CASTANEA 69(4): 249–264. DECEMBER 2004

Distribution, Habitat Characteristics, and Population Trends of the Rare Southeastern Endemic *Rudbeckia auriculata* (Perdue) Kral (Asteraceae)

ALVIN R. DIAMOND, JR.[1]* and ROBERT S. BOYD[2]

[1]Department of Biological and Environmental Sciences, Troy State University, Troy, Alabama 36082-9998;
[2]Department of Biological Sciences, 101 Life Sciences Building, Auburn University, Alabama 36849-5407

ABSTRACT

Rudbeckia auriculata is a rare wetland-associated species endemic to three southeastern states: Alabama, Florida, and Georgia. This study includes eight censuses of flowering individuals of the species during the ten-year period from 1992 to 2002. Although the number of known populations has increased during this time, the total number of flowering stems has remained relatively constant. Population size ranged from a single flowering stem to populations with over 1,000 flowering stems. Information on soils and associated species of vascular plants was collected at 20 of the 32 known sites during 1999, 2000, and 2001. Typical sites for the plant are located on wet soils along roadsides, power line right-of-ways or other disturbed sites. Associated species are those characteristic of disturbed open wetland sites. Although some large colonies of *R. auriculata* still exist, only two populations, both in the northern portion of the species' range, have been protected.

INTRODUCTION

The southeastern United States has long been recognized as an area with a significant number of endemic taxa, many of which are also considered rare (Gentry 1986, Ricketts et al. 1999, Estill and Cruzan 2001). One rare endemic southeastern species is *Rudbeckia auriculata* (Perdue) Kral. The majority of known populations occur in Alabama (30 of 32), with one known population extant in Georgia and one historical population in Florida. It is listed as critically imperiled globally, and critically imperiled within their states by the Alabama Natural Heritage Program and the Georgia Natural Heritage Program (ANHP 2001, GNHP 2001).

Rudbeckia auriculata was first described as variety *auriculata* of *Rudbeckia fulgida* Aiton, a species in subgenus *Rudbeckia* by R.E. Perdue based on collections he made on July 24, 1958 near Red Level in Covington County, Alabama (Perdue 1961). Kral (1975) subsequently raised the variety to species rank, and suggested a closer affinity of *R. auriculata* to *R. nitida* Nutt. and *R. mohrii* A. Gray, species now placed in subgenus *Macrocline*. In a taxonomic revision of the subgenus *Macrocline*, Cox and Urbatsch (1994) stated that *R. auriculata* has morphological and habitat similarities to the east Texas and west Louisiana endemic *R. scabrifolia* L.E. Brown, but is probably more closely related to the southeastern coastal plain species *R. nitida* Nutt. and *R. mohrii* A. Gray. Chloroplast DNA evidence and internal transcribed spacer (ITS) sequence data supports a close relationship between *R. auriculata* and *R. scabrifolia* (Urbatsch et al. 2000, Urbatsch and Jansen 1995).

Rudbeckia auriculata is morphologically distinctive in its genus. Plants are perennial and clonal, a life form that is prevalent throughout southeastern wetlands (Edwards and Weakley 2001). Large (to 6.5 diam) oblong to oblanceolate persistent basal leaves are produced. Under

* email address: adiamond@troyst.edu

favorable conditions each rosette produces one flowering stem up to 3 meters in height, with numerous auriculate clasping leaves. Stems are terete or slightly ribbed. Heads are numerous in open panicles, and are approximately 5.5 cm broad with an average of 12 bright orange-yellow ray flowers. Disc flowers are conical and purplish-black. Flowering begins in July and can last until November, although most plants finish by September. Achenes usually mature in October and are dispersed gradually over a period of several months as the head slowly breaks apart.

This research was designed to provide: (1) additional information on the distribution of *R. auriculata*; (2) a complete census of flowering individuals at all known extant sites and trends within populations over time; and (3) information on vegetation and soils associated with this rare species. This study provides valuable information for the management of this species as well as base-line data for continued monitoring efforts.

METHODS

Distribution

Fiedler (1986) states that determining the distribution of a species can contribute to an understanding of the possible reasons for its rarity. To that end, historical records were obtained for *Rudbeckia auriculata* by searches of the literature, and searches of the herbaria of Auburn University (AUA), the University of Alabama (UNA), the University of Georgia (GA), Troy State University (TROY), and the University of South Florida (USF). In addition, reports were obtained from The Alabama Natural Heritage Program, The Georgia Natural Heritage Program, the Florida Natural Areas Inventory, and knowledgeable individuals. Furthermore, extensive surveys of areas near or between existing populations were conducted with particular emphasis on sites up- or down-stream. Counties adjoining those containing known populations were also extensively searched, including large areas of the Florida Panhandle south of the Covington and Geneva County, Alabama populations. Voucher specimens of all newly discovered populations were deposited at TROY or AUA, with duplicates to be distributed at a later date.

Average annual and monthly data from the National Weather Service at Auburn University were obtained for precipitation and temperature at sites near the extreme ends of the species' range in order to characterize the climate pattern. Precipitation averages were obtained for St. Clair and Covington Counties in Alabama, while temperature averages were obtained for Birmingham in Jefferson County, and Andalusia in Covington County, Alabama. These represent the nearest reporting stations from which data were available for the southern-most and northern-most populations.

Census of flowering individuals and population trends

Population estimates utilizing large reproductive individuals can provide a gross index of population trends, and are more uniform among observers (Elzinga et al. 1999). Because *R. auriculata* reproduces asexually through the production of short rhizomes (Kral 1983), the determination of genetic individuals was impossible in the field. Previous research has reported that most populations consist of large clones and that most reproduction is asexual (Kral 1983, Schotz 2000). However, regardless if produced sexually or asexually, each rosette produces a single flowering stem each season. We chose to assess the size, health, and vigor of populations over time through the counting of flowering stems.

The number of flowering stems can provide information on the health and vigor of populations, since this species does not flower until at least two years old from seed and will not flower if growing in deep shade (based upon personal observations of plants in the field and under cultivation). Individuals produced asexually will flower in the summer following their production the previous autumn (A. Diamond, pers. obs.). Once plants begin to flower, they continue to flower yearly as long as conditions remain favorable (based upon personal observations of plants in the field and under cultivation). Populations were visited annually from 1998 to 2002 in early August, during peak flowering. A census of the number of inflorescences was obtained at each site by directly counting at smaller sites or by visual estimation at the largest sites. These data were combined with other data from previous years to determine population trends.

Associated vegetation

The community in which *R. auriculata* grows was described by sampling the associated vegetation using one by two meter quadrats at 20 sites (Table 1). Sample quadrats were centered on *R. auriculata* clumps with the long axis parallel to the adjacent water body. Estimated percent cover by each vascular plant species, and by bare soil or water, was recorded. At the largest sites, transects were arranged parallel to the long axis of the population and quadrats located randomly to either the right or left sides of the transect at three meter intervals. Data on associated species were only collected from quadrats containing *R. auriculata* plants. A minimum of 25% of each population was sampled, based upon a visual estimation of the total area occupied by *R. auriculata* at each site. At sites with small populations, the entire area was sampled utilizing one by two meter quadrats centered over each clump or aggregate of clumps.

Sorensen's Index of Similarity (IS) was used to calculate floristic similarities among the populations (Mueller-Dombois and Ellenberg 1974). These values were used to generate a hierarchical cluster analysis dendrogram using average linkage between groups (SPSS for Windows, 11.0.1, Standard Version). Importance values (IV) based on 200 points (relative cover + relative frequency) were calculated for each species. The IV for each species was calculated in two ways: one based on sites (n = 20) and the other based on the total number of quadrats used (n = 88). In addition, non-native species were identified based upon information presented in Kartesz (1999) and the United States Department of Agriculture, Natural Resources Conservation Service's PLANTS Database (USDA 2002a). Nomenclature follows Kartesz (1994).

Soil analysis

Soil series associated with *R. auriculata* were determined by examining county soil maps where available. Soil samples were collected from the 20 sites selected for vegetation analysis and sent to the Soil Testing Lab at Auburn University for analysis of soil group, pH, and extractable phosphorus, potassium, magnesium, and calcium. At each site a minimum of three samples were taken spanning the population. Each sample was collected within the root zone of a clump of *R. auriculata* plants. Soil was collected to a depth of 25–30 cm with a small shovel. Organic matter (if any) on the surface was removed prior to obtaining samples and any large roots, rocks, or woody debris were removed from the sample. The samples were mixed and a single sub-sample from each site was analyzed.

RESULTS

Distribution

Rudbeckia auriculata occurs in upland physiographic provinces of Alabama as well as on the East Gulf Coastal Plain of Alabama, Florida, and Georgia. It can be found in a variety of open, sunny, wetland habitats including a pitcher plant bog, a wet calcareous outcrop and the edges of hardwood flood plain forests (Table 1). However, it occurs most often in human-disturbed areas such as roadsides and power line corridors (Schotz 2000). Presently there are 32 known current or historical sites for *R. auriculata*. Thirty of these sites occur in Alabama, one in Georgia, and one in Florida (Figure 1). A total of 12 counties in these three states have supported one or more populations of *R. auriculata* (Table 1). All but one of the previously reported sites was relocated during this study. The site not relocated had insufficient location information, being reported simply as "clear-cut to the south of Luverne" (McDaniel 1981).

The Alabama county distribution of *R. auriculata* includes the following physiographic provinces: Chunnenuggee Hills District of the East Gulf Coastal Plain (Barbour and Bullock Counties), Southern Red Hills District of the East Gulf Coastal Plain (Crenshaw and Pike Counties), Dougherty Plain District of the East Gulf Coastal Plain (Covington and Geneva Counties), Cahaba Valley District of the Alabama Valley and Ridge (Bibb, Jefferson, St. Clair, and Shelby Counties),

Table 1. Distribution data for *Rudbeckia auriculata*. Sites are listed alphabetically by county, then by site name. Date of discovery, name of discoverer, first known herbarium specimen or publication reference, and habitat description are also presented. Sample sites for associated vegetation and soils are indicated with an asterisk following the site name

County	Site Name	Date of Discovery/ Discoverer	Specimen or Publication	Habitat Description
Barbour Co. Alabama	Lugo	12 Sept.1968/Kral and Blum	Kral and Blum 33300(VDB)	Roadside ditch.
Blount Co. Alabama	Blountsville*	15 Aug. 1998/Keener	Keener 1472(UNA)	Roadside edge of a wetland. Old beaver pond?
Bullock Co. Alabama	Bread Tray Hill*	17 Aug. 1993/Diamond	Diamond 8742 (AUA)	Around and below a man-made pond.
Covington Co. Alabama	Red Level*	24 July 1958/Perdue	Perdue 2177 (FSU, US)	Roadside near a small stream.
	Buck Creek*	14 Aug. 1999/Diamond	Diamond 11879 (TROY)	Roadside edge of an old beaver pond.
	Florala	24 July 1968/Kral	Kral 31970 (VDB)	Roadside and disturbed area near a small stream
	Richland Creek	25 June 1964/Godfrey and Clewell	Godfrey and Clewell 64392 (USF)	Roadside along a small stream.
Crenshaw Co. Alabama	Rutledge*	8 Aug. 1992/Diamond and Freeman	Diamond 8380 (AUA)	Power line right of way near a beaver pond.
	Patsaliga River*	16 Aug. 1968/Kral	Kral 32421 (VDB)	Roadside near a beaver pond.
	Mill Creek*	9 Aug. 1980/McDaniel and Haynes	McDaniel and Haynes 24311 (IBE)	Roadside along a small stream.
	Patsburg*	17 Aug. 1992/Diamond	Diamond 8400 (AUA)	Roadside below a man made pond.
	Gin Creek	25 Aug. 1996/Diamond	Diamond 10501 (AUA)	Roadside near a small stream.
	S. Luverne	1980/McDaniel	McDaniel 1981	Clear cut.
Geneva Co. Alabama	Sansom	3 Sept. 1966/Kral	Kral 36837 (FSU, VDB)	Roadside near a small stream.
	Poplar Creek	7 Aug. 1998/Schotz	Schotz 2000	Power line right of way near a small stream.
	Sarracenia*	12 Aug. 1966/McDaniel	McDaniel 7657 (IBE)	Along a small stream in a pitcher plant bog converted to a pine plantation. Now present only at roadside.
Jefferson Co. Alabama	Leeds 1	7 Aug. 2001/Diamond	Diamond 12597 (TROY)	Disturbed areas along a small creek.
	Leeds 2	11 Aug. 2002/Diamond	Diamond 13536 (TROY)	Disturbed areas along a small creek.
	Sweeny Hollow	11 Aug. 2002/Diamond	Diamond 13533 (TROY)	Roadside along a small creek.
	Turkey Creek*	24 Oct. 1996/Oberholster	Diamond 12604 (TROY)	Around a spring complex and beaver pond on a small stream.
Pike Co. Alabama	White Water Creek*	9 Aug. 1992/Diamond	Diamond 8387 (AUA)	Roadside along a small creek.

Table 1. Continued

County	Site Name	Date of Discovery/ Discoverer	Specimen or Publication	Habitat Description
	Pike County Lake*	10 Sept. 1968/Kral	Kral 33174 (VDB)	Bank of a man-made impoundment.
	Sandy Run Creek*	23 Aug. 1989/Diamond	Diamond 6297 (AUA)	Roadside, power line right of way and disturbed area in a pasture along a small creek and old beaver pond.
	Ala. Hwy. 10*	11 Aug. 1996/ Diamond	Diamond 10443 (AUA)	Roadside at the edge of a beaver pond.
	Tick Hill*	12 Sept. 1990/ Diamond	Diamond 7124 (AUA)	Edge of an old beaver pond.
St. Clair Co. Alabama	Leeds*	27 Sept. 1972/Kral	Kral 48579 (VDB)	Shallow soil over calcareous outcrop along a small creek.
Shelby Co. Alabama	Ebenezer Church*	5 Oct. 1993/ Allison	Diamond 11986 (TROY)	Edge of a beaver pond.
	Hwy. 107*	29 July 1997/ Oberholster	Diamond 12599 (TROY)	Along a small creek in a pasture and edge of a beaver pond.
	Hwy. 22	7 Aug. 2001/ Diamond	Diamond 12600 (TROY)	Along a small creek in a pasture.
	Dirt road	7 Aug. 2001/ Diamond	Diamond 12601 (TROY)	Along a small creek in a pasture.
Walton Co. Florida	U.S. 331	17 Aug. 2000/Searcy	Searcy (USF)	Roadside along a small creek.
Webstar Co. Georgia	Plains*	9 Sept. 1996/Allison	Allison 9473 (UGA)	Roadside along a small creek.

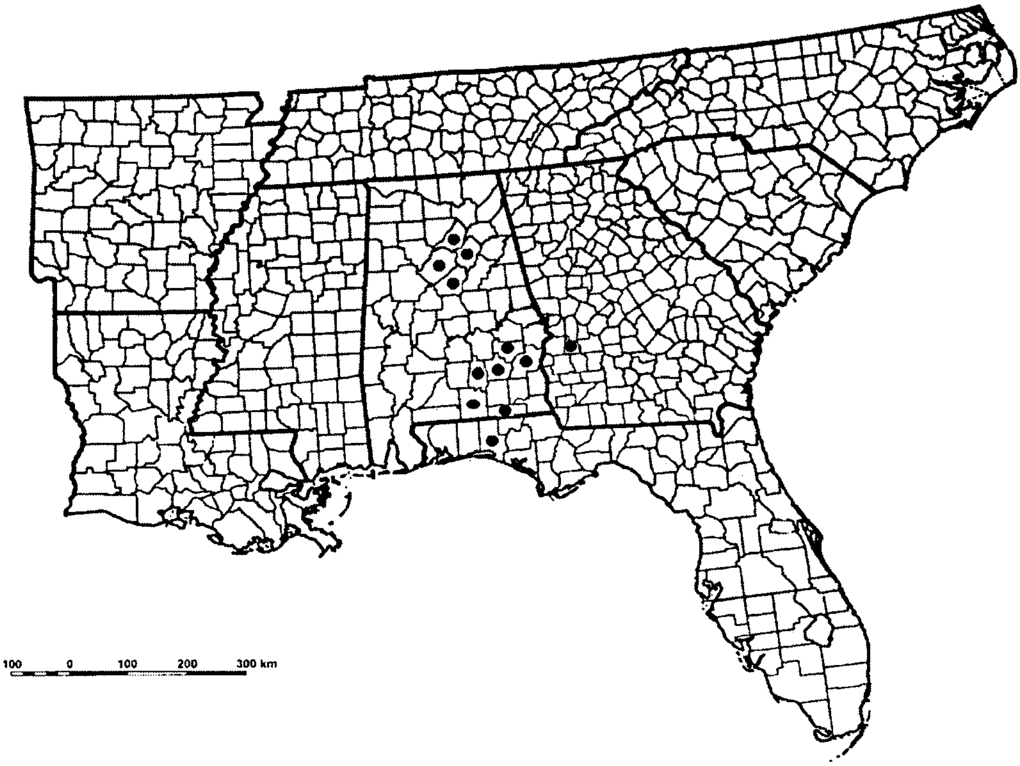

Figure 1. Distribution by county of *Rudbeckia auriculata* (Perdue) Kral in the southeastern United States.

and Sand Mountain District of the Cumberland Plateau (Blount County) (Cartographic Research Laboratory 1975). The Webster County, Georgia, site is located within the Fall Line Hills District of the East Gulf Coastal Plain (Clark and Zisa 1976). The Walton County, Florida, site is located in the Dougherty Karst District of the East Gulf Coastal Plain (Brooks 1981).

The climate throughout the range of *R. auriculata* is humid sub-tropical with long hot summers and short cool winters. The Gulf of Mexico serves to moderate the climate of the area. Precipitation is fairly constant throughout the year, with the wettest months being December through March and the driest month being October. Most precipitation falls in the form of rain. Near the northern limit of the species' range, in St. Clair County (Alabama), average annual precipitation is 132.5 cm compared to 149.8 cm in Covington County (Alabama), near the southern limit of the species' range. Average daily temperature in January for Birmingham, the nearest reporting station to the Leeds population, is 5.8°C, and 8.4°C for Andalusia, the nearest reporting station to the southern populations. Average daily July temperature for both Birmingham and Andalusia is 26.8°C.

Population trends

The first data on the size of populations of *R. auriculata* is McDaniel's 1981 status report for the United States Fish and Wildlife Service (McDaniel 1981). Based on 1980 data he estimated 2,652 flowering stems in five populations (Table 2). At the time of his report, 11 populations were known in Alabama (Table 1). Over ten years later (in 1992), the senior author visited 14 of the then 16 known populations and placed the number of flowering stems at 1,363 (Table 2). This was a decrease of 1,289 flowering stems from McDaniel's estimations even though the number of populations had increased by 50%.

Table 2. Numbers of flowering stems for populations of *Rudheckia auriculata*. Data for 1980 are from McDaniel (1981). Data in bold are from Nature Conservancy personnel. Data from Blountsville for 1998 and U.S. 331 for 2000 are from the discover of those populations. All other counts are by the senior author

	Year								
County and Site	1980	1992	1996	1997	1998	1999	2000	2001	2002
Barbour Co. Alabama									
Lugo		7	0		0	1	0	0	0
Blount Co. Alabama									
Blountsville					12		0	0	0
Bullock Co. Alabama									
Bread Tray Hill			75		7	0	25	34	87
Covingon Co. Alabama									
Red Level		10	10		3	10	0	0	0
Buck Creek						2	5	0	12
Florala		7	500		150	1000	20	75	1000
Richland Creek		10	75		28	7	0	0	0
Crenshaw Co. Alabama									
Rutledge		1000	1000		1000	1000	1000	1000	500
Patsaliga River	50	50	50		37	100	225	150	150
Mill Creek	500	0	10		32	45	75	50	75
Patsburg		20	12		16	35	14	10	42
Gin Creek			3		0	0	0	0	0
S. luveme	2								
Geneva Co. Alabama									
Sansom		3	0		0	0	0	0	0
Poplar Creek					**600**	0	0	0	0
Sarracenia		20	18		17	10	60	7	12
Jefferson Co. Alabama									
Leeds 1								7	29
Leeds 2									1000
Sweeny Hollow									500
Turkey Creek			500				7	37	0
Pike Co. Alabama									
White Water Creek		12	25		19	45	35	37	2
Pike County Lake	100	20	0		0	0	1	0	0
Sandy Run Creek		200	1000		1000	500	8	250	1000
Ala. Hwy. 10					3	10	0	0	7
Tick Hill		4	11		7	5	9	0	0
St. Clair Co. Alabama									
Leeds	1000					24	6	7	11
Shelby Co. Alabama									
Ebenezer Church				**500**			9	23	250
Hwy. 107							6	21	500
Hwy. 22								3	0
Dirt Road								35	250
Walton Co. Florida									
U.S. 331							4	0	0
Webster Co. Georgia									
Plains			**8**				12	10	125
Total number of flowering stems	2652	1363	3297	500	2931	2818	1527	1756	5552

By 1996 the number of known populations had increased to 22, including the first report from outside of Alabama (Table 1). The senior author visited 17 sites and obtained data on one additional population. The number of flowering stems was placed at 3,297, the second highest number recorded during this study (Table 2). In 1998 the senior author visited 18 of the then 25 known populations and received data on two additional populations from their discoverers. The number of flowering stems was estimated at 2,831 (Table 2). In 1999, 21 of 26 reported populations were visited with an estimated 2,818 flowering stems.

In 2000, the second population outside of Alabama was reported (Table 1). The senior author visited 25 of the 27 populations and received data for the Florida population from its discoverer. This is the first year that a complete census of all currently known and locatable populations occurred. An estimated 1,527 flowering stems were observed (Table 2). In 2001 the total number of known populations was 30 (Table 1). The senior author visited all of the locatable populations and recorded 1,756 flowering stems (Table 2). In 2002, the number of populations reached 32 (Table 1). All locatable sites were visited and 5,552 flowering stems were recorded. This was the largest number of flowering stems and populations recorded during this study (Table 2). However between the years of 1980 and 2002, while the number of known populations of *R. auriculata* has increased from 11 to 32, the total number of flowering stems has averaged only 2,335.

Of the 32 known populations, six are believed to be extirpated. The population with two flowering stems reported by McDaniel (1981) from "south of Luverne" in Crenshaw County has never been relocated despite extensive searches. Five populations whose exact location had been observed by the senior author have also disappeared. The population at Sansom in Geneva County, Alabama, was last observed in 1992 when it produced three flowering stems. The population at Lugo in Barbour County, Alabama, was last observed in 1999, and the Pike County Lake population in Pike County, Alabama, was last observed in 2000, when each produced a single flowering stem. The population on Gin Creek in Crenshaw County, Alabama has not been observed since its original discovery in 1996 when it produced three flowering stems. Likewise the population in Walton County, Florida has not been observed since its discovery in 2000 when it produced four flowering stems. While plants may remain vegetative for a number of years without producing flowering stems, searches of these sites revealed no basal rosettes. Other populations which have demonstrated a decline include the Alabama populations at Blountsville in Blount County, Red Level and Richland Creek in Covington County, Poplar Creek in Geneva County, and Alabama Hwy 10 and Tick Hill in Pike County (Table 2).

A few of the populations such as Rutledge and Patsaliga River in Crenshaw County, Alabama, and Sandy Run Creek in Pike County, Alabama have remained relatively stable during the period that they have been observed (Table 2). The Florala population in Covington County, Alabama, has increased (Table 2), possibly due to human-caused disturbance and removal of competition during the construction of a home and associated pond (A. Diamond, pers. obs., Schotz 2000). However, the long-term future of this population is unsure, as development of the site continues. The Hwy 7 and Dirt Road populations in Shelby County, Alabama, have increased, but no trend can be determined due to the low number of observations (Table 2). Populations often fluctuate in the number of flowering stems greatly from year to year due to disturbance, succession, and possibly other factors such as precipitation (Table 2).

Associated vegetation

Most species associated with *R. auriculata* are common wetland species that frequent open, sunny locations. Sampling of 20 of the known *R. auriculata* sites resulted in the documentation of 139 species of vascular plant associates. According to the National List of Vascular Plant Species that Occur in Wetlands (United States Fish and Wildlife Service 1988), 37 (27%) are obligate wetland species which occur almost always under natural conditions in wetlands; 37 (27%) are facultative wetland species which usually occur in wetlands but are occasionally found in non-wetlands; 42 (30%) are facultative species which are equally likely to occur in wetlands or non-wetlands; and 10 (7%) are facultative upland species that usually occur

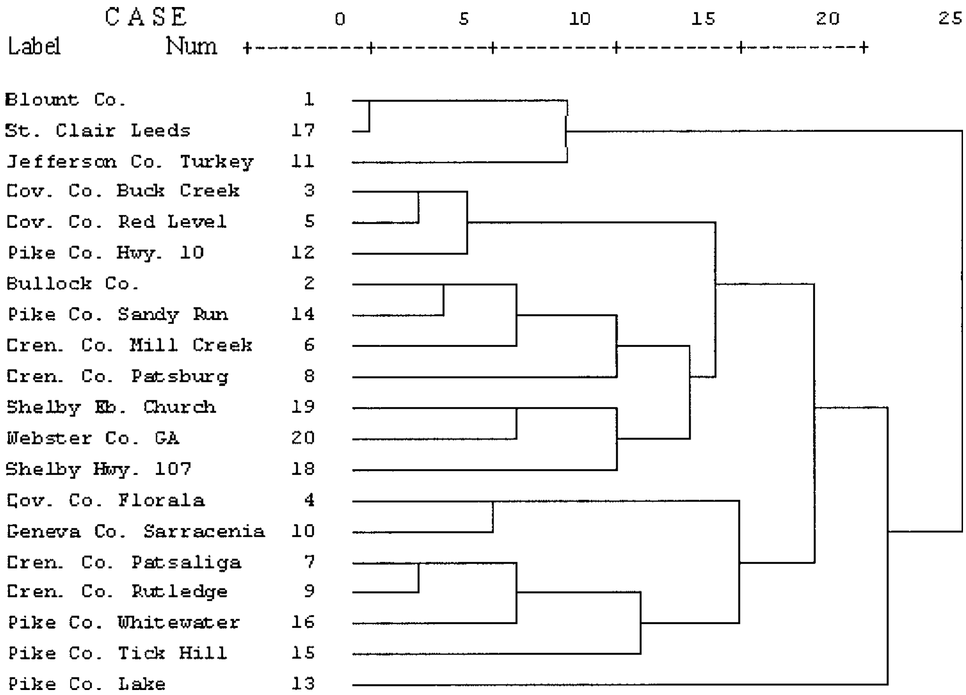

Figure 2. Dendrogram using Average Linkage (Between Groups). Sorensen's Index of Similarity (IS) was used to calculate floristic similarities among the populations and these values were used to generate a hierarchical cluster analysis.

in non-wetlands but are occasionally found in wetlands. Twelve taxa identified during the surveys were not on the wetlands plant list, but of this number three were not determined to species and one was not determined to genus.

A diverse assemblage of mainly wetland plant species resulted from sampling. Sixty-four (46%) of the 139 species collected were found at only one site and another 58 (42%) were found between two and five sites. Thirteen species (9%) were found between six and nine sites. Only three species (2%) were found at 10 or more of the 20 sites. These were *Alnus serrulata* (Ait.) Willd., *Juncus effusus* L., and *Rubus argutus* Link. All three species are widespread in eastern North America (Kartesz 1999) and thus would not serve as indicator species for *R. auriculata*. The 10 species with the highest average percent cover for all sites combined were *Alnus serrulata* (11.9%), *R. auriculata* (9.8%), *Acer negundo* L. (5.9%), *Salix nigra* Marsh. (4.8%), *Juncus effuses* (4.4%), *Clematis virginiana* L. (3.7%), *Leersia oryzoides* (L.) Sw. (3.8%), *Ligustrum sinense* Lour. (3.5%), *Panicum microcarpon* Muhl. ex Ell. (2.5%), and *Rubus argutus* (2.5%). Together they accounted for 52.8% of mean total percent cover. All of these species are classified as shade intolerant (United States Department of Agriculture, Natural Resources Conservation Service 2002a), except for *Acer negundo* which is reported as shade tolerant, *Clematis virginiana* which is reported as intermediate, and *Ligustrum sinense* and *R. auriculata* for which no shade tolerance was reported. These species are also common wetland species and thus would not be good indicators for *R. auriculata* (Godfrey and Wooten 1979, 1981). This diversity of associated species is likely the result of the number of physiographic provinces that *R. auriculata* occupies, the different stages of succession found at each site, and the variety of soil types on which the populations occur.

The species with the 10 highest IVs for sites and quadrats were *Acer negundo*, *Alnus serrulata*, *Clematis virginiana*, *Juncus effusus*, *Juncus validus* Coville, *Leersia oryzoides*, *Ligustrum sinense*, *Rubus argutus*, *Salix nigra* and *Solidago canadensis* L. The index of

Table 3. Soil data from county soil surveys for Alabama sites currently supporting *Rudbeckia auriculata* **populations**

County/Site	Soil Type	pH	General Comments
Covington/ Red Level Richland Creek	Muckalee Series	Strongly to very strongly acidic	Poorly drained soils subject to frequent flooding of brief duraion (USDA 1989)
Covington/Florala	Dorovan Muck	Strongly to very strongly acidic	Poorly drained organic soils subject to frequent flooding for extended periods of time (USDA 1989)
Pike/all sites	Iuka-Kinston Complex	Acidic to strongly acidic	Deep poorly drained soils subject to frequent flooding (USDA 1992)
Geneva/all sites	Ardilla Sandy Loam	Acidic	Deep poorly drained soils (USDA 1977)
St. Clair/all sites	Tanyard Silt Loam	Neutral to strongly acidic	Deep well drained soils of flood plains (USDA 1985)
Shelby/all sites	Tupelo Loam	Medium acidic to moderately alkaline	Deep poorly drained soils along drainage ways in areas underlain by limestone (USDA 1984)

similarity and dendrogram (Figure 2) generally revealed that sites in closest geographic proximity to each other were most similar. The north Alabama sites formed one cluster and the south Alabama and Georgia sites formed another. This would be expected due to the similar soils and vegetation in each region. The only exceptions to this are the two Shelby County sites, which cluster with the south Alabama and Georgia sites (Figure 2). No readily apparent reason seems to exist for their unusual location in the dendrogram, grouping with geographically more distantly located sites.

Non-native species accounted for 7.2% of the total associates (10 species). This figure is lower than the 15 to 20 percent generally reported in county-level floras in Alabama (Diamond and Freeman 1993, Martin et al. 2002, Diamond 2003). Non-native species associated with *R. auriculata* were *Albizia julibrissin* Durz., *Broussonetia papyrifera* (L.) L'Her. ex Vent., *Ligustrum sinense* Lour., *Lonicera japonica* Thunb., *Microstegium vimineum* (Trin.) A. Camus, *Myriophyllum aquaticum* (*Vell.*) Verdc., *Paspalum notatum* Fluegge, *Paspalum urvillei* Steud., *Phyllanthus urinaria* L. and *Verbena brasiliensis* Vell. All 10 of these non-native species are listed on the United States Department of Agriculture, Natural Resources Conservation Service's PLANTS database Invasive Plants List (2001).

Soil analysis

Soil surveys for five Alabama counties containing populations of *R. auriculata* were available. This information is summarized in Table 3. The soils vary considerably, but share the fact that all are hydric and often subject to flooding.

Soil samples collected and sent to the Auburn University Soil Testing Lab revealed great variation in texture, pH, and nutrient content (Table 4). At eight sites the soil texture was loam or light clay. Five of the sites were sandy soils and five were clays or soils high in organic matter. Two of the samples were heavy clays of the Black Belt. Thus, soil texture does not appear to be a significant limiting factor in the distribution of *R. auriculata*. Likewise, pH varied from a low of 4.6 at Bread Tray Hill in Bullock County to a high of 8.0 at Leeds in Jefferson County. Fourteen of the tested sites had soils that were slightly to strongly acidic and six were basic. Based upon these data, pH does not appear to be a limiting factor in the distribution of this species. Extractable nutrient concentration also varied considerably between the sites and no trend or pattern was discernible (Table 4).

Table 4. Soil data from 20 sites currently supporting *Rudbeckia auriculata* populations. Values for phosphorus, potassium, magnesium and calcium are expressed as extractable nutrients (kg/ha)

County	Location	Soil Group*	pH	P	K	Mg	Ca
Covington Co. Alabama	Buck Creek	1	5.8	1.1	7.9	16.8	112.1
	Florala	1	6.5	9.0	38.1	42.6	504.4
	Red Level	2	6.1	3.4	60.5	344.1	1378.6
Geneva Co. Alabama	Sarracenia	1	5.5	5.6	24.7	49.3	762.2
Crenshaw Co. Albama	Mill Creek	2	6.5	7.9	40.4	144.6	1625.2
	Patsaliga River	1	6.2	3.4	11.2	19.1	795.8
	Patsburg	2	7.3	1.1	14.6	178.2	2566.8
	Rutledge	1	6.2	3.4	11.2	19.1	795.8
Pike Co. Alabama	Ala. Hwy. 10	2	5.6	2.2	51.6	76.2	1154.5
	Pike Couny Lake	3	6.4	4.5	124.4	374.4	2914.2
	Sandy Run Creek	2	6.7	3.4	57.2	208.5	1378.6
	Tick Hill	2	5.8	2.2	62.8	137.9	1367.4
	Whitewater Creek	2	6.6	2.2	56.0	170.4	1053.6
Bullock Co. Alabama	Bread Tray Hill	2	4.6	9.0	105.4	57.2	683.7
Webster Co. Georgia	Plains	4	7.8	29.1	195.0	544.7	14503.8
Jefferson Co. Alabama	Leeds	4	8.0	59.4	123.3	764.4	37750.3
	Turkey Creek	3	7.6	13.5	28.0	527.9	3754.9
Shelby Co. Alabama	Hwy. 107	3	7.9	5.5	264.5	1423.5	7218.3
	Ebenezer Church	3	7.8	11.2	70.6	1125.3	7621.8
Blount Co. Alabama	Blountsville	3	5.8	4.5	152.4	192.8	8305.5

* 1. Sandy Soils. 2. Loams and Light Clays. 3. Clays and soils high in organic matter. 4. Clays of the Black Belt.

DISCUSSION

Among the 50 states Alabama is ranked fifth in biodiversity, fourth in number of species at risk and second in total number of extinctions (Stein 2002). With respect to vascular plants, Stein (2002) estimates that 9.4% of the species in Alabama are at risk of extinction with the leading threats being habitat degradation and destruction, and the spread of invasive species. Based upon soil data and associated species, one would expect *Rudbeckia auriculata* to be more common than surveys indicate. It is not restricted to any one soil type, and occurs on soils with pH values ranging from acidic (4.6) to basic (8.0) (Table 4). The plant associates are common widespread wetland species in the southeastern United States, and none were determined to be indicator species. However, of the 32 known populations surveyed in 2002, only 10 contained at least 100 flowering stems. Small populations are especially vulnerable to extinctions caused by local events and to reduction of genetic viability through inbreeding (Oostermeijer et al. 1998). Even in large populations, *R. auriculata* has a relatively low IV and is a minor community component. McDaniel (1981), in his report to the Fish and Wildlife Service, stated that *R. auriculata* can be so abundant as to occur in almost pure stands essentially without any significant associates, but that was not found to be the case in this study. Plot sampling of associated vegetation documented an IV for *R. auriculata* of only 27.3 for quadrats and 15.7 for sites, even though data were collected only from quadrats containing *R. auriculata*.

Why then is *R. auriculata* uncommon? *Rudbeckia auriculata* is not weedy in nature and seems to spread mostly by vegetative means (Schotz 2000). It does not seem to spread rapidly to newly-created openings by way of seed (A. Diamond, pers. obs., Schotz 2000), and thus seed viability and dispersal may be limiting factors. Natural successional trends towards hardwood forest also pose a threat to this species, and the lack of natural disturbance may be a critical limiting factor. Field observations and the reports of other researchers indicate that *R. auriculata* requires some form of disturbance and favors open sunny sites such as roadsides and power line right-of-ways (McDaniel 1981, Schotz 2000). *Rudbeckia auriculata* does not flower and does not persist for long periods when the canopy closes (A. Diamond, pers. obs., Schotz

2000). Kral states that the species "would not survive under the closed canopy of pine plantations" (Kral 1983). Most of the sites now supporting populations would become unsuitable for the continued existence of *R. auriculata* without some form of regular natural or human-caused disturbance.

There are other examples of rare sun-loving taxa in the southeastern United States associated with open roadside habitats (Jones 1994, DeSelm 1989). Campbell et al. (1991) discuss two hypotheses to explain rare taxa being found mostly on roadsides: (1) that the plants invaded the disturbed areas after European settlement, or (2) that the plants are relicts from natural openings maintained by fires. One of the least human-impacted *R. auriculata* sites was Sarracenia in Geneva County, Alabama. This population occurred in a pitcher plant (*Sarracenia leucophylla* Raf.) bog, a habitat maintained in an open sunny state by periodic fire during summer droughts. However, most of the other sites occupied by *R. auriculata* are too wet to burn frequently, occurring on low floodplains and in swampy areas.

Along with windstorms and fire, beavers (*Castor canadensis* Kuhl) were major agents responsible for disturbance in eastern North America (Kaye 1962, Kiviat 1978). Ten of the 32 populations of *R. auriculata* are located near active or abandoned beaver ponds and are subjected to periodic disturbance through the animals' activity (A. Diamond, pers. obs.). Beavers have been shown to increase landscape heterogeneity (Remillard et al. 1987) and perhaps they play a key role in providing early successional habitat essential for *R. auriculata*. Wright et al. (2002) determined that beaver activity increased the number of herbaceous species in the riparian zone by over 33%. The importance of beaver-created habitat has been well documented (Johnson and Naiman 1990, Barnes and Dibble 1988, Whitaker 1988, Wilkinson 1962, Gard 1961). However in Alabama by the late 1800's beavers had been extensively trapped and were extremely scarce. In 1938 the Alabama Department of Conservation estimated that fewer than 500 beavers remained in the entire state (Sievering 1989). Perhaps the current distribution of *R. auriculata* reflects the near disappearance of beavers and the early successional habitat they created. Other forms of natural disturbance may be important at some sites. The calcareous outcrop area in Leeds, St. Clair County, Alabama, is a site with soils too thin to support woody arborescent vegetation and is subjected to frequent scouring from a near-by stream, keeping it in an open sunny condition.

Rudbeckia auriculata is also subject to a variety of other threats including the loss or degradation of its wetland habitat, the use of herbicides along roadsides and power line right-of-ways, and competition from invasive species (Schotz 2000). Half of Alabama's wetlands have been lost since 1780 (New Mexico Center for Wildlife Law 2003). Kral states that the species "would not survive site preparation involving drainage" (Kral 1983). Wetland loss can take the form of draining and conversion for cultivation or housing. The latter occurred to a portion of the Florala site in Covington County, where a home and associated pond were constructed on approximately 10% of the site. Development can also take the form of "improvements" for recreational use, as happened at the Pike County Lake site, where the population was apparently eliminated through repeated short mowing of the bank areas to improve access for fishing. The widening of highways, and the channeling of streams for storm water runoff, pose threats to some of the populations, especially those in or near urban areas that are experiencing rapid population growth (Schotz 2000).

A serious threat to the continued existence of *R. auriculata* is the use of herbicides to maintain roadside and power line right-of-ways, and to prepare sites for loblolly pine plantations. No populations were found on roadside or power line corridors that had been sprayed with herbicide, even though they appeared to be suitable habitat in all other aspects. The sharp limit of populations along roadside and power line corridors at the edge of the range of the sprayers is evidence that the populations were once larger and that some individuals had been eliminated due to herbicide use. Schotz (2000) stated that the disappearance of the Samson site may be due to "advanced forest succession and herbicide application by the state highway department." Infrequent bush-hogging of these areas seems to have no negative effect on the plants if conducted early enough in the year so as not to interfere with flowering. In fact, some disturbance that prevents the encroachment of woody vegetation seems necessary for the survival of this species

(A. Diamond, pers. obs., Schotz 2000). Appropriate management of roadside and power line right-of-way populations may become significant to the survival of the species.

Another potential threat to *R. auriculata* occurs in the form of invasive exotic plant species. Ten species listed on the United States Department of Agriculture, Natural Resources Conservation Service National Plant Data Centers Invasive Plants List (2002b) have become established in certain populations. Of this number, privet (*Ligustrum sinense*) and Japanese stilt grass [*Microstegium vimineum* (Trin.) A. Camus] pose particular threats to *R. auriculata*. Privet forms dense stands in disturbed and natural wetlands in the southeastern United States (Dirr 1983, USDA 2002b). The deep shade produced by the semi-evergreen privet may not only prevent establishment of *R. auriculata* seedlings, but also can suppress the flowering of established plants and may lead to their death (A. Diamond, pers. obs.). Japanese stilt grass forms dense mats in moist areas that can prevent the establishment of native species (Tu 2000). Both of these species are difficult to eradicate from wetlands after they have become established (Tu 2000, USDA 2002b).

Herbivores can significantly influence the abundance of plants, including those species that are rare (Bevill et al. 1999). Damage due to native herbivores was not observed to be a major problem in natural populations of *R. auriculata* during this study. (A. Diamond, pers. obs., Schotz 2000). However, cultivated plants suffered extensive defoliation due to whitetail deer (*Odocoileus virginianus*). Studies have indicated that whitetail deer herbivory may be more severe in small populations than in large ones (Loeffler and Brett 2000, Fletcher et al. 2001). This may become of greater concern in the future when captive propagation and re-introductions may become necessary for the continued existence of this species. The Alabama Department of Conservation and Natural Resources estimate deer densities in excess of 30 animals per 2.59 km^2 in the southern portion of the state (Alabama DCNR 2000). A single whitetail deer can consume between 3.75 and 5.44 kg of plant material daily and Alabama's estimated 2.8 million whitetail deer can therefore consume over 3,810 kilotonnes of food annually, most of which is native plant material (Thomas 2003).

In Crenshaw County, Alabama, where a power line right-of-way crossed a grazed pasture, *R. auriculata* was absent from the pasture yet was abundant just outside the fence. The presence of other tall perennial herbs on the site, such as *Eupatorium* and *Rubus*, indicated that grazing by horses and cows was responsible for the absence of *R. auriculata* in the pasture. Other sites that are located in abandoned or little-used pastures include Sandy Run Creek in Pike County, Alabama, and Hwy 107, Hwy 22, and Dirt Road in Shelby County, Alabama. The possible return of these areas to heavy grazing may threaten these populations in the future and should be monitored.

Most populations of *R. auriculata* are small and occur on unprotected and disturbed sites such as highway right-of-ways and power line corridors. Of the 19 populations visited by Schotz between 1998 and 2000, only two were considered as "excellent" and two as "good" based upon the Nature Conservancy's element occurrence ranking system (Schotz 2000). Most populations remain vulnerable to destruction from human activities. Only three of the 32 known populations occur on public property or protected areas. The Cahaba/Blackwater Land Trust has purchased the Turkey Creek site in Jefferson County, and the Ebenezer Church site in Shelby County is now a part of an ecological preserve managed by the University of Montevallo. The continued existence of these two populations seems secure at this time. However, even when publicly owned, populations may be vulnerable. The Pike County Lake population, now believed to be extirpated due to repeated short mowing, occurred on a public fishing lake owned by the Alabama Department of Conservation.

The Endangered Species Act of 1973 states that endangered or threatened status is based upon the following factors: (1) the present or threatened destruction, modification, or curtailment of a species' habitat or range; (2) overutilization of a species for commercial, recreational, scientific, or educational purposes; (3) disease or predation that cause the decline of a species; (4) the inadequacy of existing regulatory mechanisms to protect a species; (5) other natural or manmade factors affecting a species continued existence (United States Fish and Wildlife Service 2003). Our findings document the lack of increase in most individual population sizes over time, along with the loss of some populations and the modification of the habitat of others. In Alabama, where the majority of the populations of *R. auriculata* occur, no state conservation laws or legislation exist for the protection of native plant species. Alabama does not have an endangered species act, and there are no penalties for taking species listed by the Natural Heritage Program as rare, threatened or endangered (New Mexico Center for Wildlife Law 2003). This lack of existing regulatory mechanisms, coupled with threats from human activities and introduced species and the fact that most populations are small and occur on marginal habitat, causes us to agree with Schotz (2000) that the United States Fish and Wildlife Service should re-evaluate *R. auriculata* and consider providing it some form of formal protection.

LITERATURE CITED

Alabama Department of Conservation and Natural Resources. 2000. White-tailed deer densities in Alabama, 2000. http://www.dcnr.state.al.us/agfd/deerden.html

Alabama Natural Heritage Program. 2001. Inventory list of rare, threatened, and endangered plants, animals, and natural communities of Alabama. Alabama Natural Heritage Program, Montgomery, Alabama.

Barnes, W.J. and E. Dibble. 1988. The effects of beaver in riverbank forest succession. Can. J. Bot. 66:40–44.

Bevill, R.L., S.M. Louda, and L.M. Stanforth. 1999. Protection from natural enemies in managing rare plant species. Conserv. Biol. 13:1323–1331.

Brooks, H.K. 1981. Physiographic divisions map. University of Florida, Institute of Food and Agricultural Sciences, Gainesville, Florida.

Campbell, J.J.N., D.D. Taylor, M.E. Medley, and A.C. Risk. 1991. Floristic and historical evidence of fire-maintained, grassy pine-oak barrens before settlement in southeastern Kentucky. p. 359–375. *In:* Nodvin, S.C. and T.A. Waldrop (eds.). Fire and the environment: ecological and cultural perspectives. Southeastern Forest Experiment Station General Technical Report SE-069, Asheville, North Carolina.

Cartographic Research Laboratory. 1975. Physiographic regions of Alabama as modified by Sapp and Emplaincourt. University of Alabama, Tuscaloosa, Alabama. http://alabamamaps.ua.edu/alabama/physical/al_physio.pdf

Clark, W.Z., Jr. and A.C. Zisa. 1976. Physiographic map of Georgia. Georgia Department of Natural Resources, Atlanta, Georgia.

Cox, P.B. and L.E. Urbatsch. 1994. A taxonomic revision of *Rudbeckia* subg. *Macrocline* (Asteraceae: Heliantheae: Rudbeckiinae). Castanea 59:300–318.

DeSelm, H.R. 1989. The barrens of Tennessee. J. Tennessee Acad. Sci. 64:89–95.

Diamond, A.R. 2003. A checklist of the vascular flora of Pike County, Alabama. Castanea 68:143–159.

Diamond, A.R. and J.D. Freeman. 1993. A checklist of the vascular flora of Conecuh County, Alabama. Sida 15:623–638.

Dirr, M. 1983. Manual of woody landscape plants. Stipes Publishing Co., Champaign, Illinois.

Edwards, A.L. and A.S. Weakley. 2001. Population biology and management of rare plants in depression wetlands of the southeastern coastal plain, USA. Nat. Areas J. 21:12–35.

Elzinga, C.L., D.W. Salzer, and J.W. Willoughby. 1999. Measuring and monitoring plant populations. Bureau of Land Management Technical Reference 1730–1.

Estill, J.C. and M.B. Cruzan. 2001. Phytogeography of rare plant species endemic to the southeastern United States. Castanea 66:3–23.

Fiedler, P.L. 1986. Concepts of rarity in vascular plant species, with special reference to the genus *Calochortus* Pursh (Liliaceae). Taxon 32:502–518.

Fletcher, J.D., L.A. Shipley, W.J. McShea, and D.L. Shumway. 2001. Wildlife herbivory and rare plants: the effects of white-tailed deer, rodents, and insects on growth and survival of Turk's cap lily. Biol. Conserv. 101:229–238.

Gard, R. 1961. Effects of beaver on trout in Sagehen Creek, California. J. Wildlife Manage. 25:221–242.

Gentry, A.H. 1986. Endemism in tropical versus temperate plant communities. p. 153–181. *In:* Soule, M.E. (ed.). Conservation biology: the science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts.

Georgia Natural Heritage Program. 2001. Tracking list of special concern plants of Georgia. http://www.dnr.state.ga.us/dnr/wild/natural/sppl_t.htm

GODFREY, R.K. and J.W. WOOTEN. 1979. Aquatic and wetland plants of the southeastern United States: monocotyledons. The University of Georgia Press, Athens, Georgia.

GODFREY, R.K. and J.W. WOOTEN. 1981. Aquatic and wetland plants of the southeastern United States: dicotyledons. The University of Georgia Press, Athens, Georgia.

JOHNSON, C.A. and R.J. NAIMAN. 1990. Browse selection by beaver: effects on riparian forest composition. Can. J. For. Res. 20:1036–1043.

JONES, R.L. 1994. The status of *Helianthus eggertii* Small in the southeastern United States. Castanea 59:319–330.

KARTESZ, J.T. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland, 2nd ed. 2 volumes. Timber Press, Portland, Oregon.

KARTESZ, J.T. 1999. A synonymized checklist and atlas with biological attributes for the vascular flora of the United States, Canada, and Greenland, 1st ed. *In:* Kartesz, J.T. and C.A. Meacham (eds.). Synthesis of the North American Flora, version 1.0. North Carolina Botanical Garden, Chapel Hill, North Carolina.

KAYE, C.A. 1962. Early postglacial beavers in southeastern New England. Science 138:906–907.

KIVIAT, E. 1978. Bog turtle habitat ecology. Bull. Chicago Herpetol. Soc. 13:29–42.

KRAL, R. 1975. *Rudbeckia auriculata* (Perdue) Kral, a species distinct from *R. fulgida* Ait. Rhodora 77:44–52.

KRAL, R. 1983. A report on some rare, threatened, or endangered forest-related vascular plants of the South. U.S.D.A. Forest Service Technical Publication R8-TP2. 2 volumes.

LOEFFLER, C.C. and W.C. BRETT. 2000. Demographics and deer browsing in three Pennsylvania populations of the globally rare glade spurge, *Euphorbia purpurea* (Raf.) Fern. Castanea 65:273–290.

MARTIN, B. H., M. WOODS, and A.R. DIAMOND. 2002. The vascular flora of Coffee County, Alabama. Castanea 67:227–246.

MCDANIEL, S. 1981. Status report on *Rudbeckia auriculata*. U.S. Fish and Wildlife Service, Endangered Species Office, Region H, Atlanta, Georgia.

MUELLER-DOMBOIS, D. and H. ELLENBERG. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York, New York.

NEW MEXICO CENTER FOR WILDLIFE LAW. 2003. State biodiversity report. http://ipl.unm.edu/cwl/statbio/alabama.html

OOSTERMEIJER, G., L. SHEILA, K. MANJA, B. ELS, and D.N. HANS. 1998. Rare plants in peril: on the problems for small populations. Levende Natuur 99:134–141.

PERDUE, R.W., JR. 1961. A new variety of *Rudbeckia fulgida*. Rhodora 63:119–120.

REMILLARD, M.M., G.K. GRUENDLING, and D.J. BOGUCKI. 1987. Disturbance by beaver (*Castor canadensis* Kuhl) and increased landscape heterogeneity. Ecological Studies: Analysis and Synthesis 64:103–122.

RICKETTS, T.H., E. DINERSTEIN, D.M. OLSON, C.J. LOUCKS, W. EICHBAUM, D. DELLASALA, K. KAVANAGH, P. HEDAO, P.T. HURLEY, K.M. CARNEY, R. ABELL, and S. WALTERS. 1999. Terrestrial ecoregions of North America: a conservation assessment. Island Press, Washington, D.C.

SCHOTZ, A.R. 2000. Status survey on *Rudbeckia auriculata* in Alabama: eared coneflower. U. S. Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C.

SIEVERING, M.E. 1989. Special report number 11: furbearers of Alabama. Alabama Department of Conservation and Natural Resources, Game and Fish Division, Montgomery, Alabama.

STEIN, B.A. 2002. States of the Union: ranking America's biodiversity. NatureServe, Arlington, Virginia. http://www.natureserve.org/publications/statesUnion.jsp

THOMAS, M. 2003. Whitetail deer eat native plants. Alabama Wildlife Federation. http://www.alawild.org.Burning.htm

TU, M. 2000. Element stewardship abstract for *Microstegium vimineum*. The Nature Conservancy's Wildland Invasive Species Program, Department of Vegetable Crops and Weed Sciences, University of California, Davis, California. http://tncweeds.ucdavis.edu/esadocs/documnts/micrvim.pdf

URBATSCH, L.E. and R.K. JANSEN. 1995. Phylogenetic affinities among and within the coneflower genera (Asteraceae, Heliantheae), a chloroplast DNA analysis. Syst. Bot. 20:28–39.

URBATSCH, L.E., B.G. BALDWIN, and M.J. DONOGHUE. 2000. Phylogeny of the coneflowers and relatives (Heliantheae: Asteraceae) based on nuclear rDNA internal transcribed spacer (ITS) sequences and chlorplast DNA restriction site data. Syst. Bot. 25:539–565.

UNITED STATES DEPARTMENT OF AGRICULTURE, NATURAL RESOURCES CONSERVATION SERVICE. 2001. The PLANTS Database, Version 3.1. National Plant Data Center, Baton Rouge, Louisiana.

USDA, NATURAL RESOURCES CONSERVATION SERVICE. 2002a. The PLANTS Database, Version 3.5. National Plant Data Center, Baton Rouge, Louisiana. http://plants.usda.gov

USDA, NATURAL RESOURCES CONSERVATION SERVICE. 2002b. Plant Guide: Chinese Privet. July 16, 2002. http://www.hear.org/pier/pdf/nrcs_plant_guide__ligustrum_sinense.pdf

USDA, Soil Conservation Service. 1977. Soil survey of Geneva County, Alabama. U.S. Government Printing Office, Washington, D.C.

USDA, Soil Conservation Service. 1984. Soil survey of Shelby County, Alabama. U.S. Government Printing Office, Washington, D.C.

USDA, Soil Conservation Service. 1985. Soil survey of St. Clair County, Alabama. U.S. Government Printing Office, Washington, D.C.

USDA, Soil Conservation Service. 1989. Soil survey of Covington County, Alabama. U.S. Government Printing Office, Washington, D.C.

USDA, Soil Conservation Service. 1992. Soil survey of Pike County, Alabama. U.S. Government Printing Office, Washington, D.C.

U.S. Fish and Wildlife Service. 1988. National list of vascular plant species that occur in wetlands. Biological Report 88(24). U.S. Government Printing Office, Washington, D.C.

U.S. Fish and Wildlife Service. 2003. The endangered species act of 1973. http://endangered.fws.gov/esa.html#TOP

Whitaker, J.O., Jr. 1988. The Audubon Society field guide to North American mammals. Alfred A. Knopf Publishers, New York, New York.

Wilkinson, P.M. 1962. A life history study of the beaver in East-Central Alabama. Masters thesis, Auburn University, Alabama.

Wright, J.P., C.G. Jones, and A.S. Flecker. 2002. An ecosystem engineer, the beaver, increases species richness at the landscape scale. Oecologia 132:96–101.

Received August 24, 2003; Accepted January 15, 2004.