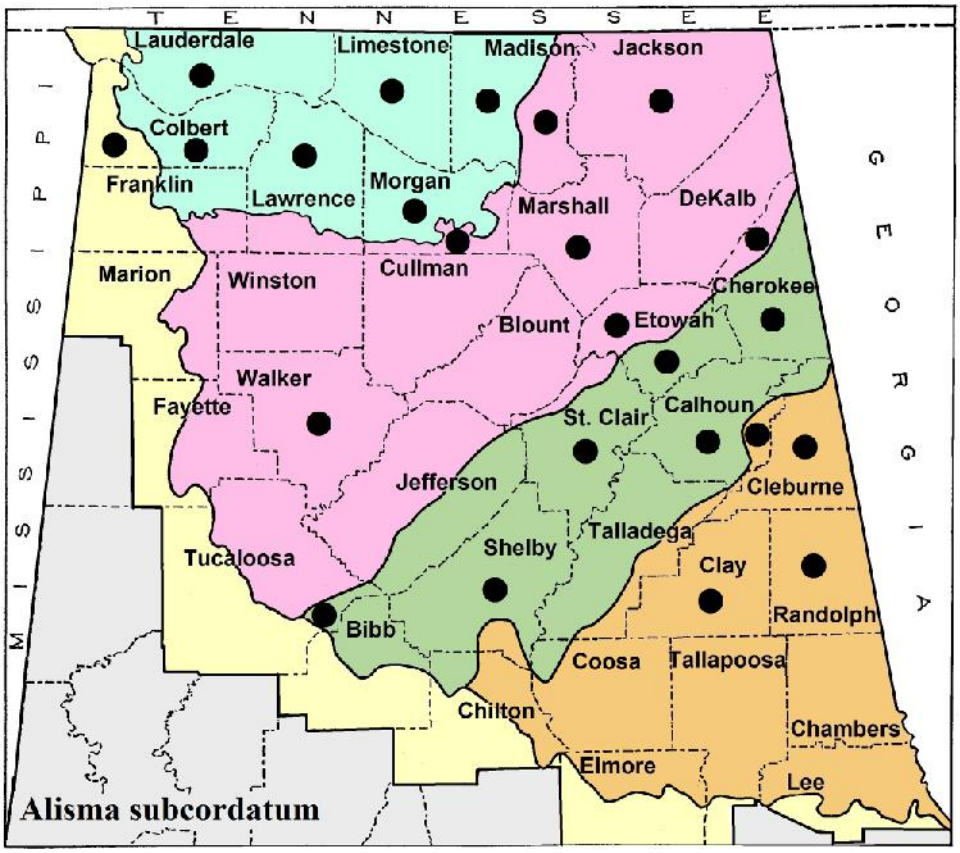


Figure 73. Distribution of *Alisma subcordatum* in northern Alabama.

Alisma is distinguished by its six stamens, highly branched inflorescence, and numerous carpels (pistils) that form a ring on a flat receptacle (Fig. 74a–b). Following pollination, floral receptacles transform into small, thin disks of scaly fruits (Fig. 74c). The spongy tissue of the fruit is well developed and provides buoyancy for aquatic dispersal. When passed through the digestive tract of waterfowl, germination of the achenes is reported to be enhanced (Rogers 1983).

(74a) Ovary side-view. (74b) Ovary top-view. (74c) Ring of achenes.

Figure 74. *Alisma subcordatum*. A–B. Wilson Co., Tennessee, 28 Jul 2014. Photos: Brian Finzel. C. AMAL, *Spaulding 12506*, Cherokee Co., Alabama, 26 Jul 2006. Photo: Dan Spaulding.

At maturity, the bulb-like bases (corms) of water-plantain become filled with starch. Once thoroughly dried, they can be used as a food source (Fernald & Kinsey 1943). Native Americans utilized the corms medicinally to treat various ailments such as heartburn, stomach aches, cramps, constipation, sores, wounds, bruises, and ulcers (Moerman 1998).

2. ECHINODORUS L.C. Richard ex Engelmann 1848
[Greek, *echinus*, hedgehog, and *doros*, leather bag; alluding to prickly fruiting head]

1. Echinodorus cordifolius (L.) Griseb. {heart-shaped leaf} — CREEPING BURHEAD; HEART-LEAF SWORD PLANT; RADICANS SWORD (Fig. 75). [*Echinodorus radicans* (Nutt.) Engelm.]

Figure 75. *Echinodorus cordifolius*, pond margin, St. Clair Co., Alabama, 8 Jul 2019. Photos: Dan Spaulding.

Amphibious or emersed aquatic, perennial herb. Swamps, marshes, ditches, margins of ponds, lakes, and streams; flowers and fruits May–October; frequent in the Highland Rim, Cumberland Plateau, Ridge & Valley, and Coastal Plain; uncommon in the Piedmont (Fig. 76). Native throughout the Americas, in the USA known from Maryland, south to peninsular Florida, west to Texas, north through the interior to southern Illinois (Weakley 2015).

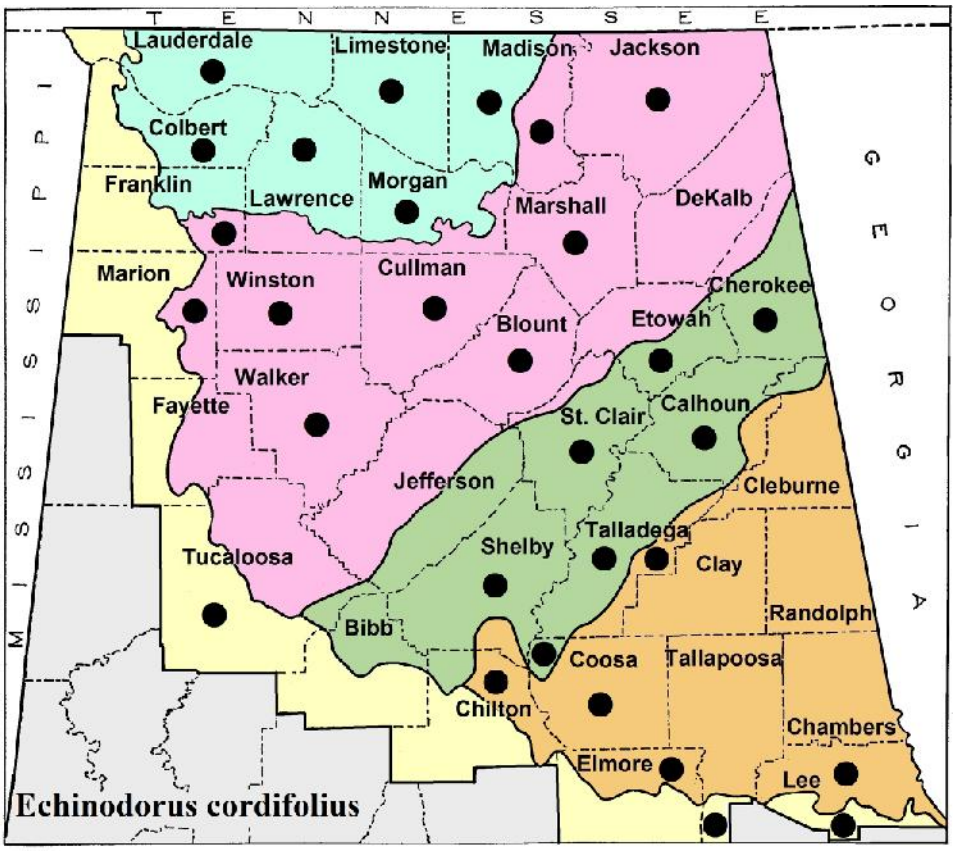


Figure 76. Distribution of *Echinodorus cordifolius* in northern Alabama.

Key characters of *Echinodorus cordifolius* are its arching or decumbent inflorescences that occasionally produce young plantlets at some of the nodes (Fig. 77), sepals with papillose veins, and flowers with over 20 stamens. *Echinodorus berteroi* (Spreng.) Fassett [Upright Burrhead] is similar (Fig. 78a–b) and has been documented from surrounding states, but its main distribution is west of the Mississippi River, ranging south to South America (Haynes & Hellquist 2000a). It differs by its erect, often compound inflorescences, smooth sepals, and flowers with usually only 12 stamens. Beaks of the fruits of *E. berteroi* are longer (Fig. 78c) than the beaks of *E. cordifolius* (Fig. 78d).

Figure 77. *Echinodorus cordifolius* plantlets, Stoddard Co., Missouri, 31 Aug 2017. Photo: Jared Gorrell.

(78a) *Echinodorus berteroi* plant.

(78b) *Echinodorus berteroi* flower close-up.

(78c) *Echinodorus berteroi* fruits.

(78d) *Echinodorus cordifolius* fruits.

Figure 78. A–C. Fulton Co., Kentucky, 8 Jul 2013. Photos: Brian Finzel. D. Inlet to the Tennessee River, Limestone Co., Alabama, 5 July 2017. Photo: Dan Spaulding.

The chopped roots and leaves of *Echinodorus cordifolius* are reported to cause skin blisters if touched (Rogers 1983). This emersed aquatic is available in the aquarium trade for larger aquariums and sold under the name Radicans Sword. It is listed as an invasive species in some countries, where sales may be prohibited (Hoveka et al. 2016).

2. **SAGITTARIA** Linnaeus 1753

[Latin *sagitta*, arrow; in reference to leaf shape of some species]

1. Emergent leaves with sagittate (arrowhead-like) leaf blades with large basal lobes and distinct petioles; submersed leaves usually absent, except when water level is high.

    2. Sepals appressed in fruit, nearly enclosing the fruiting head; lower whorls of flowers pistillate with a ring of sterile stamens (bisexual), upper flowers staminate, filaments roughened with minute scales; petioles, peduncles, and pedicels thick and spongy..... **2. Sagittaria calycina**
    2. Sepals reflexed or at least widely spreading in fruit and not enclosing the fruiting head; lower whorls of flowers pistillate, lacking stamens (unisexual); upper flowers staminate, filaments glabrous; petioles, peduncles, and pedicels not conspicuously thick and spongy.

        3. Achene beak terminal (extending along the long axis of the achene); inflorescence bracts lanceolate (5–40 mm long) flattened to slightly concave, but not boat-shaped; leaf petioles winged and deeply grooved; leaf blades, petioles, and bracts glabrous or papillate with minute, blunt projections (usually found along leaf margins, main veins, and upper petioles) ..... **1. Sagittaria australis**
        3. Achene beak lateral (at a right angle to the long axis of the achene); inflorescence with boat-shaped bracts (2–14 mm long), which have a concave "hull" and narrow "bow" with obtuse or broadly acute tips; leaf petioles roundish with low ribs, but not distinctly winged or grooved; leaf blades, petioles and bracts glabrous, or densely pubescent (hairs clear and tapering to a point) ..... **4. Sagittaria latifolia**

1. Emergent leaves, if present, with linear, lanceolate, elliptic, or ovate, blades, without well-formed basal lobes (*S. platyphylla* occasionally has small auricles at base of blade), with or without petioles; submersed leaves present and all reduced to phyllodia, which are sessile, bladeless, and linear.

    4. Leaves mostly submersed (rarely emersed); sessile, linear, and bladeless (phyllodial); abaxial wing of fruit scalloped or toothed; plants of the Cumberland Plateau inhabiting riverine shoals and pools in cracks and crevices of sandstone bedrock..... **6. Sagittaria secundifolia**
    4. Leaves submersed and emersed; emergent leaves often with an expanded blade and petiole (submerged leaves phyllodial); abaxial wing of fruit entire; plants widespread and mostly found in marshes, ponds, lakes, and slow-moving streams.

        5. Stalks of fruiting heads, especially on lower whorls, reflexed and often stout at maturity; bracts fused much of their length, free portions broadly triangular and obtuse; emergent leaves often with broadly elliptic to ovate blades, occasionally lanceolate (0.5–7 cm wide); achenes with slender beaks 0.3–0.6 mm long..... **5. Sagittaria platyphylla**
        5. Stalks of fruiting heads ascending or spreading and slender, not noticeably thickened; bracts fused only in the basal half, free portions triangular and acute; emergent leaves bladeless or with narrowly lanceolate to narrowly elliptical leaf blades (up to 2 cm wide); achene beaks less than 0.3 mm long, sometimes absent..... **3. Sagittaria graminea**

1. Sagittaria australis (J.G. Sm.) Small {southern} — LONG-BEAK ARROWHEAD; SOUTHERN ARROWHEAD; APPALACHIAN ARROWHEAD (Fig. 79). [*Sagittaria engelmanniana* J.G. Sm. ssp. *longirostra* auct. non Micheli; *Sagittaria longirostra* (Micheli) J.G. Sm. var. *australis* J.G. Sm.]

Figure 79. *Sagittaria australis*, Jefferson Co., Alabama, 28 Jul 2011. Photo: Brian Finzel.

Amphibious or emersed aquatic, perennial herb with stolons terminated by corms. Marshes, ditches, wet meadows, swamps, sloughs, springs, ponds, mudflats, and streams; flowers and fruits June–October; frequent in the Highland Rim, Cumberland Plateau, Ridge & Valley, and Piedmont; uncommon in the Coastal Plain (Fig. 80). Native to the eastern USA, occurring mostly south of the Ohio River and east of the Mississippi River, but ranging from New Jersey west to Iowa and south to Louisiana and the Panhandle of Florida (Kartesz 2018).

Sagittaria latifolia is often confused with *S. australis* because both species have arrow-head shaped leaves. *Sagittaria australis* can be differentiated by the following characters: achene beaks are terminal, projecting mostly upwards (Fig. 81a); bracts are lanceolate (Fig. 81b); petioles are deeply grooved or winged (Fig. 81c); and plants lack pubescence, but often have white papillae on the margins of the leaves and petioles (Fig. 81d).

Sagittaria engelmanniana [Engelmann's Arrowhead] is also mistaken for *S. australis* because its leaves, bracts, and achene beaks are somewhat similar. Engelmann's Arrowhead differs by the following characteristics: rounded petioles; leaves that are often narrowly sagittate; lowest leaves frequently lacking basal lobes (both leaf types are often present on an individual plant); flowers in 2–4 whorls; achenes with facial wings extending onto the beaks (Beal et al. 1982). *Sagittaria engelmanniana* is chiefly a Coastal Plain species, reports of it occurring in northern Alabama are likely erroneous.

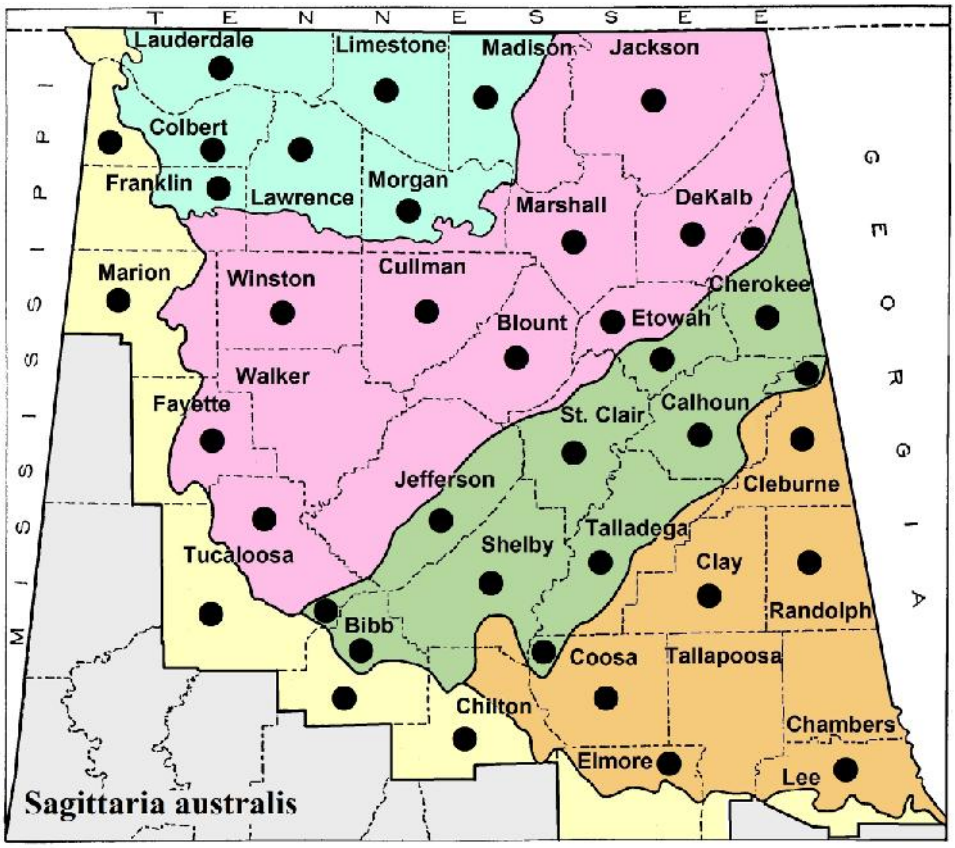


Figure 80. Distribution of *Sagittaria australis* in northern Alabama.

(81a) Achene beaks terminal.

(81b) Bracts lanceolate.

(81c) Winged/grooved petiole.

(81d) White papillate petiole.

Figure 81. *Sagittaria australis*. A–B. Madison Co., Alabama, 7 Sep 2015. Photos: Brian Finzel. C–D. Etowah Co., Alabama, 11 Aug 2018. Photos: Dan Spaulding.

2. Sagittaria calycina Engelm. {with conspicuous calyx} — HOODED ARROWHEAD; LONG-LOBE ARROWHEAD; THICK-STALK ARROWHEAD (Fig. 82). [*Lophotocarpus calycinus* (Engelm.) J.G. Sm.; *Sagittaria montevidensis* Cham. & Schlecht. ssp. *calycina* (Engelm.) Bogin]

Figure 82. *Sagittaria calycina* [with *Heteranthera limosa* (Sw.) Willd.], Tennessee National Wildlife Refuge, Humphreys Co., Tennessee, 8 Aug 2010. Photo: Brian Finzel.

Amphibious or emersed aquatic, perennial herb. Mudflats, marshes, ditches, wet meadows, swamps, sloughs, springs, borders of ponds, rivers, lakes, and streams; flowers and fruits June–October; uncommon in the Highland Rim and upper Coastal Plain; rare in the Cumberland Plateau; very rare in the Ridge & Valley (Fig. 83). Native chiefly to the central USA, ranging from Colorado to south Dakota, east to southwest Virginia, south to northern Georgia, west to Louisiana and Texas; disjunct in California and Mexico (Haynes & Hellquist 2000a). Introduced into Australia, where it is considered to be an invasive, noxious weed (Adair et al. 2012).

Sagittaria calycina is vegetatively similar to *S. australis* and *S. latifolia* because of its arrowhead shaped leaves, but the leaf stalks (petioles) of *S. calycina* are very thick and spongy (Fig. 84a). When fertile, *S. calycina* can be identified by its bisexual lower whorls of flowers, which have a ring of sterile stamens around fertile pistils (Fig. 84b). Its peduncles and pedicels are also thick and spongy. In fruit, its sepals are appressed and completely surrounding the fruiting head (Fig. 84c).

Sagittaria calycina has been recognized as a subspecies of *S. montevidensis* by some authors (Bogin 1955; Haynes & Hellquist 2000a). Keener (2005) elevated *S. montevidensis* subsp. *calycina* to species rank with two varieties, var. *calycina* and var. *spongiosa* Engelm. Weakley (2015) treats *S. calycina* var. *spongiosa* as a distinct species, *S. spathulata* (J.G. Sm.) Buch. [Tidal Arrowhead]. This taxon has only phyllodial leaves, lacking expanded blades. Tidal Arrowhead occurs in tidal mudflats along the coast from New Brunswick to North Carolina. *Sagittaria montevidensis* [Giant Arrowhead] is similar to *S. calycina* but differs by having purple-red spots at the base of the petals and lacking a ring of non-functioning stamens in the pistillate flowers. Giant Arrowhead is native to South America and is occasionally found near old seaports in the southeastern USA.

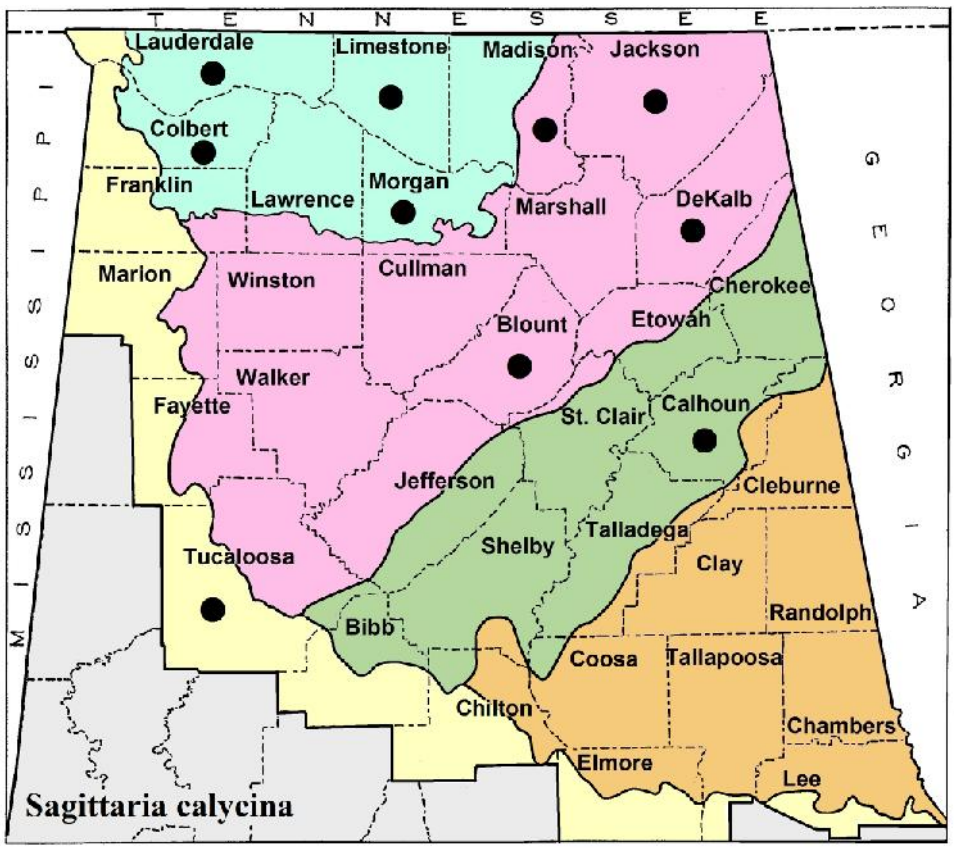


Figure 83. Distribution of *Sagittaria calycina* in northern Alabama.

(84a) Thick, spongy petioles & peduncles. (84b) Bisexual flowers in lower whorl. (84c) Calyx enclosing fruits.

Figure 84. *Sagittaria calycina*. A–C. Mud flat along Paint Rock River, Madison Co., Alabama, 6 Oct 2018. Photos: Dan Spaulding.

3. Sagittaria graminea Michx. {grass-like} — GRASSLEAF ARROWHEAD; GRASSY ARROWHEAD; LANCE-LEAF ARROWHEAD (Fig. 85). [*Sagittaria cycloptera* (J.G. Sm.) C. Mohr; *Sagittaria eatonii* J.G. Sm.]

Figure 85. *Sagittaria graminea*, Gulf Co., Florida, 28 Mar 2015. Photos: Brian Finzel.

Emersed aquatic, perennial herb with rhizomes. Pond and lake margins, also marshes, ditches, seeps, wet flatwoods, swamps, and bogs in southern Alabama; flowers and fruits late March–November; very rare in the Piedmont; frequent in the lower Coastal Plain (Fig. 86). Native to eastern North America, ranging from the West Indies to Nova Scotia west to Ontario and south to east Texas, but mostly near the coast in the South (Kartesz 2018).

The only valid specimen known of *Sagittaria graminea* within the study area was collected from Lee County, near Auburn, along the shores of Lake Condy on May 25, 1962. *Sagittaria graminea* has been reported from northern Alabama (Wooten 1973), but all such specimens examined have been annotated to *S. platyphylla*, which is a member of the *S. graminea* complex.

Sagittaria graminea has slender, ascending fruiting stalks (Fig. 87a) and the free portion of its bracts are acute. A similar species, *S. platyphylla*, has stout, reflexed fruiting stalks and the free portions of its bracts are obtuse. *Sagittaria platyphylla* typically has broader leaf blades than *S. graminea*, but they can also be lanceolate, so this character is unreliable. Both species have basally dilated filaments and smooth sepals and bracts (Fig. 87b). *Sagittaria lancifolia* L. subsp. *media* (Micheli) Bogin, which is found on the Coastal Plain, can be confused with these members of *S. graminea* complex, but its filaments are cylindric and its bracts and sepals are papillose (Fig. 87c).

Sagittaria chapmanii (J.G. Sm.) C. Mohr is another species within the *S. graminea* complex and occurs in southeast Alabama (Brian Keener, pers. comm. 2019). It usually has branched inflorescences, whereas those of *S. graminea* are usually unbranched. However, since both species can have either panicles or racemes (Brian Keener, pers. comm. 2019), it is best to examine their bracts. Those of *S. graminea* (Fig. 88a) are basally connate (fused) with acute free tips while those of *S. chapmanii* (Fig. 88b) are only slightly connate with acuminate free tips (Weakley 2015).

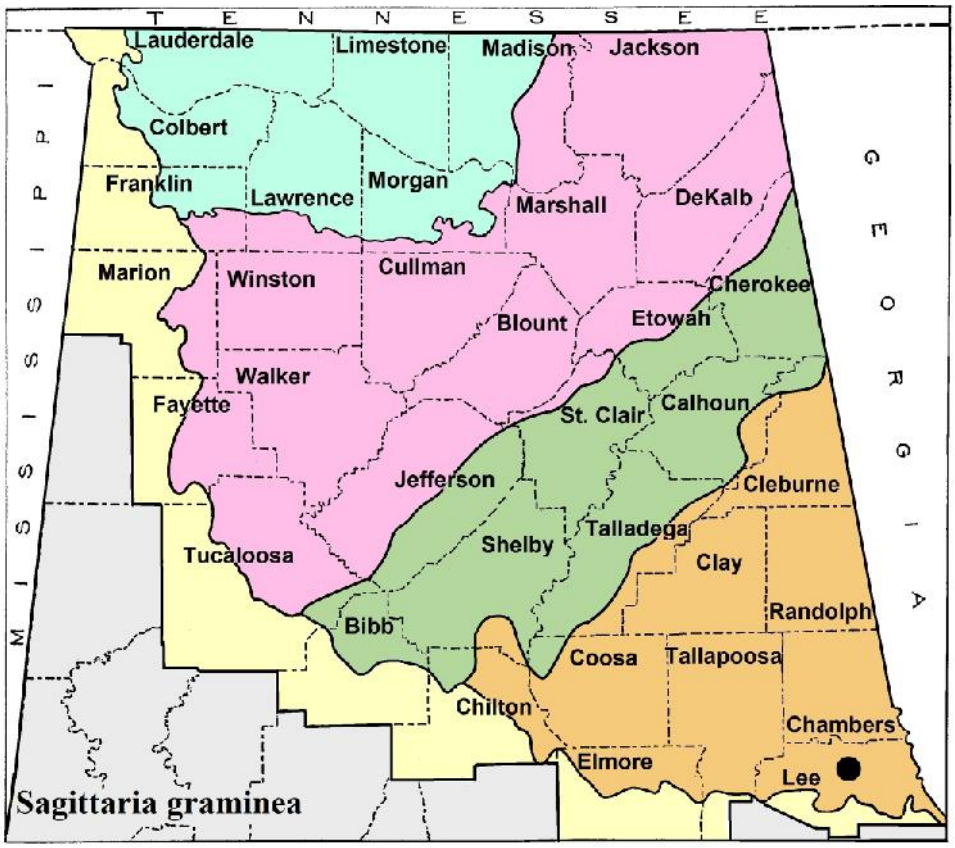


Figure 86. Distribution of *Sagittaria graminea* in northern Alabama.

(87a) *Sagittaria graminea* pedicels. (87b) *S. graminea* sepals. (87c) *S. lancifolia* subsp. *media* sepals.

Figure 87. A. Pinellas Co. Florida, 28 Mar 2019. Photo: Alexander de la Paz. B–C. Gulf Co., Florida, 28 Mar 2015. Photos: Brian Finzel

(88a) *Sagittaria graminea* bracts. (88b) *Sagittaria chapmanii* bracts.

Figure 88. A. AMAL, *Diamond 17465*, Butler Co., Alabama, 29 Apr 2007. B. AMAL, *Kral 91856*, Houston Co., Alabama, 17 Sep 2001. Photos: Dan Spaulding.

4. Sagittaria latifolia Willd. {broad-leaved} — BROADLEAF ARROWHEAD; DUCK-POTATO; WAPATO (Fig. 89). [*Sagittaria latifolia* var. *pubescens* (Muhl. ex Nutt.) J.G. Sm.; *Sagittaria obtusa* Muhl. ex Willd., non Thunb.; *Sagittaria planipes* Fern.; *Sagittaria pubescens* Muhl. ex Nutt.; *Sagittaria viscosa* C. Mohr]

Figure 89. *Sagittaria latifolia*, Leon County, Florida, 25 Nov 2018. Photos: Anthony Melton.

Amphibious or emersed aquatic, perennial herb with stolons terminated by corms. Marshes, swamps, ditches, wet pastures, mudflats, margins of ponds, lakes, rivers, and streams; flowers and fruits late May–November; uncommon in the Highland Rim, Cumberland Plateau, and Ridge & Valley; frequent in the Piedmont and Coastal Plain (Fig. 90). This is the most widespread species of the genus in the New World, ranging from Canada south through the entire USA to northern South America (Rogers 1983).

Key characteristics of *Sagittaria latifolia* are its lateral achene beaks that are frequently hooked (Fig. 91a) and its boat-shaped bracts (Fig. 91b). When sterile, *S. latifolia* can be distinguished from *S. australis* by its petioles, which have slightly have raised ribs (Fig. 92), whereas *S. australis* has petioles that are distinctly winged or grooved. Broadleaf Arrowhead can be glabrous or pubescent, but most individuals observed in northern Alabama are pubescent (Fig. 91b–c). Bogin (1955) and Weakley (2015) have recognized *S. latifolia* var. *pubescens*, which is conspicuously pubescent, especially on the leaves and bracts. Haynes & Hellquist (2000a) believe this character is insufficient to justify varietal recognition. Weakley (2015), however, notes that the two varieties also "can be separated by the presence (var. *latifolia*) or absence (var. *pubescens*) of resin-ducts on the achene-faces."

Wapato is a native North American Indian name, referring to their corms (Fernald & Kinsey 1943). Indians were reported to harvest the tubers by wading in the mud and pulling them off with their toes (Gibbons 1962). Corms are produced at the end of the growing season and prepared like

potatoes. These starchy storage organs are considered to be delicious but are only edible after being boiled or baked (Peterson 1977). If eaten raw they are acrid and reported to be toxic (Rogers 1983). The achenes ("seeds") and tubers are eaten by wildlife, especially waterfowl and muskrats (Martin et al. 1951). *Sagittaria latifolia* is cultivated as an emergent aquatic for ornamental ponds.

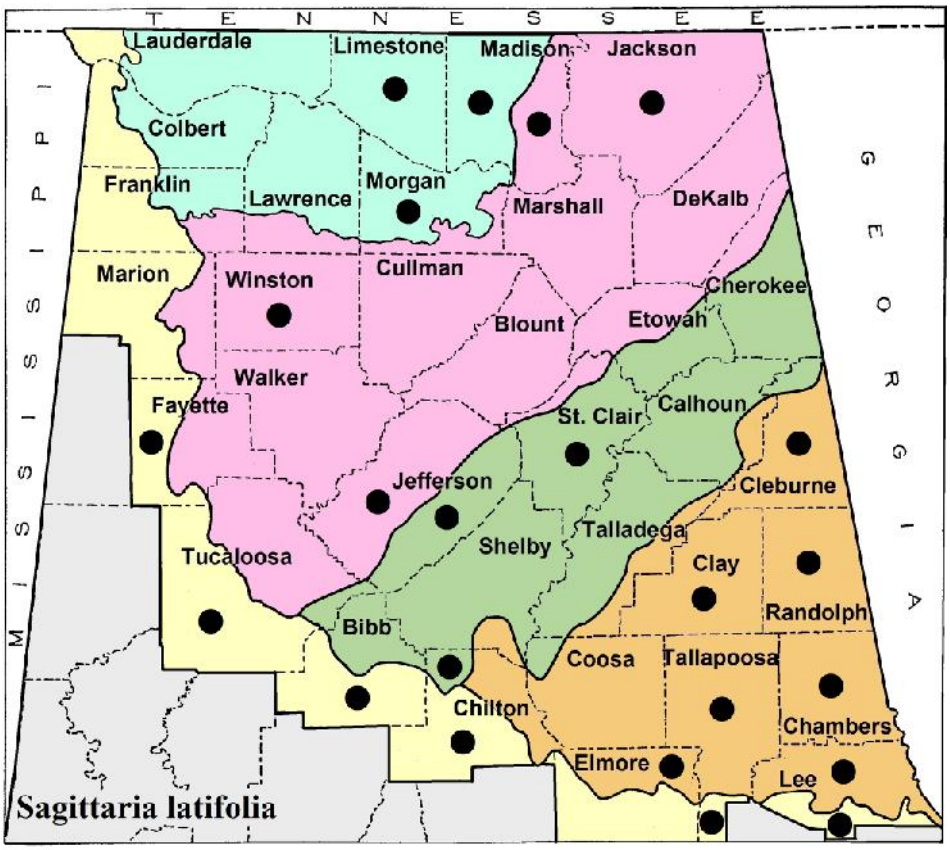


Figure 90. Distribution of *Sagittaria latifolia* in northern Alabama.

(91a) Beaks lateral. (91b) Bracts boat-shaped. (91c) Pubescent rachis. (91d) Hairy leaf and petiole.

Figure 91. *Sagittaria latifolia*. A. Fruiting head with achenes, Morgan Co., Alabama, 5 Oct 2016. Photo: Brian Finzel. B. Fayette Co., Tennessee, 25 Jun 2012. Photo: Brian Finzel. C. Chambers, Co., Alabama, 28 Jul 2018. Photo: Dan Spaulding. D. Jefferson Co., Alabama, 16 Aug 2018. Photo: Dan Spaulding.

Figure. 92. *Sagittaria latifolia* petiole, Cleburne Co., Alabama, 4 Jun 2019. Photo: Dan Spaulding.

5. Sagittaria platyphylla (Engelm.) J.G. Sm. {wide-leaved} — DELTA ARROWHEAD; DELTA DUCK-POTATO (Fig. 93a–b). [*Sagittaria graminea* Michx. var. *platyphylla* Engelm.; *Sagittaria mohrii* J.G. Sm.]

(Fig. 93a) Photo: Brian Finzel.

(Fig. 93b) Photo: Dan Spaulding.

Figure 93. *Sagittaria platyphylla* [with *Justicia americana* (L.) Vahl.]. A. North River Rock Quarry Park, Tuscaloosa Co., Alabama, 26 May 2012. B. Lake Purdy, Jefferson Co., Alabama, 16 Jul 2018.

Emersed aquatic, perennial herb with stolons and corms. Marshes, swamps, sloughs, springs, margins of ponds, lakes, and rivers; flowers and fruits late May–October; frequent in the Interior Low Plateau, Cumberland Plateau, and western Coastal Plain; uncommon in the Ridge & Valley and Piedmont (Fig. 94). Native to eastern North America, its primary range extending from central Texas to the Panhandle of Florida north to Oklahoma, southern Illinois, and Kentucky, with scattered populations in other eastern states (Haynes & Hellquist 2000a). The species has been introduced into South Africa and Australia, where it is considered to be an invasive weed (Kwong et al. 2017).

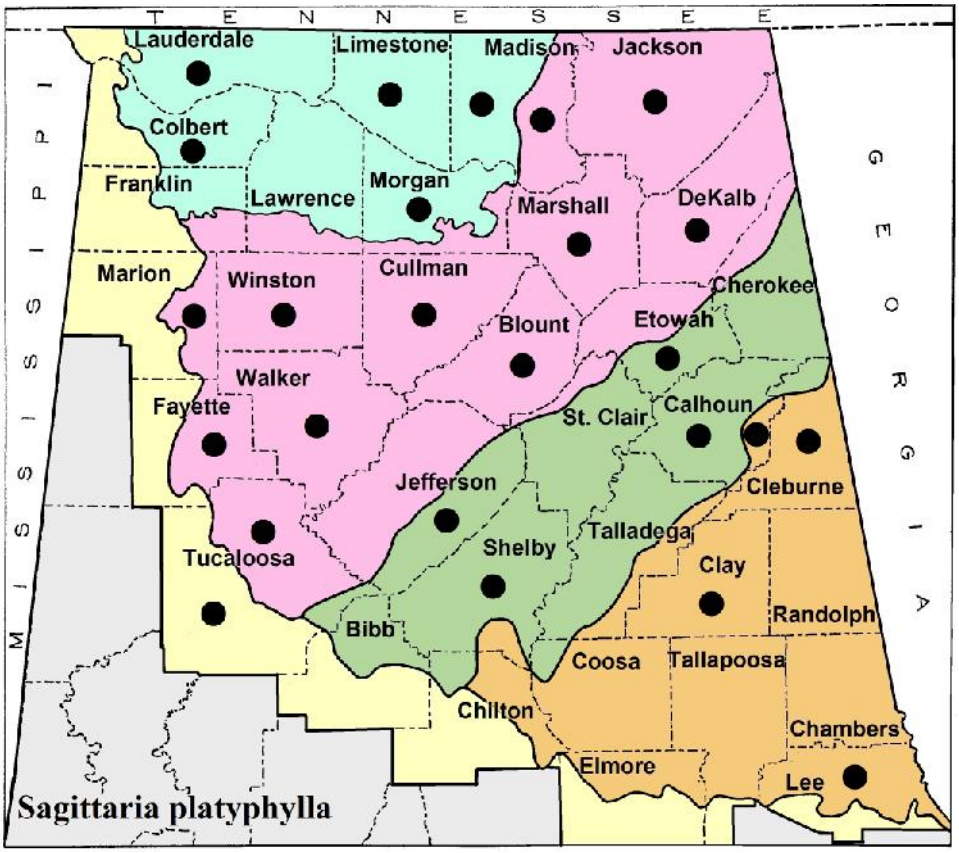


Figure 94. Distribution of *Sagittaria platyphylla* in northern Alabama.

Sagittaria platyphylla is a member of the *S. graminea* complex (Hauber & Legé 1999). It can be distinguished from closely related species by its distinctly connate (fused) bracts with obtuse free tips (Fig. 95) and by its mature fruiting stalks, which are thickened and usually reflexed (Fig. 96a). The leaf blades of *S. platyphylla* are typically broadly elliptic, or ovate, but can be lanceolate, resembling leaves of *S. graminea.* A population of *S. platyphylla* will occasionally have some individuals with narrow leaves (Fig. 96b), which can result in misidentification. This species often occurs in dense colonies along shores of ponds, lakes, and rivers (Fig. 96c).


Figure 95. *Sagittaria platyphylla* flowers and bracts, Marshall Co., Alabama, 9 Oct 2014. Photos: Brian Finzel.

(96a) Pedicels thick and often reflexed. (96b) Lanceolate leaved plant. (96c) Dense population along shore.

Figure 96. *Sagittaria platyphylla*. A. Fulton Co., Kentucky, 5 Aug 2013. Photo: Brian Finzel. B. Pond in DeKalb County, Alabama, 11 Aug 2018. Photo: Dan Spaulding. C. Pond in Helena, Shelby County, Alabama, 19 Jul 2018. Photo: Dan Spaulding.

6. Sagittaria secundifolia Kral {leaves on one side} — KRAL'S WATER-PLANTAIN; LITTLE RIVER ARROWHEAD; LITTLE RIVER WATER-PLANTAIN (Fig. 97a–b).

(97a) Photo: Alan Cressler. (97b) Photo: Wayne Barger.

Figure 97. *Sagittaria secundifolia*. A. East Fork of Little River, Chattooga Co., Georgia, 9 Jun 2011. B. West Fork of Little River, DeKalb Co., Alabama 17 Jul 2008.

Submersed aquatic, perennial herb with rhizomes. Cracks in bedrock of streams; flowers and fruits May–August; rare in the Cumberland Plateau; very rare in the Piedmont (Fig. 98). Endemic to northern Alabama, southeast Tennessee, and northwest Georgia (Weakley 2015).

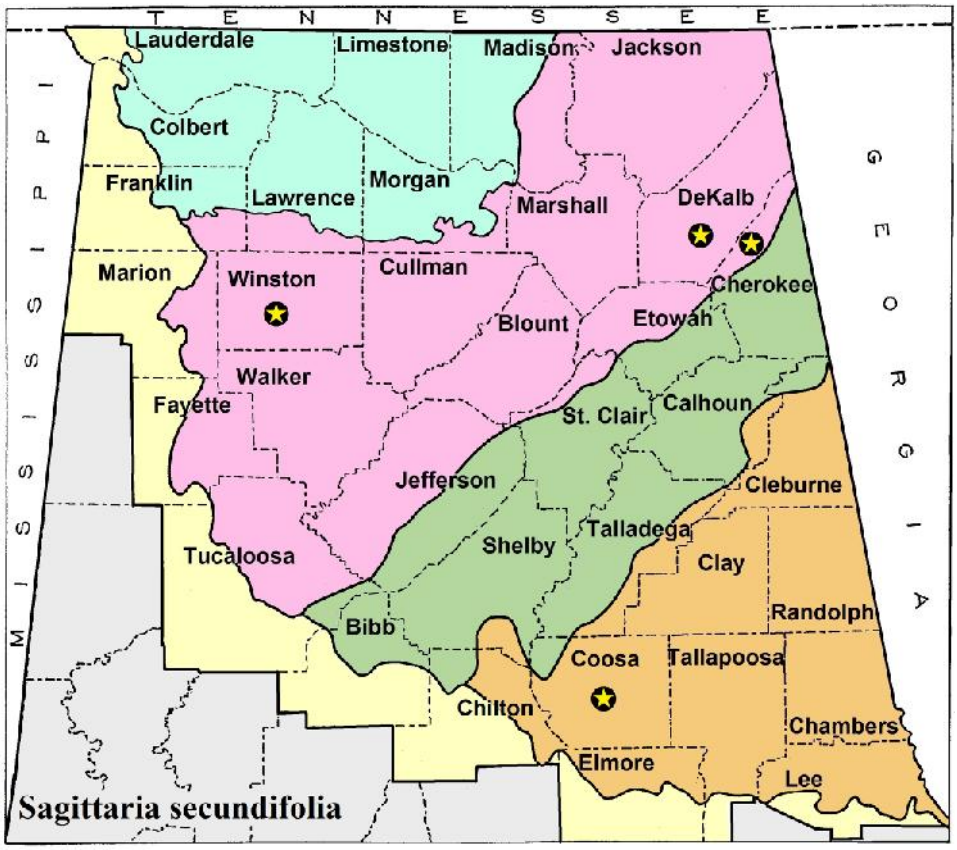


Figure 98. Distribution of *Sagittaria secundifolia* in northern Alabama.

Sagittaria secundifolia has submersed, strap-like, bladeless leaves (phyllodia), and plants are anchored by its rhizomes in rock crevices and streambeds (Fig. 99). In late spring or summer, when the water level is low, flower stalks (peduncles) project above the water surface where pollination occurs (Haynes & Hellquist 2000a). This species was first described by Robert Kral (1982) from collections made in the Little River drainage of Cherokee and DeKalb counties. Kral first observed specimens in the Vanderbilt herbarium collected by A.W. Cusick in 1972, which were misidentified as *S. graminea.* Kral noted that "they were different enough in appearance to be taxonomically provocative." He revisited the site in July 1977 to establish a better understanding of the species. Roland Harper unknowingly collected *S. secundifolia* in DeKalb County on June 6, 1951. Kral's Water-Plantain was federally listed by the U.S. Fish and Wildlife Service as a threatened species in 1990. <https://ecos.fws.gov/ecp0/profile/speciesProfile?sId=8235>

Once published, this new species was on the "radar" of many Alabama botanists. In July 1986, David Whetstone, a professor at Jacksonville State University, discovered a new population in adjacent Chattooga Co., Georgia (Whetstone et al. 1987). In 1992–1993, Scott Gunn, of the Alabama Natural Heritage Program, reported it from along the Sipsey River in Winston County in the Bankhead National Forest (Al Schotz, pers. comm. 2017). In May 2001, Steve Threlkeld and Eric Soehren (2003) discovered the only known population in the Piedmont from Coosa County. They were canoeing and surveying through shoals on Hatchet Creek and noticed *Sagittaria secundifolia*

growing in bedrock crevices of shallow water (Eric Soehren, pers. comm. 2019). Weakley (2015) reports the species occurring in the mountains of southeastern Tennessee.

Figure 99. *Sagittaria secundifolia* in bedrock cracks, DeKalb Co., Alabama 17 Jul 2008. Photo: Wayne Barger.

FAMILY 5. HYDROCHARITACEAE (Frog's-Bit Family)

Prior to the use of molecular techniques, *Najas* was placed exclusively into Najadaceae, a monotypic family. It was thought to be taxonomically distinct because of its reproductive structures. It had hypogynous (superior) ovaries, a single carpel possessing a single ovule, and basal placentation. Hydrocharitaceae sensu stricto differed by having epigynous (inferior) ovaries, 2 to 15 carpels with many ovules, and parietal placentation (Tanaka et al. 1997). However, Shaffer-Fehre (1991) suggested that Najadaceae be merged into Hydrocharitaceae based on similarities in seed coat structure. Modern phylogenetic analyses have consistently shown that *Najas* is clearly nested within the Hydrocharitaceae (Les et al. 1997; Tanaka et al. 1997; Ito et al. 2017) and this is now accepted by many contemporary authors (Stevens 2001; Chase 2004; Reveal 2012; Weakley 2015; APG 2016; Soltis et al. 2018).

1. Leaves in basal rosettes, either ribbon-like (>10 cm long) or petiolate with an expanded blade; stems short (< 2 cm long).

    2. Leaves sessile; blades linear and elongate (> 7 cm long); plants submersed and rooted in substrate; fruiting peduncles coiled and long (> 5 cm long) ..... **6. Vallisneria**
    2. Leaves with distinct petioles; blades suborbicular to ovate (< 7 cm long); plants emersed, rooting in substrate or free floating; fruiting peduncles recurved and shorter (< 6 cm long), not coiled..... **4. Limnobium**

1. Leaves cauline, mostly linear, but not ribbon-like (< 4 cm long); stems elongate (> 3 cm long).

3. Leaves mostly opposite (sometimes appearing whorled); leaf base expanded and sheath-like; flowers sessile or almost so, and borne underwater; perianth absent (lacking sepals and petals), staminate flowers with 1 stamen ..... **5. Najas**
3. Leaves distinctly in whorls of 3 or more; leaf base not expanded or sheath-like; flowers on thread-like stalks 3–6 cm long; perianth present, staminate flowers with 3–9 stamens.

4. Leaf margins with conspicuous spiny teeth; midvein of lower leaf surface often with conical bumps tipped with prickles; petals greenish; stamens 3; tubers often present ..... **3. Hydrilla**
4. Leaf margins with inconspicuous fine teeth; midvein of lower leaf surface lacking bumps or prickles; petals translucent; stamens 7–9; tubers absent.

5. Midstem leaves 1.5–3 cm long and usually in whorls of 4–6; petals showy, 8–11 mm long and longer than sepals ..... **1. Egeria**
5. Midstem leaves 0.5–1.3 cm long and in whorls of 3; petals somewhat inconspicuous, 2.5–5 mm long and about as long as sepals ..... **2. Elodea**

1. EGERIA Planchon 1849

[Latin *egeri*, a mythical water nymph, alluding to its aquatic habitat]

1. Egeria densa Planch. {dense} — BRAZILIAN WATERWEED; COMMON WATERWEED; BRAZILIAN ELODEA (Fig. 100). [*Anacharis densa* (Planch.) Victorin; *Elodea densa* (Planch.) Caspary; *Philotria densa* (Planch.) Small & St. John]

Figure 100. *Egeria densa* (in Three Mile Creek), Mobile Co., Alabama, 15 Apr 2008. Photo: Howard Horne.

Submersed aquatic, perennial herb. Lakes, ponds, springs, swamps, sluggish waters of streams and rivers; flowers April–November; uncommon in the Highland Rim and Coastal Plain; rare in the Cumberland Plateau, Ridge & Valley, and Piedmont (Fig. 101). Native to Brazil and introduced around the world in countries with mild climates, although individual plants have been reported to survive temporarily under ice (Haynes 2000a). This species is widely sold in the aquarium trade (as *Elodea* or *Anacharis*) and has escaped throughout much of North America, Europe, Africa, Asia, Australia, and New Zealand (Haynes & Holm-Nielsen 2001).

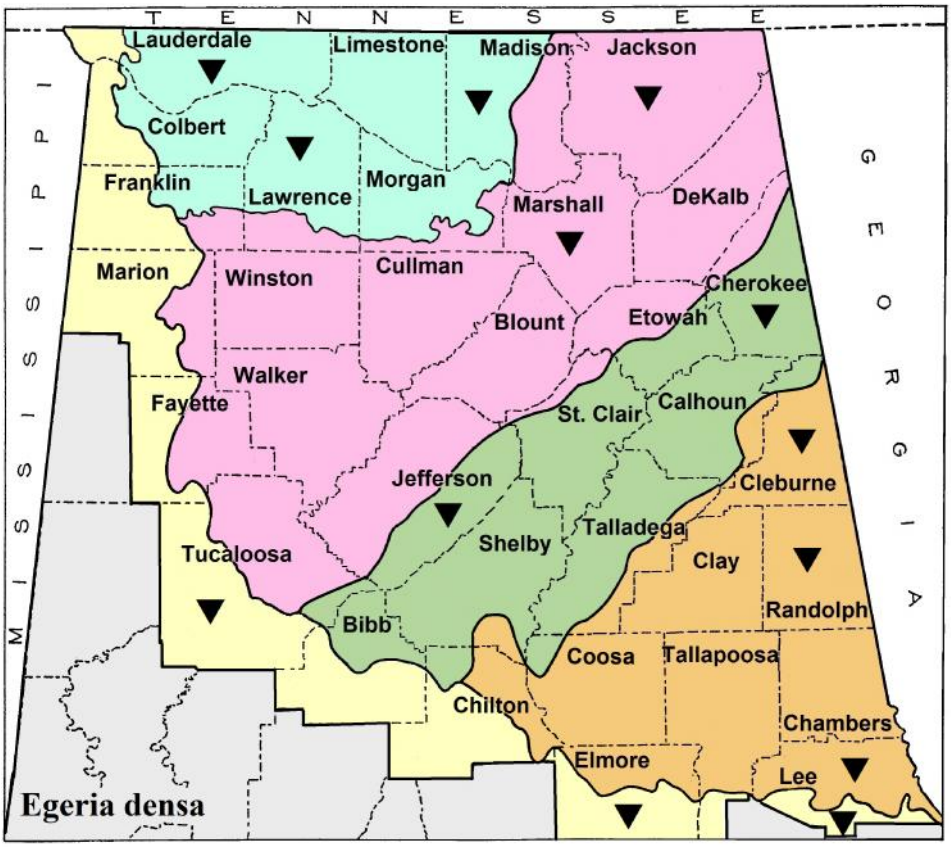


Figure 101. Distribution of *Egeria densa* in northern Alabama.

Brazilian Waterweed, is a noxious pest, able to displace native vegetation (Fig. 102). *Egeria densa* has tendency to clog waterways, impoundments, lagoons, and hydroelectric turbines (Godfrey & Wooten 1979; Yarrow et al. 2007). Populations can grow quickly through stem fragmentation that root readily and develop into new shoots (Haynes 1988). Based on collections reported in the Alabama Plant Atlas (Keener et al. 2019), it appears that *E. densa* was once more common in reservoirs along the Tennessee River in northern Alabama. *Hydrilla verticillata*, a frequent weed in Tennessee River reservoirs, is reported by Mony et al. (2007) to outcompete *E. densa*, which could be a factor in the decline of *Egeria* in northern Alabama.

(102a) Chattahoochee River. Photo: Alan Cressler.

(102b) Stream. Photo: Melanie T. Spaulding.

Figure 102. *Egeria densa*. A. Fulton Co., Georgia, 9 Jun 2011. B. Cleburne Co., Alabama, 15 Jun 2019.

Brazilian Waterweed is dioecious, but only male (staminate) plants have been recorded in North America, which suggests that all *Egeria* populations have spread by fragmentation (Haynes 2000a). *Egeria densa* flowers occur on long axillary peduncles projected at or just above the water surface (Haynes 1988). If submersed, the petals close, entrapping air bubbles, keeping the stamens or stigmas dry (Haynes & Holm-Nielsen 2001). The leaves of *Egeria* are only 2-cell-layers thick, a character that enables laboratory experiments to effectively demonstrate cytoplasmic streaming (Haynes 2000a).

Hydrilla can be mistaken for *Egeria* since both genera have whorled leaves. However, *Hydrilla* leaves have sharp teeth along their margins and a spiny midrib beneath, making the plant rough to the touch. Leaves of *Egeria* are finely serrate and lack spines on the midrib, making them smooth to the touch. The leaves *Hydrilla* are also well spaced on older lower stems and crowded near terminal portions, while the leaves of *Egeria* are crowded throughout (Fig. 103).

Figure 103. *Egeria densa* leaves, lake/3-Mile Creek, Mobile Co., Alabama, 15 Apr 2018. Photo: Howard Horne.

2. ELODEA Michaux 1803

[Greek *elodes*, marshy; alluding to their aquatic habitat]

1. Elodea canadensis Michx. {Canadian} — CANADIAN WATERWEED; BROAD WATERWEED; COMMON WATERWEED (Fig. 104). [*Anacharis canadensis* (Michx.) Planch.; *Philotria canadensis* (Michx.) Britt.]

Submersed aquatic, perennial herb. Springs, lakes, streams, and rivers; flowers and fruits July–September; very rare in the Highland Rim and Coastal Plain; rare in the Cumberland Plateau and Ridge & Valley (Fig. 105). Native to Canada and much of the USA; introduced in lakes and waterways of Europe, New Zealand, and Australia, where it is considered an invasive pest (Haynes & Holm-Nielsen 2001).

Figure 104. *Elodea canadensis* from spring in Etowah Co., Alabama, 11 Aug 2018. Photos: Dan Spaulding.

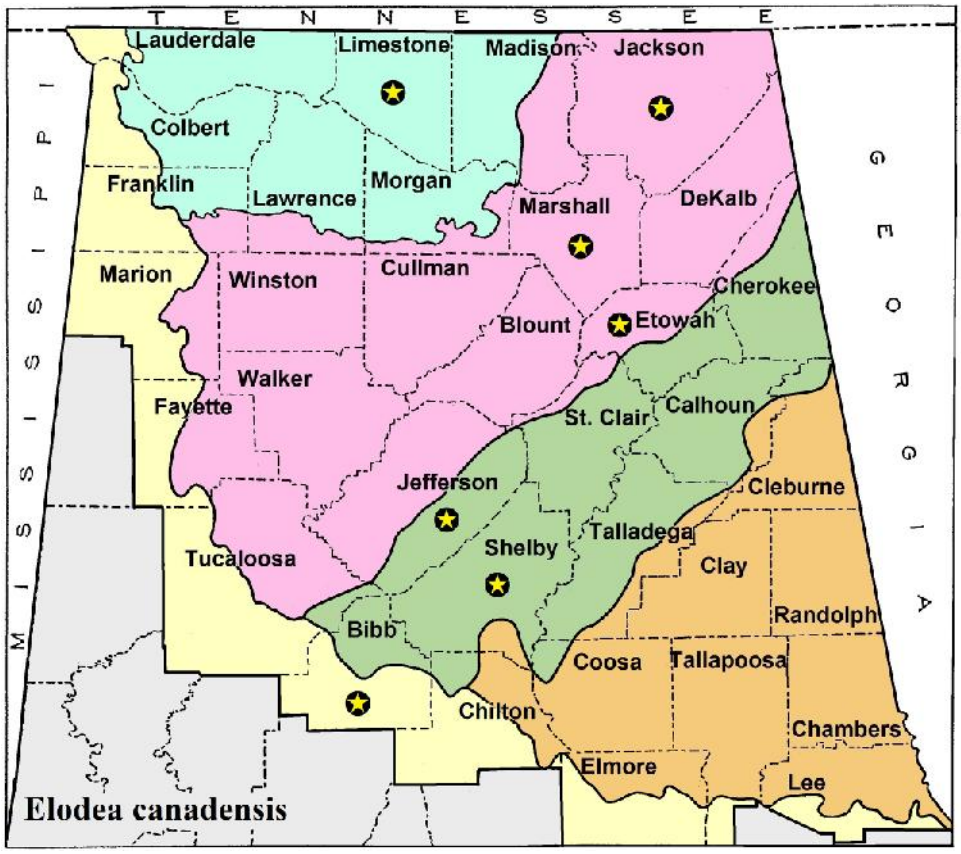


Figure 105. Distribution of *Elodea canadensis* in northern Alabama.

Canadian Waterweed is typically found growing in clear, calcareous waters. It is easily recognized by its finely serrate leaves in whorls of three (Fig. 106). The species is widespread in North America and not known to be weedy within its native range (Haynes 1988). *Elodea canadensis* increases food availability for fish and ducks by providing cover for insects and other small aquatic

organisms (Spicer & Catling 1988). The species is currently listed as critically imperiled (S1) in Alabama (ALNHP 2017) and was considered an endangered species in Alabama by Freeman et al. (1979). A possible factor in its decline is perhaps the deterioration of water quality. Haynes (1980) wrote that it was "rare in the Mobile Delta and in reservoirs of the Tennessee River, the species is probably extirpated from the State." Collections by Mohr (1901) from Baldwin and Mobile counties are historical, but more recent populations have been discovered since Haynes' publication.

Figure 106. *Elodea canadensis*, close-up of leaves, Etowah Co., Alabama, 11 Aug 2018. Photos: Dan Spaulding.

Elodea canadensis is dioecious, with male (staminate) and female (pistillate) flowers on separate plants. The flowers are elevated at or above water's surface (Fig. 107a) via an elongated floral tube (hypanthium) in female plants or on a lengthened flower stalk (pedicel) in male plants (Haynes & Holm- Nielsen 2001). Staminate flowers release a non-wettable pollen that floats until it contacts a stigma of a pistillate flower (Haynes 1988). This species can also reproduce vegetatively by stem fragmentation. In autumn, the upper stems cease to elongate and the terminal leaves become tightly clustered, forming turions (Fig. 107b) that are capable of growing new plants (Haynes & Holm-Nielsen 2001).

(107a) Flowers on long stalks. (107b) Turions formed at end of branches.

Figure 107. *Elodea canadensis* A. Yaroslavl region, Russia, 26 Jul 2010. Photo: Eduard Garin. B. Plant with turions (lighter green, clustered shoots) at tips of branches, Maine, USA. Photo: Don Cameron.

Elodea nuttallii (Planch.) St. John [Nuttall's Waterweed] is a similar species reported from Alabama (St. John 1965), but no valid specimens have been observed. It has flexuous, narrow leaves (avg. 1.3 mm long) with pointed tips (Fig. 108), which do not become densely crowded on upper stems (Haines 2011). As in *Elodea canadensis*, the pistillate flowers are on an elongated floral tube, but the staminate flowers of *E. nuttallii* are sessile and later detach from the plant and float up to the water surface. *Elodea canadensis* differs by having firm, broader leaves (avg. 2 mm) with blunt tips, which become crowded and dense in the upper portion of the stem late in season.

Figure 108. *Elodea nuttallii*, Lincoln Co., Maine, 1 Aug 2002. Photos: Don Cameron.

Egeria densa is sometimes confused with *Elodea canadensis*, but leaves of *Egeria* occur in whorls of four or more instead of threes. *Elodea* also has smaller flowers, its petals are 2.5–5 mm long and about the same length as the sepals. *Egeria* flowers are conspicuous, its petals are 8–11 mm long and distinctly exceed the sepals

3. HYDRILLA L.C. Richard 1814
[Greek *hydro*, water; referring to the habitat]

1. Hydrilla verticillata (L.f.) Royle {whorled} — HYDRILLA; WATER-THYME (Fig. 109).

Figure 109. *Hydrilla verticillata*, Mallard Creek, Lawrence Co., Alabama, 19 Aug 2018. Photos: Dan Spaulding.

Submersed aquatic, perennial herb with rhizomes and tubers. Lakes, reservoirs, swamps, marshes, ponds, sluggish streams and rivers; flowers and fruits May–August; frequent in the Highland Rim and Coastal Plain; uncommon in the Cumberland Plateau and Ridge & Valley; rare in the Piedmont (Fig. 110). This species is often locally abundant. It occurs in reservoirs along the Tennessee River and has invaded the Cahaba River and Tallapoosa River. The origin of *Hydrilla* is uncertain, but it is believed to be native to the warmer areas of Asia, where it is widespread (Langeland 1996). *Hydrilla* has become an invasive weed throughout the world in tropical, subtropical, and temperate regions (Haynes & Holm-Nielsen 2001).

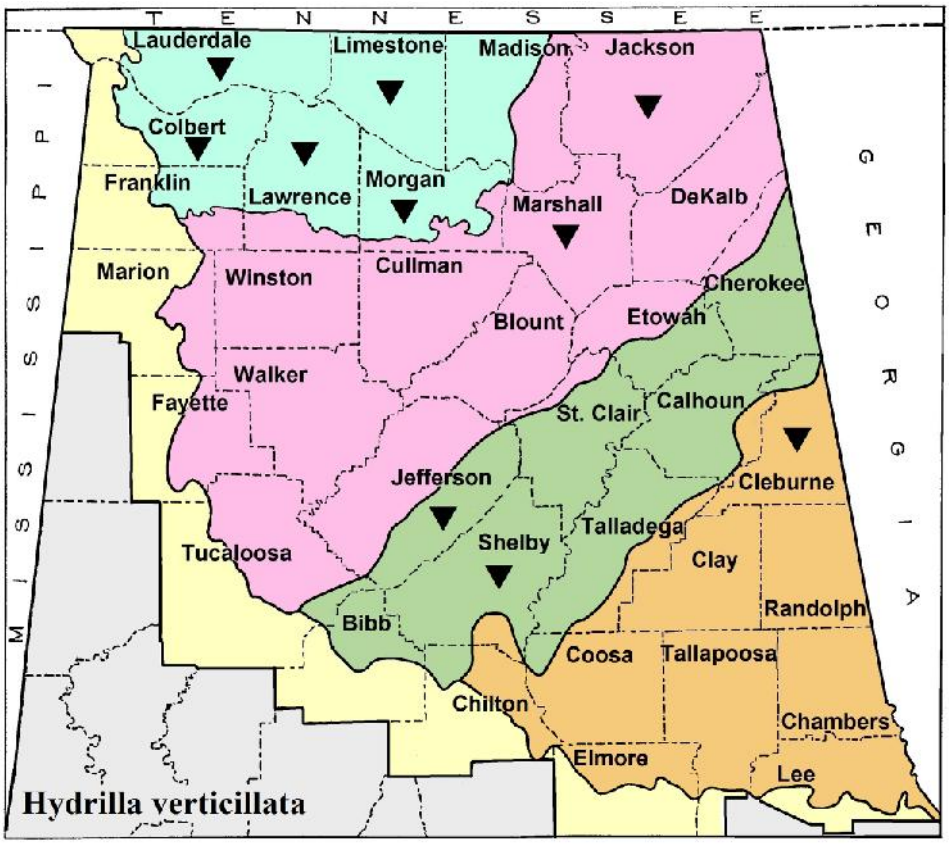


Figure 110. Distribution of *Hydrilla verticillata* in northern Alabama.

Hydrilla was first discovered from Austin, Florida, in 1959. It has since become a noxious pest, spreading rapidly and choking waterways in warmer regions throughout the USA (Haynes & Holm-Nielsen 2001). *Hydrilla* is a monotypic genus with a single variable species that grows in a variety of aquatic habitats in fresh or brackish waters. Plants multiply and spread most rapidly by turions, tubers, and fragmentation of stems, yielding new plants very quickly (Haynes 2000a). Monetary losses can occur when waterfront property values drop or when recreational access is hindered, and water movement for irrigation is impacted. This species is often transported into new locations by vegetative fragments, often when attached to boats and trailers (Haynes 1980). *Hydrilla* management methods include introduction of the grass carp (*Ctenopharyngodon idella*), mechanical removal, and use of herbicides (Langeland 1996). Haynes (1980) documented *Hydrilla* only from Clarke and Choctaw counties (Coffeeville Lake, Tombigbee River), but it has now spread throughout Alabama.

The flowers of *Hydrilla* are unisexual, with staminate (male) and pistillate (female) flowers on separate plants or on the same plant (Haynes 2000a). These two biotypes, dioecious and

monecious, have been documented as occurring in the USA. Only pistillate dioecious plants, however, are known in the USA (Madeira et al. 2000). Both biotypes occur in the large reservoirs along the Tennessee River in northern Alabama (David Webb, pers. comm. 2019). The biotypes can often be distinguished by their growth habit. Pistillate dioecious plants are robust, growing vertically and creating surface mats, whereas the monoecious biotype is more slender and generally forms horizontal mats underwater (Tennessee Flora Committee 2014). The monecious biotype is capable of producing viable seeds (Madeira et al. 2009). Pistillate flowers (Fig. 111c) remain attached to the plant and extend to the water surface by an elongated floral tube. Staminate flowers (Fig. 111b) are released under water and float to the surface, often in large numbers (Fig. 111c). Initially, anthers adhere in "pockets" of each sepal and later the stamens spring forward, "catapulting" their pollen into the air, with most landing in the water but some ultimately landing on stigmas of the female (Haynes & Holm-Nielsen 2001).


(111a) Female flower.


(111b) Male flower.


(111c) Male flowers floating on water.

Figure 111. *Hydrilla verticillata*. A. Mallard Creek, Lawrence Co., Alabama, 19 Aug 2018. B-C. Guntersville Reservoir/Tennessee River, Marshall Co., Alabama, 8 Oct 2018. Photos: Dan Spaulding.

Egeria densa and *Elodea canadensis* can be confused with *Hydrilla* since both are submersed aquatics with whorled leaves. *Hydrilla* is easily separated by its toothed leaves (Fig. 112a) and by its small spine-like teeth on the midribs underneath (Fig. 112b), which make the plant rough to the touch. Leaves of the other species (*Egeria* and *Elodea*) have finely serrate margins and lack teeth on the midribs, thus are smooth to the touch.


(112a) Conspicuously toothed leaves.


(112b) Undersurface of leaves with spine-like teeth.

Figure 112. *Hydrilla verticillata*, Tennessee River, Jackson Co., Alabama, 14 Aug 2018. Photos: Dan Spaulding.

4. Limnobium L.C. Richard 1814
[Greek *limnobios*, living in pools; a reference to its habitat]

1. Limnobium spongia (Bosc) L.C. Rich. ex Steud. {a sponge} — AMERICAN FROG'S-BIT; AMERICAN SPONGE-PLANT; NORTH AMERICAN FROGBIT (Fig. 113).

Figure 113. *Limnobium spongia*, Montgomery Co., Alabama, 28 Aug 2015. Photo: Wayne Barger.

Emersed or floating aquatic, perennial herb with stoloniferous stems. Lake margins, sloughs, marshes, swamps, and ponds; flowers and fruits June–September; rare in the Cumberland Plateau; uncommon in the Coastal Plain (Fig. 114). Its native distribution ranges from New Jersey along the Atlantic Coastal Plain south to Florida and west mostly through the Gulf Coastal Plain to east Texas and northward through the Mississippi drainage to southern Illinois (Catling & Dore 1982). Non-persisting, introduced populations have been documented from New York, Connecticut, and northern Indiana (Les & Capers 1999). This species has also been introduced into California, where it has become an invasive weed (Hrusa et al. 2002).

In northern Alabama, *Limnobium spongia* is known only from Guntersville Reservoir (Tennessee River) in the Sequatchie Valley district of the Cumberland Plateau. It was first discovered in 2015 by David Webb in Marshall County and again in 2018 from Jackson County (David Webb, pers. comm. 2019). Intensive field work of aquatic environments by Haynes (1980) and a floristic survey of the Guntersville Reservoir in the 1990's (Spaulding 1999) failed to document this species from the northern regions of the state. *Limnobium* is likely to have been introduced recently in northern Alabama (David Webb, pers. comm. 2019) and could potentially spread to other reservoirs of the Tennessee River system. The dispersal of *Limnobium* in the USA is believed to be by natural agents, not by horticultural introductions (Lowden 1992). The seeds are likely dispersed by various duck species, which are known to consume the fruit (Les & Capers 1999).

Although American Frog's-Bit is indigenous to North America, it has the potential to become weedy in certain regions of its range (Les & Capers 1999). *Limnobium spongia* usually forms dense mats from stoloniferous stems that are floating or suspended just below water surface (Fig. 115), but

plants can also be stranded during low water. Populations are free-floating (Fig. 116a) or rooted at the nodes of its stolons in shallow water or on mudflats. The floating leaves have short petioles and a leaf blade with a central disc of inflated, spongy cells (aerenchyma) underneath (Fig. 116b). The emersed leaves have longer petioles and these leaf blades lack a central spongy area (Lowden 1992). The two leaf types are frequently found on the same plant (Haynes 2000a).

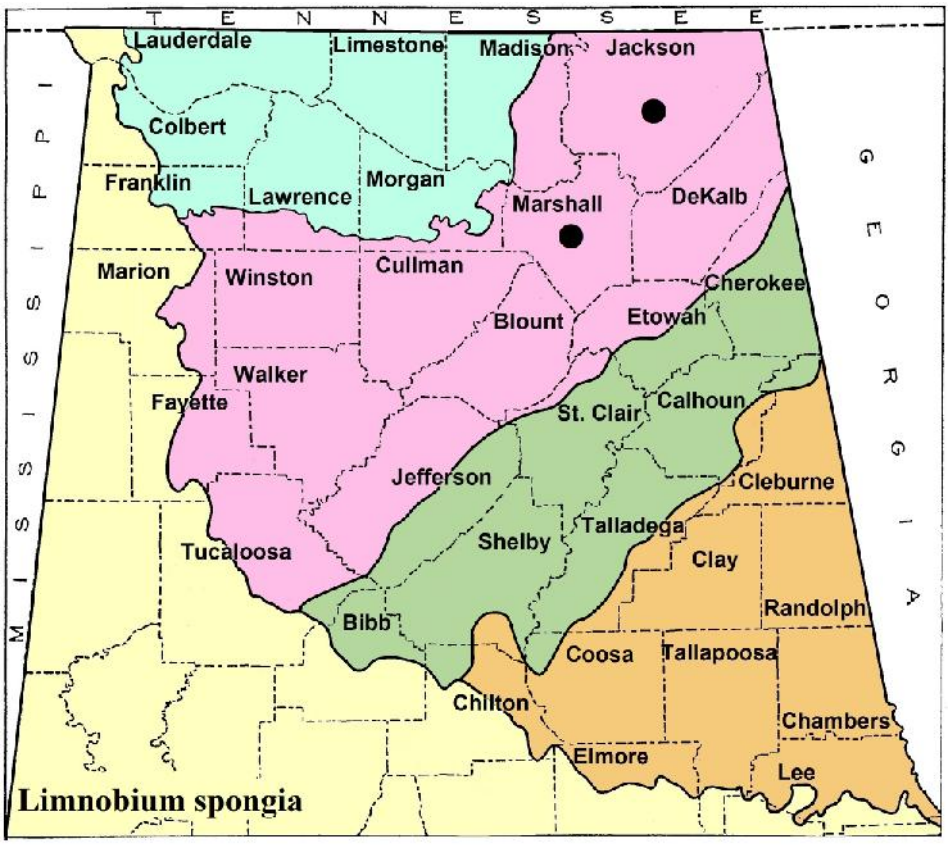


Figure 114. Distribution of *Limnobium spongia* in northern Alabama.

Figure 115. *Limnobium spongia*, reservoir margin, Marshall Co., Alabama, 23 Sept 2015. Photo: David Webb.

(116a) Free floating form. (116b) Spongy disc on underside of floating leaves.

Figure 116. *Limnobium spongia*, St. Johns County, Florida, 18 Mar 2019. Photos: Eric M. Powell.

Spongeplant is monoecious — it has unisexual flowers (male & female) on the same plant (Fig. 113). It is principally wind pollinated (anemophily), but aphids (Aphididae) and their predators, ladybird beetles (Coccinellidae), are often present on the floral parts during anthesis (Lowden 1992). Flowering occurs primarily on rooted plants with emersed leaves. Following pollination, fruiting stalks curve downward (Fig. 117a–b), with fruit usually forming under water (Haynes 2000a).

Figure 117. *Limnobium spongia* with fruits, Marshall Co., Alabama, 14 Oct 2015. Photos: David Webb

5. NAJAS Linnaeus 1753

[Greek, *Naias*, a water-nymph; a reference to their aquatic habitat]

Hydrocharitaceae has some of the most specialized pollination mechanisms found within the angiosperms, and *Najas* is the only freshwater genus in the family with subsurface, hydrophilous pollination (Les et al. 2010). In submerged hydrophily, pollen grains are released underwater from male flowers, sink and attach to the stigmas of female flowers (Cox 1988). Molecular data show that *Najas* is most likely closely related to a clade that includes the genera *Hydrilla* and *Vallisneria* (Tanaka et al. 1997; Chen et al. 2012).

1. Leaf blades with conspicuous spinulose teeth along margins; leaves stiff and recurved with age; terminal internodes becoming shorter, therefore leaves are tufted at top, giving plant a bushy habit; areolae (cell-like pits) of seed coat in ladder-like rows (seen in mature fruit).....**3. Najas minor**
1. Leaf blades with small, inconspicuous teeth along margins; leaves flaccid, mostly straight: terminal internodes about equal in different parts, therefore plant not tufted at top; areolae of seed coat not in ladder-like rows (best observed in dried mature fruit).

    2. Leaves filiform, 0.1–0.3 mm wide with a gradually tapering apex and an abruptly expanded base; leaf margins with 13–17 multicellular teeth > 0.5 mm long; leaf sheaths with truncate or auriculate shoulders; areolae longer than broad.....**1. Najas gracillima**
    2. Leaves linear, 0.5–1.4 mm wide with an abruptly tapering apex and a gradually expanded base; leaf margins with 50–100 minute unicellular teeth per side < 0.5 mm long; leaf sheaths with sloping or rounded shoulders; areolae of seeds about as long as broad...**2. Najas guadalupensis**

1. Najas gracillima (A. Braun ex Engelm.) Magnus {very slender} — SLENDER WATER-NYMPH; THREAD-LIKE NAIAD; SLENDER NAIAD (Fig. 118).

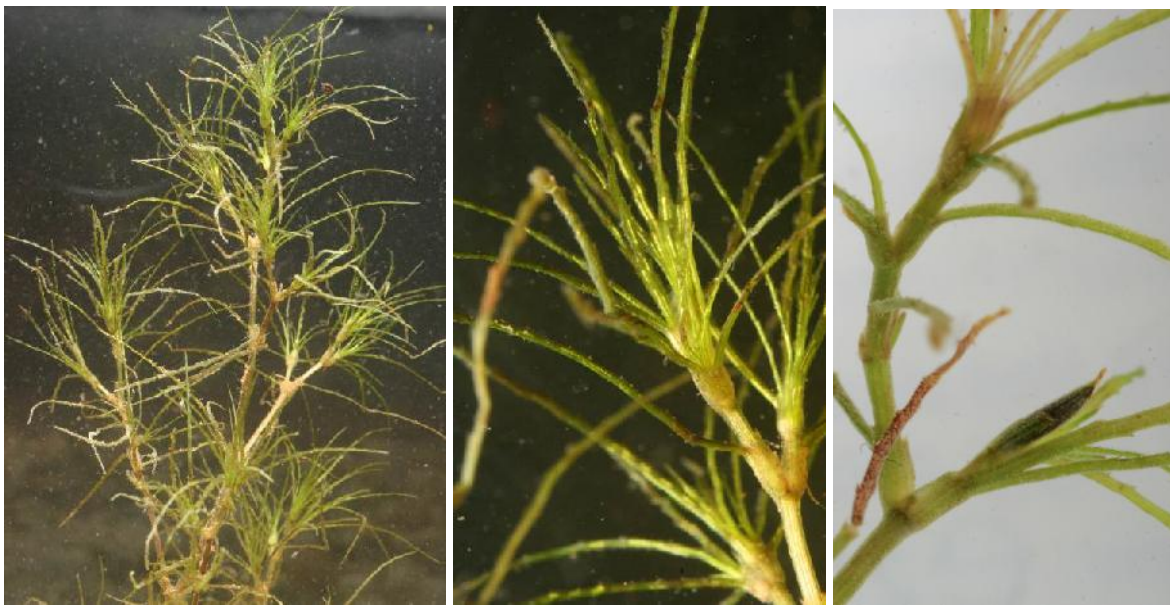


Figure 118. *Najas gracillima*, from karst pond near Sgonico, Italy (Friuli region), 30 Sep 2008. Photos: Alexander Mrkvicka. <http://flora.nhm-wien.ac.at >

Submersed aquatic, annual herb. Lakes; flowers and fruits July–October; very rare in the Piedmont (Fig. 119). This species is native to Eurasia and the eastern half of North America. Populations are scattered from Ontario to Newfoundland, south through Minnesota and Maine, to Alabama and Mississippi; disjunct in California. Through genetic studies, Les et al. (2013) concluded that *Najas gracillima* was introduced into California from Asian material, and it is potentially invasive on the West Coast. In eastern North America, however, it is indigenous and imperiled.

Fernald (1923) stated that *Najas gracillima* "is one of the most distinct species of the genus on account of its straight linear-setaceous leaf-blades strongly divergent from the conspicuously auricled and scarious sheathing base and its commonly subfalcate, very slender fruits with about 24 rows of longitudinal elongate areolae." *Najas gracillima* looks somewhat like *N. minor*, but Slender Water-Nymph has flexible, mostly straight leaves with small teeth along its margins (Fig. 120a), and areolae on the seed coat are longer than broad (Fig. 120b). *Najas minor* has stiff, distinctly curved

leaves with conspicuous teeth along the margins (when mature), and areolae on the seed coat are broader than long (transversely elongate) in ladder-like rows.

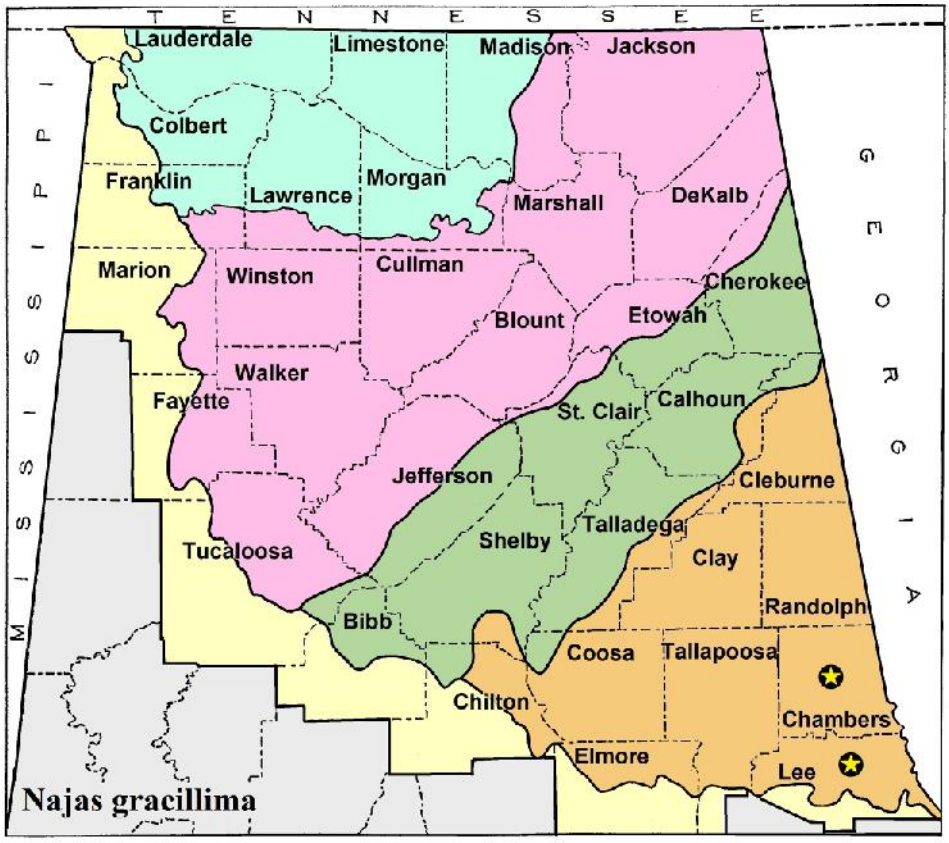


Figure 119. Distribution of *Najas gracillima* in northern Alabama.

(120a) Leaves with small multicellular teeth.

(120b) Areolae longer than broad.

Figure 120. *Najas gracillima.* A–B. UNA, *Myhre 7219*, Benfield Lake, Carlton Co., Minnesota, 17 Aug 1997. Photos: Dan Spaulding.

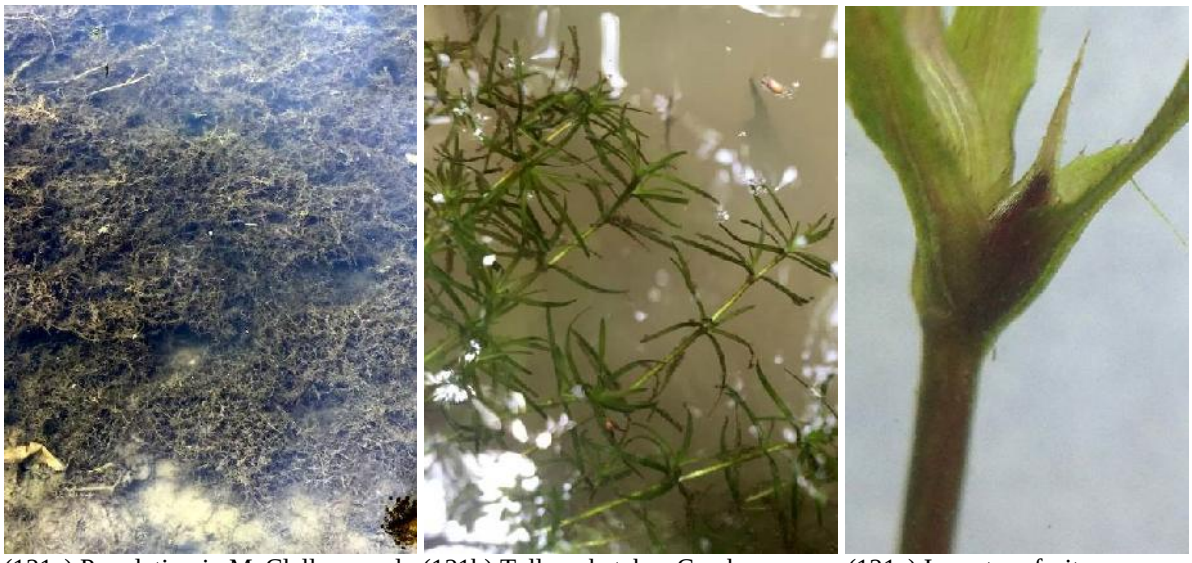
Najas gracillima was first discovered in Alabama by Lovett E. Williams in the Piedmont of Lee County on July 5, 1958. Williams collected the plant in Lake Ogletree, just south of Auburn, where it was apparently abundant in 2 feet of water. He deposited his collection at Florida State University Herbarium (FSU) but did not identify it to species. The FSU herbarium specimen was

examined and annotated to *N. gracillima* in 1974 by Robert Haynes and W. Alan Wentz (1974), students at Ohio State University. The population at Lake Ogletree was never visited by Haynes (Robert Haynes, pers. comm. 2019).

On July 2, 1979, Haynes discovered another population of *Najas gracillima* in the Piedmont in Lafayette City Lake in Chambers County, Alabama. He recorded it as being abundant in water to about 3 feet deep. In 1983, during a later visit to this public fishing lake, he noted *N. gracillima* was now rare, found only in hollow stumps, apparently protected from marauding grass carp (*Ctenopharyngodon idella*). Unfortunately, this population is now believed to be extirpated because of the introduction of this fish species (Robert Haynes, pers. comm. 2018). Studies on grass carp reveal that they prefer *Najas* to other aquatic plants (Wiley et al. 1986). *Najas gracillima* has been erroneously reported for Barbour and Cleburne counties (SERNEC 2018) — duplicates of these specimens have been annotated to *N. guadalupensis* by Haynes.

Najas gracillima thrives in clear, clean waters and is intolerant of pollution (Haynes 1977). It has disappeared or been reduced in abundance throughout much of its range due to the degradation of water quality (Wentz & Stuckey 1971). Conversely, *Najas minor*, more tolerant of eutrophic waters, has become abundant and widespread. The Alabama Natural Heritage Program (2017) lists *Najas gracillima* as critically imperiled (S1).

2. Najas guadalupensis (Spreng.) Magnus var. **guadalupensis** {of the Island of Guadalupe} — SOUTHERN WATER-NYMPH; COMMON WATER-NYMPH; SOUTHERN NAIAD; GUADALUPE WATER-NYMPH (Fig. 121a–c).



(121a) Population in McClellan pond. (121b) Tallaseehatchee Creek. (121c) Immature fruit.

Figure 121. *Najas guadalupensis*. A. Calhoun Co., Alabama, 21 Jun 2018. B. Calhoun Co., Alabama, 23 May 2018. C. South Branch Cane Creek, Calhoun Co., Alabama, 22 May 2018. Photos: Dan Spaulding.

Submersed aquatic, annual herb. Lakes, ponds, impoundments, rivers, and streams; flowers and fruits May–October; frequent in the Highland Rim, Cumberland Plateau, Ridge & Valley, and Coastal Plain; uncommon in the Piedmont (Fig. 122). Native to portions of southern Canada and widely distributed throughout the USA (except in Rocky Mountain States) ranging south to the West Indies, Mexico, Central America, and South America (Haynes 2000b).

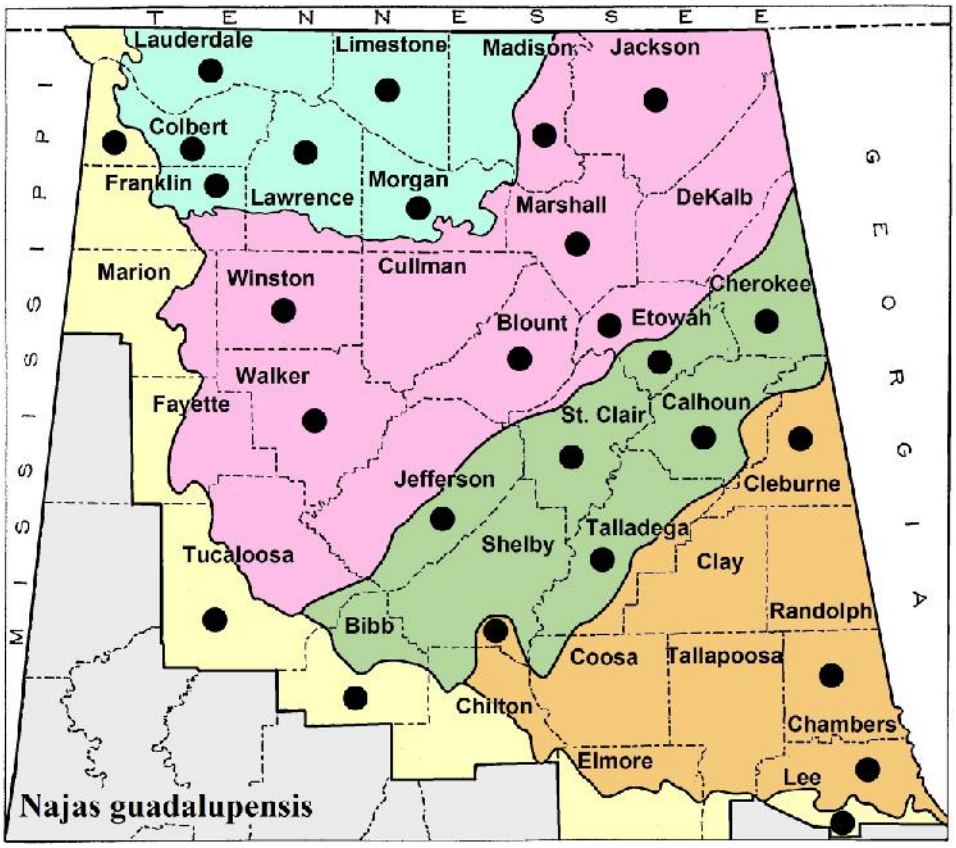


Figure 122. Distribution of *Najas guadalupensis* in northern Alabama.

Najas guadalupensis is a highly variable taxon and has been separated into several varieties or subspecies (Haynes 2000b). Only *N. guadalupensis* var. *guadalupensis* occurs in northern Alabama. *Najas guadalupensis* var. *floridana* is found in rivers, streams, and ponds throughout Florida and in portions of southern Georgia and Alabama (Haynes 2000b). It differs from the typical variety by having 1-locular anthers and leaf blades with 18–42 teeth per side that are often evident to the naked eye. *Najas guadalupensis* var. *guadalupensis* has 4-locular anthers and its leaf blades have 50–100 minute teeth per side (Fig. 123), barely visible to the unaided eye (Haynes 1979).


Figure 123. *Najas guadalupensis* leaves, Calhoun Co., Alabama, 22 May 2018. Photos: Dan Spaulding.

The leaf sheath of Southern Water-Nymph has distinctly rounded, sloping shoulders (Fig. 124a). Its single-seeded fruits are fusiform and the areolae (cell-like pits) of seed coat are about as long as wide (Fig. 124b). *Najas guadalupensis*, like most naiads, is highly fertile and produces a lot of fruits (Meriläinen 1968). The seeds are an important food source for waterfowl and a favorite food of eastern ducks, which eat every part of the plant (Martin et al. 1951).

(124a) Leaf sheaf with rounded shoulders.

(124b) Areolae of seed coat about as long as broad.

Figure 124. *Najas guadalupensis*. A. Valley Creek, Jefferson Co., Alabama, 31 Jul 2018. B. AMAL, *Keener 4919*, pond in St. Clair Co., Alabama, 28 Sep 2008. Photos: Dan Spaulding.

3. Najas minor All. {smaller} — BRITTLE WATER-NYMPH; BRITTLE NAIAD; SPINY-LEAF NAIAD; BRITTLE-LEAF NAIAD (Fig. 125a–c).

(125a) Population in lake.

(125b) Toothed, curved leaves.

(125c) Immature fruit.

Figure 125. *Najas minor*. A. Cherokee Co., Alabama, 22 Aug 2018. B–C. Lafayette City Lake, Chambers Co., Alabama, 30 Jul 2018. Photos: Dan Spaulding.

Submersed aquatic, annual herb. Ponds, lakes, impoundments, marshes, swamps, and sluggish rivers; flowers and fruits July–October; frequent in the Highland Rim, Cumberland Plateau, Ridge & Valley, and Coastal Plain; uncommon in the Piedmont (Fig. 126). Native to Europe, Asia, and North Africa; introduced in the USA (Haynes 2000b).

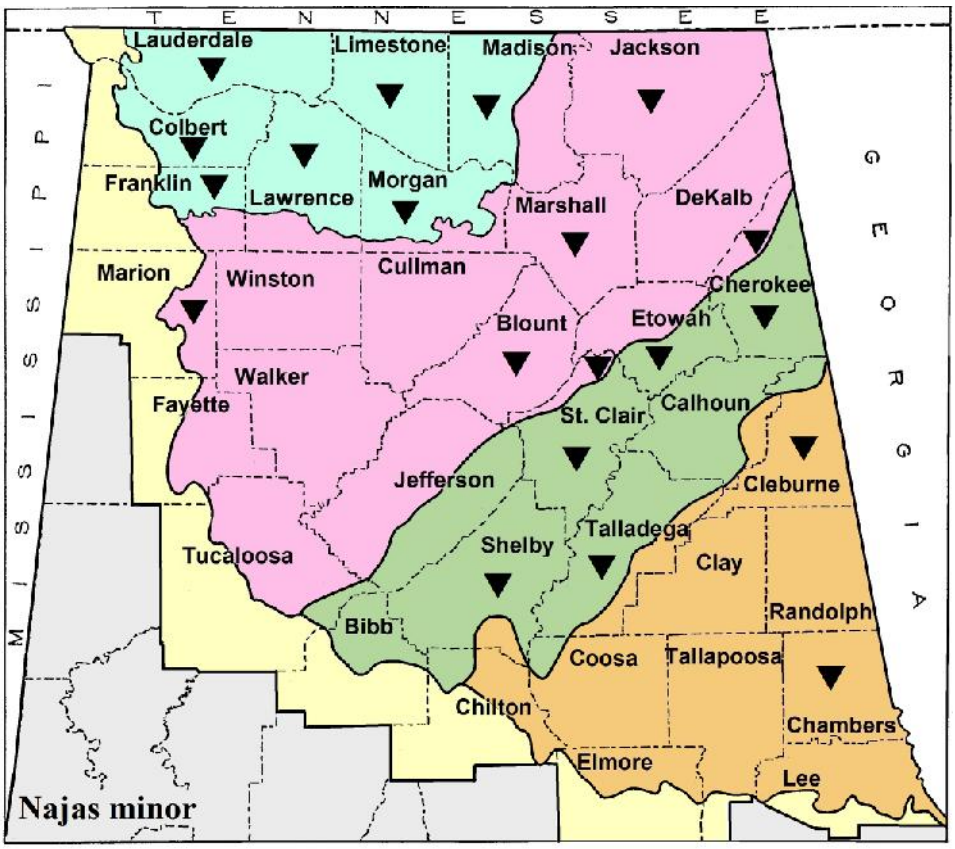


Figure 126. Distribution of *Najas minor* in northern Alabama.

This species invaded North America over 80 years ago. It was first collected in 1932 by Lawrence E. Hicks in 1932 from Lake Cardinal in Ohio, then again by R.T. Clausen in 1934 from the Hudson River in New York (Wentz & Stuckey 1971). *Najas minor* has become widespread in eastern North America but also occurs in California and Washington State (Kartesz 2018). It can thrive in eutrophic to somewhat polluted waters and is likely dispersed in North America by waterfowl that relish its fruits (Meriläinen 1968). *Najas minor* grows in the shallows of lakes, ponds, and large, sluggish rivers with muddy or silty bottoms. In northern Alabama, Brittle Water-Nymph has become a common aggressive weed in reservoirs along the Tennessee River.

As an annual, Brittle Water-Nymph requires seed development for reproduction. It is monoecious, with solitary, unisexual flowers developing within the leaf axils of the same plant, with staminate (male) flowers produced mostly above the pistillate (female) flower. Pollination occurs completely underwater. Male flowers release pollen grains that slowly sink, with some making contact with a stigma of the female flower, enabling pollination (Haynes 1988).

Najas minor is one of the more distinctive species of the genus because of its tufted, curved leaves with conspicuous teeth along the margins (Fig. 127a). The leaves of *N. gracillima* are straight, very narrow, with smaller, less noticeable teeth. Wentz and Stuckey (1971) note that "*N. minor* superficially resembles *N. gracillima* in early growth stages, and the often-mentioned recurved-leaf

character of *N. minor* usually does not appear until late in the growing season." The teeth of *Najas minor* are also not as conspicuous on younger leaves.

Mature fruits of *Najas* can help to separate the various species. Those of *Najas minor* have seed coat areolae (cell-like pits) that are transversely elongate (broader than long) and arranged in ladder-like rows (Fig. 127b). Those of *Najas gracillima* have seed coat areolae that are longitudinally elongate (longer than broad) and arranged in offset rows (Haynes 2000b). Characteristics of the seed coat of *Najas* are conspicuous and visible through their transparent fruit wall but are best observed on dried specimens (Meriläinen 1968). Furthermore, the style of *N. minor* is located at the center of fruit apex, while the style of *N. gracillima* is slightly offset to one side.

(127a) Leaves with conspicuous teeth. (127b) Areolae broader than long; fruit curved.

Figure 127. *Najas minor*. A–B. AMAL, *Spaulding 15684*, Marion Co., Alabama, 8 Sep 2018. Photos: Dan Spaulding.

6. **VALLISNERIA** Linnaeus 1753

[Named after Antonio Vallisneri, 1661–1730, an Italian botanist]

1. Vallisneria americana Michx. {American} — AMERICAN EELGRASS; TAPEGRASS; WATER-CELERY; WILD-CELERY (Fig. 128). [*Vallisneria spiralis* auct. non L.]

Figure 128. *Vallisneria americana*, Jackson Co., Alabama, 11 Aug 2018. Photos: Dan Spaulding.

Submersed aquatic, perennial herb with rhizomes. Rivers, lakes, streams, and ponds, as well as brackish bays and estuaries on the coast; flowers and fruits late May–October; frequent in the Highland Rim; uncommon in the Cumberland Plateau and Coastal Plain; rare in the Ridge & Valley; very rare in the Piedmont (Fig. 129). Native to Canada and USA, south through Mexico to Venezuela; also in Asia and Australia (Haynes & Holm-Nielsen 2001). In North America, *Vallisneria americana* occurs primarily east of the Rocky Mountains but grows sporadically in West Coast states and British Columbia (Kartesz 2018).

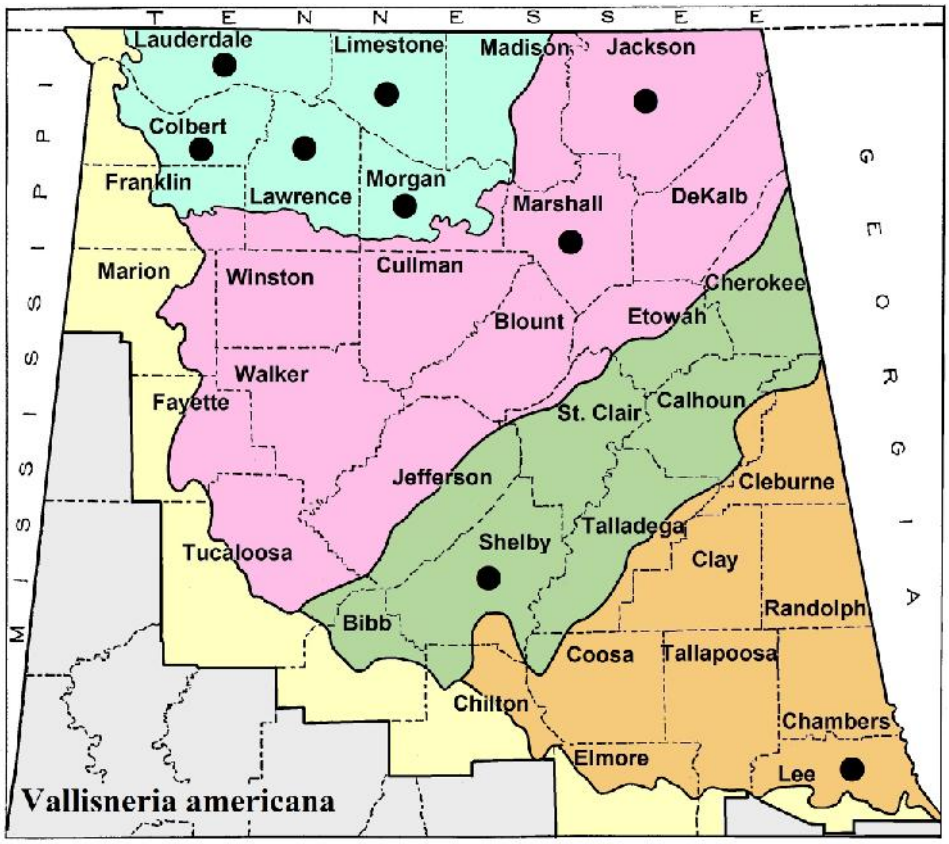
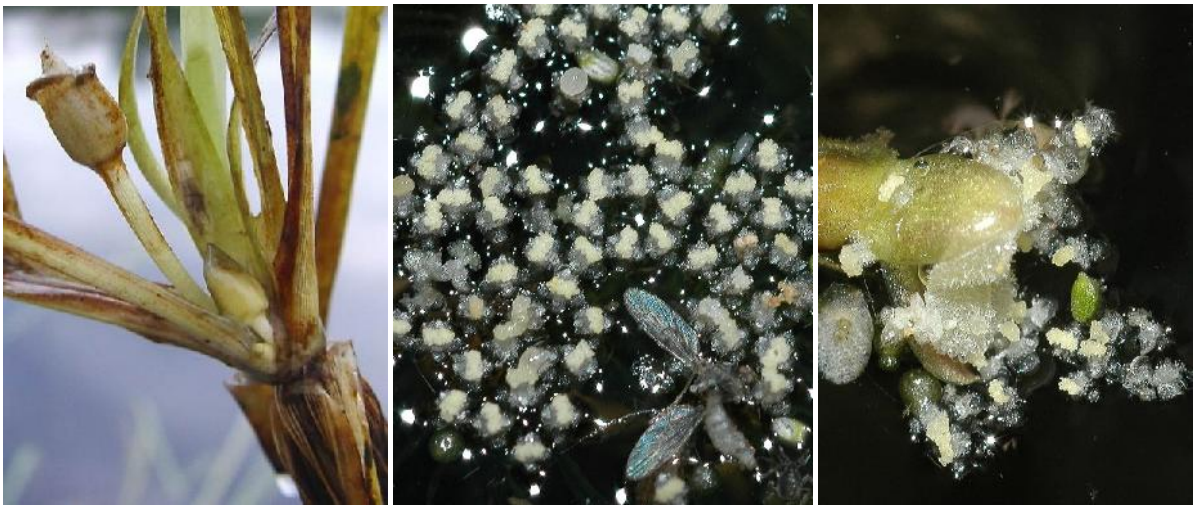


Figure 129. Distribution of *Vallisneria americana* in northern Alabama.

In northern Alabama, American Eelgrass is abundant in larger reservoirs along the Tennessee River and has become a nuisance plant that is being managed with herbicides in areas with developed shoreline (David Webb pers. comm. 2019). *Vallisneria americana* has also been documented in portions of the Cahaba River and from Auburn fishery ponds, where it was likely introduced. Nearly all populations on the Coastal Plain are from Baldwin and Mobile counties (Keener et al. 2019). An Old World species, *Vallisneria spiralis* L. [European Eelgrass], is distinct from *V. americana* but the name has been misapplied in the past to our species (Fernald 1918).

Vallisneria americana is dioecious, with unisexual flowers occurring on separate plants. Haynes & Holm-Nielsen (2001) described the elaborate pollination mechanism. The staminate (male) flowers are tightly packed in a spathe, which is a pouch-like inflorescence attached underwater to the base of the plant by a short stalk (Fig. 130a). At maturity, the valves of the floral spathe separate, releasing numerous unopened staminate flowers that rise to the surface (Fig. 130b). The differences in air pressure outside and inside the flower causes the spathe to open, with the sepals becoming reflexed, forming a floating "boat-like" structure. Staminate flowers drift along the water surface, with some making contact with pistillate (female) flowers (Fig. 130c), which are borne singly

on a long flower stalk (Fig. 131a–c). After pollination the pistillate flower stalk recoils, pulling the fruit underwater where it matures (Fig. 132a). American Eelgrass populations are connected by rhizomes (Fig. 132b) buried in the mud, and when fragments break free, they can produce new colonies.



(130a) Staminate spathes. (130b) Floating raft of male flowers. (130c) Female flower with males.

Figure 130. *Vallisneria americana*. A. Staminate inflorescences, opened and unopened. Photo: Don Cameron. B–C. Schuyler Co., New York, 17 Aug 2005. Photos: ©Kevin C. Nixon. < http://www.plantsystematics.org/>

(131a) Pistilate flowers on long stalks. (131b) Floral tube. (131c) Female flower.

Figure 131. *Vallisneria americana*. A. Ontario, Canada, 14 Aug 2018. Photo: Liv Monck-Whipp. B-C. New Brunswick, Canada, 6 Aug 2018. Photos: Kitty Maurey.

Sterile plants of *Vallisneria americana* are often confused with immature *Sparganium americanum* Nutt. [American Burr-Reed]. Both species have long linear leaves in basal rosettes, but when *Sparganium* is completely underwater they look extremely similar because the leaves are long and flaccid (Fig. 133). *Vallisneria* can be distinguished by its more flattened leaf base, leaves without a raised midvein, and leaf blades with bands of lacunae (air spaces), which appear as lighter colored wavy lines (Fig. 128). *Vallisneria* also has minute scattered teeth along margin of its leaves and *Sparganium* has smooth margins (Haynes 2000).

Vallisneria neotropicalis Vict. [Large Eel-Grass], is a similar species but has wider leaves often suffused with red and is found mostly in warmer waters of Florida and Cuba (Long & Lakela 1971). Large Eel-Grass has been documented from brackish waters on the coast of Alabama, but

reports (Haynes 1980) of *Vallisneria neotropicalis* from the Cahaba River in Shelby County are in error. This species has occasionally been placed in synonymy with *V. americana* (Godfrey & Wooten 1979; Haynes 2000a; Lowden 1982). However, Les et al. (2008) showed via molecular research that the two are genetically distinct and that "*V. neotropicalis* is not simply a larger growth form of *V. americana*, resulting from a prolonged growing season in more southern latitudes."

(132a) Fruits underwater with coiled stalks. (132b) Rhizomes (horizontal stems) connecting plants.

Figure 132. *Vallisneria americana.* A. Portage Co., Ohio, 11 Sep 2018. Photo: Mark Warman. B. Tennessee River, Marshall Co., Alabama, 8 Oct 2018. Photo: Dan Spaulding.

Figure 133. *Sparganium americanum*, Cleburne Co., Alabama, 18 Aug 2018. Photos: Dan Spaulding.

Vallisneria americana is valued commercially and is sold in aquarium trade. It has the potential of becoming a noxious weed due to its widespread cultivation (Les et al. 2008). It is an important food source for many waterfowl species. The Canvasback (*Aythya valisineria*), a diving duck species, makes extensive use of the plant as food source, which is reflected in its scientific name (Martin et al. 1951). The common names "tapegrass" and "eelgrass" refer to its long, narrow leaves (Shosteck 1974), and "celery" may allude to the edibility of the plant for wildlife.

FAMILY 6. POTAMOGETONACEAE (Pondweed Family)

Zannichellia had historically been included within its own family, Zannichelliaceae (Haynes & Holm-Nielsen 1987). Its distinction from other aquatic monocot families was based on its sac-like reproductive structures, which envelop the inflorescence (Les & Haynes 1995; Lindqvist et al. 2006). However, various molecular markers suggest that *Zannichellia* has a closer relationship to the Potamogetonaceae (Les & Haynes 1995; Lindqvist et al. 2006; Les & Tippery 2013).

The association between *Zannichellia* and Potamogetonaceae is still somewhat unclear. Some studies show either a sister relationship exist between the two (Petersen et al. 2006; Iles et al. 2009; Les & Tippery 2013) or that *Zannichellia* is embedded within Potamogetonaceae (Les et al. 1997; Lindqvist et al. 2006). Most authors merge Zannichelliaceae into Potamogetonaceae (Stevens 2001; Trias-Blasi et al. 2015; Weakley 2015; APG 2016; Kartesz 2018; Soltis et al. 2018), while Reveal (2012) opted to maintain it as a separate family.

1. Leaves opposite or in pseudo-whorls (appearing whorled because smaller leaves in axils are sometimes elongated); plants entirely submersed; inflorescence axillary, sessile, usually consisting of two unisexual flowers; perianth absent; staminate flowers with 1 stamen, pistillate flowers with cone-like stigmas; fruits oblong-linear, often on a short stalk (stipitate), usually curved and with a persistent beak-like style, 1–2 mm long ..... **3. Zannichellia**
1. Leaves alternate; plants submersed with or without some floating leaves; inflorescence an axillary or terminal spike on a short or long peduncle with whorls of bisexual flowers; perianth consisting of 4 short-clawed sepaloid segments; flowers with 4 stamens and slender or capitate stigmas; fruits ovate, obovate, obovoid or suborbicular, usually oblique with a short beak < 1 mm long (or 2–3 mm long in *Potamogeton crispus*).

    2. Leaves all submersed; leaf blades linear, opaque, stiff, septate, channeled, and turgid; peduncle of inflorescence flexible, flowering spikes borne below or on surface of water; stipules fused to leaf bases forming long leaf sheaths, 10–30 mm long ..... **2. Stuckenia**
    2. Leaves submersed or submersed and floating; submersed leaf blades linear to broader, translucent, flexible, and flat; peduncle of inflorescence stiff, flowering spikes elevated above the water surface or submersed; stipules of submersed leaves free in axils of leaves or fused with leaf bases to form short leaf sheaths, less than 10 mm long ..... **1. Potamogeton**

1. POTAMOGETON Linnaeus 1753

[Greek *potamos*, river, and *geton*, neighbor; alluding to their aquatic habitat]

Potamogeton is an important food source for many waterfowl species and marsh birds. They consume the seeds or sometimes the entire plant (Martin 1951). Populations of some species of pondweeds can become so dense and abundant that weed control methods must be employed (Haynes 1978).

1. Leaf margins sharply serrate with small, conspicuous teeth and distinctly wavy or ruffled; leaves all submersed, sessile, often partially clasping stem; leaf tips rounded to slightly acute; stem flattened; fruit with a conical beak 2–3 mm long; turions present (hardened over-wintering buds produced later in season)..... **3. Potamogeton crispus**
1. Leaf margins entire (rarely with tiny, unicellular denticles on young leaves), either ruffled, wavy, undulate, or flat; leaves submersed or floating, petiolate or sessile, but not clasping the stem; leaf tips obtuse, acute, or acuminate; stem rounded (terete); fruit with a beak usually < 1 mm long; turions rarely formed.

2. Submersed leaves narrowly linear or linear-lanceolate (< 3 mm wide), sessile, and usually 1–3 veined floating leaves, if present, < 10 cm long (measurement includes petiole and leaf blade); inflorescence (including peduncle and spike) < 6 cm long; fruit usually < 3 mm long; stipules of submersed leaves inconspicuous (< 2.5 cm long).

    3. Floating leaves often present, although sometimes lacking; stipular sheaths of submersed leaves fused (adnate) to base of leaf blades with free tips projecting as a ligule; fruit 3-keeled fruit wall paper thin and coiled embryo easily seen ..... **4. Potamogeton diversifolius**
    3. Floating leaves absent; leaf base axillary and free, not fused to stipules, forming a sheath or tube around stem above leaf; fruits 1-keeled or lacking a keel; fruit wall thick and embryo obscured.

        4. Fruit with a knobby, undulate, or dentate dorsal keel, peduncles (flower stalks) thickened towards apex (clavate) and short, usually < 3 cm long; inflorescences all axillary; nodes of stem lacking glands; stipules free (wrapped around stem, margins not fused) ..... **5. Potamogeton foliosus**
        4. Fruit lacking a keel, dorsally smooth and rounded; peduncles cylindrical, not thickened at apex and often longer, 1.5–8 cm long; inflorescences axillary or terminal; nodes of stem (at least some of them) with minute oil glands (wart-like & resinous); stipules free or with fused margins.

            5. Stipules with fused margins (connate), forming a tube surrounding the stem (extending a few millimeters up internode); leaf blades with 0–2 rows of lacunae (empty air cavities with thickened borders) on each side of midvein; inflorescence interrupted with 2–4 widely spaced whorls of flowers; fruit typically widest above middle with concave sides; beak of fruit occurring off to one side, not aligned in the middle ..... **9. Potamogeton pusillus**
            5. Stipules free (convolute), margins not fused (stipules form a sheath wrapping partially around stem); leaf blade with 1–5 rows of lacunae on each side of midvein; inflorescence with 1–3 crowded whorls of flowers; fruit widest at or below middle with rounded sides; beak of fruit centered in middle ..... **2. Potamogeton berchtoldii**

2. Submersed leaves elliptic, ovate, lanceolate, or broadly linear-oblong (> 3 mm wide), sessile or petiolate, with 3 or more veins; floating leaves, if present, > 10 cm long (measurement includes petiole and leaf blade); inflorescence (including peduncle and spike) > 6 cm long; fruit usually > 3 mm long; stipules of submersed leaves conspicuous (> 2.5 cm long).

    6. Stems and petioles with raised blackish spots (wart-like dots); floating leaves cordate or truncate at base; margins of submersed leaves distinctly wavy or curly (bases rounded to truncate and petioles often with wedge-shaped wings) ..... **8. Potamogeton pulcher**
    6. Stems and petioles not spotted or with inconspicuous reddish-brown spots; floating leaves rounded, truncate or tapering at base; margins of submersed leaved broadly undulate or flat.

        7. Submersed leaves with petioles 4–13 cm long, usually much longer than blades; submersed leaf blades mostly flat to sometimes slightly wavy (1–3.5 cm wide); floating leaves usually present; fruit reddish, pinkish-brown to green, with a single, undulate dorsal keel with small knobs (lateral ridges rarely develop) ..... **7. Potamogeton nodosus**

7. Submersed leaves sessile or with petioles 0.5–4 cm long, usually shorter than blade; submersed leaf blades either flat, undulate, folded, or curved (1–7.5 cm wide); floating or transitional leaves are occasionally present, but populations often consisting mostly submersed leaves; fruit with three low, rounded keels (one dorsal and two smaller lateral ridges).

    8. Submersed leaves either strongly folded longitudinally (convolute) and distinctly curved like a bow (arcuate) or strongly undulate and twisted; submersed leaf blades (median and upper) mostly broadly ovate, 2.5–7.5 cm wide with 23–49 veins (lowest leaves often lanceolate with fewer veins); fruits with a beak centered in the middle of fruit ..... **1. Potamogeton amplifolius**
    8. Submersed leaves often flat and straight or occasionally folded near the base and slightly curved or undulate; submersed leaf blades ovate, elliptic, oblong, lanceolate, or linear, 1.5–4.5 cm wide with 7–19 veins; fruits with a beak occurring near the edge of the fruit..... **6. Potamogeton illinoensis**

1. Potamogeton amplifolius Tuck. {large-leaved} — LARGE-LEAF PONDWEED; BROADLEAF PONDWEED; BIGLEAF PONDWEED; MUSKIE-WEED (Fig. 134).

Figure 134. *Potamogeton amplifolius*, Coldwater Spring Branch, Talladega Co., Alabama, 25 May 2018. Photos: Dan Spaulding.

Floating or submersed aquatic, perennial herb with rhizomes. Streams, creeks, rivers, springs, lakes, and ponds; flowers and fruits late May–September; uncommon in the Cumberland Plateau and Ridge & Valley; very rare in the Coastal Plain (Fig. 135). Native to Canada and the USA but more common in the northern half of North America and rare on the southeastern Coastal Plain (Kartesz 2018).

Potamogeton amplifolius has the largest leaves of any other species within the genus in Alabama (Haynes 2002). Large-Leaf Pondweed has both submersed and floating leaves (Fig. 136a), but some populations lack floating leaves or they are very scarce. Floating leaves are more leathery in texture and borne on long petioles (Fig. 136b). Submersed leaves are flaccid and sessile or have short petioles. Submersed leaves are often present in two forms. The blades can be folded along their mid-rib and curved like a bow (Fig. 136c) or wavy to twisted and only slightly folded (Fig. 134).

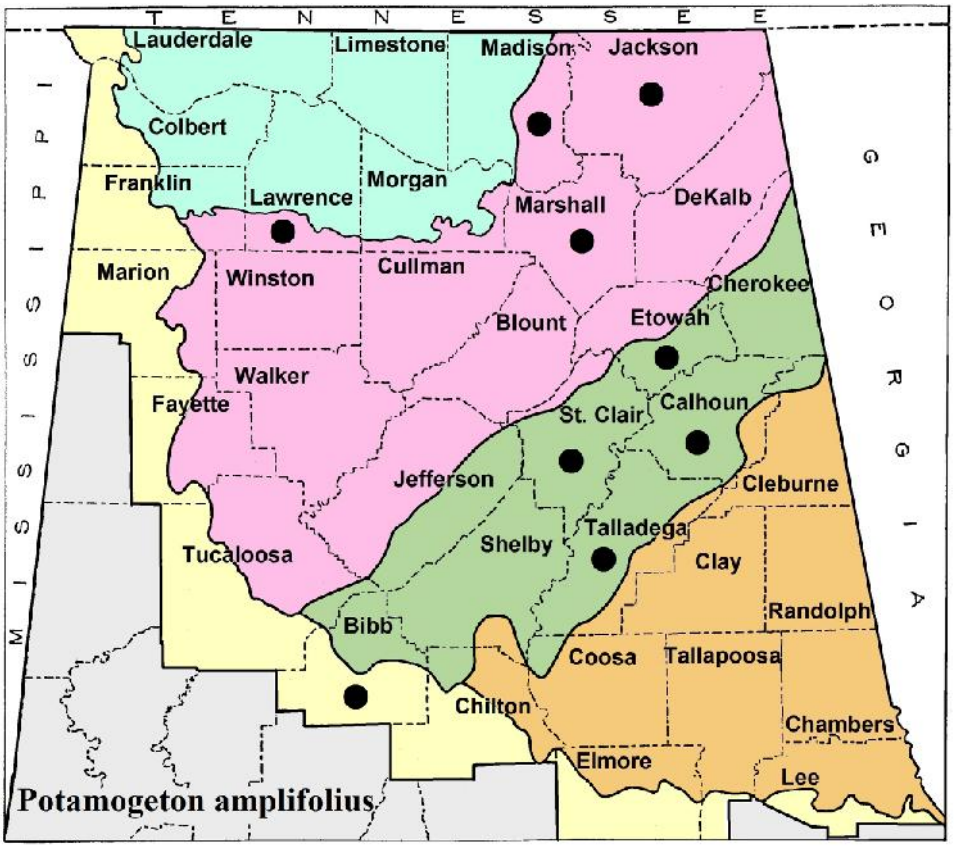


Figure 135. Distribution of *Potamogeton amplifolius* in northern Alabama.

(136a) Population in Cedar Creek. (136b) Floating leaves. (136c) Submersed leaves.

Figure 136. *Potamogeton amplifolius*, Talladega Co., Alabama, 4 Aug 2018. Photos: Dan Spaulding.

Potamogeton amplifolius is sometimes mistaken for *P. illinoensis*, which has narrower leaves with fewer veins. Both species have inflorescences with conspicuous spikes of flowers with thick peduncles (Fig. 137a) and their fruits have three, mostly smooth keels, one dorsal keel and two lateral (Fig. 137c). Large-Leaf Pondweed differs by having a beak located in the center the fruit (Fig. 137b), whereas Illinois Pondweed has a beak off to one side of the fruit.

(137a) Thick peduncle. (137b) Beak of fruit in center. (137c) Fruit with three rounded ridges.

Figure 137. *Potamogeton amplifolius*, Big Cove Creek, Etowah Co., Alabama, 11 Jul 2018. A. Fruiting spike. B. Close-up of fresh fruit. C. Dried fruit, AMAL, *Spaulding 15461*, Etowah Co., Alabama, 11 Jul 2018. Photos: Dan Spaulding.

2. Potamogeton berchtoldii Fieber subsp. **berchtoldii** {for Freidrich von Berchtold, 1781-1876, Austrian botanist} — SLENDER PONDWEED; BERCHTOLD'S PONDWEED (Fig. 138). [*Potamogeton pusillus* L. ssp. *tenuissimus* (Mert. & W.D.J. Koch) Haynes & C.B. Hellquist; *Potamogeton pusillus* var. *tenuissimus* Mert. & W.D.J. Koch]

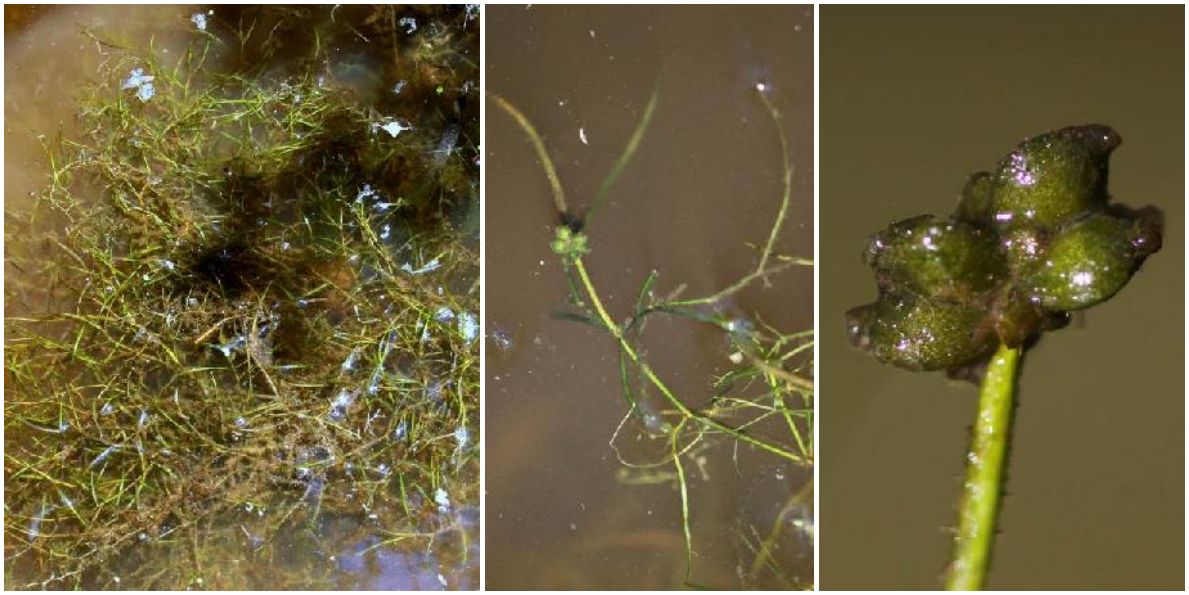


Figure 138. *Potamogeton berchtoldii*, swamp in Bullock Co., Alabama, 7 Jun 2018. Photos: Eric Soehren.

Submersed aquatic, perennial herb. Lakes, ponds, rivers, streams, swamps, and ditches; flowers and fruits May–September; uncommon in the Highland Rim; rare in the Cumberland Plateau (Tennessee River); frequent in the Coastal Plain (Fig. 139). Native to North America (Canada & USA), Europe, the Middle East, and Asia (Youhao et al. 2010).

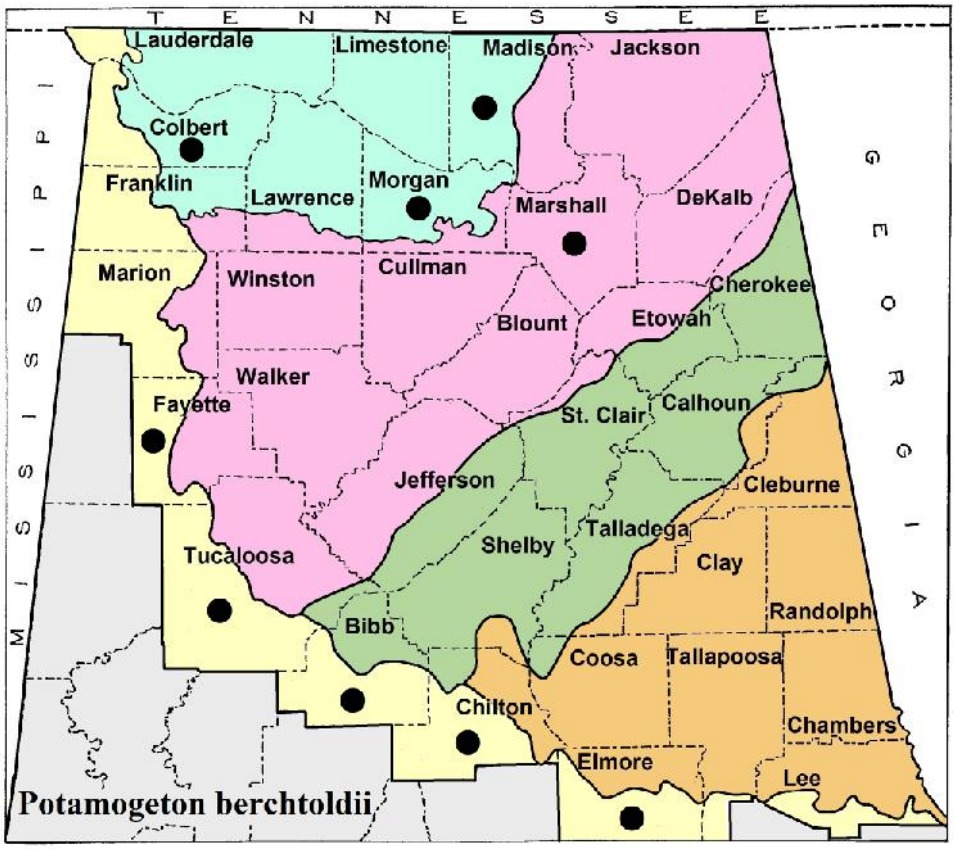


Figure 139. Distribution of *Potamogeton berchtoldii* in northern Alabama.

Potamogeton berchtoldii subsp. *berchtoldii* is easily identified by the following characters: inflorescence with crowded whorls of flowers (Fig. 140a); fruit rounded and widest at or below the middle with a beak located in the center (Fig. 140b); and linear leaves with 1–5 rows of lacunae (air spaces) on each side of the midvein (Fig. 140c). *Potamogeton berchtoldii* dies back at the end of the growing season, surviving winter by turions (over-wintering buds that detach and remain dormant underwater until spring).

Three closely related taxa are occasionally recognized as subspecies or species (Haynes & Hellquist 2000b; Les et al. 2009). *Potamogeton gemmiparus* (J.W. Robbins) J.W. Robbins ex Morong [*P. berchtoldii* subsp. *gemmiparus* (J.W. Robbins) Les & Tippery] has single-veined, subulate leaves and is confined to New England and adjacent Canada. *Potamogeton clystocarpus* Fern. [*P. berchtoldii* subsp. *clystocarpus* (Fern.) Les & Tippery] has keeled fruits and is known from only one county in Texas. *Potamogeton groenlandicus* Hagstr. [*P. berchtoldii* subsp. *groenlandicus* (Hagstr.) Feilberg] has leaves with 7–11 veins and is endemic to Greenland.

Haynes and Hellquist (2000b) treated *Potamogeton berchtoldii* subsp. *berchtoldii* and subsp. *gemmiparus* together as a subspecies of *P. pusillus* but recognized subsp. *clystocarpus* and subsp. *gemmiparus* as distinct species. *Potamogeton berchtoldii* differs from *P. pusillus* by having stipules that partially overlap the stem and easily separate from it (Fig. 141a). *Potamogeton pusillus* has stipules that are fused along their margins, forming a tube around the stem. *Potamogeton berchtoldii* and *P. pusillus*, unlike *P. foliosus*, have nodal glands that look like amber warts (Fig. 141b).

(140a) Flowers in tight clusters. (140b) Fruits crowded; beak centered in middle. (140c) Leaf with lacunae.

Figure 140. *Potamogeton berchtoldii*. A. Jefferson Co., Wisconsin, 15 Jun 2018. Photo: Brenton Butterfield. B–C. Swamp in Bullock Co., Alabama, 18 May 2018. Photos: Dan Spaulding.

(141a) Stipules free; margins not fused. (141b) Glands occur on both sides of most nodes.

Figure 141. *Potamogeton berchtoldii*, Bullock Co., Alabama, 18 May 2018. Photos: Dan Spaulding.

3. Potamogeton crispus L. {curly} — CURLY PONDWEED; CURLY MUCKWEED; CURLED PONDWEED; CRISP PONDWEED (Fig. 142).

Figure 142. *Potamogeton crispus*, Chagrin Lake, Cuyahoga Co., Ohio, 9 May 2019. Photos: Mark Warman.

Submersed aquatic, perennial herb with slender rhizomes. Lakes, ponds, rivers, creeks, streams, swamps, and brackish bays along the coast; flowers and fruits May–September; uncommon in the Highland Rim, Cumberland Plateau, and lower Coastal Plain (Mobile and Baldwin counties); rare in the Ridge & Valley (Fig. 143). Native to Europe, Asia, and Africa; introduced in the Pacific islands, New Zealand, and North America to South America (Youhao et al. 2010). The first report of *Potamogeton crispus* in North America occurred in the mid-19th Century, and the species quickly spread in the early 20th Century to most of the conterminous USA and southern Canada (Stuckey 1979). The first known collections for Alabama were made in 1943 (Bouldan et al. 1994).

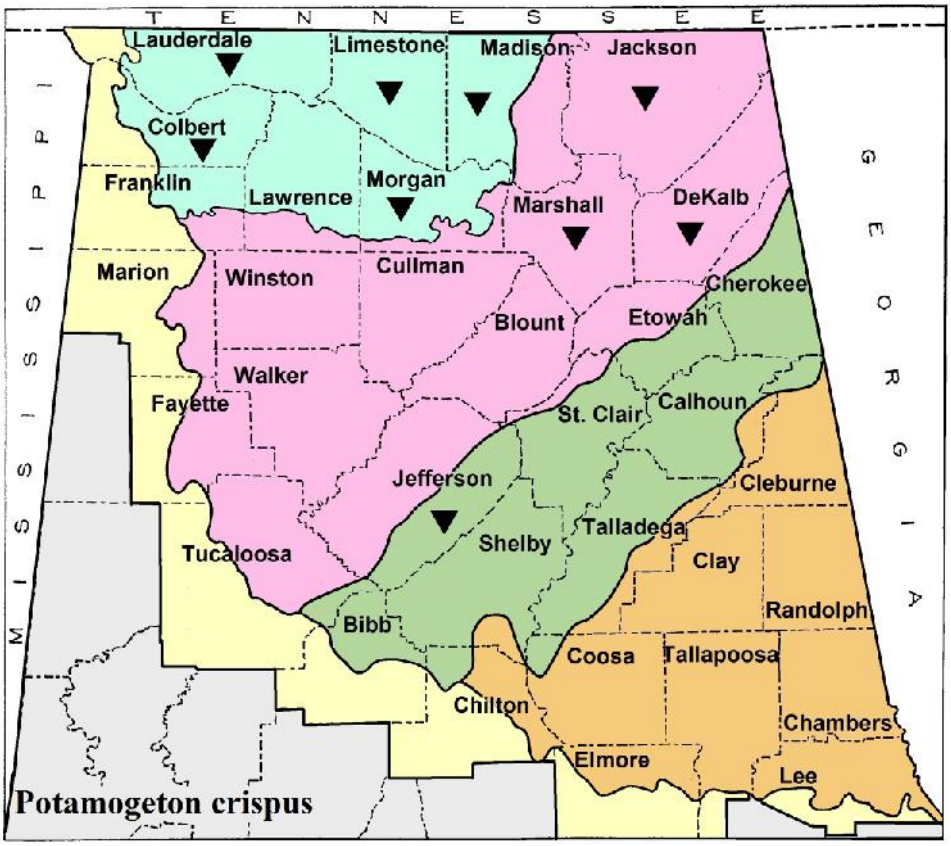


Figure 143. Distribution of *Potamogeton crispus* in northern Alabama.

Curly Pondweed is an aggressive exotic weed that invades clear, turbid, or polluted fresh to brackish waters. It has become a serious pest in some streams, rivers, and lakes utilized for recreation and navigation (Stuckey 1979). *Potamogeton crispus* grows in submerged colonies connected by rhizomes. It can be easily distinguished from other *Potamogeton* species by its flattened stems and oblong, sessile or clasping leaves with conspicuously serrate, wavy margins (Fig. 144). The flowers (Fig. 145a) produce a distinct fruit with a peculiar cone-shaped beak, 2–3 mm long (Fig. 145b).

Potamogeton crispus also spreads vegetatively by turions (Fig. 146a–c), which are formed by shortening of internodes of the stem apex (Haynes 1978). Following turion development, the parent plants will soon decay, leaving only the hardened modified shoots (turions) that remain dormant through winter and produce new cloned populations in spring (Haynes & Hellquist 2000b).

Figure 144. *Potamogeton crispus*, Valley Creek, Jefferson Co., Alabama, 30 Jul 2018. Leaves partially clasp a flattened stem and leaf margins are finely toothed and wavy (crisped). Photos: Dan Spaulding.

(145a) Inflorescence with mature flowers. (145b) Fruits with long, slender beaks.

Figure 145. *Potamogeton crispus.* A. South Slang Creek, Addison Co., Vermont, 29 Jun 2016. Photos: Susan Elliott. B. UNA, *Meigs, Wiersema, & Horn 203*, Shades Creek, Jefferson Co., Alabama, 9 May 1981. Photos: Dan Spaulding.

(146a) Turion forming. (146b) Turion at maturity. (146c) Turion producing new plant.

Figure 146. *Potamogeton crispus*. A. Valley Creek, Jefferson Co., Alabama, 30 Jul 2018. Photo: Dan Spaulding. B. Pond in Medina Co., Ohio, 25 Jul 2017. Photo: Mark Warman. C. Mogadore Reservoir, Portage Co., Ohio, 27 Jul 2017. Photo: Mark Warman.

4. Potamogeton diversifolius Raf. {diverse-leaved} — WATER-THREAD PONDWEED; COMMON SNAILSEED PONDWEED; DIVERSE-LEAF PONDWEED (Fig. 147). [*Potamogeton capillaceus* Poir.]

Figure 147. *Potamogeton diversifolius*, pond in Cleburne Co., Alabama, 20 May 2018. Photo: Dan Spaulding.

Floating or submersed aquatic, perennial herb with rhizomes. Ponds, lakes, swamps, marshes, ditches, mudflats, and shallow waters of rivers, creeks, and streams; flowers and fruits late April–October; frequent throughout Alabama (Fig. 148). Native to Mexico and almost the entire USA; probably the most common *Potamogeton* in the southeastern USA (Haynes & Hellquist 2000b).

Potamogeton diversifolius typically has some floating leaves with expanded blades, but its most diagnostic characters are its linear, submersed leaves, with stipules that are fused (adnate) to the leaf base with the free tip extending out as a ligule (Fig. 149). The adnate portion is less than 1/2 the length of the free ligule. This character makes the leaf blade appear to be attached near the upper portion of a sheath, partially clasping the stem. A terrestrial form with shortened internodes and mostly dilated leaves can occur in very shallow water or on exposed mudflats and shores (Fig. 150).

Inflorescences of *Potamogeton diversifolius* are dimorphic. The emersed flower spike is cylindric, 6–15 mm long (Fig. 151), and the submersed spike of flowers is produced in head-like clusters, 2–3 mm long (Fig. 152a). Fruits have three knobby keels (Fig. 152b) and a very thin fruit wall, clearly revealing the strongly coiled embryo (Fig. 152c), hence the name "snailseed" pondweed. This species fruits freely with or without floating leaves (Reznicek & Bobbette 1976).

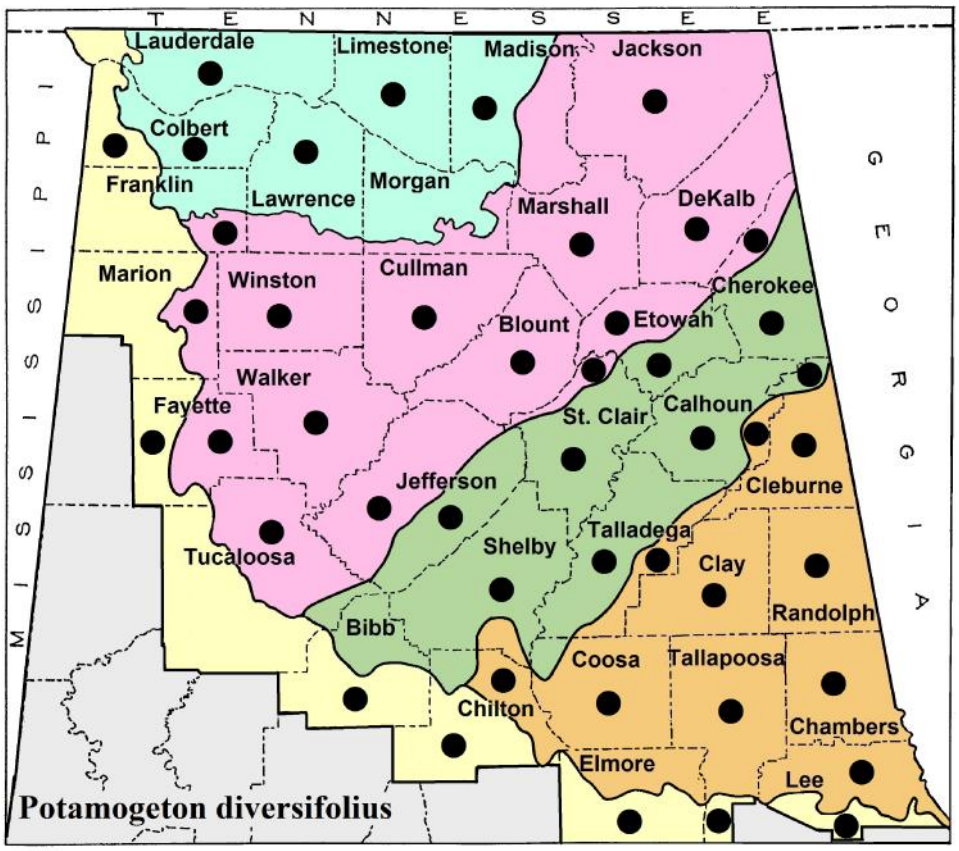


Figure 148. Distribution of *Potamogeton diversifolius* in northern Alabama.

Figure 149. *Potamogeton diversifolius*, floating leaves and submersed leaves with a close-up of adnation of stipule and leaf on submersed leaves. Plants from South Branch Cane Creek, Calhoun Co., Alabama, 24 May 2018. Photos: Dan Spaulding.

Figure 150. *Potamogeton diversifolius* population showing numerous leaves with expanded blades [growing with *Myriophyllum aquaticum*], Jefferson Co., Alabama, 2 Jun 2018. Photo: Dan Spaulding.

Figure 151. *Potamogeton diversifolius*, with emersed flowering spike, Ocean Co., New Jersey, 3 Aug 2017. Photos: Jason Ksepka.

(152a) Submersed fruiting spike. (152b) Keels (on emersed spike). (152c) Coiled seeds evident.

Figure 152. *Potamogeton diversifolius*. A. Cleburne Co., Alabama, 20 May 2018. B. Jefferson Co., Alabama, 2 Jun 2018. C. JSU, *Spaulding 10910*, Cleburne Co., Alabama, 8 Aug 2000. Photos: Dan Spaulding.

5. Potamogeton foliosus Raf. subsp. **foliosus** {leafy} — LEAFY PONDWEED (Fig. 153). [*Potamogeton curtissii* Morong; *Potamogeton foliosus* var. *macellus* Fern.]

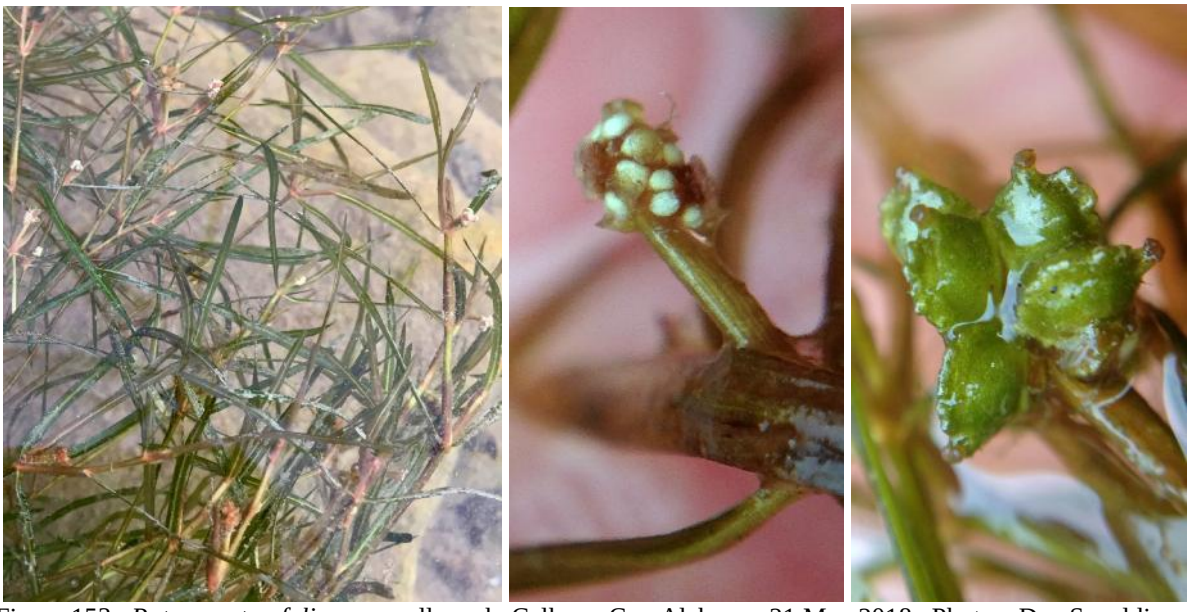


Figure 153. *Potamogeton foliosus*, small creek, Calhoun Co., Alabama, 21 May 2018. Photos: Dan Spaulding.

Submersed aquatic, perennial herb. Rivers, streams, creeks, lakes, ponds, and springs; flowers and fruits May–October; uncommon in the Highland Rim, Cumberland Plateau, and Ridge & Valley; rare in the Coastal Plain (Fig. 154). Native to almost all of North America south through Mexico to Costa Rica (Haynes & Hellquist 2000b).

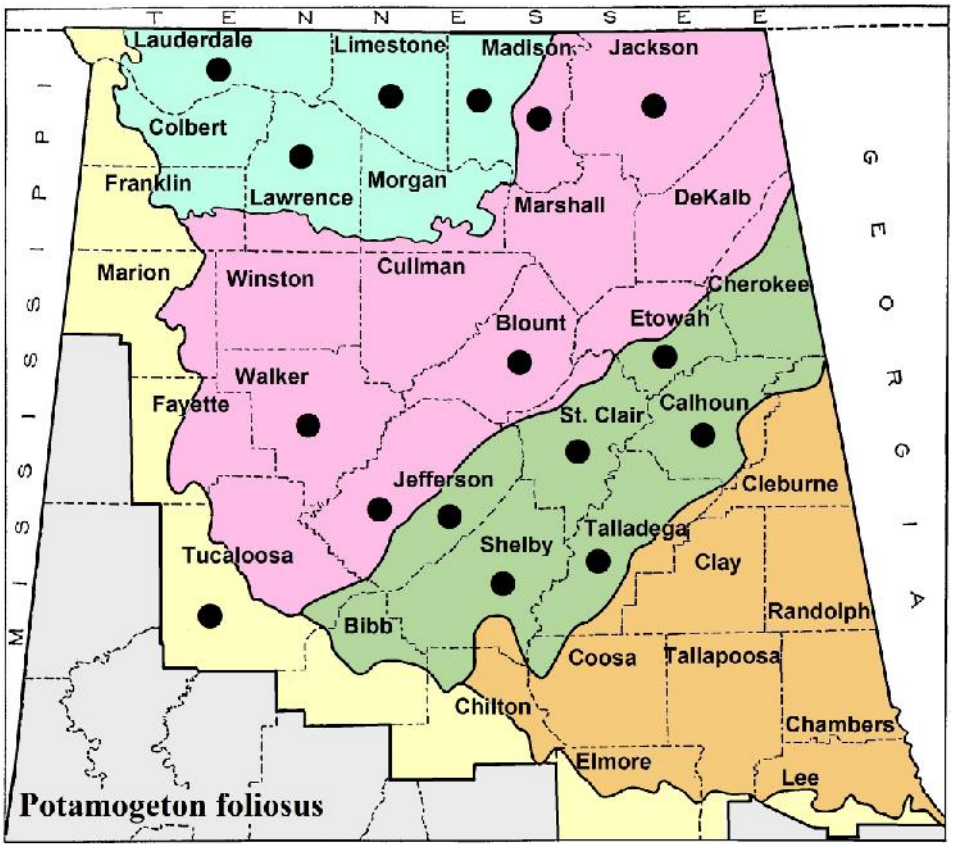


Figure 154. Distribution of *Potamogeton foliosus* in northern Alabama.

Because *Potamogeton pusillus* and *P. berchtoldii* have only submersed linear leaves, they are often confused with *P. foliosus*. However, *P. foliosus* stems lack nodal glands, its fruits are keeled on the back, and its stipules are fused (connate). *Potamogeton pusillus* and *P. berchtoldii* have stems with nodal oil glands, their fruits are rounded on back, and their stipules are free (convolute). *Potamogeton foliosus* rarely has bands of lacunae on each side of midrib (0–2 rows), whereas *P. berchtoldii* always has prominent lacunae (1–5 rows) and *P. pusillus* lacks them entirely.

Only *Potamogeton foliosus* subsp. *foliosus* is found in Alabama; the other subspecies, *P. foliosus* subsp. *fibrillosus* (Fern.) Haynes & C.B. Hellquist [Fibrous Pondweed], occurs in the northwestern USA. This subspecies can be distinguished by its stipular tissue between the veins that decomposes, leaving only strands of fibrous veins (Haynes & Hellquist 2000b).

6. Potamogeton illinoensis Morong {of Illinois} — ILLINOIS PONDWEED; SHINING PONDWEED (Fig. 155). [*Potamogeton angustifolius* Bercht. & C. Presl; *Potamogeton heterophyllus* Schreb.; *Potamogeton lucens* auct. non L.]

Floating or submersed aquatic, perennial herb with rhizomes. Found mostly in calcareous waters of rivers, streams, ponds, and lakes; flowers and fruits late May–September; rare in the Ridge & Valley and Coastal Plain (Fig. 156). Native to the Americas; scattered throughout Canada and the contiguous USA, south through Mexico to South America (Haynes & Hellquist 2000b).

Figure 155. *Potamogeton illinoensis*, Baldwin Co., Alabama, 4 Sep 2018. Photo: Howard Horne.

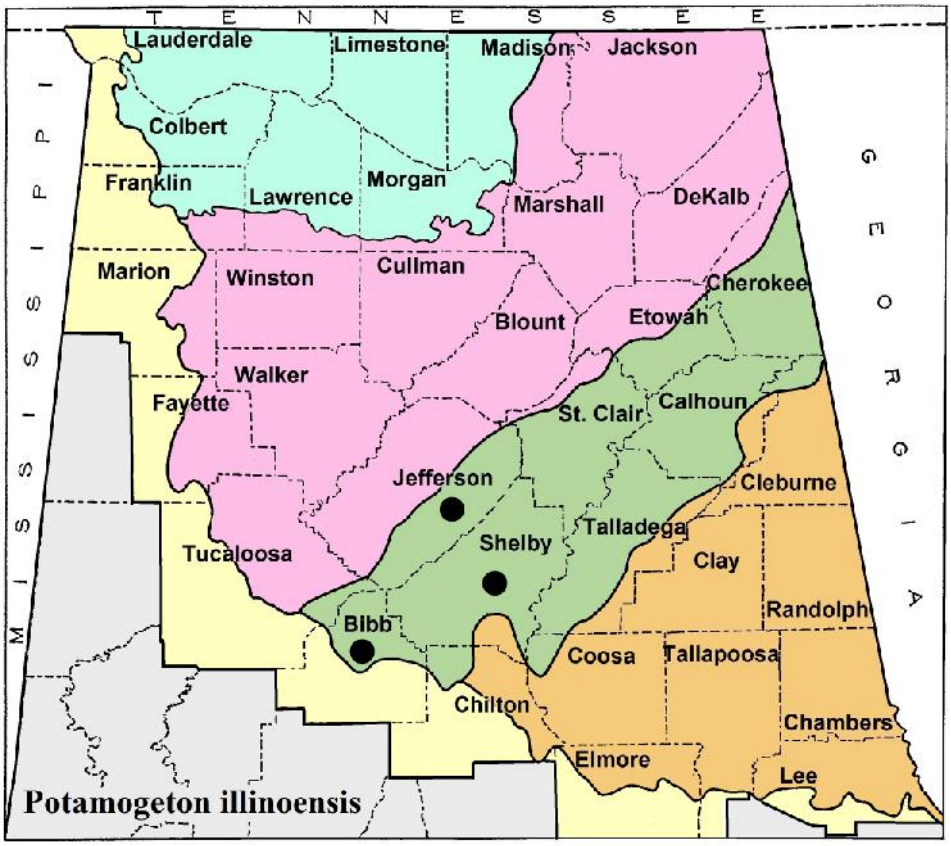


Figure 156. Distribution of *Potamogeton illinoensis* in northern Alabama.

Potamogeton illinoensis can be confused with *P. amplifolius* because both species have similar sized submersed leaves that are sessile or short-petioled. *Potamogeton illinoensis* differs by having fewer veins (< 20) and it submersed leaves (Fig. 157) are 3–4 times as long as broad and not completely folded or strongly curved (arcuate). The leaf apex of Illinois Pondweed is often abruptly acuminate, mucronate, or awl-shaped (Fig. 158). The fruit of *P. illinoensis* have a short beak (0.5 mm) that occurs near the edge rather than in the center. When floating leaves are present, *P. illinoensis* can be mistaken for *P. nodosus*, but the submersed leaves of *P. illinoensis* are either sessile or with petioles less than 4 cm long (Fig. 159a). *Potamogeton nodosus* submersed leaves have long petioles that are more than 4 cm long. The fruits of *P. illinoensis* (Fig. 159b–c) are greenish with three mostly smooth keels; *P. nodosus* fruits are typically reddish (when mature) with only a single, knobby dorsal keel.

Figure 157. *Potamogeton illinoensis*, Santa Clara Co., California, 17 Jul 2012. Photo: Edward Rooks.

Figure 158. *Potamogeton illinoensis* floating and submersed leaves, some with awl-shaped tips, in shallow water of Little Schultz Creek, Bibb Co., Alabama, 18 Jul 2018. Photos: Wayne Barger.

(159a) Submersed leaves short-petioled. (159b) Fruiting spike. (159c) Fruit 3-keeled (2 showing).

Figure 159. *Potamogeton illinoensis*. A. Little Schultz Creek, Bibb Co., Alabama, 18 Jul 2018. Photo: Wayne Barger. B–C. BRIT, *Kral & Moffett 90113*, Little Schultz Creek, Bibb Co., Alabama, 14 Aug 2000. Photo: Dan Spaulding.

7. Potamogeton nodosus Poir. {knotty} — LONGLEAF PONDWEED; AMERICAN PONDWEED; KNOTTY PONDWEED (Fig. 160). [*Potamogeton americanus* Cham. & Schlecht.; *Potamogeton fluitans* Roth; *Potamogeton lonchites* Tuck.]

Figure 160. *Potamogeton nodosus*, Franklin Co., Alabama, 22 Sep 2018. Photo: Dan Spaulding.

Floating or submersed aquatic, perennial herb with elongated rhizomes. Lakes, ponds, rivers, and streams; flowers and fruits May–September; frequent in the Highland Rim; uncommon in the Cumberland Plateau, Piedmont, and Coastal Plain; rare in the Ridge & Valley (Fig. 161). Native to the Americas; scattered throughout Canada and the contiguous USA, south through Mexico to South America (Haynes & Hellquist 2000b).

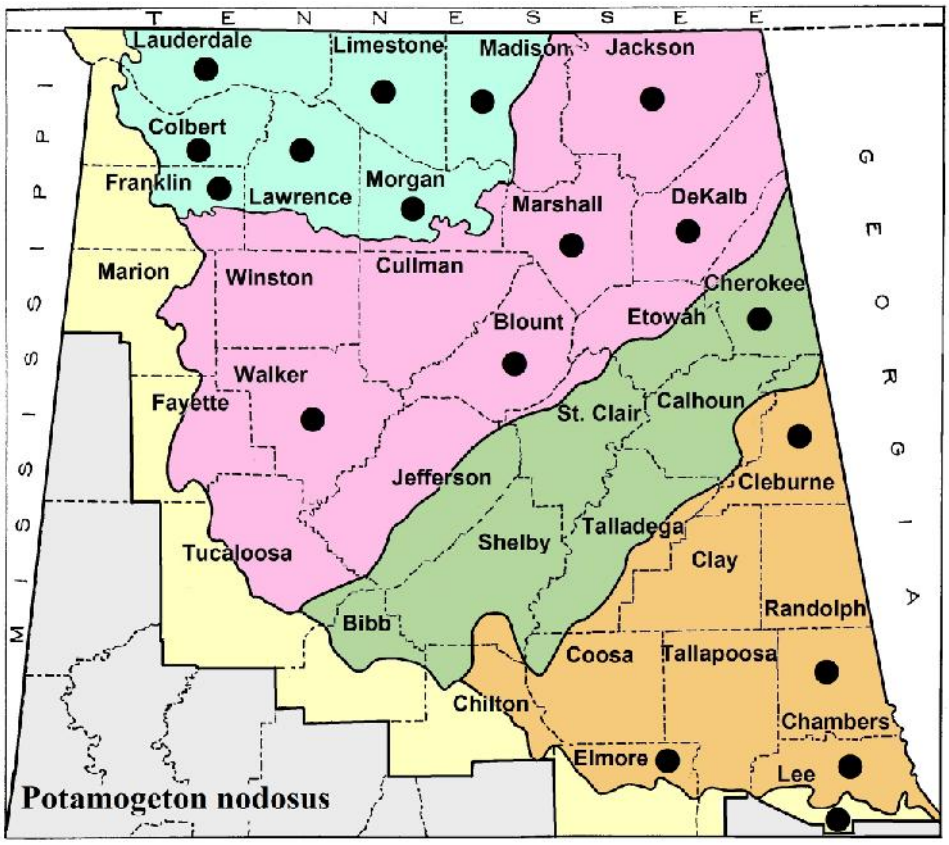
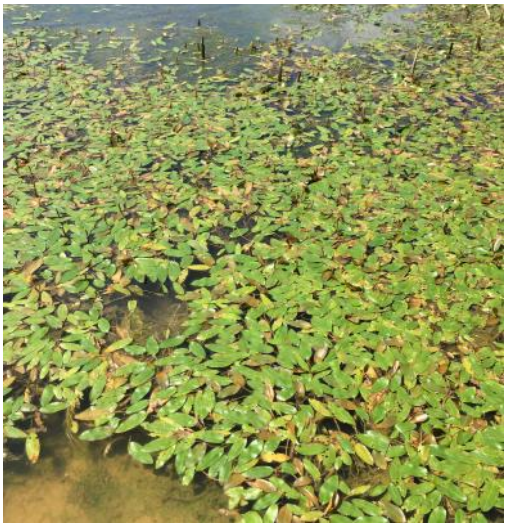


Figure 161. Distribution of *Potamogeton nodosus* in northern Alabama.


Figure 162. *Potamogeton nodosus*, Limestone Co., Alabama, 15 Jul 2018. Photo: Dan Spaulding.

Longleaf Pondweed often has numerous long-petioled, floating leaves with blades that are typically elliptic-oblong to lanceolate-oblong (Fig. 162). Its flowers are predominantly wind-pollinated (Philbrick & Anderson 1987) and the inflorescence is an elongated, compact spike held above the water on thick peduncles (Fig. 163a). This species often spreads by rhizome growth and can become locally abundant (Fig. 163b), covering large areas of the water surface (Haynes 1988).

(163a) Inflorescence with a thick peduncle.



(163b) Numerous floating leaves are typical.

Figure 163. *Potamogeton nodosus*. A. Tallapoosa River, Cleburne Co., Alabama, 14 Jul 2018. B. Pond in DeKalb Co., Alabama, 11 Aug 2018. Photos: Dan Spaulding.

Potamogeton nodosus is sometimes mistaken for *P. illinoensis*, but *P. nodosus* has submersed leaves with petioles > 4 cm long (Fig. 164a), and its fruits are often tan to reddish (Fig. 164b) with one undulate keel (Fig. 164c). In contrast, *P. illinoensis* has submersed leaves that are sessile or on short petioles (< 4 cm) and its fruits are greenish with three, mostly smooth keels.

(164a) Submersed leaves.

(164b) Fruiting spike.

(164c) Fruit with undulate keel.

Figure 164. *Potamogeton nodosus*. A. Cleburne Co., Alabama, 20 May 2018. B. DeKalb Co., Alabama, 11 Aug 2018. B. AMAL, *Spaulding 15546*, DeKalb Co., Alabama, 11 Aug 2018. Photos: Dan Spaulding.

Ribbon-Leaf Pondweed, *Potamogeton epihydrus* Raf. (Fig. 165a–b), superficially resembles *P. nodosus*, but *P. epihydrus* can be distinguished by its flattened stems and linear submersed leaf blades (< 6 mm wide) with prominent lacunar bands on each side of the midrib (Haynes 1980). *Potamogeton epihydrus* has been documented from the Coastal Plain of Lee County, as well as from 3 other counties south of the study area (Keener et al. 2019). It also occurs in adjacent Tennessee (Kartesz 2018) and is common in the northern USA and southern Canada (Haynes & Hellquist 2000b).

(165a) Floating leaves mostly oblong and submersed leaves linear.

(161b) Broad lacunar bands.

Figure 165. *Potamogeton epihydrus*. A. Thunder Bay, Ontario, Canada, 15 Aug 2017. Photo: Rob Foster. B. Submersed leaves, Wisconsin River, Lincoln Co., Wisconsin, 6 Jun 2017. Photo: Brenton Butterfield.

8. Potamogeton pulcher Tuck. {handsome} — SPOTTED PONDWEED; HEARTLEAF PONDWEED (Fig. 166).

Figure 166. *Potamogeton pulcher*, Butler Co., Alabama, 14 Apr 2010. Photo: Alvin Diamond.

Floating or submersed aquatic, perennial herb with rhizomes. Ponds, lakes, swamps, and slow moving to stagnant streams; flowers and fruits May–September; rare in the Highland Rim, Cumberland Plateau, Ridge & Valley, and Piedmont, frequent in the Coastal Plain (Fig. 167). Native to eastern North America from southern Canada south to east Texas and northern Florida (Haynes & Hellquist 2000b).

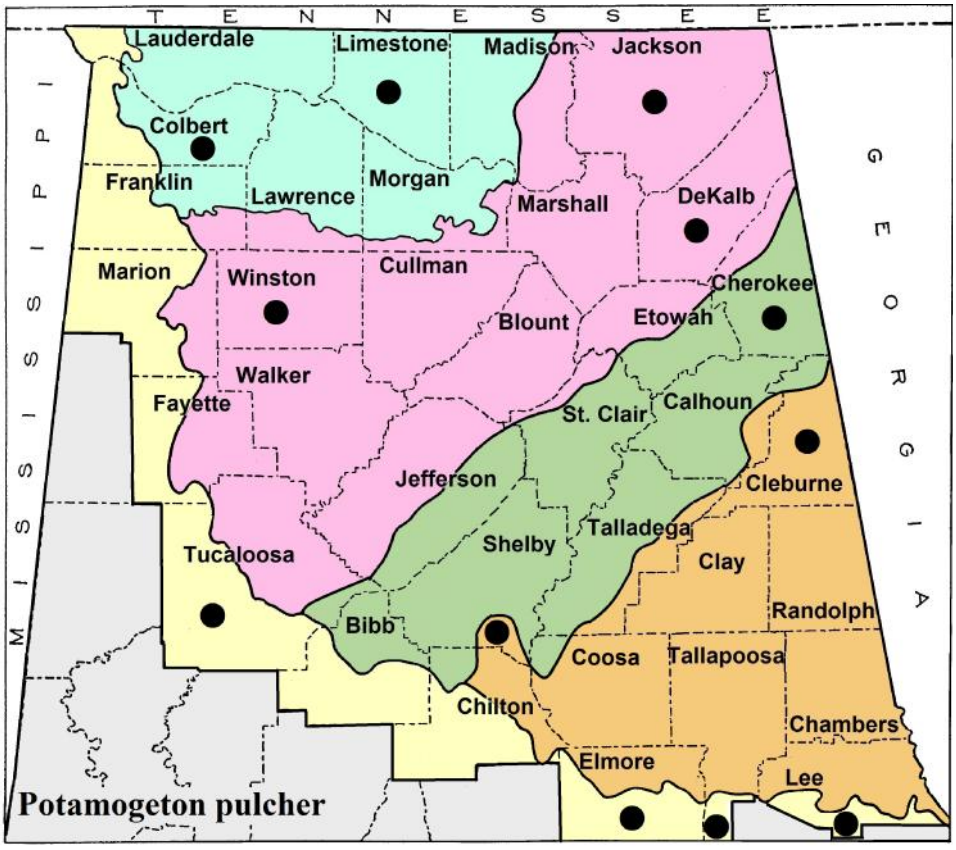


Figure 167. Distribution of *Potamogeton pulcher* in northern Alabama.

Potamogeton pulcher is a distinct pondweed that can be easily identified by its numerous floating leaves with cordate or truncate leaf bases (Fig. 168a–b), dark-spotted stems, and submersed lanceolate leaves with wavy margins and short, wedge-shaped petioles (Fig. 169).

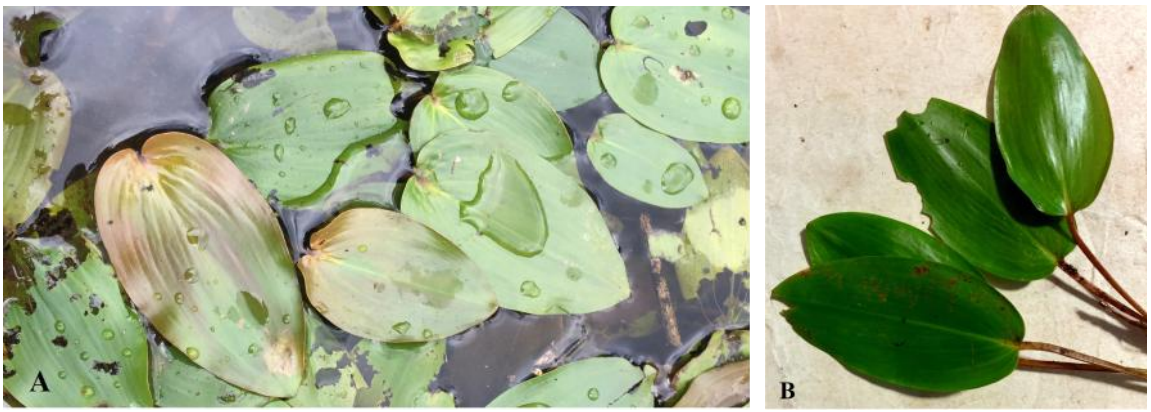


Figure 168. *Potamogeton pulcher*, floating leaves with cordate or truncate bases. A. Tallapoosa Co., Alabama, 28 May 2018. Photo: Dan Spaulding. B. Cleburne Co., Alabama, 11 Jun 2019. Photo: Melanie T. Spaulding.

Figure 169. *Potamogeton pulcher*, Tallapoosa Co., Alabama, 28 May 2018. Photos: Dan Spaulding.

Potamogeton amplifolius is similar in morphology to *P. pulcher*, but *P. amplifolius* differs by having floating leaves with mostly rounded bases, submersed leaves that are ovate with more than 20 veins, and stems lacking black spots (plants will occasionally have small, red-brown spots).

9. Potamogeton pusillus L. {very small} — SMALL PONDWEED (Fig. 170).

Figure 170. *Potamogeton pusillus*, spring in Etowah Co., Alabama, 11 July 2018. Photos: Dan Spaulding.

Submersed aquatic, perennial herb. Streams, rivers, lakes, and ponds; flowers and fruits May–September; uncommon throughout Alabama (Fig. 171). Widely distributed globally in the Northern Hemisphere; native to North America, South America, Eurasia, and Africa (Haynes & Hellquist 2000b).

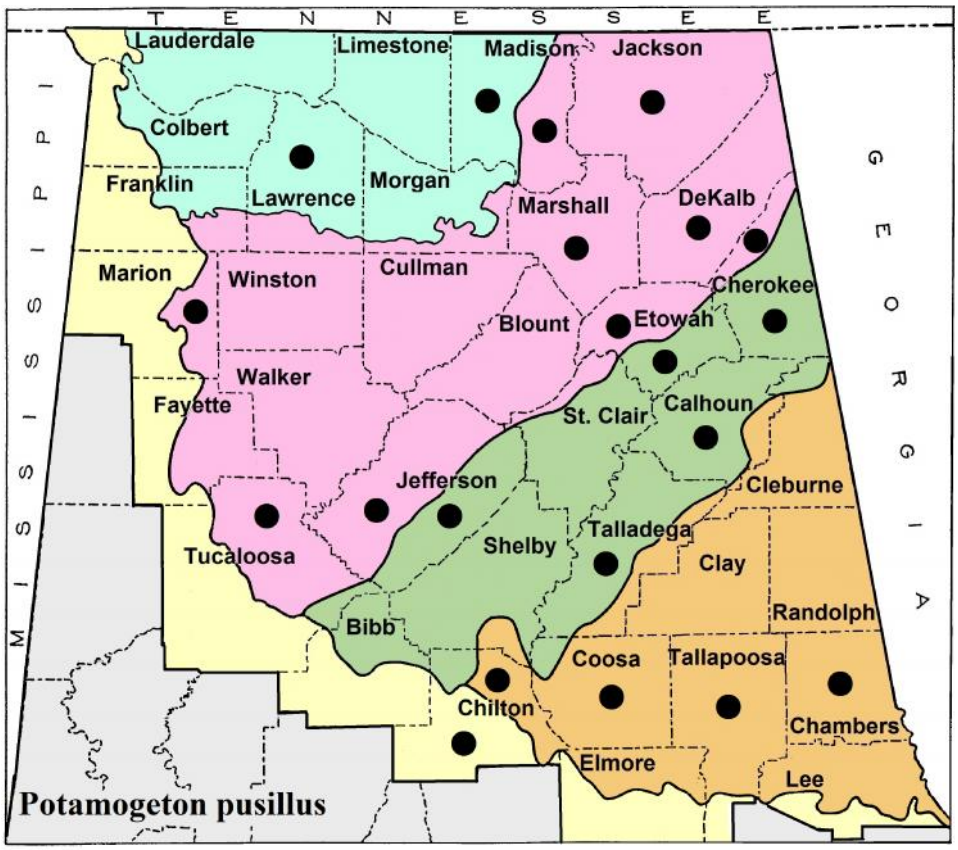


Figure 171. Distribution of *Potamogeton pusillus* in northern Alabama.

Potamogeton pusillus is very similar to *P. berchtoldii* and *P. foliosus.* Haynes (1974) treated *P. berchtoldii* as a variety of *P. pusillus*. The defining characters of *P. pusillus* are: its stipule margins being fused, forming a tube around stem (Fig. 172); most nodes having a pair of oil glands (Fig. 173a); leaves with 0–2 rows of lacunae (Fig. 173b); mature inflorescence with interrupted whorls of flowers/fruits (Fig. 174a–b); and fruits with concave sides and off-centered beaks (Fig. 174c). *Potamogeton berchtoldii* flowers are crowded, its fruits have rounded sides with beaks centered in the middle, the leaves have 1–5 rows of lacunae along the midrib, and its stipule margins are not fused. *Potamogeton foliosus* lacks nodal glands and its fruits have knobby keels.

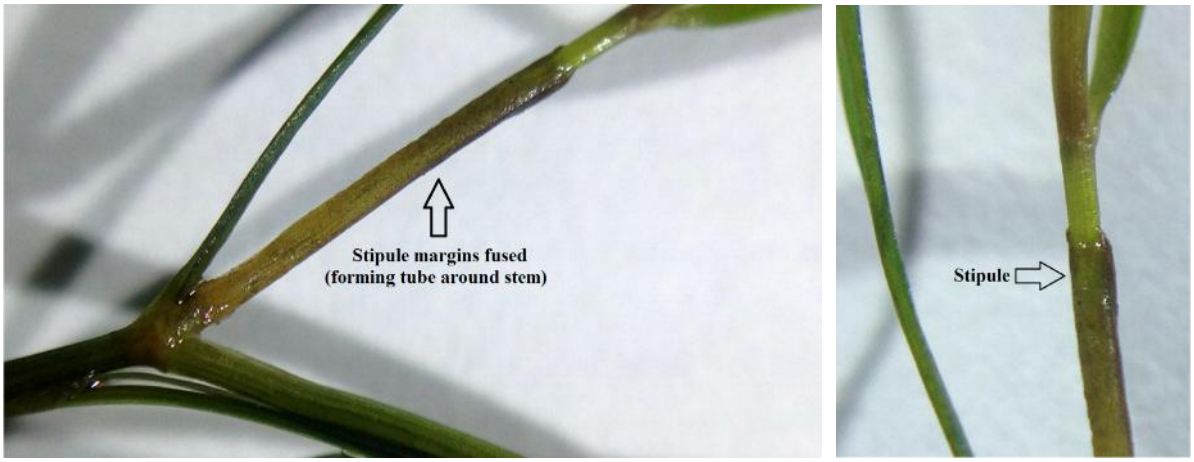


Figure 172. *Potamogeton pusillus* stipules, Calhoun Co., Alabama, 24 May 2018. Photos: Dan Spaulding.

(173a) Nodal oil gland.

(173b) Leaves usually lacking lacunae (banded air-spaces).

Figure 173. *Potamogeton pusillus*. A. Close-up of an oil gland at node, Calhoun Co., Alabama, 24 May 2018. B. Close-up of leaf, Etowah Co., Alabama, 11 Jul 2018. Photos: Dan Spaulding.

(174a) Spike of flowers.

(174b) Spike of fruits.

(174c) Beak off-center; sides concave.

Figure 174. *Potamogeton pusillus*. A–C. Etowah Co., Alabama, 11 Jul 2018. Photos: Dan Spaulding.

2. STUCKENIA C. Börner 1912

[Named after Wilhelm Adolf Stucken, 1860–1901, amateur German botanist and entomologist]

1. Stuckenia pectinata (L.) Börner {comb-like} — SAGO PONDWEED; FENNEL-LEAF PONDWEED; SAGO FALSE PONDWEED; FENNEL PONDWEED (Fig. 175). [*Coleogeton pectinatus* (L.) D.H. Les & Haynes; *Potamogeton pectinatus* L.]

Figure 175. *Stuckenia pectinata*, Prestile Stream, Aroostook Co., Maine, 29 Jul 2005. Photos: Don Cameron.

Submersed aquatic, perennial herb with rhizomes and tubers. Rivers, lakes, and bays along the coast; flowers and fruits June–September; very rare in the Highland Rim (Tennessee Valley district), and Cumberland Plateau (Sequatchie Valley district); rare in lower Coastal Plain (Fig. 176). In fresh or brackish waters on all continents in the Northern Hemisphere (Kaplan 2008).

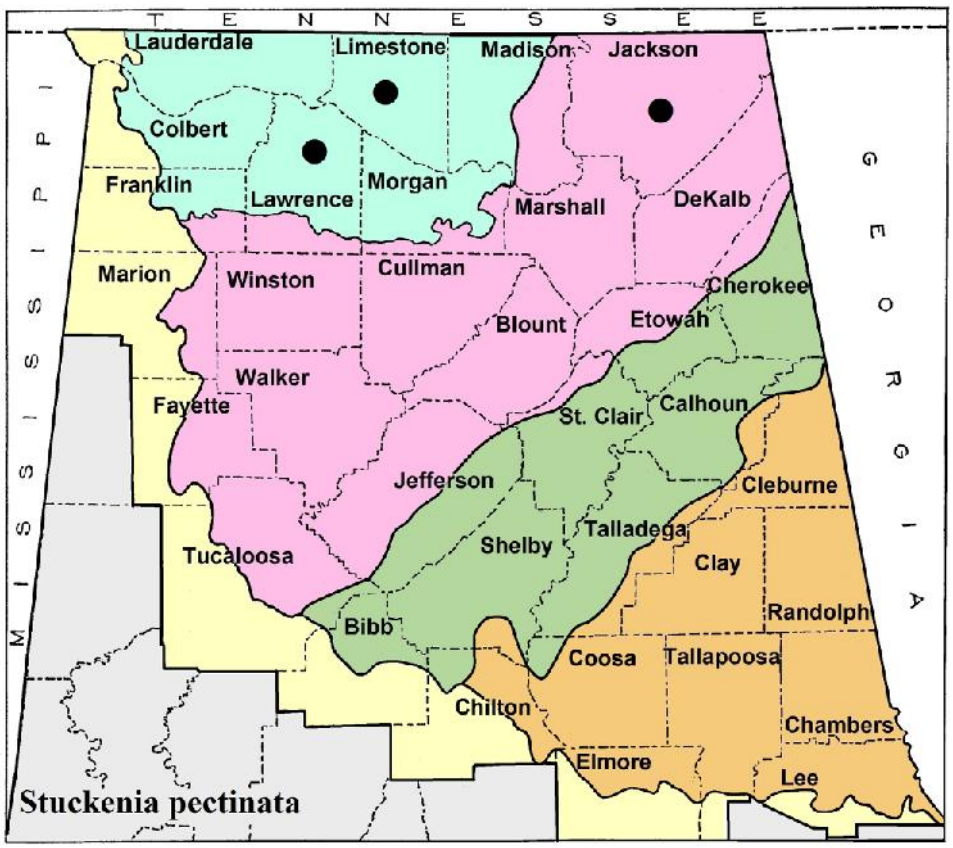


Figure 176. Distribution of *Stuckenia pectinata* in northern Alabama.

According to Haynes & Hellquist (2000b), the best diagnostic character differentiating *Stuckenia* from *Potamogeton* is the stipules. *Stuckenia* stipules are fused (adnate) with the basal portion of the leaf for at least 2/3 of the length, forming a long stipular sheath with a ligule (Fig. 177). *Stuckenia pectinata* has sessile, tubular leaves with air channels (lacunae) along the midribs (Fig. 178). Its inflorescences are on long, flexuous peduncles that float rather than being held above water (Holub 1997). The flowering spike has 2–5 whorls of flowers that are clustered together when immature but separate during anthesis (Fig. 179). Fruiting spikes are interrupted, and the fruits are greenish-brown to light brown with a beak off to one side (Fig. 180).

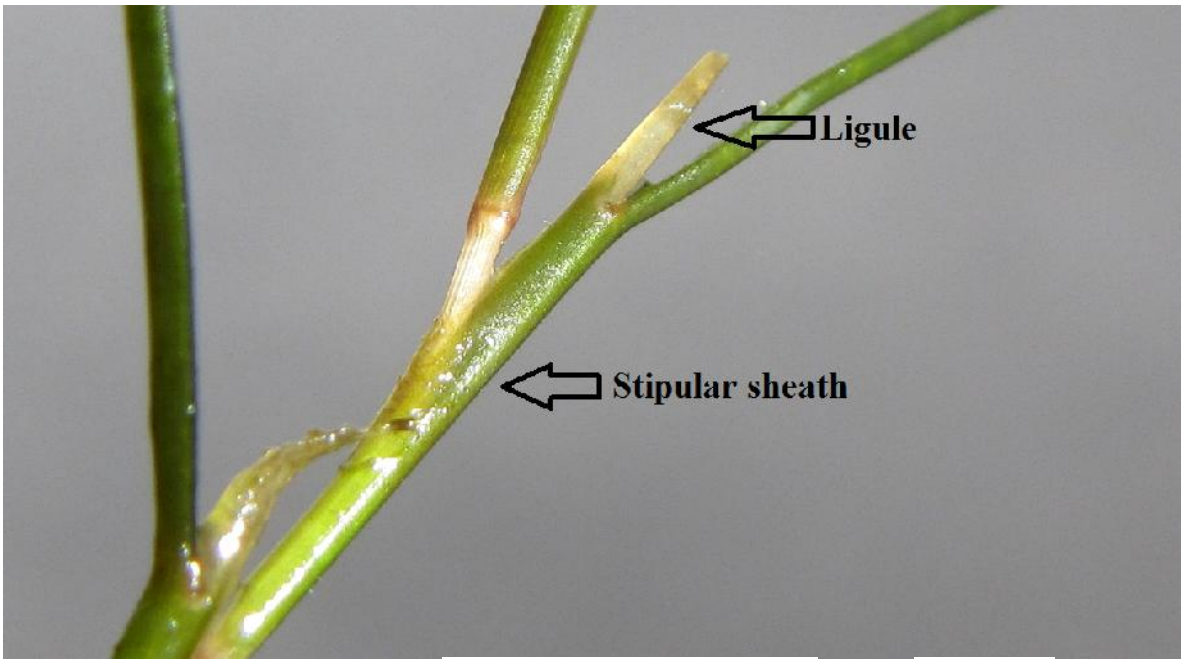


Figure 177. *Stuckenia pectinata* stipule, Mjindi, South Africa, 10 Nov 2017. Photo: Ricky Taylor.


Figure 178. *Stuckenia pectinata* leaves, Baldwin Co., Alabama, 4 Aug 2009. Photo: Howard Horne.

Figure 179. *Stuckenia pectinata*, Matveevo-Kurganskiy District, Russia, 9 Jun 2010. Photos: Sergey Mayorov.

Figure 180. *Stuckenia pectinata*. Orange Co., California, 28 Jun 2018. Photos: Ron Vanderhoff.

Sago Pondweed is rare in Alabama, known only from portions of the Tennessee River and in brackish waters of Mobile Bay. However, the widespread distribution of *Stuckenia pectinata* makes this pondweed a very valuable food source for waterfowl, marshbirds, and shorebirds. These birds readily consume the leaves, stems, rhizomes, and large seeds (Martin 1951). *Stuckenia* also reproduces vegetatively by underground tubers, which are eaten and spread by a variety of ducks, especially Canvasbacks (Haynes & Hellquist 2000b).

3. ZANNICHELLIA Linnaeus 1753
[Named in honor of Gian Girolamo Zannichelli, 1662-1729, a Venetian botanist]

1. Zannichellia palustris L. {of marshes} — HORNED PONDWEED; COMMON POOLMAT (Fig. 181). [*Zannichellia palustris* var. *major* (Hartm.) W.D.J. Koch]

Figure 181. *Zannichellia palustris*, Summit Co., Ohio, 28 Jul 2018. Photos: Mark Warman.

Submersed aquatic, annual herb. Lakes, rivers, springs, brackish bays and estuaries on the coast; flowers and fruits February–October; rare in the Highland Rim, Cumberland Plateau, and lower Coastal Plain (Fig. 182). Occurring nearly worldwide; found throughout North America, Mexico, Central America, South America, Eurasia, Africa, and Australia (Haynes & Hellquist 2000c).

Zannichellia palustris has long, linear leaves, mostly opposite or in pseudo-whorls and often rooting at the nodes (Fig. 183). It grows clonally in inland freshwater lakes or in shallow, brackish, coastal waters (Haynes & Holm-Nielsen 2001). In northern Alabama, this species has been collected sporadically in springs, reservoirs, and cooling channels at power plants, especially along the Tennessee River. The species is fairly frequent on the Coastal Plain in estuaries and bays of Mobile and Baldwin counties.

Horned Pondweed is an annual that does not reproduce vegetatively by leaf fragmentation, budding or turion formation; therefore, it requires seed production for survival (Haynes 1988). *Zannichellia* is monoecious and produces two unisexual flowers lacking a perianth, produced on sessile inflorescences within the leaf axil. Male flowers have a single stamen and female flowers have 4–5 separate carpels, enclosed by a membranous envelope (Haynes & Hellquist 2000c).

Pollen transfer takes place underwater, with most seeds developing from self-pollination; rarely are plants cross-pollinated (Guo et al. 1990). The pollination system of *Zannichellia* is unusual in that the stamen arches over the pistillate flower, releasing a gelatinous mass onto funnel-shaped stigmas, enabling reproduction (Haynes & Holm-Nielsen 2001). Fertilized carpels produce an axillary cluster of falcate or banana-shaped fruits (Fig. 184a), which is an achene on a short stalk with an undulate, dorsal keel and a conspicuous, horn-like beak (Fig. 184b). Various duck species are reported to consume the fruits and vegetative parts (Martin et al. 1951).

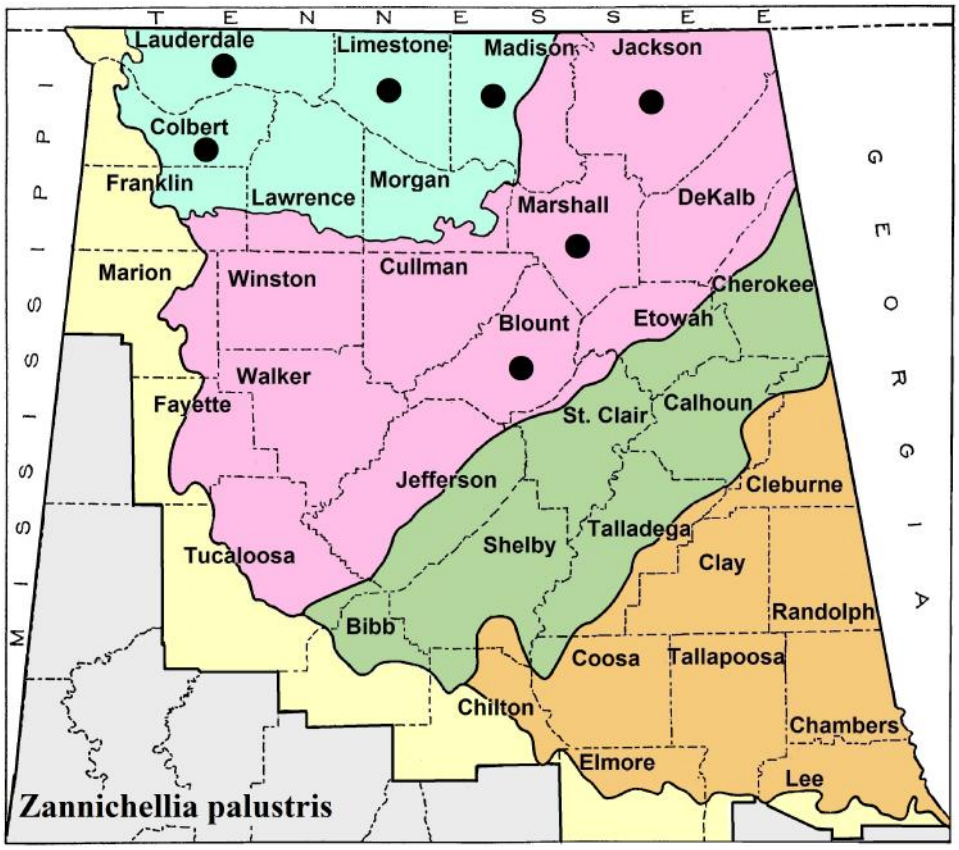


Figure 182. Distribution of *Zannichellia palustris* in northern Alabama.

Figure 183. *Zannichellia palustris*, Lower Saxony, Germany, 18 Sep 2012. Photo: Christian Fischer.

(184a) Axillary clusters of fruits. (184b) Close-up of dried fruits.

Figure 184. *Zannichellia palustris*, Lower Saxony, Germany, 18 Sep 2012. Photo: Christian Fischer. B. VDB, *Dennis & Price 2108*, 9 May 1979. Photo: Dan Spaulding.

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