Coefficient of Conservatism Rankings for the Flora of Georgia: Wetland Indicator Species

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Abstract - Wetland habitats currently cover about one-fifth of Georgia and have been reduced in acreage by as much as twenty-five percent over the past two centuries due to anthropogenic activities. Accurate identification and careful study of these areas are crucial for their preservation and for compliance with federal and state environmental regulations. Several vegetation-based biological assessment methodologies have been developed to define wetlands and to assess their quality. One major wetland delineation system, mandated by federal law, incorporates the National Wetland Plant List (NWPL), a classification system ranking plant species in five indicator categories according to fidelity and preference for wetlands or uplands. These rankings were recently updated via a comprehensive and collaborative nationwide effort involving four government agencies and teams of wetland specialists. Another expert-based indicator system, coefficients of conservatism, is the foundation of the floristic quality index, a metric widely used in the United States for assessing ecological condition of wetlands (as well as other plant communities). The coefficients are based on breadth of habitat preference(s) and tolerance to disturbance, with exotic and ruderal species receiving the lowest scores and ecologically conservative species assigned the highest scores. A team of four botanists, proficient with the flora of Georgia, convened to assign coefficient of conservatism rankings to the 2262 NWPL species for the state. The resulting web-accessible database, which includes information such as regional wetland rankings and conservation status, is described here.

Introduction

Georgia is a keystone for understanding the complex floristic diversity of the southeastern United States; with over 3800 species (W.B. Zomlefer, D.E. Giannasi, and J.R.Carter, unpubl. data), the state has been ranked seventh nationally for vascular plant diversity (Stein 2002), second to Florida (≈4200 spp.; Wunderlin and Hansen 2008) among the eastern states. Underlying this diversity are fourteen major river systems (e.g., Altamaha, Chattahoochee, and Savannah), extending from the upland physiographic regions to the outer Coastal Plain, representing ancient migration corridors and Pleistocene refugia responsible for complex floristic patterns with admixtures of diverse geographical origin (Wharton 1978). Depending on the classification system, the state includes portions of as many as six basic physiographic zones and ecoregions (Fig. 1A; e.g., US EPA 2012a, Wharton 1978). These areas have substantial floristic overlap with both Atlantic and Gulf Coastal Plains and with subtropical Floridian and Interior Continental systems.

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Wetlands, in particular, contribute to the high level of biodiversity in Georgia. As defined here, the hydrology of these habitats ranges from permanent inundation (shallow water) to periodic soil saturation at or near the soil surface (seasonally waterlogged; Tiner 2012). Approximately 20 percent (3,116,000 ha [7,700,000 acres]) of the state's area is classified as wetland, including a wide variety of estuarine and palustrine habitats. Estuarine wetlands comprise approximately 148,500 ha (367,000 acres), and the remaining 2,954,000 ha (7,300,000 acres) are forested, scrub-shrub, and emergent freshwater wetlands (GA-DNR 2010a). A recent classification of Georgia's wetlands by physiographic province (Edwards et al. 2013) recognizes 14 general wetland types based on hydrologic origins (Table 1; Chafin 2011).

One of the most significant wetlands in Georgia is the extensive swamp and bottomland system associated with the Altamaha River, the largest drainage basin in the state (3,678,000 ha; 9,088,000 acres) and the third-largest freshwater contributor to the Atlantic Ocean (GA-DNR 2004). Two other outstanding types of Georgia wetlands defy easy classification and contribute disproportionally to Georgia's biodiversity: vernal pools (Piedmont granite outcrops) and the Okefenokee Swamp (southeast Georgia Atlantic Coastal Plain). Piedmont granite outcrop pools were created by weathering of certain granite types and provide habitat for three federally listed plant species (*Amphianthus pusillus* Torr. [Pool Sprite], *Isoetes melanospora* Engelm. [Black-spored Quillwort], *I. tegetiformans* Rury [Mat-forming Quillwort]) and the state-listed *Isoetes melanopoda* J. Gay & Durieu (Blackfoot Quillwort) (GA-DNR 2010b, 2011). The Okefenokee Swamp, one of the largest freshwater wetland systems in the world (177,300 ha; 438,000

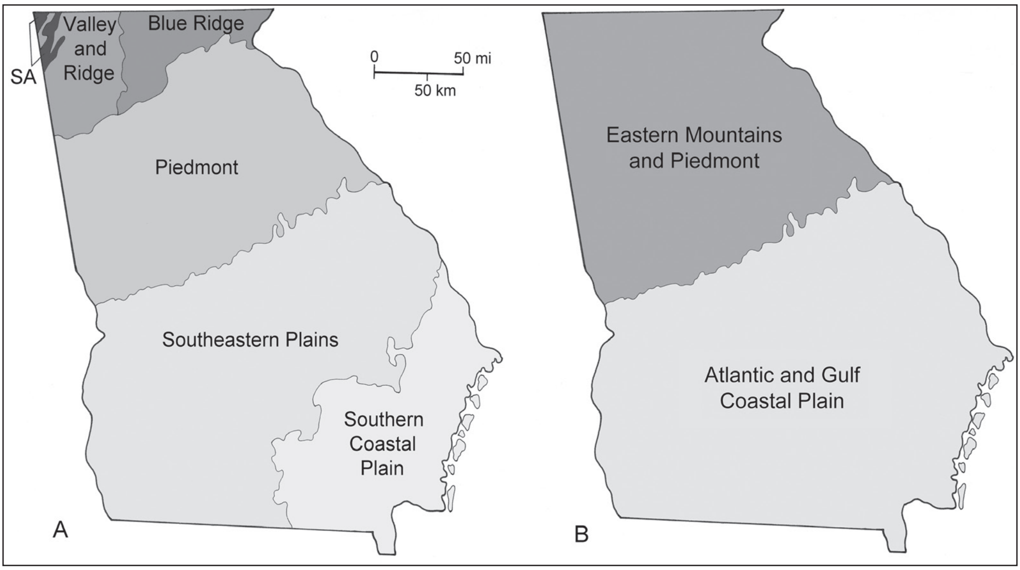

Figure 1. Ecological regions of Georgia. A. Environmental Protection Agency Level III Ecoregions (US EPA 2012a). SA = Southwestern Appalachians. B. Wetland regions designated by the US Army Corps of Engineers for the National Wetland Plant List (Lichvar and Minkin 2008; USACE 2010, 2012a). Both maps modified by W.B. Zomlefer from the referenced sources.

acres), is a complex of wetland types fed mainly (80 percent) by rainwater and has been designated a "wetland of international importance" by the United Nations (Ramsar Convention on Wetlands 2012).

An estimated 20 to 25 percent of Georgia's original wetland acreage has been lost in the 230 years since colonial settlement (GA-DNR 2010a), and development and encroaching urbanization continue to impact remaining wetlands. Accurate identification and careful study of these areas are crucial for preserving them and for compliance with federal and state environmental laws. Vegetation, an accessible and conspicuous component of wetlands, can serve as a sensitive measure of anthropogenic effects. Plant species characteristically have differential tolerances to environmental change, and they have been utilized extensively as indicators to define wetlands and in assessments of wetland condition and quality (Fennessy et al. 2002).

An example of a plant-based indicator scheme is the recently revised National Wetland Plant List (NWPL; Lichvar 2012, Lichvar and Kartesz 2012), a ranking system applied to 7828 species in the United States, which serves as a standard research reference for wetland identification and delineation. The five wetland indicator categories (Table 2) are based on qualitative ecological descriptions of each species' fidelity to and preference for wetlands or uplands (Lichvar et al. 2012, Lichvar and Minkin 2008), depending upon its occurrence within 10 broad geographic regions (Lichvar 2012). Georgia lies within two of these regions (Fig. 1B)—the Atlantic and Gulf Coastal Plain region (USACE 2010) and Eastern

Table 1. Summary of wetland types for the six Level III Ecoregions of Georgia (US EPA 2012a) depicted in Figure 1A. Data from Chafin (2011) and Edwards et al. (2013). BR = Blue Ridge, P = Piedmont, RV = Ridge and Valley, SA = Southwestern Appalachians (Cumberland Plateau), SCP = Southern Coastal Plain (outer Coastal Plain and barrier islands), SP = Southeastern Plains (inner Coastal Plain).

	Ecoregion					
Wetland type	BR	P	RV	SA	SCP	SP
Isolated freshwater wetlands						
Depression marshes					×	×
Depression swamps		×			×	×
Sag ponds, sinkholes			×	×		
Seepage forests, meadows, bogs, fens	×	×	×	×	×	×
Spray cliffs	×					
Wet savannahs, flatwoods			×	×	×	×
Riverine wetlands						
Beaver ponds	×	×	×	×		
Bottomland hardwood forests	×	×	×	×		
Floodplain swamps	×	×	×	×	×	×
Tidally influenced wetlands						
Interdunal wetlands					×	
Salt marshes, brackish marshes					×	
Sand bars, intertidal flats					×	
Tidal freshwater marshes					×	
Tidal swamps					×	

Table 2. Wetland-indicator status rankings and indicator-rank tallies and example species for Georgia. For more detailed descriptions of these categories including plant characteristics and exemplar species, see Lichvar and Minkin (2008), Lichvar et al. (2012), and Lockwood (2012). For authorities and common names of species given in the Table, see Lichvar and Kartesz (2012). Hydrophyte = plants that grow in water or on a substrate that is saturated at a frequency and duration during the growing period sufficient to affect plant occurrence (Tiner 2012); wetland = a habitat with hydrologic conditions ranging from permanent inundation (shallow water habitats) to periodic soil saturation at or near the soil surface (seasonally waterlogged habitats; Tiner 2012). AGCP = Atlantic and Gulf Coastal Plain region (USACE 2010), EMP = Eastern Mountains and Piedmont region (USACE 2012a), NWPL = National Wetland Plant List (Lichvar 2012). For Georgia, the AGCP comprises 2241 species and the EMP comprises 2042 species. Percentages given in brackets for number of species is for percentage of total in that region.

			Number of Georgia NWPL species		
Indicator status [code]	Ecological description (Lichvar and Minkin 2008)	Short version of indicator descriptor (Lichvar et al. 2012)	AGCP [%]	EMP [%]	Example species in Georgia
Obligate [OBL]	Almost always a hydrophyte, rarely in uplands	Almost always occur in wetlands	634 [28.3]	540 [26.4]	*Alnus maritima*, *Lemna minor*, *Nuphar lutea*, *Pontederia cordata*, *Taxodium distichum*
Facultative Wetland [FACW]	Usually a hydrophyte but occasionally found in uplands	Usually occur in wetlands, but may occur in non-wetlands	564 [25.2]	466 [22.8]	*Agalinis purpurea*, *Cornus asperifolia*, *Quercus laurifolia*, *Rhynchospora plumosa*, *Viburnum obovatum*
Facultative [FAC]	Commonly occurs as either a hydrophyte or non-hydrophyte	Occur in wetlands or non-wetlands	484 [21.6]	409 [20.0]	*Agrostis scabra*, *Carpinus caroliniana*, *Staphylea trifolia*, *Ulmus rubra*, *Zizia aurea*
Facultative Upland [FACU]	Occasionally a hydrophyte but usually occurs in uplands	Usually occur in non-wetlands, but may occur in wetlands	501 [22.4]	538 [26.3]	*Ambrosia artemisiifolia*, *Carya ovata*, *Oenothera biennis*, *Ostrya virginiana*, *Prunus serotina*
Upland [UPL]	Rarely a hydrophyte, almost always in uplands	Almost never occur in wetlands	58 [2.6]	89 [4.4]	*Acer spicatum* [AGCP only], *Actaea pachypoda* [EMP], *Aristida longespica* [EMP], *Rhus copallinum* [AGCP], *Tillandsia usneoides* [EMP]

Mountains and Piedmont region (USACE 2012a)—and has a total of 2262 NWPL species for the state (USACE 2012b).

Updating the NWPL was a well-established collaborative effort involving four federal agencies: the US Army Corps of Engineers (USACE), the US Environmental Protection Agency, the US Fish and Wildlife Service, and the USDA Natural Resources Conservation Service. The wetland indicator rankings were assigned by extensive review and consensus of national and regional panels, professional scientists, and other technical experts, and are based on regional botanical/ecological expertise and field observations, reappraisal of previous indicator status designations (i.e., Reed 1988), literature review, and herbarium specimen data (details in Lichvar 2012, Lichvar and Gillrich 2011, Lichvar and Minkin 2008). The official list has a specific legal role in defining the hydrophytic vegetation parameter for wetland delineation protocols required under Section 404 of the Clean Water Act and the Swampbuster provision of the 2008 Farm Bill (Lockwood 2012). More generally, the indicator rankings are also used to support wetland restoration and research and as indicators to measure various environmental conditions (e.g., for the National Wetland Inventory Program [USFWS 2013a]).

The coefficient of conservatism (C, C of C, or CoC) is another indicator system with rankings assigned to plant species by regional experts and is also often used in assessing wetlands, as well as other plant communities (Table 3). Each rank, an integral value from 0 to 10, reflects a particular species' fidelity to habitat and tolerance of disturbance within a specified geographical region. The least conservative species (exotic and ruderal; ranked 0–3) occur in a wide range of habitats and thrive with disturbance, while the most conservative species (9 and 10) are habitat specialists restricted to a narrow range of ecological conditions and are intolerant of disturbance (Table 3; e.g., Swink and Wilhelm 1979, 1994; Taft et al. 1997). Each coefficient, thus, represents an ordinal weighting factor reflecting the degree of that particular species' habitat fidelity in relation to other species of that region (Andreas et al. 2004).

Coefficient values have been incorporated into community-based site assessment methods for wetland biological integrity—in particular, the floristic quality assessment index (FQI or FQAI), a robust metric of species richness used in evaluation of natural areas and verification of mitigation and restoration efforts (Fennessy et al. 2002, Lopez and Fennessy 2002). Assessment methodologies based on FQI have been developed by regulatory agencies of several states (e.g., Bernthal et al. 2003, Herman et al. 2006, Taft et al. 1997) to monitor wetland conditions in compliance with Section 305(b) of the Clean Water Act, including the current nationwide effort, the National Wetland Condition Assessment (US EPA 2012b).

The FQI is most commonly calculated by multiplying the average C ("Mean C") by the square root of the total number of species in an inventory unit (Swink and Wilhelm 1979, 1994; Taft et al. 1997), although there are modifications of this basic equation, including the inclusion or exclusion of non-native species (see Andreas et al. 2004, Bourdaghs et al. 2006). The Mean C relates directly to aggregate conservatism, while FQI values are sensitive to factors that increase species richness.

Table 3. Summary of coefficient of conservatism (C of C) ranking definitions used for the Georgia NWPL database, modified from Andreas et al. (2004). NWPL = National Wetland Plant List (Lichvar and Kartesz 2012). For authorities and common names of species given in the Table, see Lichvar and Kartesz (2012). Percentages given in brackets for number of species is for percentage of total assigned C values.

C of C ranking	Definition	Examples of NWPL species in Georgia	Number of NWPL Georgia species [%]
0	Invasive non-native species that displace native species, to the extent of altering ecosystem function or community structure and diminishing native species composition	*Alternanthera philoxeroides*, *Ligustrum sinense*, *Murdannia keisak*, *Panicum repens*, *Pueraria montana*	36 [1.6]
1	Relatively benign non-native species	*Amaranthus spinosus*, *Morus alba*, *Murdannia nudiflora*, *Persicaria hydropiper*, *Ranunculus sardous*	294 [13.0]
2	Native invasives (native weedy species) very tolerant of anthropogenic disturbance and exhibiting a broad ecological amplitude	*Campsis radicans*, *Mikania scandens*, *Persicaria hydropiperoides*, *Pinus taeda*, *Typha latifolia*	126 [5.6]
3	Native species with an intermediate range of ecological tolerances; typifying a stable phase of some native community, but thriving under substantial natural or anthropogenic disturbance	*Acer rubrum*, *Andropogon glomeratus*, *Juncus effusus*, *Morella cerifera*, *Smilax glauca*	240 [10.6]
4	Native species with an intermediate range of ecological tolerances; typifying a stable phase of some native community, but persisting under moderate disturbance	*Amorpha herbacea*, *Boehmeria cylindrica*, *Cornus amomum*, *Mimulus ringens*, *Vitis aestivalis*	427 [19.0]
5	Native species with an intermediate range of ecological tolerances; typifying a stable phase of some native community, but persisting under limited disturbance	*Asimina parviflora*, *Chasmanthium laxum*, *Crataegus viridis*, *Quercus alba*, *Vitis vulpina*	448 [19.9]

Table 3, continued.

C of C ranking	Definition	Examples of NWPL species in Georgia	Number of NWPL Georgia species [%]
6	Native species with a more or less narrow range of ecological tolerances, typifying a stable or near climax community (including fire-dependent and other disclimax communities); tolerating limited disturbance	*Carphephorus corymbosus*, *Decumaria barbara*, *Pinguicula caerulea*, *Sapindus saponaria*, *Sarracenia minor*	352 [15.6]
7	Native species with a somewhat narrow range ecological tolerance, typifying a stable or near climax community; not tolerating disturbance	*Aesculus pavia*, *Calopogon tuberosus*, *Lindera benzoin*, *Polygonatum biflorum*, *Ulmus americana*	203 [9.0]
8	Native species with a narrow range of ecological tolerance; typifying a stable or near climax community; not tolerating disturbance; showing a moderate degree of habitat fidelity	*Cypripedium parviflorum*, *Juglans cinerea*, *Parnassia grandiflora*, *Sabal minor*, *Salix floridana*	71 [3.1]
9	Native species with a narrow range of ecological tolerance; exhibiting a high degree of fidelity to a narrow range of habitat requirements; often listed as threatened or rare (but rarity not due to its distribution at the limit of geographical range)	*Alnus maritima*, *Calopogon multiflorus*, *Helonias bullata*, *Mitella diphylla*, *Sedum pulchellum*	35 [1.5]
10	Native species with a very narrow range of ecological tolerance; exhibiting a high degree of fidelity to a narrow range of habitat requirements; often listed as threatened or rare (but rarity not due to its distribution at the limit of geographical range)	*Diamorpha smallii*, *Hymenocallis coronaria*, *Isoetes melanospora*, *Trichomanes boschianum*, *Uniola paniculata*	20 [0.9]

In general, a higher Mean C and FQI for a site indicate greater floristic quality and biological integrity and a lower level of disturbance impacts. Thus, coefficient of conservatism and floristic quality indices are relative values that provide baseline reference data for tracking a single wetland over time and for comparing different sites. Advantages and limitations (e.g., plant community effects) in their application are summarized in Andreas et al. (2004), Bernthal et al. (2003), Bourdaghs et al. (2006), Ervin et al. (2006), Lopez and Fennessy (2002), and Taft et al. (1997).

The National Park Service (NPS) is incorporating C and FQI indices as part of a long-term ecological inventory and monitoring program initiated in 1999 to establish baseline data on park ecosystems for resource management decisions (see Fancy et al. 2009). This program included comprehensive floristic surveys of the 20 parks comprising the Southeast Coast Network (SECN), covering ≈74,460 ha (184,000 acres) in Alabama, Florida, Georgia, North Carolina, and South Carolina (DeVivo et al. 2008). Every SECN park includes considerable wetlands; six parks are classified as inland riverine, and 14 as coastal (DeVivo et al. 2011). The vouchered inventories established a species list for each park (e.g., Zomlefer and Giannasi 2005; Zomlefer et al. 2004, 2012).

When the NPS contracted coauthors W.B Zomlefer, L.G. Chafin, and D.E. Giannasi to generate coefficient of conservatism rankings for the ≈3000 SECN park species, we discovered that Georgia lacked a C of C treatment, although indices were available for some surrounding states in the Southeast (e.g., Mississippi [Herman et al. 2006]; Florida [Mortellaro et al. 2012]). Based on our C-assignment database for the NPS (W.B. Zomlefer, L.G. Chafin, and D.E. Giannasi, unpubl. data), we subsequently assembled a coefficient list for Georgia. To create this new database, we reassessed our SECN coefficient assignments with focus on the state, rather than the five-state region, and limited coverage to wetland species, as defined by the new NWPL.

Methods

We compiled a database for the 2262 NWPL species for Georgia (USACE 2012b), based on previous coefficient of conservatism assignments generated for the NPS (W.B Zomlefer, L.G. Chafin, and D.E. Giannasi, unpubl. data), and including newly generated C rankings for the state. The database, in Excel format, comprises 10 columns (A–J) of information, detailed below.

Column A. Family

Family circumscriptions follow FNA (1993) for gymnosperms, Smith et al. (2006) for lycophytes and monilophytes ("ferns and allies"), and APG III (2009) for angiosperms.

Column B. Scientific name

These are the official names (required for reporting federal wetland delineations) taken directly from the National Wetland Plant List (Lichvar and Kartesz 2012) that adopted the nomenclature of the Biota of North America Program (Kartesz 2009).

Column C. Authority

The authorities are from Tropicos® (http://www.tropicos.org/) and The International Plant Names Index (IPNI; http://www.ipni.org/), using standard author abbreviations established by IPNI.

Column D. Nativity

The native status follows the *Flora of the Southern and Mid-Atlantic States* (Weakley 2012), which incorporates the most current information on non-native taxa (whether naturalized, persistent, waif, etc.) targeting the primary southeastern flora area. Weakley also indicates and/or discusses species of questionable nativity. The designation in the database reflects the probable status for Georgia. An asterisk indicates some uncertainty about nativity in the state (as noted by Weakley 2012), briefly summarized in “Column J. Nativity and other notes”.

Column E. Coefficient of conservatism rankings

The coefficient rankings were assigned by a team of the following four professional plant taxonomists, representing many years of regional field experience: (1) J. Richard Carter (Curator, Valdosta State University Herbarium) is an expert on sedges (e.g., Bryson and Carter 2008, Carter and Bryson 2000) and floristics in Georgia, including rare plant surveys (e.g., Carter et al. 2009); (2) Linda G. Chafin (Conservation Botanist, State Botanical Garden, University of Georgia) has particular expertise in floristics and rare and invasive plants of Florida (Chafin 2000) and Georgia (Chafin 2007); (3) David E. Giannasi (Emeritus Director, University of Georgia Herbarium) taught wetland plant courses for over 20 years and has been involved with plant surveys throughout the state (e.g., Zomlefer et al. 2010, 2013); and (4) Wendy B. Zomlefer (Curator, University of Georgia Herbarium) studies petaloid monocots (e.g., Zomlefer et al. 2006) and has collected extensively in Florida (e.g., Zomlefer 1994, Zomlefer et al. 2007) and Georgia (e.g., Zomlefer et al. 2008, 2012). Chafin, Giannasi, and Zomlefer compiled the original coefficient list, and Carter reviewed the previous assignments for the NPS park taxa and also independently ranked over 600 species (Cyperaceae, Poaceae, and several other crucial taxa such as *Juncus* and *Xyris*).

The eleven rankings (Table 3) generally follow the recommendations detailed in Andreas et al. (2004) with the exception of the assignment options for non-native species. As advocated by Michael Byrne, Terrestrial Ecologist for the NPS SECN (Cumberland Island National Seashore, St. Marys, GA, pers. comm.), exotics are here treated more precisely—in two ranks (0 for invasive; 1 for relatively [and currently] benign) —rather than as in one group (all ranked 0). We devised a dichotomous key as a guide for assigning coefficient rankings (Fig. 2).

The coefficient assignments were based on the authors' collective field experience, supplemented with specimen label data from the extensive herbarium collections at the University of Georgia (264,000 specimens) and Valdosta State University (65,000), and regional manuals such as Cronquist (1980), Godfrey (1988), Godfrey and Wooten (1979, 1981), Isely (1990), Radford et al. (1968), Snyder and Bruce (1986), Weakley (2012), Wunderlin and Hansen (2000, 2011), and appropriate volumes of the *Flora of North America* (FNA 1993+). The team also considered various state and federal indices of conservation or invasive status (see "Columns F–G. NWPL rating" and "Column H. State and federal rankings" below).

We tested our assignment criteria by carefully deliberating coefficients for a sample set of 50 species and comparing our results. Coauthors Chafin, Giannasi, and Zomlefer then convened in a series of 14 face-to-face meetings (27 Feb.–23 Nov. 2009; 29 Oct. 2012–31 Jan. 2013) and conference calls (later joined by coauthor Carter) to reevaluate our previous rankings for 1499 species extracted from the NPS SECN list (W.B. Zomlefer, unpubl. data) and to generate new C of Cs for the

Dichotomous Key for Coefficient of Conservatism Rankings

(a) Non-native species....................(b)
  (b) invasive....................**rank 0**
  (b) relatively benign....................**rank 1**
(a) Native species....................(c)
  (c) opportunistic, broad range of ecological tolerance, more or less restricted to areas subject to human disturbance....................**rank 2**
  (c) non-opportunistic, intermediate to narrow range of ecological tolerance....................(d)
    (d) intermediate range of ecological tolerance, typifies a stable phase of some native community, thrives and/or persists under natural or human disturbance....................(e)
      (e) persists and/or thrives under natural or human disturbance....................**rank 3**
      (e) persists but does not thrive under limited natural or human disturbance....................(f)
        (f) persists with some disturbance....................**rank 4**
        (f) persists with a little disturbance....................**rank 5**
    (d) narrow range of ecological tolerance, typifies a stable or near climax community (including fire-dependent disclimax communities), tolerates little to no disturbance (unless surrogate for fire or other natural disturbance)....................(g)
      (g) moderate fidelity to a narrow habitat requirement, may or may not tolerate limited disturbance....................(h)
        (h) more or less narrow range of ecological tolerance, tolerates limited disturbance....................**rank 6**
        (h) narrower range of ecological tolerance, does not tolerate disturbance....................(i)
          (i) somewhat narrow range of ecological tolerance....................**rank 7**
          (i) narrow range of ecological tolerance....................**rank 8**
      (g) high fidelity to a narrow range of habitat requirement, does not tolerate disturbance....................(j)
        (j) narrow range of ecological tolerance, relatively high fidelity to a narrow range of habitat requirement....................**rank 9**
        (j) very narrow range of ecological tolerance, very high fidelity to a very narrow range habitat requirement....................**rank 10**

Figure 2. Dichotomous key for assigning coefficient of conservatism rankings.

balance of 763 species to complete the Georgia NWPL. Throughout the process, we periodically confirmed consistent application of the concept of conservatism—for example, that a rare plant did not always receive a high coefficient ranking, and a widespread species was not always necessarily assigned a low ranking (see "Results"). Consensus on conflicting coefficients was achieved through discussion of the particular species and consultation of appropriate reference data.

Columns F–G. NWPL rating

The database lists the NWPL wetland indicator rankings for 2241species of the Atlantic and Gulf Coastal Plain region (AGCP; USACE 2010) and 2042 species for the Eastern Mountains and Piedmont region (EMP; USACE 2012a), with an overlap of 2021 species (89.3%) in common for these two regions in Georgia. The rating for a particular species may vary depending upon the region.

Column H. State and federal rankings

Government agency rankings in this column include Georgia non-native invasive categories (GA-EPPC 2006) and state, federal, and global conservation status/rank (GA-DNR 2010b, 2011; USFWS 2013b) for listed species. These rankings are defined and referenced under the "Legend for Wetland Plant List" tab of the database.

Column I. Synonyms

When differing from the NWPL, the scientific name (synonym) used in Weakley (2012) is provided for database users since this flora is the primary source for identifying plants in Georgia. Additional commonly used synonyms are included in Weakley (2012), and more comprehensive listings are available at the PLANTS Database (http://plants.usda.gov) and the Integrated Taxonomic Information System (http://www.itis.gov/).

Column J. Nativity and other notes

The annotations in this column briefly address concerns about nativity (see "D. Nativity", above) and on the dubious occurrence of a particular species in Georgia. Noted here also are pertinent intraspecific issues, including species with subspecies or varieties assigned state or federal rarity rankings and/or species with both native and non-native infraspecific elements.

Results

For the complete database including new coefficient of conservatism rankings for the 2262 species of the two NWPL wetland regions of Georgia, see Supplemental File 1, available online at http://www.eaglehill.us/SENAonline/suppl-files/s12-4-S1195-Zomlefer-s1, and, for BioOne subscribers, at http://dx.doi.org/10.1656/S1195.s1. Coefficient values were assigned to all species supported by vouchers at the University of Georgia and Valdosta State University herbaria. A few species (such as *Proserpinaca intermedia* Mack. [Intermediate Mermaidweed]) lacked vouchers for the state but were indicated in historical or Georgia Department of Natural Resource records as occurring in Georgia. These were ranked with reference to literature and specimen-label data from adjacent states. However, 10 species (e.g., *Thuja occidentalis* L. [Northern White Cedar] and *Carex vexans* F.J. Herm. [Florida Hammock Sedge]) included in the NWPL very likely never have occurred in Georgia and remain unranked.

Table 3 and Figure 3 summarize the number of species in each coefficient category for the remaining 2252 species. Three hundred and thirty species (≈14.6%) on the list are non-native (C = 0 or 1): 36 are ranked as invasive exotics (C = 0), and 294, as relatively benign (C = 1). The frequency distribution of coefficients of conservatism ranks for native species (C = 2–10; 1922 spp.; Fig. 3, light gray bars) is somewhat skewed towards the less conservative end of the spectrum due to the highest number of species ranked at C = 4 (427 spp.), 5 (448 spp.), and 6 (352 spp.). The most-generalist natives (native invasives; C = 2; 126 spp.) and the most-conservative species (C = 8, 9, 10; collectively 126 spp.), comprise the lowest number of species.

Discussion

Since the NWPL specifically targets wetland species in the state, we initially expected somewhat higher-end fidelity reflected in the C values. However, rankings 4–6 comprised ≈63.4 percent of the native species on the list (Fig. 3).

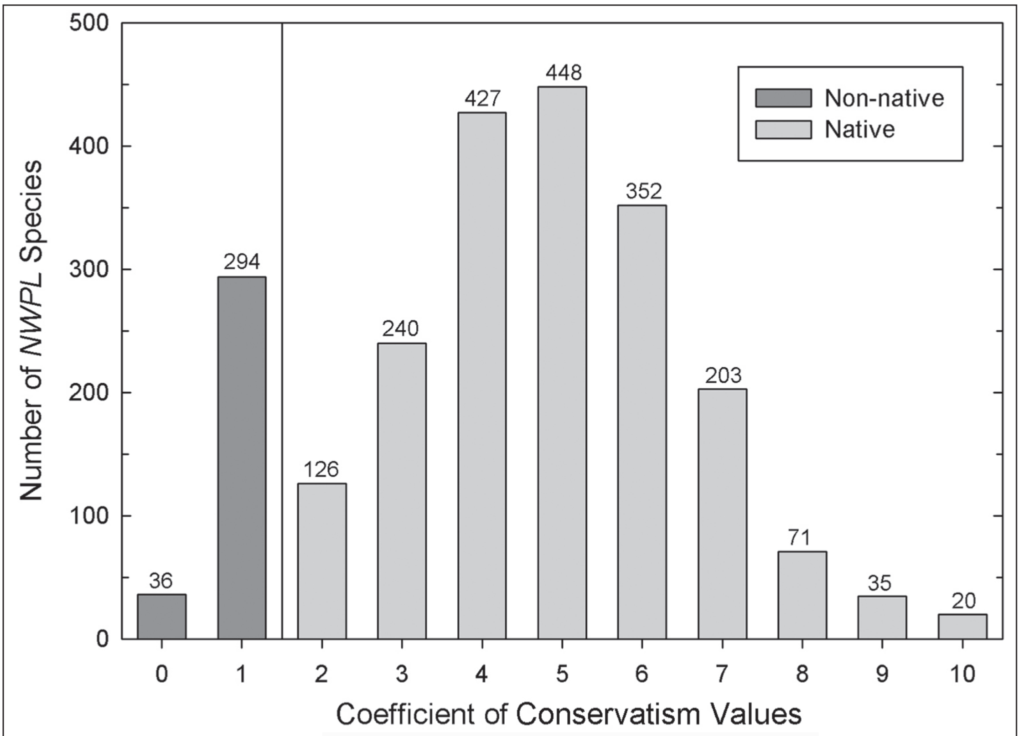

Figure 3. Bar graph depicting distribution of coefficient of conservatism designations for the 2252 Georgia National Wetland Plant List (NWPL) species (see Table 3; USACE 2012b) ranked for this project.

This result reflects that wetland-adapted species may be likely to survive—despite disturbance—as long as sufficient water is available. Further, wetland species are generally tolerant of a wide range of soil moisture levels, and some wetland habitats, such as alluvial floodplains and exposed bars and banks along streams and coasts, are naturally maintained by disturbance. Many wetland species are heliophytes, adapted to exposed sunny areas with reduced competition from taller shading trees and shrubs in these communities dependent on disturbance (Bryson and Carter 2008, Carter 2005). Various wetland species, such as sedges, have intrinsic characteristics (e.g., rapid growth, vegetative proliferation, extended seed dormancy) that promote population expansion after disturbance and may have originally evolved as colonizers of disturbed habitats (Baker 1965, 1974).

As reported for other large-scale regional C-assignment efforts (e.g., Bried et al. 2012), members of our team usually were most confident ranking the least (C = 2 or 3) and most (C = 8–10) conservative native species. For example, several ubiquitous natives with low coefficients, such as *Ambrosia artemisiifolia* L. (Common Ragweed) (C = 2 in our scale), likely would receive similar C value assignments throughout their geographical range. Other species, such as *Saxifraga micranthidifolia* (Haw.) Steud. (Branch-lettuce) (C = 9), are so restricted in their ecological requirements, they were obvious candidates for the other extreme of the coefficient scale. The most difficult rankings involved assignment of species to coefficient 6 vs. 7, particularly when floras and herbarium specimen labels provided limited habitat data. Tree species (e.g., *Quercus alba* L. [White Oak], *Fagus grandifolia* Ehrh. [American Beech]), which may be long-lived components of climax forests, were also sometimes difficult to assign with certainty due to lack of information about re-establishment of populations after disturbance.

Various indices for rare or invasive species were helpful guides but not necessarily definitive for assigning C values. Many species of conservation concern are indeed highly conservative (C = 9 or 10) and restricted to specific remnant natural communities. An example is *Sedum pusillum* Michx. (Granite Stonecrop) (state-ranked threatened; C = 10), confined to granite outcrops, a rare habitat (Chafin 2007). However, since rarity is not always due to limited ecological tolerance (Taft et al. 1997), conservation status did not always correlate with high conservatism rankings. For example, some rare species, such as *Fimbristylis perpusilla* R.M. Harper ex Small & Britton (Harper's Fimbry; state-ranked endangered, C = 4), can thrive in very disturbed areas, while others, such as *Pinguicula primulifolia* Wood & Godfr. (Clearwater Butterwort) (threatened; C = 6), typically occur in pristine habitats but exhibit some tolerance of disturbance (Godfrey and Wooten 1981). Furthermore, several highly conservative species are not rare in Georgia, such as *Uniola paniculata* L. (Sea Oats) (not state listed; C = 10), a perennial grass restricted to beach dunes (not an uncommon habitat).

The coefficient key (Fig. 2; see "Methods, Column E. Coefficient of conservatism rankings") provided an effective approach for ranking species, allowed modification as the team gained experience, and serves as a model for other state floras. Overall, team members exhibited some bias due to differing perspectives, from one career focused on rare species vs. others emphasizing broad ranging floristic surveys and/or collecting in disturbed areas for instructional purposes. Generally, one botanist consistently assigned lower or higher coefficients compared to another. An informal comparison of Chafin vs. Zomlefer and Carter vs. Zomlefer of the assignments for ≈300 non-graminoid species (using our key) revealed approximately one-third of species with the same rank, and another one-third, within one integer. Most discrepancies were resolved by direct field experience and personal observation confirming a particular species' sensitivity to disturbance. Despite differences in opinion for ranking species, team effort is valuable, especially when members have wide-ranging field experiences with the flora.

These coefficient assignments represent the first such effort for Georgia and will facilitate floristic quality assessment in the state. The National Wetland Plant List for Georgia, which includes at least 60 percent of the species in the state, serves here as a foundation for developing C coverage for the entire flora. The values were applied provisionally in a study of the Atlantic Coastal Plain limestone forest association (Lynch 2012) and were provided to S. Fennessy (Kenyon College, Gambier, OH, pers. comm.) for data analysis as part of the National Wetland Condition Assessment project (US EPA 2012b) and to K. Gianopulos (North Carolina Department of Environment and Natural Resources, Raleigh, NC, pers. comm.) as reference data for the Southeast Wetlands Workgroup (SEWWG 2013). We encourage further input and refinement of these C-assignments from experts as we continue forward with our goal of ranking the entire flora of Georgia—including intraspecific taxa (varieties, subspecies)—based on a vouchered checklist compiled from an ongoing collaborative herbarium digitization endeavor supported by the National Science Foundation (Wichmann et al. 2012, Zomlefer and Carter 2012).

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