Recovery Plan for
Spigelia gentianoides
(Gentian pinkroot)

S. gentianoides var. *gentianoides, Geneva State Forest, Alabama.*

S. gentianoides var. *alabamensis, Bibb Co., Alabama.*

Recovery Plan

for

Spigelia gentianoides
(Gentian pinkroot)

Prepared by

Vivian Negron-Ortiz
Panama City Field Office, Florida
U.S. Fish and Wildlife Service
Panama City, Florida

for

U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

January 2012

Approved: _____

Acting Regional Director, U.S. Fish and Wildlife Service

Date: January 24, 2012

DISCLAIMER

Recovery plans delineate reasonable actions that are believed to be required to recover and/or protect listed species. Plans published by the U.S. Fish and Wildlife Service (Service) are sometimes prepared with the assistance of recovery teams, contractors, State agencies, and other affected and interested parties. Plans are reviewed by the public and submitted for additional peer review before they are adopted by the Service. The objectives of the plan will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not obligate other parties to undertake specific tasks and may not necessarily represent the views or the official positions or approval of any individuals or agencies involved in the plan formulation, other than the Service. Recovery plans represent the official position of the Service only after they have been signed by the Regional Director as approved. Approved recovery plans are subject to modification as dictated by new information, changes in species status, and the completion of recovery actions.

By approving this recovery plan, the Regional Director certifies that the data used in its development represent the best scientific and commercial information available at the time it was written. Copies of all documents reviewed in the development of the plan are available in the administrative record, located at the Panama City Field Office in Panama City, Florida.

Literature Citation:

U.S. Fish and Wildlife Service. 2012. Recovery Plan for *Spigelia gentianoides* (Gentian pinkroot). Atlanta, GA. 60 pp.

Additional copies may be obtained from:

U.S. Fish and Wildlife Service
Panama City Field Office
1601 Balboa Avenue
Panama City, FL 32405-3721
Telephone: 850-769-0552

Recovery Plans can be downloaded from the U.S. Fish and Wildlife Service website:
http://www.fws.gov/endangered/species/recovery-plans.html

Cover photos of gentian pinkroot by V. Negrón-Ortiz, USFWS.

ACKNOWLEDGEMENTS

The U.S. Fish and Wildlife Service gratefully acknowledges the following individuals for their commitment and efforts toward the recovery of *Spigelia gentianoides*.

Mr. W. Wilson Baker
Biological Consultant
Tallahassee, Florida

Mr. Angus Gholson
Botanist
Chattahoochee, Florida

Mr. Gary Knight, Director
Florida Natural Areas Inventory
Tallahassee, Florida

Ms. Amy Jenkins, Botanist
Florida Natural Areas Inventory
Tallahassee, Florida

Mr. Chris Mead, Manager
Alabama Forestry Commission
Geneva State Forest, Alabama

Mr. Brian Martin, Botanist
The Nature Conservancy, Alabama

Dr. James Affolter, Professor
The State Botanical Garden of Georgia
Athens, Georgia

Dr. David L. Gorchov, Professor
Miami University
Oxford, Ohio

Dr. Katherine Mathews, Associate Professor
Department of Biology, Western Carolina University, Cullowhee, North Carolina

Ms. Tova Spector
Florida Park Service
Department of Environmental Protection
Panama City, Florida

U.S. Fish and Wildlife Service

Ms. Janet Mizzi, Southeast Region
Ms. Kelly Bibb, Southeast Region

Dr. Donald Imm, Ms. Patty Kelly, Mr. Paul Lang, and Ms. Lorna Patrick
Panama City Field Office
1601 Balboa Ave.
Panama City, Florida 32405

EXECUTIVE SUMMARY

CURRENT SPECIES' STATUS: *Spigelia gentianoides* (gentian pinkroot) is a narrow endemic plant in the Family Loganiaceae. It was federally listed as an endangered species under the Endangered Species Act of 1973, as amended, on November 26, 1990 (55 FR 49046) and listed as endangered in the State of Florida under the Preservation of Native Plant Flora of Florida Act (Rule: 5B-40.0055, Section 581.185-187). It is not protected in the State of Alabama. At the time of federal listing, only three populations from Florida were known. Currently, this species comprises two varieties: *S. gentianoides* var. *gentianoides*, known from only five populations located in Jackson and Calhoun counties (Florida) and Geneva County (Alabama); and *S. gentianoides* var. *alabamensis*, restricted to the Bibb County Glades (Alabama). The plant is found on both public and private lands. The species has a recovery priority number of 2, which indicates a species with a high degree of threat and a high recovery potential.

HABITAT REQUIREMENTS AND LIMITING FACTORS: *Spigelia gentianoides* is a small herbaceous plant found in fire-dependent ecosystems. Variety *gentianoides* is restricted to longleaf-wiregrass, pine-oak-hickory woods, and in open space within forests (glades) of Florida and Alabama, whereas var. *alabamensis* is only found in open areas within woodlands (glades) of Bibb County, Alabama. The primary threat to gentian pinkroot is habitat loss and alteration. Factors contributing to this threat include clearcutting and/or selective thinning, mechanical site preparation, conversion of land to pine plantations, disruption of fire regimes, and permanent habitat loss through development (Appendix 1).

RECOVERY STRATEGY: The first step toward recovering this plant is to protect and stabilize the current populations. A strong focus on surveying for additional undocumented populations is imperative, specifically on sites managed with prescribed fire. Surveys should include areas between Bibb Co., Alabama and northern Florida. The maintenance of the current *ex-situ* populations will help maintain germplasm and will be useful for re-establishing viable populations within the species' former natural habitat and range (e.g., extirpated sites). Effective population management will require gaining knowledge about the life history of the species and the functioning of the ecosystem on which it depends. Therefore, research and monitoring are key components of the recovery strategy. Monitoring will provide critical information including

practices that potentially affect the species viability. Studies on reproductive and seed ecology as well as life history and life expectancy investigations will provide essential information important for the long-term survival of the species, to establish effective management protocols, to determine the minimum viable population size (MVP; Shaffer 1981), and for reintroduction.

RECOVERY GOAL: The goal of this plan is to conserve and recover gentian pinkroot, allowing initially for reclassification to threatened status, and ultimately removing the species from the Federal List of Endangered and Threatened Plants, i.e., delisting. Defining reasonable delisting criteria is not possible at this time given the current low number of populations and individuals, the lack of information about the species' biology, and the magnitude of current threats from development. Therefore, this recovery plan establishes downlisting criteria for *S. gentianoides* so that it may be downlisted to threatened status. Downlisting criteria will be reevaluated and delisting criteria will be created as new scientific data and information become available and recovery actions are implemented.

RECOVERY CRITERIA: The recovery of *S. gentianoides* is challenging because our knowledge about the species biology is limited. Surveying, monitoring, conducting demographic studies, improving management protocols including the establishment of fire management regimes, and securing extant populations are the most immediate priorities.

Downlisting of *S. gentianoides* from endangered to threatened status will be considered when: (1) extant populations and newly discovered sites are identified and mapped; (2) inventories (i.e., the total number of individuals, number of flowering vs. non-flowering plants, presence of pollinators, and whether seedling recruitment is occurring) have been conducted across the species historic sites and/or on new locations; (3) monitoring programs and management protocols on selected populations (e.g., populations with largest number of individuals) are established for at least 15 years to track threats to the species and habitat (e.g., control exotic species, minimize site disturbance, urban development); (4) the extant populations (including subpopulations at the Ketona Glades, Bibb Co., Alabama) located on public land are stable[1] for at least 15 years; (5) the minimum viable population has been determined for each variety using population viability analyses (PVA); (6) research on key aspects related to demography (e.g.,

[1] Stable population: a population where fertility and mortality are constant.

density, effect of fire on seedling establishment), reproductive biology, and seed ecology is accomplished; (7) viable germplasm representing > 50% of the populations for each variety is maintained *ex-situ*. In addition, the following specific actions are completed for each variety:

Var. *gentianoides*: (1) sizes of populations # 1 to # 4 (Table 3) are increased via prescribed burns until plant numbers are stabilized over a period of 15 years; (2) at least one new population is found, and 3) at least one population is re-established within the historic range, specifically in the sites where the plants are currently known to be extirpated.

Var. *alabamensis*: (1) 50 % of the Bibb Co. glades known to support the variety on private land are protected through conservation agreements, easements, or land acquisition.

ACTIONS NEEDED:

1. Protect, manage, and secure existing populations and habitat.
2. Conduct surveys/inventories.
3. Establish new occurrences within the historic range of var. *gentianoides,* specifically in the sites where the plants are known to be extirpated.
4. Maintain the species *ex-situ* in a protected facility.
5. Conduct research and long-term monitoring on known populations
6. Facilitate the recovery of *S. gentianoides* through public awareness, outreach, and education.
7. Review and track recovery progress.

ESTIMATED COST TO DOWNLIST TO THREATENED: The estimated cost to implement recovery actions over the next five years is approximately $367,500 (Table 1). As new information is gained on this plant and we are able to establish delisting criteria, we will further define reasonable costs to recovery.

Table 1. Estimated Cost of Recovery (in $1000s) for five years.

Year	Action 1	Action 2	Action 3	Action 4	Action 5	Action 6	*Total*
1	14	45	5	3	75	1	143
2	10	35	10	3	55	1	114
3	7	16	5	3	18	1	50
4	3	7	3	3	16	1	33

5	2.5	7	2	1	14	1	27.5
Total	36.5	110	25	13	178	5	***367.5***

ESTIMATED DATE TO DOWNLIST TO THREATENED: it is estimated that *S. gentianoides* will be eligible for downlisting in 2027.

Table of Contents

APPENDICES

LIST OF TABLES

LIST OF FIGURES

I. BACKGROUND

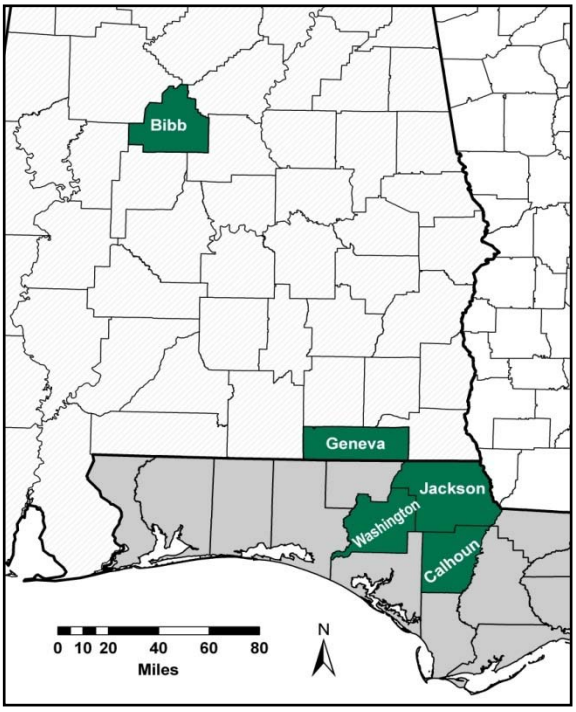

Fig. 1. Location of counties in Florida and Alabama with known populations of *S. gentianoides* (green). The Washington County population is thought to be extirpated.

This recovery plan for *Spigelia gentianoides* Chapman ex A. de Candolle (gentian pinkroot), an endangered plant that is known from a few counties in Florida and Alabama (Fig. 1), provides information on the species' biology, distribution, status, and threats, and outlines strategies and actions needed to help recover gentian pinkroot.

A. LISTING HISTORY AND RECOVERY PRIORITY

The U.S. Fish and Wildlife Service listed *Spigelia gentianoides* as an endangered species under the Endangered Species Act (Act) of 1973, as amended, on November 26, 1990 (55 FR 49046). The Secretary of the Interior is responsible for administering the Act's provisions as they apply to this species. Day-to-day management authority for endangered and threatened species under the Department's jurisdiction has been delegated to the Service. To help identify and guide species' recovery needs, section 4(f) of the Act directs the Secretary of the Interior to develop and implement recovery plans for listed species or populations. Such plans are to include: (1) a description of site-specific management actions necessary to conserve the species or population; (2) objective measurable criteria which, when met, will allow the species to be removed from the list of threatened and endangered species; and (3) estimates of the time and funding required to achieve the plan's goals and intermediate steps. The State of Florida also affords the species endangered status (Rule: 5B-40.0055, Section 581.185-187). The plant is not protected in the State of Alabama. The recovery priority number designated for this species is a 2 on a scale of 1 (highest) to 18 (lowest).

This ranking is based on the high threat of extinction due to habitat destruction, high recovery potential, and its status as a species.

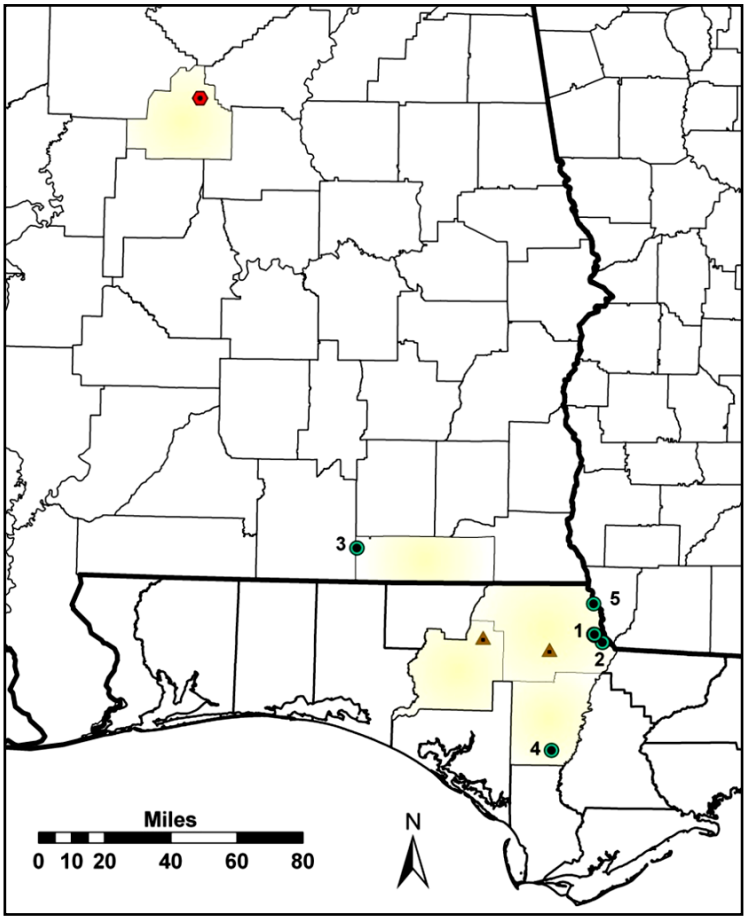

Fig. 2. Location of *S. gentianoides* populations in Florida and Alabama. (red hexagon) Var. *alabamensis*, Bibb County; (orange triangles) Extirpated populations of var. *gentianoides* in Washington and Jackson counties; (green circles) Extant populations of var. *gentianoides* in Jackson, Calhoun, and Geneva counties. Numbers represent population sizes from high (1) to low (5), see Table 3.

At the time the species was listed, only three populations were known in Florida. Additional populations have been found since then in Florida; two sites are considered to be extirpated and new findings have extended the species range into Alabama. In addition, two varieties[2] have been recognized (Gould 1996; Figs. 1 & 2): *Spigelia gentianoides* var. *gentianoides* (hereafter var. *gentianoides*) restricted to five locations within three counties in the Florida Panhandle and southern Alabama, and *S. gentianoides* var. *alabamensis* K. Gould (hereafter var. *alabamensis*) limited to Bibb County, Alabama (Weakley 2007; Figs. 1 & 2). The populations are located on both public and private lands. The extant plants of var. *gentianoides* (Figs. 3A & 4A, Table 3) are located in fire-dependent longleaf pine-wiregrass and pine-oak-hickory ecosystems (Fig. 6). Since much of this habitat has been altered (e.g., reduced in its range, and/or converted to

[2] Variety: a low-level taxonomic rank below that of species; a group of plants within a species distinctive and unique from each other often geographically separated, but still capable of interbreeding.

pine plantation (an action that causes severe soil disturbance) and managed without fire), the loss or alteration of habitat (Appendix 1) is thought to be the primary reason for the species decline. Canopy shading, since the plant appears to prefer partially open canopies (Fig. 6; Negrón-Ortiz, pers. obs.), is assumed to negatively affect this variety.

Variety *alabamensis* (Figs. 3B & 4B) is a narrow endemic restricted to the Bibb County Glades[3], Alabama (Figs. 2, 5, & 7). In this county, the variety is found in 17 out of 40 glades. Some of the 17 glades are owned and protected by The Nature Conservancy (TNC). This variety is threatened by potential development of privately owned glades.

B. SPECIES DESCRIPTION AND TAXONOMY

Fig. 3. Growth habit of *S. gentianoides*. ***A***. Variety *gentianoides*, Calhoun Co., Florida. **B**. Variety *alabamensis*, Bibb Co., Alabama. Photos by V. Negrón-Ortiz, 2008.

Spigelia gentianoides is a perennial herb belonging to Loganiaceae, a family mainly distributed in the tropics and subtropics. This species was first collected in north Florida by Alvan Wentworth Chapman in 1837, probably from the west side of the Apalachicola River, in either Jackson or Calhoun counties. He identified the plant as *S. floridana*, later Alphonse de Candolle (1845) established the current epithet, *S. gentianoides*. The holotype specimen, which was transferred from Chapman to Asa Gray to Edmond Boissier and later to de Candolle, is in the

[3] Glades: open, almost treeless areas within woodland.

Fig. 4. Flowers of *S. gentianoides*. **A**. Var. *gentianoides*, Geneva State Forest, Alabama. Photo by V. Negrón-Ortiz, 2007. **B**. Var. *alabamensis*, Bibb Co., Alabama. Photo by J. Affolter.

Conservatoire et Jardin botaniques de la Ville de Genève (G; Geneva, Switzerland) (K. Wurdack, Smithsonian Institution, 2005, pers. comm.).

This small herbaceous species possesses a single, erect, sharply ridged stem 10-30 centimeters (cm) (3.9-11.8 inches (in.)) long. The leaves are opposite, sessile, and in pairs at right angles to the next set of leaves. The leaves are largest at the top of the stem, 3-5 cm long, with lower leaves smaller. Flowers are borne in a short, few-flowered, terminal, determinate cyme. The flower consists of a narrow corolla tube of about 2.5-5 cm long (Table 2), with five triangular lobes (Figs. 3 & 4), each 5-6 mm long. The corolla is pale to dark pink; slightly darker at the margins of the lobes for the var. *gentianoides* (Fig. 4A). The stamens are within the flower (Kral 1983), and the pollen grains are deposited along the bristles of the style (secondary pollen presentation; Affolter 2005; Negrón-Ortiz 2007, pers. observ.). At anthesis[4], the corolla lobes of var. *gentianoides* are partially open (Fig. 4A), occasionally fully reflexed; whereas the corolla lobes of var. *alabamensis* are always fully reflexed (Fig. 4B). The green sepals are 4-6 cm long. The fruit is a capsule with two conspicuous round lobes. Peak flowering season occurs between May and June, however, plants have been seen flowering as early as April and as late as October. In a greenhouse, individual flowers last 2 to 5 days before wilting (Affolter 2005). Most seeds can be collected in June or July.

As previously mentioned, the var. *gentianoides* was described in 1887, whereas the var. *alabamensis* was first found in 1992 by James R. Allison (Georgia Natural Heritage

[4] Anthesis: the period during which a flower is fully open and functional.

Program, Georgia Department of Natural Resources) with Timothy Stevens, Jim Rodgers, and Debbie Rodgers while exploring the Little Cahaba River in Bibb County, Alabama. This discovery led to a careful survey of the barrens by Allison and his collaborators, including Chris Oberholser and Scott Gun of the Alabama Natural Heritage Program. The USDA Soil Conservation Service provided assistance in locating additional glades with the use of aerial photographs. The plants were found at 17 Ketona[5] Glade locations, with plant populations totaling several thousand individuals (http://www.eztow.trailer.com/supergraphics/enhanced.aspx?site_id=27&sort_order=1). This variety was later described by Gould (1996). The taxonomic ranking was based on morphological differences in the leaf shape and floral traits, and more obviously, by the number of flowers per inflorescence (Affolter 2005) and the behavior of the corolla lobes at anthesis (Fig. 4; Table 2). Floral morphological differences were maintained when both varieties were grown in a common greenhouse (Affolter, 2007, pers. comm.), thus these varieties are good taxonomic taxa[6], and possibly could represent two different species.

Table 2. Morphological characters distinguishing both varieties of *S. gentianoides*.

Characters	Varieties of *Spigelia gentianoides*	
	alabamensis	***gentianoides***
Leaves	Lanceolate to elliptic	Broadly ovate
# of flowers/inflorescence	2-4	3-8
Corolla length	36-50 mm	25-30 mm
Corolla lobes at anthesis	Reflexed	Barely open or not reflexed

Electrophoretic studies indicated that the genetic identity between these two varieties is high. The Florida sample used in the study, presently growing at the Bok Tower Garden (BTG), Lake Wales, FL, from seeds collected at Calhoun County, was composed of a subset of the genetic variation found in the *alabamensis* populations (Affolter 2005).

SPECIES RELATIONSHIPS. DNA sequences of the Internal Transcribed Spacer of nuclear ribosomal DNA suggested that gentian pinkroot and *S. marilandica* (L.) L. (pinkroot,

[5] Ketona: deep, poorly drained, slowly permeable soils that formed in alluvium and residuum from limestone (http://ortho.ftw.nrcs.usda.gov/osd/dat/K/KETONA.html)

[6] A good taxon has predictive values: can predict many of its characteristics, including those that were not considered when the taxon was originally described (www.herbarium.usu.edu/teaching/4420/planttaxonomy.htm)

Indian pink, worm-grass) are sister species (Gould and Jansen 1999), although floral morphology and growth habits are quite distinct. *Spigelia marilandica* is a widespread species that grows in clumps rather than as single stems and has longer (3.5-5.5 cm) tubular, bright red flowers (Kral 1983), apparently pollinated by the ruby-throated hummingbird (*Archilochus colubris*). The two species, however, have similar vegetative characters, which may have generated taxonomic problems related to species recognition when the collected specimen was not fertile. At present, A. Hershberger (graduate student, University of Georgia) is determining the genetic diversity between populations of *S. marilandica*, *S. gentianoides* var. *alabamensis*, and *S. gentianoides* var. *gentianoides* with the goal of understanding of how closely related the above species are.

C. POPULATION TRENDS AND DISTRIBUTION

Spigelia L. is a genus composed of about 50 herbaceous and/or shrubby species, mostly distributed in the Neotropics. Five species including two varieties are found in the eastern United States with four occurring in Florida. *Spigelia marilandica*, located in the Southeast throughout 17 states, occurs in eight Florida panhandle counties (Clewell 1985, Wunderlin et al. 1980). The West Indian pinkroot, *S. anthelmia* L., occurs in four south Florida counties, and its distribution extends to Puerto Rico and the Virgin Islands. *Spigelia loganioides* (Torr. & A. Gray ex Endl. & Fenzl) A. DC. (Levy pinkroot, Florida pinkroot), a State endangered species endemic to central Florida, consists of 10 populations, six of which occur within protected state parks and preserves.

SPIGELIA GENTIANOIDES* VAR. *GENTIANOIDES is restricted to four counties west of the Apalachicola River, including Washington, Calhoun, and Jackson counties in Florida, and Geneva County in Alabama (Figs. 1 & 2). The Washington County population in Rock Hill Preserve was documented based on a herbarium specimen collected in 1941. This population was revisited in 2005 (B. Martin, 2005, pers. comm.) but plants were not located, consequently it is thought to be extirpated. Additionally, one of the four populations in Jackson County is also considered to be extirpated (Fig. 2). Historically, the site was a pine hardwood upland forest, but when surveyed in 2000 consisted of a few

larger trees with no mid-story or ground cover. Liberty and Levy counties were included as part of *S. gentianoides* distribution (Wunderlin et al.1980), but the collection was determined to be *S. loganioides* (Wunderlin, 2005, pers. comm.).

HERBARIUM COLLECTION. Dr. Alvan Chapman, notable for his *Flora of the Southern United States,* discovered and described gentian pinkroot. Seven of Chapman's collections are housed at the Herbarium of The New York Botanical Garden (NYBG); one is at the U.S. National Herbarium (Smithsonian Institution), one is at G (Geneva, Switzerland), and another at Grey Herbarium (Harvard University). Dr. Kenneth Wurdack (Botany Department, Smithsonian Institution) found an incorrect date and an unreliable locality on one specimen labeled as "Quincy. 1836, not seen since" (55 FR 49046). Wurdack (B. Martin, 2005, pers. comm.) believed that Chapman lived in Quincy during that time and that he was referring to his place rather than the locality of the plant. Wurdack also stated that the phrase "1836, not seen since" and the locality were written on the label at different times.

The finest collection of gentian pinkroot is at the British Museum of Natural History [London, England; Wurdack (B. Martin, 2005, pers. comm.)]. These were collected by Ferdinand Rugel, a field botanist who primarily collected in the Southern Appalachians, Florida, and Cuba in the late 1830s. In August of 1843, he collected a specimen near Mount Vernon (an old name for Chattahoochee, on bluffs east of the Apalachicola River, Gadsden County), which is housed at NYBG (Wurdack, 2005, pers. comm.). Three Rivers State Park (hereafter Three Rivers) is just across the river from Chattahoochee and could plausibly be the site of Rugel's collection since Gary Knight (B. Martin, 2005, pers. comm.) observed var. *gentianoides* in 1982 at Three Rivers near the site of Rugel's collection.

Specimens were collected during the 1940s and 1950 at locations in Chipley, in Washington County, and in "oak pine clay upland" 8 miles north of Wewahitchka, Calhoun County [collected by Ford # 3331, 1954 (FLAS)]. Wilson Baker, a retired botanist, observed var. *gentianoides* in Calhoun County in 1988 at a site purchased by

TNC in 2002, possibly the same site or near the site where Ford found the plant in 1954. The Calhoun County population is south of Blountstown and north of Wewahitchka, in pineland flatwoods with sparse wiregrass (*Aristida stricta*). With the exception of the buffer strip along the road, the site has been in silviculture, and the trees were cut in 1988 and re-planted in slash pines in 1989. Flowering plants were located when the area was revisited in 1989, and have been sporadically surveyed since 2006 by the MacClendon TNC volunteers.

From 1953 to 1956, T.H. Hubbell, A.M. Laessle, and J.C. Dickinson Jr. completed field surveys for the pre-impoundment of Lake Seminole, supported in part by grants from the U.S. National Park Service and the National Science Foundation. The author's description of the vegetation for Tan Vat Hill on the east side of Florida Highway 126, about 3 miles north of the junction of Highway 126 and U.S. Highway 90, Jackson County, Florida included *S. marilandica* and *S. gentianoides*. According to Angus Gholson, Tan Vat Hill is what is known today as Three Rivers.

Several specimens of var. *gentianoides* were collected from Jackson County near Oakdale in the1970s (http://www.gilnelson.com/PanFlora/). The site was recently revisited, and the population is believed to be extirpated (B. Martin, 2005, pers. observ.). Dr. Robert Kral collected a specimen 4.5 miles south of Cottondale, Jackson County, Florida in 1976. Kral and George Rogers revisited the site in 1988, finding about 30 plants in a remnant of pine-oak woods surrounded by a cleared and highly disturbed area containing mixed loblolly (*Pinus taeda*), longleaf pines (*P. palustris*), southern water oaks (*Quercus nigra*), laurel oaks (*Q. hemisphaerica*), southern red oaks (*Q. falcata*) and blackgum (*Nyssa sylvatica*), and an understory that included flowering dogwood (*Cornus*), and blueberry (*Vaccinium*). This population appeared to be extirpated as the plants were not found by Jim Allison and Angus Gholson when the site was revisited in 1993 (B. Martin, 2005, pers. comm.).

In 1999, John MacDonald, a graduate student at Mississippi State University, discovered a population of var. *gentianoides* in Geneva State Forest, Geneva County, Alabama,

extending its distribution and habitat type. The site in Alabama is approximately 70 miles from the other extant populations.

POPULATIONS. To date, only five extant populations of var. *gentianoides* have been documented and will be described in this section (Table 3). One of the largest populations is located in Jackson County, Florida at Apalachee Wildlife Management Area (Apalachee WMA; Table 3). Apalachee WMA consists of about 8,000 acres alongside the Chattahoochee River and Lake Seminole, three miles north of Sneads. This area is managed by the Florida Fish and Wildlife Conservation Commission (FFWCC) in cooperation with the U.S. Army Corps of Engineers. This population, recently discovered in June 2007 by biologist Nathan Bunting and surveyed by Florida Natural Areas Inventory's (FNAI) staff and a FWS botanist, is composed of more than 1,700 individuals in two element occurrences or subpopulations (Jenkins and Diamond 2007). These subpopulations were located in two distinct areas in pine-oak-hickory woods habitat.

Table 3. Var. *gentianoides* populations, number of individual plants and the County.

Population	No. of Individuals	Date	Location	County, State
1	1,746	2007	Apalachee WMA	Jackson, FL
2	< 400/600-800	2010/2011	Three Rivers State Park	Jackson, FL
3	400	2007	Geneva Sate Forest	Geneva, AL
4	32/78	2009/2005	Calhoun *Spigelia* Preserve	Calhoun, FL
5	3	2006	Guy Anglin property	Jackson, FL

A second large population is also located in Jackson County, Florida at the Three Rivers (Table 3). The population was found to be less than 400 in 2010. A survey in 2011 estimated the population at 600-800 individuals with each cluster counted and estimated (T. Spector, 2011, pers. comm.). The Three Rivers, comprised of 670 acres managed by the Florida Park Service of the Florida Department of Environmental Protection, is situated on the western bank of Lake Seminole just above the Jim Woodruff Dam on the Chattahoochee/Apalachicola River. It consists of pine oak mixed woods, but historically it might have consisted of longleaf pine (*Pinus palustris)* with scattered hardwoods and a glade. Fire was reintroduced as part of management in 1974 and has been implemented at a frequency of 1 to 6 years (C. Hawthorn, 2005, pers. comm. to B. Martin). According to T. Spector (2011, pers. comm.), observations have indicated that the population of var.

gentianoides decreases during the first growing season post-burning, but increases after the second growing season; however, the long-term effect of fire is unknown.

The third largest population is found in Geneva County, Alabama within Geneva State Forest (Forest; Table 3). The forest encompasses 7,120 acres and has several well established stands of mature longleaf pines. Timber production is the primary goal for the forest with wildlife and recreation as secondary objectives. The forest is managed using prescribed fire. In the early 1930s, Jackson Lumber Company donated the land, which is now Geneva State Forest, to the State of Alabama. Prior to state ownership Jackson Lumber Company extensively cleared timber from the land. The Civilian Conservation Corps replanted most of the forest, allowing some areas to regenerate naturally. There are approximately 400 *S. gentianoides* plants located in the Forest according to surveys conducted on June 2005 and July 2007 by FWS biologists. The site contains mature longleaf pine at approximately 80 ft^2 /acre of basal area (C. Mead, June 2005, pers. comm.). The site containing gentian pinkroot was burned in May 2005, the first time that prescribed fire has been implemented within a population of *S. gentianoides* during the growing season. The plants responded well to the fire and flowering took place approximately 7-8 weeks after the burn (C. Mead, June 2005, pers. comm.).

Located in Calhoun County, Florida, the fourth population of var. *gentianoides* is on a site owned by TNC. This 32.5 acre site was purchased from the St. Joe Company and the FWS provided funding to manage the site with prescribed fire in September of 2002. This site was described as having 30 plants in 1988. The site was bedded and timbered by prior owners with the exception of a small buffer strip along S.R. 71 where remnants of longleaf pine still persist. The population was larger prior to TNC acquisition; however, just before acquisition the timber company thinned the area disturbing the ground. Fire management practices and reduced soil disturbance were implemented by TNC. TNC has conducted three prescribed winter burns on the property since acquisition, the most recent in June 2008. A 2005 survey conducted after a winter burn documented a total of 78 plants, 76 of which were in flower. Subsequent 2006 and 2009

surveys found only 33 and 32 plants, respectively (Russo 2006, FWS Panama City Florida (PCFL) botanist 2009 survey).

The last known site for this variety contains only three plants. Guy Anglin purchased a property north of Jackson County approximately 10 miles north of the Three Rivers in 1997 (B. Martin, 2005, pers. comm.). The site, believed to be clear-cut in 1993, is thought to be historically longleaf pine hardwood mix, similar to that of the nearby Three Rivers. An agreement with the State of Florida and the owner was established under the Service's Landowner Incentive Program (LIP) to enhance and restore the property to a more natural system.

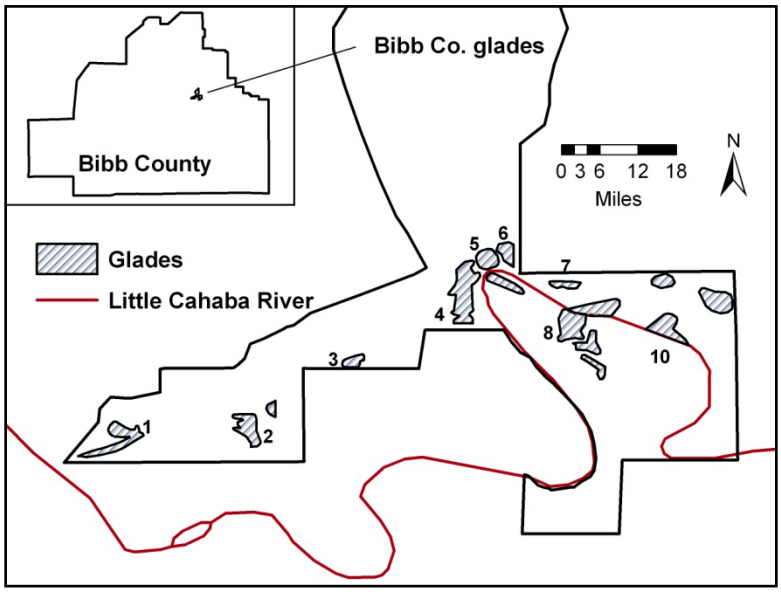

Fig. 5. Map of Bibb County Glades, Bibb Co., AL**,** showing the locations of a few glades. Numbers were provided by TNC.

SPIGELIA GENTIANOIDES **VAR.** ***ALABAMENSIS*** is located at the Bibb County Glades (Fig. 5), the most biologically diverse area known in the state of Alabama (http://www.nature.org/wherewework/northamerica/states/alabama/preserves/art902.html). The glades contain 61 rare plant species with eight of the species (including this variety) restricted only to the Glades. The Nature Conservancy purchased 480 acres and created the Kathy Stiles Freeland Bibb County Glades Preserve in 1996. According to K. Tassin (Director of Science and Stewardship, TNC, 2011, pers. comm.), they own and protect about a dozen larger glades and some smaller glades. The preserve is being managed and protected at the ecosystem level (B. Martin, 2007, pers. comm.). Strategies include the control of visitor use, restoration, prescribed burning, monitoring and inventory.

The plants of this variety, found at 17 Ketona Glade locations, are abundant. However, no inventory exists to estimate the total number of individuals present at all of these glades. During a recent visit to the glades in 2008, Negrón-Ortiz and collaborators estimated 3,653 plants for four glades (Table 4, Fig. 5) using belt transects and covering approximately 85 to 90% of each glade.

Table 4. Number of var. *alabamensis* plants found in four glades in Bibb Co., Alabama in 2008

Glade number	Total	Flowering
3	1,527	56
4	1,232	46
5	768	17
7	126	2
Total	**3,653**	**121**

D. LIFE HISTORY AND ECOLOGY

Knowledge of the life history and ecology of var. *gentianoides* is limited; however, the var. *alabamensis* has been more extensively studied by Affolter (2005). This section includes information obtained from his studies, and inferences based on his data are applied to var. *gentianoides*.

Spigelia gentianoides' peak flowering season, which coincides with rainfall, is from May to July (Gould and Jansen 1999), but a few flowers can be seen as early as April and as late as mid-October (Affolter 2005). Prior to floral anthesis, anthers of var. *alabamensis'* dehisce[7] on the short bristles of the style (Affolter 2005). Therefore, pollen is presented on a structure other than the anther, a mechanism called secondary pollen presentation. This mechanism appears to also be present in var. *gentianoides* (Negrón-Ortiz, 2007 pers. observ.). Hand pollination experiments suggested that the var. *alabamensis* is capable of both self-fertilization and outcrossing; therefore, consequently it possesses a mixed mating system. However, slightly higher seed production occurred within the outcrossing treatment. Treatments have not been conducted for the var. *gentianoides*.

[7] Dehisce: open at definite places, discharging seeds, pollen, or other contents.

Secondary pollen presentation, also reported for other species of *Spigelia* (Erbar and Leins 1999), is a mechanism that promotes outcrossing; therefore, visitors are required to perform pollination. Affolter (2005) observed about 25 insect visitors on the Alabama variety, including a green swallowtail butterfly (*Battus philenor*) and a large bee fly (*Bombylius* spp.), and Rogers (1988) documented visitors such as bumblebees, ants, beetles, and a moth. At the Geneva State Forest population small Halictidae bees (sweat bees) were observed entering and exiting the flower of the var. *gentianoides*. Visitors have not been observed at the BTG *ex situ* population, which is understandable given that the historical range of the species does not include this region.

Spigelia gentianoides can be propagated vegetatively and from seeds. This species produces explosive fruit capsules that forcefully eject the seeds when mature. Seed germination in the greenhouse is low, but if the seeds are treated with gibberellic acid or by cold stratification the germination rate is high. Transplantation of entire plants is the more successful vegetative technique followed by shoot cuttings (Affolter 2005). The BTG is studying seed germination and developing propagation protocols with var. *gentianoides* for their *ex-situ* population.

Species within *Spigelia* contain among the most powerful anthelmintics (Kress 2007), drugs that cause the expulsion or death of intestinal worms. *Spigelia gentianoides* produces a powerful toxin that is poisonous to livestock, but its chemical composition has not been tested for potential medicinal qualities (Wiesner 1994).

E. HABITAT /ECOSYSTEM REQUIREMENTS

In Florida and southern Alabama, var. *gentianoides* can be found growing as a solitary individual or in small clumps in soil somewhat dry but with rich humus, and in areas where limestone outcrops and calcareous soils are widespread. This variety is found predominately in well drained upland pinelands where it is a component of a fire-prone longleaf pine-wiregrass ecosystem. It is found in association with overstory trees such as loblolly pine, longleaf pine, water oak, Laurel oak, southern red oak and blackgum. The

understory and herb layer includes dogwood, blueberry, *Rhododendron, Agrimonia, Gentiana, Mitchella* and *Pedicularis* (NatureServe 2001). This variety is also found in pine-oak-hickory woods at Apalachee WMA (Fig. 6; Jenkins and Diamond 2007), which consists of two soil types, Blanton coarse sand and Chipola loamy sand, each with 0 to 5 % slopes. The Blanton series consists of very deep, somewhat excessively drained to moderately well drained, and moderately to slowly permeable soils on uplands and stream terraces in the Coastal Plain (USDA 2006). The pine-oak-hickory woods has an open to partially closed canopy of southern red oak, mockernut hickory (*Carya alba*), post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*) and longleaf pine.

Fig. 6. Habitat of var. gentianoides**.** Apalachee WMA, Jefferson Co., FL. Photo by V. Negrón-Ortiz, 2007.

Var. *alabamensis* is found in glades (Fig. 7) that have developed over an ancient (upper Cambrian) rock formation known as Ketona Dolomite (Allison and Stevens 2001). The Ketona formation contains a pure form of dolomite, crystalline in texture with only about 2% of siliceous impurities (Garland 2008). The glades vary in size from about 0.1 to 5 hectares, and possess an excellent composition of rare plants (Fig. 7; Grossman et al. 1994). The soil is high in magnesium and calcium, and low in phosphorus and potassium, with a pH ranging from 7.4 to 7.6 (Grossman et al. 1994).

Fig. 7. Ketona Dolomite glade, habitat of var. alabamensis**,** Bibb County Glades Preserve, Alabama. Photo by V. Negrón-Ortiz, 2008.

The topography, mostly gently sloping, varies from flat to sometimes very strongly sloping. There are patches of exposed substratum, thin-soiled areas dominated by grasses and other herbaceous vegetation. The plants in these glades are exposed to extreme heat and drought, as well as to partial shade from the glade-forest ecotones, or from transitions between two adjacent ecological communities. At these sites, var. *alabamensis* is quite abundant, and mainly found in small clumps adjacent to rocks.

F. THREATS

Species are determined to be threatened or endangered under the Act based on one or more of five listing factors: (A) The present or threatened destruction, modification, or curtailment of habitat or range; (B) Over-utilization for commercial, recreational, scientific, or educational purposes; (C) Disease or predation; (D) Inadequacy of existing regulatory mechanisms; and (E) Other natural or manmade factors affecting the species' continued existence. Table 5 summarizes the reasons for the species' decline and current threats.

Table 5. Summary of threats

Listing factor	Threat
A	Clearcutting, mechanical site preparation, and conversion of land to pine plantations coupled with disruption of fire regimes
A	Permanent habitat loss
D	Unprotected populations on private lands
E	Competition from invasive species
E	Reduction, disappearance of pollination agents

A. THE PRESENT OR THREATENED DESTRUCTION, MODIFICATION, OR CURTAILMENT OF ITS HABITAT OR RANGE

Spigelia gentianoides var. *gentianoides* is restricted to a few counties in NW Florida, and one county in southern Alabama. Conversion of much of the upland forest land in these counties to pulpwood plantations (clearcutting, mechanical site preparation, and pine plantations) possibly extirpated other populations. Clearcutting and/or selective thinning are of concern since typical silvicultural operations often result in soil disturbance and compaction. Fire, a natural disturbance for the maintenance of the ecosystems where this species occurs (longleaf pine and the pine-oak forests), has been suppressed over the past several decades (Glitzenstein et al. 1995). In recently burned areas, emergence of var. *gentianoides* plants has been prolific, suggesting that plants have been in a dormant stage as a result of fire suppression (Allison and Stevens 2001). However, the role of fire frequency and timing (early vs. late in the growing season) on this variety is not well understood. For example, we do not know if fire is needed for seedling establishment. Thus, land conversion coupled with disruption of fire regimes of the longleaf pine-wiregrass ecosystem is responsible for the rapid decline of the ecosystem where var. *gentianoides* is found.

The habitat of var. *alabamensis* is quite different. Fire has been considered to some extent a natural disturbance in the Ketona dolomite glades since this outcrop ecosystem is surrounded by longleaf forests, an ecosystem dependent on frequent fires. Based on experimental burns conducted early in the growing season on eight glades in 2004, Duncan et al. (2008) concluded that there was not a strong fire effect on most species. Specifically, survival of var. *alabamensis* was not significantly different between burned and control plots. This short-term study suggested that fire may play a role in preventing forest invasion in the glades by killing young trees. Although the edaphic characteristics of the glades, seasonal temperature extremes, severe summer drought, erosion, prolonged winter and spring saturation are factors attributed in preventing tree establishment, the study suggested that fire (i.e., infrequent fire) also plays a role in maintaining a suitable

habitat. The study, however, did not address how timing or frequency may affect populations of glade species long-term.

According to Kral (1983), var. *gentianoides* would not survive mechanical site preparation involving pine monoculture. This observation seems accurate due to the fragile nature of these plants. However, the population located on what is now referred to as the Calhoun *Spigelia* Preserve seems to have survived, at least over the short term, after cutting and planting. Nevertheless, the population exhibited a decline immediately after the last timber harvest (B. Martin 2005, pers. comm.).

As discussed earlier, var. *alabamensis*, is restricted to one county in northern Alabama and is found in 17 glades, some of which are protected by TNC. Populations on private property are threatened by future development for home-sites, agriculture, logging of associated hardwoods, recreational facilities, or other purposes.

Thus, primarily because of habitat loss, and secondarily because of poor forest management practices this species is in decline.

B. Over-utilization for Commercial, recreational, scientific, or educational purposes

In the nineteenth century, pinkroot was a popular folk cure for intestinal worms in the southern states, although it has been blamed for killing patients (Rogers 1986). *Spigelia gentianoides* has not been tested for potential drug uses, and there is no evidence of overexploitation. However, other species within the genera have been exploited for their medicinal and/or poisonous properties. For instance, *S. marilandica* was heavily collected for medicine, and was perhaps extirpated from northern portions of its range as a result of overcollection (Rogers 1988). Currently, there is no evidence to suggest that this factor is a threat, but this could eventually become a concern.

C. Disease or predation

Neither disease nor predation is currently known to be a threat to this species.

D. THE INADEQUACY OF EXISTING REGULATORY MECHANISMS

The Act prohibits the removal of federally listed threatened and endangered plants or the malicious damage of such plants on areas under federal jurisdiction, or the destruction of endangered plants on non-federal areas in knowing violation of state law or regulations or in the course of any violation of a state criminal trespass law. However, the Act does not provide protection for plants on private lands unless it is in violation of state law. Sites owned by the U.S. Army Corps of Engineers and TNC should be considered protected, although close coordination with land managers is necessary to ensure *S. gentianoides* requirements are included and implemented in approved management protocols.

Florida. Var. *gentianoides* is listed as endangered under the Preservation of Native Plant Flora of Florida Act (PNPFF Act) (Rule: 5B-40.0055, Section 581.185-187, Florida Statutes; https://www.flrules.org/gateway/RuleNo.asp?ID=5B-40.0055). The PNPFF Act addresses the protection of endangered, threatened, or "commercially exploited" plants (http://www.sfrc.ufl.edu/Extension/florida_forestry_information/planning_and_assistance/threatened_and_endangered_species.html). The removal of protected plants from a property, whether for transplant, sale, or any other purpose, requires both the written permission of the landowner and a permit from the Florida Department of Agriculture and Consumer Services. The law contains an exemption for agricultural and silvicultural uses.

Alabama. The State of Alabama does not provide protection to gentian pinkroot (http://wildlifelaw.unm.edu/statbio/alabama.html). In Alabama, var. *alabamensis* partially occurs in areas well managed and protected by TNC. Damage or destruction would be trespass and vandalism of private property under state law.

Therefore, given that there are limited protections for *S. gentianoides* on private lands, inadequacy of regulatory mechanisms is a threat to the species.

E. OTHER NATURAL OR MANMADE FACTORS AFFECTING ITS CONTINUED EXISTENCE

a. Non-native plant interactions

If the ecosystem where *S. gentianoides* is found is disrupted; this can encourage the invasion of noxious weeds. Non-native species are known to have significant effects on native species at local scales in many countries. Non-indigenous species often spread aggressively displacing the native taxa. Threatened and endangered plants have an additional disadvantage due to their already low numbers. Currently the Three Rivers has a severe infestation of *Lygodium japonicum* (Thunb. ex Murr.) Sw. (Japanese climbing fern), *Nandina domestica* Thunb. (nandina, heavenly bamboo or sacred bamboo), *Lonicera japonica* Thunb. (Japanese honeysuckle), *Pueraria montana* (Lour.) Merr. (kudzu) and *Albizia julibrissin* Durazz. (Persian silk tree, pink siris) (T. Spector, 2011, pers. comm.). In addition, *L. japonicum* has been found in the vicinity of var. *gentianoides* and is becoming problematic in areas of the southeast. Similarly, *Ligustrum sinense* Lour. (Chinese privet) poses a potential threat to var. *alabamensis* (D. Borland, 2007, pers. comm.) due to its presence in counties near where this variety occurs and its ability to successfully compete with and displace native vegetation (http://plants.usda.gov/). Monitoring and controlling for non-indigenous plants at *S. gentianoides* populations will be necessary to prevent these from becoming a serious threat.

b. Plant/pollinator interactions and ecology

Although *S. gentianoides* is self-compatible, it does exhibit higher fruit set when out-crossed (Affolter 2005). Given that secondary pollen presentation is present, it is possible that pollinators participate in cross pollination. Currently, the reduction of pollination agents, or even their possible disappearance, has raised concern, and the conservation of pollinators has become part of biodiversity conservation efforts. Because little is known about the pollination ecology of *S. gentianoides*, it is unknown if any of the plant's pollinator(s) are imperiled. More research on pollination and reproduction biology of *S. gentianoides* is needed to determine the degree of threat this may pose.

c. Climate change

Fish, wildlife, and plants are also threatened by climate change. According to the 2007 Intergovernmental Panel on Climate Change (IPCC) Report, warming of the earth's climate is "unequivocal," as is now evident from observations of increases in average global air and ocean temperatures, widespread melting of snow and ice, and rising sea level. Scientific evidence indicates a rapid and abrupt climate change, rather than the gradual changes that have been forecasted (IPCC 2007), posing a significant challenge for fish, wildlife, and plant conservation. As climate changes, the abundance and distribution of species may also change. Highly specialized or endemic species are likely to be most susceptible to the stresses of a changing climate. The 2007 IPCC report predicted a 90 percent probability of 7 to 23 inches of sea level rise by 2100. Based on these findings and other similar studies, the USFWS (2009 a, b) will incorporate potential climate change effects as part of our long-range planning for species conservation.

Plants are of importance as they are regulators of global climate by removing carbon dioxide (CO_2), one of the principle greenhouse gases, from the atmosphere during photosynthesis. The distribution of different plant species, and vegetation type associations are controlled by climatic factors (e.g., annual and seasonal temperature, annual and seasonal precipitation) and their interactions (Maslin 2004). Changes in these climatic factors may result in altered species compositions and therefore, ecosystem structure (Hawkins et. al 2008). These changes may also result in the spread of diseases, pests, and invasive species into new ranges. Species that are already rare may become rarer. This may be even more pronounced for those species with restricted ranges, poor dispersal ability, long generation times, susceptibility to extreme conditions (such as flood or drought), extreme habitat/niche specialization, or symbiotic relationship requirements (Hawkins et. al 2008).

Spigelia gentianoides is a narrowly-distributed endemic plant, restricted to a few localities; therefore it is potentially at risk, specifically since Florida is one of the areas most vulnerable to the consequences of climate change (Stratus Consulting 2010).

Weather permutations may cause permanent retraction of species' ranges, causing or increasing gaps in the distribution patterns, and therefore affecting dispersal (Opdam and Wascher 2004). Consequently, the present habitat could become reduced and more fragmented, increasing the chance of local extinction. It is well established that climate change will force species to shift their range; this emphasizes the need for functional habitat corridors where plant species can migrate naturally across the landscape (Kelly and Goulden 2008). Therefore, habitat protection and management are vital to gentian pinkroot populations.

G. CONSERVATION MEASURES

To date, conservation measures have included development of propagation protocols from seeds and vegetatively; establishment of an *ex-situ* collection at the BTG and at the State Botanical Garden of Georgia (SBGG), Athens, GA; endorsement of a grant to prepare a historic vegetation analysis for Apalachee WMA; habitat management; surveys; and current legal protection.

PROPAGATION AND EX-SITU COLLECTION

The development of good propagation techniques is important for the purposes of establishing *ex-situ* collections and reintroducing species to the wild. Affolter (2005) successfully propagated var. *alabamensis*: by transplanting entire plants from the field to well drained potting mix; from stem cuttings; and by germinating seeds collected in the field. Seeds were either cold stratificated or treated with gibberellic acid. Although both treatments induced germination, cold stratification provided excellent germination rates. Currently, the SBGG has 10 individuals of the F_1 hybrid between var. *alabamensis* and *S. marilandica*, and five individuals of var. *alabamensis* from the Bibb Co. glades in cultivation. The few var. *gentianoides* plants brought in for propagation have all died off over the years (Affolter, 2008, pers. comm.).

Ex-situ populations are located at the BTG (Peterson and Campbell 2007) with the objectives of maintaining a germplasm and re-establishing the plant in its historical

range. The BTG has worked on propagation of var. *gentianoides* for several years. They have 870 seeds stored at the BTG that were collected in 1989 and 20 collected from their progeny in the collection beds in 2005. Efforts to collect seeds from the Three Rivers and the *Spigelia* Preserve were attempted in September 2007 (Campbell, 2007, pers. comm.), but neither population was robust enough for seed collection. Seed germination has been typically low, about 30%. In 2004, the BTG maintained 50 individuals as part of their collection (from seeds collected in Calhoun Co. in 1988), but as of 2007 the plants were reduced to one because the rest died off.

MANAGEMENT

Var. *gentianoides*. The Apalachee WMA has one of the largest populations of *S. gentianoides*. This wildlife management area is owned by the U.S. Army Corps of Engineers (ACOE) and managed by FFWCC. The original plan was to restore to "typical longleaf" ecosystem, but FNAI established a new habitat type based primarily on where they have been finding *Spigelia*. In collaboration with the Service, FFWCC funded a grant to prepare a historic vegetation analysis for Apalachee WMA, a document that provided information about where the pine-oak-hickory woods occur on the property in order to help manage and restore the land appropriately.

Management activities have involved the use of prescribed fire on TNC property, at the Three Rivers, and Geneva State Forest, Alabama. Fire management practices, i.e., winter burns, implemented by TNC on its property and reduced soil disturbance practices, have resulted in a slight increase of var. *gentianoides*. In Geneva State Forest, var. *gentianoides* responded well to growing season prescribed fire with plants flowering about 7-8 weeks after the burn. Similarly, growing season prescribed burns have been implemented at the Three Rivers for several years, and the population remains large and is increasing in numbers.

The ACOE, collaboratively with FWCC, FWS, and FNAI, developed special management actions or avoidance measures on Apalachee WMA. A site containing gentian pinkroot proposed for timber harvest/thinning in 2007 was removed from harvest

activities, and actions were limited to the longleaf pine-wiregrass habitat that did not support var. *gentianoides*.

Guy Anglin, a landowner whose private holdings include a site containing a small population of gentian pinkroot has a cooperative agreement with the State of Florida to manage his property under the Landowner Incentive Program. Management activities include restoring and enhancing native ground cover, reestablishing longleaf pine, and conducting prescribed burning.

Var. *alabamensis*. This variety occurs in 17 glades owned by TNC and private landowners. The Nature Conservancy created the Kathy Stiles Freeland Bibb County Glades preserve in 1996. Their management strategies include control of visitor use, restoration, prescribed burning, inventory and monitoring.

SURVEYS

New occurrences were found in 1992 after intensive surveys of the Glades in Bibb County, Alabama (Allison 1993). These plants were described as a variety distinct from the Florida populations. In 1999, a former graduate student from the University of Mississippi discovered a population in Geneva State Forest, Alabama. In 2004, Guy Anglin documented gentian pinkroot on his private land. One new population consisting of more than 1,700 individuals was discovered on Apalachee WMA in June 2007. For these areas, surveys were completed by FNAI, FWS, botanical gardens, professors, graduate students, and State Park staff from 2005 to 2011.

H. BIOLOGICAL CONSTRAINTS / NEEDS

The most critical biological constraints on *S. gentianoides* are its extremely narrow distribution and low population density. This species occurs in fire-prone habitats, which have declined in number due to development and land alteration coupled with disruption of fire regimes. Lack of fire, or reduced fire frequency, and subsequent growth of shrubs and saplings in the understory, reduces var. *gentianoides* abundance in areas where it was

previously at high density. Therefore, habitats with a semi-open canopy and limited competition are essential for this variety. Limiting habitat constraints for var. *alabamensis* include the Ketona Dolomite formation and glades with soil high in magnesium and calcium and low in phosphorus and potassium. Reproductive requirements may include reliance on pollinators due to the presence of secondary pollen presentation, and habitat alteration likely poses problems and negative consequences to pollinator diversity. Seedling establishment and seed dormancy are not understood, but it is possible that seedling establishment might require prescribed fires.

II. RECOVERY

A. RECOVERY STRATEGY

Spigelia gentianoides is distributed over a relatively small range across Northwest Florida extending into two counties in Alabama (Figs. 1 & 2). The first step toward recovering this plant is to protect and stabilize the current populations. Another important component of recovery is to survey for additional undocumented populations, specifically at sites with implemented prescribed fire management regimes which are likely to reveal new occurrences. Surveys should include areas between Bibb Co., Alabama and northern Florida.

An effective integration between reintroduction and e*x-situ* approaches should be sought wherever possible. The established *ex-situ* populations at the BTG and SBGG will help maintain and preserve a germplasm (genetic diversity of an organism stored as seeds or trees) for this species, which can be useful for reintroduction or the re-establishment of viable populations within the species' former natural habitat and range (e.g., extirpated sites).

Monitoring is a significant aspect of the recovery of *S. gentianoides* because it will provide critical information including practices that potentially affect the species viability. Like other rare plants in fire dependent ecosystems, it is reasonable to assume that var. *gentianoides* is a taxon that requires a semi-open canopy, with an understory composed mostly of herbs and little woody competition. Therefore, to maintain a diverse understory, management with regular prescribed burnings are encouraged, with subsequent monitoring of the sites to determine the response of seedling recruitment to prescribed fire (growing and non-growing seasons burns).

Research on the biology and taxonomy of *S. gentianoides* is needed and will help improve our understanding of the mechanisms necessary for recovery. Reproductive and seed ecology as well as life history and life expectancy investigations are components of

information important for planning and managing for the long-term survival of the species. A taxonomic study using a multi-data approach is encouraged for discerning whether the two varieties represent distinct species.

Prospects for conserving *S. gentianoides* on private land are at the discretion of landowners, who are under no legal obligation to conserve this or any other endangered plant. Consequently, it is imperative to develop collaborative conservation strategies with landowners.

B. RECOVERY GOAL

The goal is to conserve and recover gentian pinkroot, allowing initially for reclassification to threatened status, and ultimately removal of the species from the Federal List of Endangered and Threatened Plants (i.e., delisting). Defining reasonable delisting criteria is not possible at this time given the current low number of populations and individuals, the lack of information about the species' biology, and the magnitude of current threats from development. Therefore, this recovery plan establishes downlisting criteria for *S. gentianoides* so that it may be downlisted to threatened status. Downlisting criteria will be reevaluated, and delisting criteria will be created as new scientific data and information become available and recovery actions are implemented.

C. RECOVERY CRITERIA

The recovery of *S. gentianoides* is challenging because our knowledge about the species' biology (e.g., population biology and ecology) is limited. Protection, securing extant populations, surveying, monitoring, research on key aspects (e.g., demography, reproduction, seed ecology), and improving management protocols, including the establishment of fire management regimes, are the most immediate priorities.

Downlisting of *S. gentianoides* from endangered to threatened status will be considered when: (1) extant populations and recently discovered sites are identified and mapped; (2)

inventories (i.e., the total number of individuals, number of flowering vs. non-flowering plants, presence of pollinators, and whether seedling recruitment is occurring) have been conducted across the species' historic sites and/or on new locations; (3) monitoring programs and management protocols on selected populations (e.g., largest populations) are established for 15 years to track threats to the species and its habitat (e.g., control exotic species, minimize site disturbance, urban development); (4) the extant populations (including subpopulations at the Ketona Glades, Bibb Co., Alabama) located on public land are stable[8]; (5) the minimum viable population (MVP) has been determined for each variety using PVA; (6) research on key aspects related to demography (e.g., density, effect of fire on seedling establishment), reproductive biology, and seed ecology is accomplished; and (7) viable germplasm representing > 50% of the populations for each variety is maintained in *ex-situ*. In addition, the following specific actions are completed for each variety:

Var. *gentianoides*: (1) sizes of populations # 1 to # 4 (Table 3) are increased via prescribed burns until plant numbers are stabilized over a period of 15 years; (2) at least one new population is found, and; (3) at least one population is re-established within the historic range, specifically at sites where the plants are currently known to be extirpated.

Var. *alabamensis*: (1) 50 % the Bibb Co. glades known to support the variety on private land are protected through conservation agreements, easements, and/or land acquisition.

Narrative Outline of Recovery Actions

1. **PROTECT, MANAGE, AND SECURE EXISTING POPULATIONS AND HABITAT.**
   The distribution of *Spigelia gentianoides* is limited to a few areas in Northwest Florida extending into central Alabama (Fig. 2), thus it is important to secure and stabilize current and any newly discovered populations to prevent further decline of this plant.

[8] Evidence of a stable (or increasing) population trend is indicated if 95% probability of persistence is achieved for at least 15 years based on data obtained from accepted standardized monitoring methods and population viability analyses (PVAs).

1.1 IMPROVE PROTECTION BY REVISIONS OF (OR WHERE APPROPRIATE, DEVELOPMENT OF) AND IMPLEMENTATION OF HABITAT MANAGEMENT PLANS.

Populations of *S. gentianoides* are located on both public and private lands. With the exception of the Anglin Tract and privately owned glades, these lands have management plans, but these plans need to be revised and updated to help guide future management. Revisions should address the biological and ecological needs of the species, timber harvesting, weed control, the use and application of herbicide, and fire management protocols. Pineland thinning should be conducted manually to avoid soil disturbance.

1.2 COORDINATION WITH LANDOWNERS TO INCLUDE DEVELOPMENT AND IMPLEMENTATION OF PROTECTION AGREEMENTS WITH LANDOWNERS.

Coordination with landowners of the Anglin Tract and privately owned glades is needed in order to place *S. gentianoides* parcels into a conservation easement or other type of protection and to assist landowners in creating management plans (Action 1.1). Similarly, if additional populations are found and/or re-established, those populations will require a management plan (Action 1.1) and/or a cooperative protection agreement(s).

1.3 MONITOR AND MANAGE FOR INVASIVE SPECIES

Invasive plant management at *Spigelia* sites should be actively followed. Frequent inventories or surveys of each population for the presence of invasive species should be conducted (Action 2.1), which will help with the early detection of small patches of invasive plants near *Spigelia*. Detection should be followed by appropriate treatment to eradicate the invasive species without harming *Spigelia*.

1.4 COOPERATE WITH STATE AGENCIES IN FLORIDA AND ALABAMA TO INCREASE OR IMPROVE CONSERVATION MEASURES FOR VAR. *ALABAMENSIS*

The State of Alabama does not have an endangered species law, and/or a formal biodiversity policy (http://wildlifelaw.unm.edu/statbio/alabama.html). The

Department of Conservation and Natural Resources has a policy to protect, conserve and increase the wildlife of the state [Ala. Code 9-2-2 (1)], but provides little direction as to how this is to be accomplished. While the state's Natural Heritage Program maintains lists of non-game species considered endangered, threatened, of special concern or poorly known, it does not apply penalties for taking listed plant species or for altering their habitats. Therefore, we want to work cooperatively with the Alabama Natural Heritage Program and TNC to create and foster a working partnership with the Bibb Co. glades' landowners, in order to initiate species' protection in privately owned glades. The Service also wants to continue to work with Florida to find or continue to improve upon protection mechanisms for this plant. Var *gentianoides* is listed as endangered under the PNPFF Act (Rule:5B-400055, Section 581.185-187, FL Statutes).

2. CONDUCT SURVEYS/INVENTORIES.

2.1 INVENTORY OF CURRENT AND FOR NEW POPULATIONS

Inventory data may provide the baseline, or the first measurement, for a long-term monitoring study (Elzinga et. al 2001). For each current known population the following data should be collected annually (for at least 15 years): the total number of individuals, number of flowering vs. non-flowering plants, presence of visitors to the flowers, and whether seedling recruitment is occurring. The data will be useful for determining the effective population size, i.e., members of a population that are actually breeding.

2.2 FIELD SURVEYS AND SPECIES DISTRIBUTION MODELING TO DETERMINE SURVEY SITES

Field searches may identify new populations. *Spigelia gentianoides* is a perennial plant found in a fire maintained ecosystem. Much of the habitat has been fire suppressed for the past 100 years. However, in the past decade many sites, including newly acquired public lands within the species range, are being managed with prescribed fire. Surveys within these areas should be conducted during the flowering

season (May to June) and information should be collected using point-in-time measurements commonly called inventories (Action 2.1). Additional surveys should include areas between Bibb Co., Alabama and northern Florida (Fig. 2).

This action can include the use of species distribution modeling methods to initially determine potential sites containing gentian pinkroot, with subsequent validation or inspection of the sites for plants. In addition, these models can assist in identifying sites of high candidacy for reintroductions (Hernandez et. al. 2006), and can be used to project the potential effects of climate change on this species distribution (Franklin 2009).

Additionally, counties included within the historic range should be further inspected (Figs. 1 & 2). All new populations should be secured (Action 1.2) and management plans should be created according to Action 1.1.

3. ESTABLISH NEW OCCURRENCES WITHIN THE HISTORIC RANGE OF VAR. *GENTIANOIDES*, SPECIFICALLY IN THE SITES WHERE THE PLANTS HAVE BEEN EXTIRPATED.

A carefully prepared reintroduction plan, propagation (Action 4), and reintroduction research will be necessary before this action is carried out. Once reintroduction is completed, the plants need to be actively managed and monitored (Action 5.1) for at least ten years, or until they are actively reproducing and the numbers are stable.

4. MAINTAIN THE SPECIES *EX-SITU* IN A PROTECTED FACILITY

Ex-situ populations will serve as an important component for storage of germplasm and reintroducing *S. gentianoides* populations within the species range. This action is currently in progress, conducted by the BTG and Dr. James Affolter of the SBGG.

5. CONDUCT LONG-TERM MONITORING AND RESEARCH

5.1 ESTABLISH AND IMPLEMENT A LONG-TERM MONITORING PROGRAM ON SELECTED SITES

This action will assess whether monitoring is carried out as designed, whether the planned management is being implemented, and identify which variables are limiting. Initially, a pilot study should be implemented for testing the feasibility of the monitoring approach and for identifying improvements (e.g., monitoring design, sampling objectives, time-frame, and resource requirements). Once the pilot study data is analyzed, necessary changes should be made to the monitoring design and plan. Both qualitative and quantitative assessment of populations and habitats should be considered.

Plants should be monitored several times during a 12-month cycle (e.g., flowering and fruiting seasons) the first year, then annually or biannually over an extended number of years, i.e., 10-15 years. Several years of monitoring data will 1) provide sufficient data for testing groups (e.g., winter vs. growing season fire regimes); 2) help avoid or minimize Types I[9] and II[10] statistical errors; and 3) help understand how *S. gentianoides* responds to climate variation.

5.1.1 POPULATION BIOLOGY/DEMOGRAPHIC STUDIES

To understand the dynamic aspect of the population, this action should examine density and abundance of individuals. Observations of flowering and fruiting are important and should be integrated with environmental factors (e.g., precipitation, moisture, soil characteristics, herbivores). Variables such as plant size and seedling data should be examined. Since gentian pinkroot occurs in fire prone habitats, the effect of this disturbance (winter vs. growing season prescribed fire, fire frequency, intensity, duration, and timing) on survival and fecundity should also be monitored. Such studies should be conducted on large populations (Table 3).

Population census data should include counting number of individuals per population over time (population size), which helps predict extinction risks

[9] Type I Error is the chance the researcher will conclude there is a relationship when there is not.

[10] Type II Error is the chance the researcher will conclude there is no relationship when in fact there is.

using PVA (Morris et al. 2002, Thomson and Schwartz 2006). It is well accepted that there is not an exact number below which populations are lost or above which they are safe (Given 1994, Matthies et al. 2004, Menges 1990); that is studies have demonstrated variation among the number of plants necessary for a population to survive risks of extinction. Empirical evidence has stressed the predicted negative correlation between population size and the probability of extinction, although it is not always the case for some small populations (Matthies et. al. 2004). In conservation biology, the smallest size at which a population can exist without facing extinction, i.e., MVP, can be estimated using computer simulations known as PVA. For instance, PVA of 379 populations of eight threatened species in northern Germany demonstrated that very small populations face a considerable risk of extinction, while the risk for populations with more than 1000 individuals was very small (Matthies et al. 2004). Therefore, PVA will help determine the MVP after data are acquired and evaluated through 5-year status reviews.

5.1.2 PHENOLOGICAL STUDIES

Plant phenology involves the timing, duration and abundance of recurrent biological processes, including reproductive events such as flowering, fruiting, seed dispersal and germination. Studies have attributed longer growing seasons and earlier spring phenology to rising temperatures, but have found different effects on the end of growing season (Bertin 2008, Kelly and Goulden 2008). According to Primack et al. (2009), the same species in different localities can show different responses to climate change due to the nonlinear relationship between phenology and temperature. Species lacking phenological adaptability may require a stronger signal or may be unable to adapt to climate warming (Bradley et al. 1999), and therefore may experience greater stress or even extinction during extended climate change.

Phenological data have emerged as useful tools for studying the impact of climate change on plants, but long-term phenological records are rare and

required for understanding species phenological responses to global warming (Lavoie and Lachance 2006). Herbarium collections have been used for phenological reconstructions, overcoming the lack of long-term data (Bolmgren and Lönnberg 2005, Lavoie and Lachance 2006). Consequently, phenological studies should include both long-term observations coupled with herbarium specimens' records.

5.2 RESEARCH

5.2.1 REPRODUCTIVE STUDIES

Plants exhibit a puzzling display of breeding systems, revealed by variation in gender, floral form and display, mechanisms of pollen transfer, and pathways of fertilization and seed maturation. This sexual diversity is important because of its significance for population persistence, reproductive isolation, and the organization of genetic diversity within and among populations. Since secondary pollen presentation (a system associated with outcrossing and biotic pollination) appears to be present in this species, pollination ecology and breeding systems studies should be conducted. Mating system information and actual population size can be useful for determining the effective population size, and should be taken into account in future management plans to ensure the conservation and protection of the species. In addition, data from these studies will help determine whether the species has specific pollinator(s) and their requirements. Dr. James Affolter investigated the mating system, floral biology, and to some extent the visitors of the var. *alabamensis*; however, such investigations are lacking for var. *gentianoides*.

5.2.1.1 POLLINATION ECOLOGY

Pollination ecology is concerned with pollination vectors, attractants, flower morphology and the environment. Research in this field has significant bearing on evolution, systematics, conservation and propagation (Catling and Catling 1991). Several visitors have been observed in the flowers of *S. gentianoides*, but it has not been determined if they are performing

pollination. Since site disturbance occurs within the populations of var. *gentianoides*, it is likely that it will pose problems and harmful consequences to pollinator diversity (Kevan and Phillips 2001). Therefore, it is important to determine which insects are pollinators and understand the value and pollinators' requirements so that actions can be taken to incorporate specific management or protection plans.

5.2.1.2 BREEDING SYSTEM STUDIES

Knowledge of the type of mating systems is essential for conservation of rare plant taxa because mating systems affect genetic diversity within and among populations (Navarro and Guitian 2002). Var. *alabamensis* exhibits both self- and cross-fertilization (i.e., a mixed mating system) but there are no data available for var. *gentianoides*. Therefore, floral morphological analysis and experimental hand-pollinations should be performed. Treatments could include: open pollination, outcrossing, self pollination, close outcrossing (pollen from plant at 1 m distance within population), far outcrossing (between populations). Treatments of no pollination, with and without emasculation, are needed as control. According to Affolter (2010, pers. comm.), it is also worth considering conducting some treatments using plants in pots in a climate controlled greenhouse to over-come tissue wilting due to water loss after flower emasculation.

5.3 SEED BANK, GERMINATION AND SEEDLING SURVIVAL STUDIES

Conservation of plant species requires information on seed germination and soil seed bank. The soil seed bank is important for the reestablishment of populations after disturbances such as drought or fire. In addition, seed banks could serve as reservoirs for seeds and increase the likelihood of species survival. After seed germination, seedlings typically suffer the highest mortality of any life history stage because they are highly susceptible to their environment. Therefore, studies should be focused on descriptive and field experiment studies determining whether a persistent seed bank exists, *in-situ* seed germination, and the effects of

post-disturbance conditions such as fire on seed germination and seedling survival.

5.4 Taxonomic studies

The objective of this action is to assist in determining whether there are enough characters to rank *S. gentianoides* varieties at the species level. Analyses including morphology and other appropriate data, and molecular studies using appropriate markers between varieties and populations of *S. gentianoides* are encouraged. Outcomes of these studies will be useful for determining whether the varieties are taxonomically distinct and better understanding the conservation recovery planning.

5.5 Genetic studies

Estimate the levels and distribution of genetic diversity. Knowledge of the levels and distribution of genetic variation in species of conservation concern can be important for the development of efficient and effective conservation practices. For example, the identification of populations with rare alleles or with elevated levels of genetic diversity may lead to greater efforts for their preservation relative to less genetically unique populations.

6. Outreach

Develop and distribute information to the general public about *S. gentianoides*, how to protect and manage it for its recovery, and how lands can be managed to benefit the plant along with meeting landowner needs. Promote the implementation of the recovery actions via private landowners, academia, and public agencies.

7. Review and track recovery progress

The plan needs to be revised periodically to incorporate new findings, address current conditions, and update recovery actions.

III. IMPLEMENTATION SCHEDULE

Recovery plans are intended to assist the Service and potential Federal, state, and private partners in planning and implementing actions to recover and/or protect endangered and threatened species. The Implementation Schedule (Table 6) that follows lists the actions and estimated costs for the recovery program for *S. gentianoides*. It is a guide for meeting recovery goals outlined in this plan. Parties with authority, responsibility, or expressed interest to implement a specific recovery action are identified in the Implementation Schedule. The listing of a party in the Implementation Schedule does not require, nor imply a requirement, that the identified party has agreed to implement the action(s) or to secure funding for implementing the action(s). However, parties willing to participate may benefit by being able to show in their own budgets that their funding request is for a recovery action identified in an approved recovery plan and is therefore considered a necessary action for the overall coordinated effort to recover this plant.

1) **Recovery Action Priority**. Priorities in column 1 of the following Implementation Schedule are assigned as follows:

Priority 1	An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.
Priority 2	An action that would prevent significant decline in species population/habitat quality or some other significant negative impact short of extinction
Priority 3	All other actions necessary to provide for full recovery of the species.

2) **Action number and description.** The action number and description are obtained from the narrative outline of the recovery actions found in Part II of this plan.

3) **Action duration (years).** This represents the number of years estimated to complete the action. This number could be revised as the action is implemented or reevaluated if additional time is required.

4) **Participants**. This lists the agencies, organizations, and collaborators that are expected to be involved in completing these tasks. Other partners/contributors may be included as they are identified. Lead or potential lead organization is indicated with an asterisk (*).

   Acronyms:

   BG: Botanical Gardens
   FNAI: Florida Natural Areas Inventory
   FWS: U.S. Fish and Wildlife Service
   BTG: Bok Tower Garden
   Nat Her P: Natural Heritage Program of Alabama
   SBGG: State Botanical Garden of Georgia
   Land managers: TNC; FWCC; Florida Park Service, Florida Department of Environmental Protection (FDEP)

Table 6. Implementation Schedule

Action Priority	Action number	Action description	Years	Responsible Agency * = lead	Cost estimate (in $1,000s)						Comments
					Total	2012	2013	2014	2015	2016	
1	1.1	Revise and implement (where appropriate develop) management plans	3	FWS, FNAI, *land managers	10	5	3	2	-	-	Assumes revisions every 5 years; from 2017-2027 cost assumes $1,000/5 yr cycle.
1	1.2	Development and implementation of protection agreements with landowners	5	FWS	10	3	3	2	1	1	
1	1.4	Cooperate with FL and AL to establish or improve conservation measures for var. *alabamensis*	ongoing	FWS, AL *Nat Her P	10	3	3	2	1	1	
1	2.1	Conduct inventories for each known population	15	BG, FWS, land managers	50	20	10	10	5	5	From 2017-2027 cost assumes $4,000/ yr.
1	2.2	Conduct surveys and develop species distribution models to determine survey sites	ongoing	FWS, FNAI, universities, land managers	60	25	25	6	2	2	Assumes reduced data collection overtime. New sites require protection agreements & management plans.
1	3	Reintroduction within the historic range	5	FWS, land managers	25	5	10	5	3	2	Reintroduction requires monitoring.

1	4	Maintain the species *ex-situ* in protected facilities	ongoing	*BTG, SBGG	13	3	3	3	3	1	
2	5.1.1	Population biology/Demographic studies	10	BG, FWS, universities, land managers	46	17	10	7	7	5	From 2017-2022 cost assumes $600/yr
2	5.1.2	Phenological studies	15	FNAI, FWS, land managers, universities	15	6	5	2	1	1	From 2017-2027 cost assumes $1,000/ yr.
2	5.2.1.1	Conduct studies on pollination ecology	ongoing	BG, FWS, universities	12	6	6	-	-	-	
2	5.3	Conduct studies on seed ecology (seed bank, germination, and seedling survival)	5	BG , BTG, FWS, universities, land managers	15	5	3	3	2	2	
2	5.4	Conduct taxonomic studies to determine whether the varieties represent two species	5	BG, FWS, universities	44	20	15	3	3	3	
2	5.5	Genetic studies	2	Universities	25	15	10	-	-	-	
2	6	Outreach- develop materials and distribute	5	BG , BTG, FWS, universities, land managers	5	1	1	1	1	1	
2	7	Track recovery progress	ongoing	FWS	-	-	-	-	-	-	
3	5.2.1.2	Conduct studies on breeding system	ongoing	BG, FWS, universities	21	6	6	3	3	3	
3	1.3	Monitor and manage for invasive species	Intermittent	FWS, universities, land managers	6.5	3	1	1	1	0.5	From 2017-2027 cost assumes $500/yr
Total					**367.5**	**143**	**114**	**50**	**33**	**27.5**	

LITERATURE CITED

Affolter, J. M. 2005. Conservation biology of *Spigelia gentianoides* and *S. marilandica*: genetic variation, reproduction biology, and propagation. Final project report to the Georgia Cooperative Fish and Wildlife Research Unit. 33 pp.

Allison, J.R. 1993. Status of three federal listed plants in Bibb County, Alabama. Manuscript report to U.S. Fish and Wildlife Service, Jackson Mississippi. 68 pp.

Allison, J.R., and T.E. Stevens. 2001. Vascular flora of Ketona Dolomite outcrops in Bibb County, Alabama. Castanea. 66: 154-205.

Bertin, R. I. 2008. Plant phenology and distribution in relation to recent climate change. Journal of the Torrey Botanical Society. 135: 126-146.

Bolmgren, K. and K. Lönnberg. 2005. Herbarium data reveal an association between fleshy fruit type and earlier flowering time. Int. J Plant Sci. 166: 663–670.

Bradley, N.L., A.C. Leopold, J. Ross, and W. Huffaker. 1999. Phenological changes reflect climate change in Wisconsin. Proc. Natl. Acad. Sci. 96: 9701–9704.

Catling, P.M., and V.R. Catling. 1991. A synopsis of breeding systems and pollination in North American orchids. Lindleyana. 6: 187-210.

Clewell, A.F. 1985. Guide to the vascular plants of the Florida panhandle. Univ. Presses of FL., Gainesville. 605 pp.

de Candolle, A. 1845. Prodromus systematis naturalis regni vegetables 9: 5.

Duncan, R.S., C.B. Anderson, H.N. Sellers, and E.E. Robbins. 2008. The effect of fire reintroduction on endemic and rare plants of a southeastern glade ecosystem. Restoration Ecology. 16: 39–49

ELZINGA, C.L., D.W. SALZER, J.W. WILLOUGHBY, AND J. P GIBBS. 2001. MONITORING PLANT AND ANIMAL POPULATIONS. BLACKWELL SCIENCE, INC. 360PP.

Erbar, C., and P. Leins. 1999. Secondary pollen presentation and a curious rupture of the style in *Spigelia* (Spigeliaceae, Gentianales). Plant Biology. 1: 389-402.

Franklin, J. 2009. Mapping species distributions. Spatial inference and prediction. Cambridge Univ. Press. New York.

Garland, B. 2008. Bibb County Glades, botanical discovery of the century. Outdoor Alabama Magazine. 11pp.

Given, D. 1994. Principles and practices of plant conservation. Timber Press, Inc. Portland, Oregon.

Glitzenstein, J.S., W.J. Platt, and D.R. Streng. 1995. Effects of fire regime and habitat on tree dynamics in north Florida longleaf pine savannas. Ecological Monographs. 65: 441–476.

Gould, K.R. 1996. A new, disjunct variety of *Spigelia gentianoides* (Loganiaceae) from Bibb County, Alabama. Sida 17: 417-421.

Gould, K.R., and R.K Jansen. 1999. Taxonomy and phylogeny of a gulf coast disjunct group of *Spigelia* (Loganiaceae *sensu latu*). Lundellia. 2: 1-13.

Grossman, D. H., K. L. Goodin, and C. L. Reuss. 1994. Rare plant communities of the conterminous United States: An initial survey. The Nature Conservancy, Arlington, VA.

Hawkins, B., S. Sharrock, and K. Havens. 2008. Plants and climate change: which future? Botanic Gardens Conservation International, Richmond, UK.

Hernandez, P. A., C.H. Graham, L.L. Master, and D.L. Albert. 2006. The effect of sample size and species characteristics on performance of different species distribution modeling methods. Ecography. 29: 773-785.

http://www.gilnelson.com/PanFlora/. PanFlora. A database of flowering times for plants of the Florida Panhandle. Information accessed in 2010.

http://plants.usda.gov/. U.S. Department of Agriculture, Natural Resources Conservation Service. Plant database. Information accessed in 2008.

http://www.nature.org/wherewework/northamerica/states/alabama/preserves/art902.html. Kathy Stiles Freeland Bibb County Glades Preserve. The Nature Conservancy. Information accessed in 2010.

http://www.sfrc.ufl.edu/Extension/florida_forestry_information/planning_and_assistance/threatened_and_endangered_species.html. Florida forest stewardship. Threatened & Endangered Species. University of Florida, IFAS extension. Information accessed in 2008.

http://wildlifelaw.unm.edu/statbio/alabama.html. Alabama, State biodiversity report. Saving Biodiversity: A status report on state laws, policies and programs produced in 1996 by the Center for Wildlife Law at the University of New Mexico and The Defenders of Wildlife. Information accessed in 20010.

Hubbell, T. H., A. M. Laessle, and J.C. Dickinson. 1956-1957. The Flint-Chattahoochee-Apalachicola region and its environments. Bull. Florida State museum biological sciences. 1: 58-59.

Intergovernmental Panel on Climate Change Report (IPCC). 2007. Climate Change 2007: Synthesis Report. 52 pp. http://www.ipcc.ch/publications_and_data/publications_and_data_reports.htm.

Jenkins, A.M., and P. Diamond. 2007. Status survey for gentian pinkroot, *Spigelia gentianoides*, at Apalachee Wildlife Management Area. Florida Natural Areas Inventory, Tallahassee, Florida. Final Report submitted for the Division of Forestry, FL.

Kelly, A.E. and M. L. Goulden. 2008. Rapid shifts in plant distribution with recent climate change. PNAS. 105: 11823–11826.

Kevan, P.G., and T. P. Phillips. 2001. The economic impacts of pollinator declines: An approach to assessing the consequences. Conservation Ecology 5: 8. [online] URL: http://www.consecol.org/vol5/iss1/art8/.

Kral, R. 1983. Loganiaceae. *In*: A report on some rare, threatened, or endangered forest-related vascular plants of the South. USDA Forest Service, Southern region. Tech. Publ. R8-TP2, 2: 877-880.

Kress, H. 2007. *Spigelia*. Henriettes' herbal homepage http://www.henriettesherbal.com. http://www.uhaul.com/supergraphics/pinkroot/four.html

Lavoie, C., and D. Lachance. 2006. A new herbarium-based method for reconstructing the phenology of plant species across large areas. Amer. J Bot. 93:512-516.

MacDonald, J. 1999. Preliminary report on field surveys for *Spigelia gentianoides* in Southeastern Alabama. Unpublished report submitted to U.S. Fish and Wildlife Service, Jackson, Mississippi. 6 pp.

Maslin, M. 2004. Atmosphere: Ecological versus climatic thresholds. Science. 2: 2197-2198.

Matthies, D., I. Bräuer, W. Maibom, and T. Tscharntke. 2004. Population size and the risk of local extinction: empirical evidence from rare plants. Oikos. 105: 481-488.

Menges, E. 1990. Population viability analysis for an endangered plant. Conservation Biology. 4: 52-62.

Morris, W.F., P.L. Bloch, B.R. Hudgen, L.C. Moyle, and J.R. Stinchcombe. 2002. Population viability analysis in endangered species recovery plans: Past use and future improvements. Ecological Applications. 12: 629-719

NatureServe. 2001. URL: http://www.natureserve.org/. Information accessed in 2008.

Navarro, L., and J. Guitian. 2002. The role of floral biology and breeding system on the reproductive success of the narrow endemic *Petrocoptis viscosa* Rothm. (Caryophyllaceae). Biological Conservation 103: 125–132.

Opdam, P., and D. Wascher. 2004. Climate change meets habitat fragmentation: linking landscape and biogeographical scale levels in research and conservation. Biological Conservation 117: 285–297.

Peterson, C.L, and C.C. Campbell. 2007. Seed collection and research on eight rare plants species of the Florida Panhandle region. USFWS grant agreement 401815G173.

Primack, R.B., I. Ibáñez, H. Higuchi, S.D. Lee, A.J. Miller-Rushing, A.M. Wilson, J.A. Silander. 2009. Spatial and interspecific variability in phenological responses to warming temperatures. Biol. Conservation. 149: 2569-2577.

Rogers, G. K. 1986. The genera Loganiaceae in the Southeastern United States. J. Arnold Arboretum. 67: 143-185.

Rogers, G. K. 1988. *Spigelia gentianoides* -- a species on the brink of extinction. Plant Conservation. 3: 1, 8.

Russo, P.F. 2006. 2006 *Spigelia gentianoides* survey at The Nature Conservancy's Calhoun Spigelia Preserve, Calhoun County, Florida. Contract number- FLFO 041706. The Nature Conservancy.

Shaffer, M. L. 1981. Minimum population sizes for species conservation. *BioScience* 31: 131–134.

Stratus Consulting, Inc. 2010. Climate change impacts in the southeastern United States. Draft discussion paper. The report was produced by Stratus Consulting under U.S. Environmental Protection Agency, contract number EP09H001299. 59 pp.

Thomson, D.M., and M.W. Schwartz. 2006. Using population count data to assess the effect of changing river flow on an endangered riparian plant. Conservation Biology. 20: 1132-1142.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2006. Soil Survey Geographic (SSURGO) database for Jackson County, Florida. Available at: URL:http://SoilDataMart.nrcs.usda.gov/

U.S. Fish and Wildlife Service. 1990. Endangered and threatened wildlife and plants; the plant "*Spigelia gentianoides*" (gentian pinkroot) determined to be endangered. Federal Register 55: 49046.

U.S. Fish and Wildlife Service. 2009a. Rising to the challenge. Strategic plan for responding to accelerating climate change. Draft document. http://www.fws.gov/home/climatechange/

U.S. Fish and Wildlife Service. 2009b. Appendix: 5-year action plan for implementing the climate change strategic plan. Draft document. http://www.fws.gov/home/climatechange/

Weakley, A. 2007. Flora of the Carolinas, Virginia, Georgia, and surrounding areas. University of North Carolina Herbarium, Chapel Hill NC. Electronic copy.

Wiesner, M.B. 1994. Natives at Risk: Gentian pinkroot. American Horticulturist. 73: 10.

Wunderlin, R. P., D. Richardson, and B. Hanson. 1980. Status report on *Spigelia gentianoides*. Unpublished report submitted to U.S. Fish and Wildlife Service, Jacksonville, Florida. 13 pp.

Wunderlin, R.P., and B. F. Hansen. 2003. Guide to the Vascular Plants of Florida. 2nd edition. University Press of Florida.

APPENDICES

APPENDIX 1. Summary of threats and recommended recovery actions for *S. gentianoides*

Listing factor	Threat	Recovery Actions	Tasks
A	Clearcutting, mechanical site preparation, and conversion of land to pine plantations coupled with disruption of fire regimes	1, 4, 5, 6, 7	1.1, 1.2, 1.3, 4, 5.1, 5.2.1, 5.3, 5.4, 5.5, 6, 7
A	Permanent habitat loss	1, 2, 3, 4, 5, 6, 7	1.1, 1.2, 1.3, 2.1, 2.2, 3, 4, 5.1, 5.2.1, 5.3, 5.5, 6, 7
D	Unprotected populations on private lands	1, 4, 5, 6, 7	1.1, 1.2, 1.4, 5.1, 5.2.1, 5.3, 5.4, 5.5, 6, 7
E	Competition from invasive species	1, 5, 6, 7	1.1, 1.2, 1.3, 5.1, 6, 7
E	Reduction, disappearance of pollination agents	1, 4, 5, 6, 7	1.1, 1.2, 1.3, 4, 5.1, 5.2.1, 5.3, 5.5, 6, 7

Listing Factors:
Factor A: The Present or Threatened Destruction, Modification, or Curtailment of Its Habitat or Range
Factor B: Overutilization for Commercial, Recreational, Scientific, Educational Purposes (N/A)
Factor C: Disease or Predation (no known diseases)
Factor D: The Inadequacy of Existing Regulatory Mechanisms
Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence

Recovery Criteria for Downlisting
1. Identify and map all extant populations and likely additional sites.
2. Conduct inventories across the species historic sites and/or on new locations.
3. Establish monitoring programs and management protocols on selected populations for at least 15 years.

4. Maintain stability in the extant populations (including subpopulations at the Ketona Glades) located on public land over a period of 15 years.
5. Determine the minimum viable population size for each variety.
6. Research on key aspects related to demography, reproductive biology, and seed ecology is accomplished.
7. Maintain in *ex situ* a viable germplasm representing > 50% of the populations for each variety.
8. **Var. *gentianoides*:** (1) increase sizes of populations #1 to #4 (Table 3) via prescribed burns until plant numbers are stabilized over a period of 15 years; (2) find one new population; (3) and re-establish at least one population within the historic range.
9. **Var. *alabamensis***: (1) protect 50% of the glades known to support the variety on private land through conservation agreements, easements, verbal agreements, or land acquisition.

Tasks (see plan for details)

1.1 Improve protection by development of habitat management plans.
1.2 Establish protection agreements with landowners.
1.3 Monitor and manage for invasive species.
1.4 Cooperate with FL and AL to establish or improve conservation measures for var. *alabamensis*
2. Conduct surveys/inventories on potentially new sites.
3. Establish new occurrences within the historic range of var. *gentianoides*, specifically in the sites where the plants have been extirpated.
4. Maintain *ex-situ* program.
5.1 Conduct long-term monitoring and research
    5.1.1 Population biology/demographic studies
    5.1.2 Phenological studies
5.2.1 Conduct reproductive studies
    5.2.1.1 Pollination ecology
    5.2.1.2 Breeding system studies
5.3 Conduct studies on seed ecology
5.4 Taxonomic studies
5.5 Genetic studies
6. Outreach
7. Review and track recovery progress

APPENDIX 2: Summary of Peer Review

The Service sought early peer review on the science reflected in this plan from 3 independent peer reviewers (see below). During the public comment period, we obtained additional peer review and public comment.

A. Early Peer Review

Reviewers:

1. Ms. Amy M. Jenkins, Senior Botanist, Florida Natural Areas Inventory (FNAI), 1018 Thomasville Road, Suite 200C, Tallahassee, FL 32303.
2. Dr. James Affolter, Professor and Director of Research, The State Botanical Garden of Georgia, University of Georgia, Athens, GA 30605-1624
3. Dr. Katherine Mathews, Associate Professor of Botany, Department of Biology, Western Carolina University, Cullowhee, NC 28723

Two reviews were received from peer reviewers. Both peer reviewers indicated that the draft plan represented an excellent summary of the current state of knowledge concerning *S. gentianoides.* They mentioned that the document also contains a great deal of new information concerning the abundance and distribution of the species that is critical for understanding what recovery actions will be necessary prior to downlisting the species to threatened status. Comments requested clarification of topics such as fire frequency and management practices, mixed mating systems, and genetics. All comments received were considered and incorporated where appropriate. One peer reviewer was not able to provide comments because the reviewer's affiliation agency changed its policies for responding to requests for services from both public and private users.

B. Public Comment Period

On March 13, 2011, the Service released the Technical/Agency Draft Recovery Plan for Gentian Pinkroot for a 60-day peer review and public comment period ending on May 23, 2011. The Service received comments from two reviewers/organizations during the 60-day comment period: the National Park Service (NPS) and the Florida Park Service (FPS). The NPS stated that they have no comments. The FPS suggested edits to the text and adjustment of several topics (e.g., effect of fire on growing season-post burning, the numbers of individuals, seed collection calendar) related to the population of var. *gentianoides* at the Three Rivers State Park. Based on the staff hours at Three Rivers State Park, the FPS also suggested increasing the cost estimate for annual surveying and monitoring and revising recovery actions 1.3 and 5.2. All comments received were considered and incorporated where appropriate.

APPENDIX 3: List of Stakeholders/Reviewers

FEDERAL GOVERNMENT

U. S. Army Corps of Engineers
Mobile District
P.O. Box 2288
Mobile AL 36628-0001

USDA Natural Resources Conservation Service
P.O. Box 141510
Gainesville FL 32614-1510

Ms. Angela H. Griffin
U.S. Army Corps of Engineers
P.O. Box 96
2832 Booster Club Road
Chattahoochee, Florida 32324

ALABAMA STATE GOVERNMENT

Alabama Forestry Commission
PO Box 302550
Montgomery, AL 36130-2550

Mr. Chris Mead
Alabama Forestry Commission
Geneva State Forest
1119 Forest Area Road
Kinston, AL 36453

Mr. Jo Lewis
Alabama Dept. of Conservation and Natural Resources
State Lands Division
64 N. Union Street, Suite 468
Montgomery, AL 36130

FLORIDA STATE GOVERNMENT

Dr. Nancy Coile, Botanist
Florida Dept. of Agriculture & Consumer Services
Division of Plant Industry
P.O. Box 147100
Gainesville FL 32614-7100

Dr. E. Dennis Hardin
Florida Dept. of Agriculture & Consumer Services
Division of Forestry
3125 Conner Boulevard
Tallahassee FL 32399-1650

Division of Forestry
Florida Dept. of Agriculture and Consumer Services
Administration Building, Room 269
3125 Conner Boulevard
Tallahassee FL 32399-1650

Florida Dept. of Environmental Protection
Environmental Land Management, Room 110
3900 Commonwealth Boulevard
Tallahassee FL 32303

Environmental Management Office
Florida Dept. of Transportation
Mail Station 37
605 Suwannee Street
Tallahassee FL 32301

SCIENTIST/HORTICULTURALIST/ ENVIRONMENTAL GROUPS

Dr. Loran Anderson
Dept. of Biological Sciences
319 Stadium Drive
Florida State University
Tallahassee, FL 32306

Dr. Michael Woods
Dept. of Biological Sciences
Troy University
213 Math Science Complex
Troy, AL 36082

Dr. Wayne Barger, State Botanist
Dept. Conservation and Nat Resources
State Lands Division, Nat Heritage Section
64 North Union Street
Montgomery, AL 36130

Mr. Angus Gholson
P.O. Box 385
Chattahoochee FL 32424

Mr. Wilson Baker
1422 Crestview Avenue
Tallahassee, FL 32303

Ms. Kathryn Kennedy
Center for Plant Conservation
Missouri Botanical Garden
P.O. Box 299
St. Louis MO 63166

Dr. Wiley Kitchens
Florida Cooperative Fish and Wildlife
Research Unit
University of Florida
P.O. Box 119450
Gainesville FL 32611-0450

Dr. Michael Van Den Avyle
Georgia Cooperative Fish and Wildlife
Research Unit
Warnell School of Forest Resources
University of Georgia
Athens GA 30602-2152

Dr. Robert Kral
1425 Pine Circle N.W.
Cario, GA 39828-1548

Mr. Robert McCartney
Woodlanders, Inc.
1128 Colleton Avenue
Aiken SC 29801

Dr. Gil Nelson
Robert K. Godfrey Herbarium
Florida State University
Tallahassee, FL 32306

Dr. Ronald Myers
Tall Timbers Research Station
Route 1, Box 678
Tallahassee FL 32618

Ms. Cheryl Peterson
Bok Tower Gardens
1231 Tower Boulevard
Lake Wales FL 33853-3412

Dr. Richard P. Wunderlin
Institute for Systematic Botany
Department of Cell Biology, Microbiology, and
Molecular Biology
University of South Florida
4202 East Fowler Avenue, BSF 218
Tampa, FL 33620-5150

The Nature Conservancy
10394 NW Longleaf Dr.
Bristol, FL 32321-2631

The Nature Conservancy
P.O. Box 118526
Gainesville FL 32611
222 S. Westmonte Drive, Suite 300
Altamonte Springs FL 32714-4269

Mr. Gary Knight
Florida Natural Areas Inventory
1018 Thomasville Rd, Suite 200-C
Tallahassee FL 32303

Florida Native Plant Society
P.O. Box 6116
Spring Hill FL 34606-0906

Mr. Dan Spaulding
Anniston Museum of Natural History
Curator of herbarium
P.O. Box 1587, Anniston, AL 36202-1587

Ms. Tova Spector
Florida Park Service
Department of Environmental Protection
4620 State Park Lane, Panama City, FL 32408