Bunched arrowhead
(*Sagittaria fasciculata*)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service photograph

U.S. Fish and Wildlife Service
Southeast Region
Asheville Ecological Services Field Office
Asheville, North Carolina

5-YEAR REVIEW
Bunched arrowhead (*Sagittaria fasciculata*)

LIST OF ABBREVIATIONS

AFO	Asheville Field Office, U.S. Fish and Wildlife Service
EOR	Element Occurrence Record (a mapping unit commonly used by Natural Heritage Programs)
ES	Ecological Services
ESA	Endangered Species Act
FR	Federal Register
NCNHP	North Carolina Natural Heritage Program
SCDNR	South Carolina Department of Natural Resources
USFWS	U.S. Fish and Wildlife Service

5-YEAR REVIEW
Bunched arrowhead/*Sagittaria fasciculata*

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office:
Southeast Region, Chris Davidson (assisting on detail in recovery in the Regional Office), 501/513-4481, Southeast Region, Kelly Bibb, 404/679-7132

Lead Field Office:
Asheville, North Carolina ES Field Office, Carolyn Wells (originating author; moved to a new office and position)
Asheville, North Carolina ES Field Office, Mara Alexander (new lead), phone 828/258-3939 ext. 238

Cooperating Field Office(s):
Charleston, South Carolina, ES Field Office, Morgan Wolf, 843/727-4707 ext. 219

1.2 Methodology used to complete the review:

Public notice of the initiation of this 5-year review was given in the *Federal Register* on July 6, 2009 (74 FR 31972) and a 60 day comment period was opened. During the comment period, we did not receive any additional information about bunched arrowhead (*Sagittaria fasciculata*) other than responses to specific requests for information from biologists familiar with the species (see Appendix A for a summary of peer review of this document). Information used in this report was gathered from published and unpublished reports. Records were provided by North Carolina Natural Heritage Program (NCNHP) and South Carolina Department of Natural Resources (SCDNR) Heritage Trust offices. The review was completed by the lead recovery biologist for the species in the Asheville, North Carolina Ecological Services Field Office (AFO).

1.3 Background:

1.3.1 FR Notice citation announcing initiation of this review:
July 6, 2009 (74 FR 31972)

1.3.2 Species status: (2013) Stable. Significant threats remain for this species but we have multiple colonies protected in conservation. There are 11 extant populations of *S. fasciculata* (Appendix B, Table B.1); seven of these populations contain at least one colony in protective ownership.

1.3.3 Recovery Achieved: 1 (1=0-25% species recovery objectives achieved)

1.3.4 Listing history

Original Listing
FR notice: 44 FR 43700
Date listed: August 31, 1979
Entity listed: species
Classification: endangered

Revised Listing, if applicable
(n/a)

1.3.5 Associated rulemakings: n/a

1.3.6 Review History:
Recovery Plan: 1983
Recovery Data Call: 2013-1998
The Service conducted a five-year review for the bunched arrowhead in 1991 (56 FR 56882). In this review, the status of many species was simultaneously evaluated with no in-depth assessments of the five factors or threats as they pertain to the individual species. The notice stated that the Service was seeking any new or additional information reflecting the necessity of a change in the status of the species under review. The notice indicated that if significant data were available warranting a change in a species' classification, the Service would propose a rule to modify the species' status. No change in the plant's listing classification was found to be appropriate.

1.3.7 Species' Recovery Priority Number at start of 5-year review (48 FR 43098):
5C (This number reflects a high degree of threat and a low recovery potential.)

1.3.8 Recovery Plan

Name of plan:
Bunched Arrowhead Recovery Plan (*Sagittaria fasciculata*)
Date issued: September 8, 1983

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy

The Act defines species as including any subspecies of fish or wildlife or plant, and any distinct population segment (DPS) of any vertebrate wildlife. Because *Sagittaria fasciculata* is a plant, the DPS policy is not applicable and is not addressed further in this review.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan[1] containing objective, measurable criteria?

Yes.

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

No. The number of populations, and colonies within known populations, has increased since the recovery plan. The targeted number of protected populations and colonies specified in the recovery criteria should be revised to reflect these changes. Refer to Section 2.3, Updated Status, and Section 4.0, Recommended Future Actions, for more information.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?

Yes. The recovery criteria could not be met without adequately addressing the applicable listing factors. There is no new information to consider regarding existing or new threats, although threats such as accelerated climate change are expected to exacerbate previously identified threats.

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

The recovery plan does not contain itemized or enumerated recovery criteria, but consists of a narrative with statements which are interpreted as such. These are presented here following the sequence in which they are presented in the recovery plan narrative:

Criterion 1: At least three colonies in each of four of the five populations should be protected.

There are 11 extant populations of *S. fasciculata* (Appendix B, Table B.1); seven of these populations contain at least one colony in protective ownership (Table B.2). However, only one population (the Enoree River – mainstem in South Carolina) contains more than a single protected colony. Thus the number of protected populations, and colonies within populations, is less than specified in the recovery plan and this criterion has not been met.

Criterion 2: …the following colonies should be protected: the two North Carolina colonies in the East Flat Rock population, the single colony in the Beaverdam Creek – Enoree River population, the single colony in the Beaverdam Creek – Tyger River population, all three colonies in the Reedy River population, and eight colonies in the Enoree River population.

Not met. The North Carolina East Flat Rock population does not contain any protected colonies. The Beaverdam Creek – Enoree River population is extirpated, and there are no protected colonies within the Beaverdam Creek – Tyger River populations. The Reedy River population contains one colony subject to a voluntary landowner agreement with Furman University; three colonies within the Enoree River (mainstem) population are protected as South Carolina Department of Natural Resources (SCDNR) Heritage Preserves.

Criterion 3: Within each of the populations, sufficient colonies must be protected and located near enough to one another to ensure that there is normal gene flow between the colonies.

Not met. The number of protected colonies within all populations is lower than the minimum numbers called for in the recovery criteria. The recovery plan calls for multiple protected colonies within each protected population; as of this review only one population (the Enoree River - mainstem) contains more than a single protected colony.

2.3 Updated Information and Current Species Status

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

Newberry (1991b) conducted a series of transplant experiments during the fall of 1990. In her summary of these efforts, Newberry notes that all increases in cover and/or plant numbers were attributable to vegetative propagation from rhizomes. This finding has significant implications for the genetic structure within and among populations of this species (discussed in Section 2.3.1.3, below).

Snipes *et al.* (1986) examined the hydrology and geology of the French Broad – Bat Fork, Enoree (mainstem), and Reedy River populations of *S. fasciculata*. They characterized occupied habitat as muck-filled seep areas on alluvial flood plains, with a few noteworthy exceptions where the species occurred in small sand bars in streams. Analyses of soil chemistry, particle size, and x-ray diffraction revealed that the species tends to occur in acidic (pH 5.3 to 6.8) soils in which the primary organic content is humus, which attributes both porosity and water holding to the soil. Ground water wells (piezometers) installed at one site revealed ground water levels close to the surface, a finding regarded as consistent with the observation that larger seeps occupied by *S. fasciculata* do not dry up even in hot, dry summers. These authors also attribute a consistent source of ground water to the greater volume (roughly 20 times) of residual soil beneath the alluvial and muck sediments. They also speculate that the residual soil beneath the alluvium and muck functions as an aquitard (bed of low permeability along an aquifer) slowing downward migration of ground water.

Baxter *et al.* (2007) examined the hydrogeologic, physical and chemical characteristics of 14 Greenville County locations supporting colonies of *S. fasciculata*. Sites were characterized by (1) visual characterization of land cover, topography and hydrologic setting, (2) measurements of pH, dissolved oxygen, conductivity, temperature and numerous chemical analyses of surface water, and (3) grain size and organic content analysis of the substrate. These authors reached similar conclusions as others familiar

with the species, namely that *S. fasciculata* appears to require well shaded, hydrated soils fed by a constant source of freshwater. Baxter *et al.* (2007) found that plants tend to occur in organic-rich (average 10% organic), shallow (less than 5cm) sandy mucks in shallow (< 5 cm), acidic (pH 4-5), sodium mixed cation-bicarbonate waters with moderate levels of dissolved oxygen (3-7 mg/L) and relatively low conductivities (20-50 µS).

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features, or demographic trends:

Abundance

The recovery plan recognized a total of five extant populations. As of this review, the total number of extant populations has increased to 11. This review adopts the same definition of "population" as used in the recovery plan, with groups of colonies related by drainage and in relatively close physical proximity (generally within 2 km of each other as measured in river or stream miles). A list of populations recognized by USFWS for purposes of this review, along with the number of colonies they contain, is provided in Appendix B (Table B.1). Table B.1 also identifies the corresponding Natural Heritage Program element occurrence records (EORs) that occur within the boundaries of each population recognized by USFWS. The locations of populations discovered since the recovery plan are discussed in Section 2.3.1.5 (Spatial Distribution).

The recovery plan recognizes 28 colonies within five extant populations. AFO files do not contain maps or any other information identifying the location of these colonies. As of this review, there are 37 colonies presumed extant, distributed among 11 populations (Table B.1; this table and tally includes one colony not mapped as an NHP EOR). Four populations are represented by a single colony; five populations contain two colonies each. The only two populations containing more than two colonies are the Enoree River – mainstem (15 colonies) and Reedy River (eight colonies).

Across the species' range, colonies have been estimated to contain anywhere from a few dozen to several thousand rosettes (NCNHP, 2010; SCDNR, 2010; Newberry, 2000; Boyer, 1992). Aggregating the last available size estimates for all extant colonies suggests that the total species range may consist of 97,500 to 120,000 rosettes. Eleven colonies (all in South Carolina) lack even a single estimate of the number of rosettes present. Of the remaining 31 colonies for which at least one size estimate is available, five are estimated to contain greater than 10,000 rosettes. By contrast, eight colonies were last estimated to contain fewer than 500 rosettes. The three largest populations occur in Greenville County, South Carolina within the Enoree River – mainstem, South Tyger – Clear Creek, and Reedy River watersheds. These populations are likely to contain over 10,000 rosettes each.

Population trends

There is little information available to inform a discussion of trends within populations of *S. fasciculata*. AFO files do not contain baseline data sufficient for estimating abundance within or among populations known at the time of listing or the final recovery plan. The recovery plan does not provide estimates of population size (number of individuals), but does identify the need to estimate population and colony size as a Priority 2 recovery task.

Boyer (1992) visited four North Carolina colonies (representing portions of the French Broad – Bat Fork Creek and French Broad – Mud Creek populations) in 1990, and

provides estimates of rosettes present. Boyer and Frost (1996) re-visited these four colonies during the 1995-1996 field seasons, and reported that the Mud Creek colony within the French Broad – Mud Creek population and Bat Fork colony within the French Broad – Bat Fork population were possibly extirpated.

Newberry (2000) visited all North Carolina colonies previously surveyed by Boyer (1990) and Boyer and Frost (1996), as well as all known South Carolina colonies, during the 1999-2000 field seasons. Newberry was unable to relocate the two North Carolina colonies reported as possibly extirpated by Boyer and Frost (1996). The French Broad – Mud Creek colony was presumed extirpated until 2012 when *S. fasciculata* was found in abundance at this site growing in a private landowner's ditch; the Bat Fork colony was last observed by USFWS in early 2010, but was not relocated in subsequent surveys by USFWS later that same year. In 2011, plants were found growing in this colony again (NCNHP 2013). Newberry's observations suggest declines at a third colony (the Ochlawaha Bog colony within the French Broad – Mud Creek population), with fewer than 50% of the rosettes reported by Boyer (1992). This colony underwent further declines, nearing extirpation, with only a single uprooted (floating) rosette found at the site during 2010, but after restoration work in this site, *S. fasciculata* reemerged. In 2011, 1,685 rosettes were observed, though by 2012, this colony seemed to decline (NCNHP 2013).

Newberry (2000) visited 26 South Carolina sites during 1999-2000. There is no simple, one-to-one correspondence between Newberry's 26 sites and colonies recognized by USFWS for purposes of this review. Some of her sites correspond to a single colony as recognized by USFWS, whereas others consist of multiple spatially discrete locations regarded as separate colonies by USFWS. Regardless, she assessed 12 of 26 (46%) South Carolina sites as declining relative to her own anecdotal observations from prior years, and another five (19%) as extirpated. Of the remaining sites visited by Newberry, three could not be relocated, two appeared to have increased, and four were described as extant with no comment on trends in the number of *S. fasciculata* present. The majority of the locations visited by Newberry in 1999-2000 have either not been visited since, or have no subsequent population size estimate in the SCDNR Heritage Trust database (SCDNR 2010).

In 1984, Newberry (1991a) installed 47 permanent monitoring plots within five populations and summarized findings from monthly data collection spanning from 1984-1986. Newberry reported 10% of plots (n=5) contained no plants at the end of this monitoring period, while 66% (n=31) exhibited declines, with nine of 31 plots declining by more than 20%. Newberry identified reduced/altered surface water (n=11 plots), overgrowth/competition from other species (n=10), conversion to pasture and/or cattle trampling (n=6), power line clearing (n=3), and siltation (n=3) as factors correlated with declines. Increases and decreases in the flow of surface water were correlated with declines in the number of plants. However, most declines were associated with decreased flow and partial drying of the substrate. Newberry (1991b) states that annual monitoring (presumably of all or a subset of these same plots) continued through 1991, but provides little additional monitoring data. However, Newberry notes that populations situated alongside streams appear healthier in low rainfall years and seep populations appear healthier in years with higher rainfall. Newberry offers the explanation that high rainfall tends to scour streamside populations and leads to detrimental levels of sedimentation in those habitats, whereas these same rainfall events tend to recharge seep habitats thereby

decreasing stagnation and increasing the extent of suitable habitat for *S. fasciculata* colonization.

Within the French Broad – East Flat Rock population (Henderson County, NC), two colonies of *S. fasciculata* have been monitored annually since 2000 (Geosyntec, 2009 and references therein). As of December 2009, both colonies had been assessed as generally stable over the ten-year monitoring period. However, the distribution of plants was not, with the location and extent of occupied habitat fluctuating annually within those seeps known to contain the species. That *S. fasciculata* tends to shift locations within occupied seeps is corroborated by other sources (Environmental Permitting Consultants, Inc., 2010; Bunch, M., SCDNR, pers. comm. 2010). It is unclear whether these patterns are the result of established plants washing downstream during high-flow events, mortality and recruitment within sites due to changes in microhabitat, or a combination of these factors.

In 2008, *S. fasciculata* was introduced to a location within the Reedy River population from another colony within the same population and watershed that was threatened with destruction as a result of commercial development (Environmental Permitting Consultants, Inc., 2008). This introduced colony received annual monitoring during 2009 - 2012 growing seasons (Environmental Permitting Consultants, Inc., 2009, 2010, 2011, and 2012). In the 2012 report, Environmental Permitting Consultants, Inc. portray data suggesting the colony decreased in percent cover of *S. fasciculata* rosettes within monitoring plots by less than 1 % below baseline levels recorded in 2008, essentially remaining stable over the last four years. USFWS is concerned that these results may not be accurate due to changes in methods over the four years of monitoring and that this colony may have decreased more substantially than reported.

The French Broad – Mud Creek population in Henderson County, NC contains two colonies of *S. fasciculata*. One colony that grows on private land, which was assumed extirpated, reemerged after the landowner dredged the ditch located on their property (NCNHP 2013). The second colony (Ochlawaha Bog) was found to contain a single, uprooted rosette during 2010 after repeated flowering season surveys failed to reveal any individuals. This site consistently contained several hundred to many thousand rosettes, reportedly containing 2,000 rosettes in 1995 (NCNHP 2010). The uprooted rosette was taken to the North Carolina Botanical Garden at Chapel Hill, where efforts are underway to propagate this individual for use in subsequent efforts to reintroduce *S. fasciculata* to Ochlawaha Bog. Increases in beaver activity, changes to sedimentation levels and deposition patterns, and changes in land use practices (namely a cessation in dredging sediment from the ditch where the plants were previously known to occur) each have been implicated in the decline of *S. fasciculata* at this site. However, each of these explanations represents little more than speculation given the lack of adequate baseline data and routine visitation to the site over the years. The Ochlawaha Bog site was the focus of habitat restoration efforts jointly undertaken (and funded) by USFWS and many of its conservation partners, with a focal restoration objective being the creation of suitable habitat for, and a self-sustaining population of, *S. fasciculata*. The restoration work was completed in 2011. Without reintroductions to the site, 1,685 rosettes were found growing in the restored wetland in August 2011, although this number seemed to decline in 2012 (NCHP 2013).

In 2010, the USFWS and its partners confirmed the extirpation of the French Broad – Memminger population (at St. Johns in the Wilderness Church).

According to a review of SCDNR database records, the majority of South Carolina colonies have had no recorded observation since 2000 (SCDNR 2010). One new record, consisting of one large plant, was found growing in a newly discovered seepage in the Reedy watershed in close proximity to a previously recorded colony growing in Duke Energy right-of-way (Bunch, M., SCDNR, pers. comm. 2013).

Demography

There is only a single effort to obtain demographic level information for *S. fasciculata* (Newberry, 1991a). Newberry followed the survival of 100 marked plants during 1985-1987. It is unclear at what frequency these plants were monitored; however Newberry states that only 10% of the marked plants could be relocated two years after first being marked (in March, 1985). From this, she concludes that *S. fasciculata* plants may not live longer than two years – however this hypothesis requires further investigation before it can be generally accepted.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation:

A pilot investigation of genetic diversity in *S. fasciculata* using inter-simple sequence repeats (ISSR) revealed evidence of genetic differentiation among watersheds, but little genetic differentiation among colonies within watersheds (Liao, M., Furman University, pers. comm. 2010). This undergraduate research project, conducted from 2005-2006, consisted of a comparison of an unspecified number of sites within the Enoree and Reedy watersheds in South Carolina. In 2012, AFO staff worked with Min-Ken Liao of Furman University to expand her South Carolina study into North Carolina. Mara Alexander collected leaf samples from all North Carolina populations with the exception of the Mills River population due to lack of landowner approval. Dr. Liao examined the genomic diversity of the samples and did not find that the North Carolina populations differed from one another genomically (Liao 2012). In 2010, staff affiliated with the Bent Creek Institute at the North Carolina Arboretum collected chloroplast DNA samples from multiple sites across the range of the species, with the intent of subjecting these samples to genetic analysis should funding become available.

2.3.1.4 Taxonomic classification or changes in nomenclature:

There have been no changes applicable to the classification or nomenclature of *S. fasciculata*.

2.3.1.5 Spatial distribution, trends in spatial distribution, or historical range:

The recovery plan describes the current range as consisting of Henderson County, North Carolina and Greenville County, South Carolina. The recovery plan identifies a single herbarium specimen from Buncombe County, North Carolina, while acknowledging concerns (citing Wooten, pers. comm.) that this specimen may have been collected in Henderson County. Thus, the recovery plan describes the current range as consisting of Henderson County, NC and Greenville County, SC. Within these counties, the recovery plan identifies a total of five extant populations (one in NC and four in SC).

The county-level distribution of the species has not changed since the final recovery plan. The number of known populations has increased from five to 11, with new populations discovered in the Mills River and Mud Creek watersheds of the French Broad basin (both

in Henderson County, NC); North Enoree River watershed (Greenville County, SC); and Clear Creek watershed of the South Tyger River basin (Greenville County, SC). As noted elsewhere, this review adopts the same definition of population used in the recovery plan, with groups of colonies related by drainage and in relatively close physical proximity (generally within 2 km of each other as measured in river or stream miles). There are no other necessary corrections to the historical or current range.

2.3.1.6 Habitat:

There are no estimates of the amount of habitat occupied by *S. fasciculata*, as most locations have been mapped as a single centroid rather than polygons depicting the full extent of the colony(-ies).

In terms of habitat suitability, North Carolina populations of *S. fasciculata* typically occur in highly degraded habitats representing ditched and channelized remnants of former wetland and stream systems. By contrast, the majority of South Carolina colonies occur in areas that appear (at least superficially) to have suffered fewer obvious hydrologic impacts from adjacent land use, have intact forest canopies (albeit young or immature, with an average stand age between 20 and 80 years) and contain unaltered perennial seep habitat. However, despite these differences, populations across the range of *S. fasciculata* continue to exhibit marked fluctuations in response to drought or high rainfall events (Newberry, 2000; Bunch, M., SCDNR, pers. comm. 2010).

Across the range of the species, habitats occupied by *S. fasciculata* are threatened by numerous invasive exotic plant species. Some of these species, like *Murdania keisak*, are herbaceous and reduce the availability of suitable substrates for seedling recruitment and vegetative growth; others, like *Rosa multiflora* and *Ligustrum* spp., threaten *S. fasciculata* by forming dense, low canopies which intercept sunlight.

2.3.2 Five-Factor Analysis -

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

As described in greater detail above (Section 2.3.1.2), Newberry (1991a) identified reduced/altered surface water (n=11 plots), overgrowth/competition from other species (n=10), conversion to pasture and/or cattle trampling (n=6), powerline clearing (n=3), and siltation (n=3) as being correlated with declines in 47 permanent plots monitored from 1984-1986. Increases and decreases in the flow of surface water were correlated with declines in the number of plants. However, most declines were associated with decreased flow and partial drying of the substrate. In a subsequent unpublished report, Newberry (1991b) described "significant changes" to habitat resulting from nutrient runoff, flooding, and sedimentation following heavy rains. Populations located adjacent to streams typically suffer scouring and sedimentation during heavy flows, while seeps tend to improve as a result of increased hydration, reduced stagnation and increased suitable habitat area. The weather-related threats are likely to be intensified under most general circulation climate change models (Karl *et al.* 2009).

Newberry (1991a) concluded that interspecific competition is a significant threat to *S. fasciculata*. The number of *S. fasciculata* plants tripled during the first year of removing

invasive plant species surrounding *S. fasciculata* plants, showed moderate increases the following year and remained higher than controls one year post the removal of nearby invasive plants. *Murdania keisak*, an invasive exotic plant, is increasingly found in wetland habitats throughout the range of *S. fasciculata*, including within habitats occupied by *S. fasciculata* (Newberry 1991a; Geosyntec, 2010). The fibrous root system and vigorous rhizomatous growth of *M. keisak* may directly threaten *S. fasciculata* by reducing water flow and stabilizing the suspended muck substrate, both of which appear to be key habitat requirements for *S. fasciculata* (Newberry, 1991a).

Newberry (2000) identified the following sources of ongoing or potential threats to *S. fasciculata* at 26 sites in South Carolina: grazing and trampling by cattle or horses (six sites); invasive exotics (esp. *Ligustrum* spp. and *M. keisak*, ten sites); encroachment by native competitive vegetation (six sites); siltation/sediment (one site); drought (four sites); stagnant/reduced flows (two sites); and scouring/flash flooding (one site). Across the range of the species, several colonies of *S. fasciculata* occur in managed road, railroad, or utility rights-of-way (ROW) where overspray or drift from herbicides poses a threat to *S. fasciculata* (Bunch, M., SCDNR, pers. comm. 2010; Geosyntec, 2009; Newberry, 2000). Overspray or drift has been implicated in at least temporary reductions in the number of *S. fasciculata* plants in a given area, however in some instances these declines may have been offset by a reduction in the density of encroaching vegetation (primarily woody), which also poses a threat to *S. fasciculata* (Bunch, M., SCDNR, pers. comm. 2010; Worton, A., Geosyntec, pers. comm. 2010; Geosyntec, 2009). Despite attempts by SCDNR to inform utility companies about consistent, appropriate management practices to benefit *S. fasciculata*, managed right-of-ways continue to be an impediment to conservation efforts for this species (Bunch, M., SCDNR, pers. comm. 2010).

2.3.2.2 Over utilization for commercial, recreational, scientific, or educational purposes:

This was not known to be a significant threat to *S. fasciculata* at the time of listing, but in March 2012, this plant was poached from the Bunched Arrowhead Heritage Preserve in South Carolina. SCDNR staff discovered a 2' x 2' section of *S. fasciculata* plants missing. Whoever stole the plants came prepared with tools to cut, dig and remove the plants en masse. SCDNR offered a reward to anyone who provided information regarding this theft, but they never received any information (SCDNR 2012). Although this new evidence of poaching is concerning and the Service will closely monitor this potential threat with partners, we do not have evidence to suggest it is a significant threat at this time.

2.3.2.3 Disease or predation:

This was not known to be a significant threat to *S. fasciculata* at the time of listing, and the USFWS has no new information to suggest that this now represents a significant threat to the species.

2.3.2.4 Inadequacy of existing regulatory mechanisms:

The North Carolina Plant Conservation and Protection Act (NC State Code Article 19B, § 106-202.12) provides limited protection from unauthorized collection and trade of plants listed under that statute. However, this statute does not protect the species or its habitat

from destruction in conjunction with development projects or otherwise legal activities. Plant species are afforded less protection in South Carolina, where they are protected only from disturbance at South Carolina Heritage Preserves (SC State Code of Regulations Part 123 § 200-204). There are no other statutes that afford significant protections to *S. fasciculata*.

In South Carolina, one colony is afforded some protection through a registration agreement between the landowner (Furman University) and SCDNR Heritage Trust Program. This agreement, signed in 1981, recognizes the natural heritage significance of the property, and acknowledges the mutual interests of SCDNR and the landowner in preserving its habitat. The agreement is non-binding but remains in effect. Despite the University authorizing activities that threaten the long-term viability of this *S. fasciculata* population (Newberry, 2000), faculty of Furman University Biology Department have been instrumental in increasing awareness among the University administration staff about the significance of the site and activities that adversely affect it (Dr. Joe Pollard, Furman University, pers. comm. 2010).

2.3.2.5 Other natural or manmade factors affecting its continued existence:

None beyond those already addressed under Factor A.

2.4 Synthesis –

The status of *S. fasciculata* has not appreciably changed since listing, and the current federal status of endangered remains appropriate. The global distribution of this narrow-ranging endemic of the Carolinas is confined to four major watersheds: the French Broad River in Henderson County, North Carolina, and the Enoree, Reedy, and Tyger River watersheds in Greenville County, South Carolina. There are a total of 11 extant populations of the species, and two populations are presumed extirpated. The recovery criteria for *S. fasciculata* specify minimum numbers of protected colonies distributed across the range of the species. As of this review, there are fewer protected colonies within each population than specified in the recovery criteria, and previously identified threats remain significant at most sites. Recent status surveys and other anecdotal observations suggest that many sites have declined from historic levels, and other sites have been extirpated (Newberry 2000; NCNHP 2013; SCDNR 2012). A lack of robust, structured, and quantitative monitoring makes objective characterization of trends difficult and hinders efforts to determine the causes of apparent declines in colonies and the larger populations of which they are a part.

3.0 RESULTS

3.1 Recommended Classification:

__X__ No change is needed

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

These actions are listed in order of priority, and cross-walked to tasks identified in the recovery plan, where appropriate.

- *Obtain the most appropriate and highest protection for each population or colony (Recovery Task 12, Priority 1).*

  Once updated information on the size and vigor of extant colonies is obtained, protection efforts should be undertaken immediately. The current number of protected colonies/populations is far less than that specified in the current set of recovery criteria.

- *Estimate current colony and population size and vigor (Recovery Task 111, priority 2).*

  Updated information on the size and vigor of extant colonies/populations is critically needed in order to assess and refine protection priorities. It would be particularly useful to include detailed mapping of the spatial extent of occupied habitat.

- *Monitor colonies, populations, permanent plots, transplants and propagation facilities (Recovery Task 4, priority 3).*

  The lack of monitoring data hinders objective assessments of colony/population trends. Anecdotal observation suggests that this species exhibits considerable fluctuation in response to drought and heavy rainfall events; monitoring would help to determine the range of acceptable fluctuations in colony/population size, and critical thresholds for management intervention.

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U.S. FISH AND WILDLIFE SERVICE

5-YEAR REVIEW of *Sagittaria fasciculata* (bunched arrowhead)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__X__ No change needed

Review Conducted By: Carolyn Wells and Mara Alexander, Asheville, North Carolina Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve _____ Date 3/3/14

REGIONAL OFFICE APPROVAL:

for

Lead Regional Director, Fish and Wildlife Service

Approve _____ Date 3-24-14

Appendix A: Summary of peer review for the five-year review of *Sagittaria fasciculata* (bunched arrowhead)

A. Peer Review Method:

A draft of this document was circulated to those with direct and substantive knowledge of *Sagittaria fasciculata*, including Dr. Gill Newberry (cited numerous times throughout the document) and representatives from the North Carolina Natural Heritage Program (NCNHP), the North Carolina Plant Conservation Program (NCPCP), the South Carolina Department of Natural Resources (SCDNR), and Furman University.

B. Peer Review Charge: Peer reviewers were asked to conduct a scientific review of technical information presented. Reviewers were not asked to review the legal status determination.

C. Summary of Peer Review Comments:

Comments were received from NCNHP and SCDNR. Editorial comments provided by these reviewers were incorporated as appropriate, and are not reviewed here. The following summary addresses only substantive comments provided by these reviewers.

The reviewer from the SCDNR initially responded (by e-mail) with comments relating to threats associated with herbicide application in utility rights-of-way. A follow-up phone call to this reviewer (by the USFWS species recovery lead) yielded additional information on the current size of several colonies, including new information suggesting that one population regarded as possibly extirpated by Newberry (2000) was actually extant (M. Bunch, pers. comm.). This reviewer also provided information on SCDNR decisions not to pursue protection for a colony within the population on the Enoree River below Cane Creek, citing numerous concerns over the long term viability of that population.

The reviewer from NCNHP suggested revisions to the delineation of population boundaries in North Carolina, noting that some colonies treated as part of a single population in the first draft of this review were actually separated by more than 2 km when measured along drainages (as opposed to the closest overland distance). This reviewer also noted additional protections afforded to *S. fasciculata* by virtue of Registry and Dedication Agreements with the NCNHP (portions of two populations) and also alluded to additional protections afforded to the species under the Clean Water Act and North Carolina state stream and wetland regulations. The NCNHP reviewer suggested that these additional protection mechanisms be discussed in the five factor analysis (under the section "Inadequacy of Other Regulatory Mechanisms").

D. Response to Peer Review:

In response to comments from the SCDNR reviewer, sections describing the distribution and abundance of *S. fasciculata* (esp. Section 2.3.1.5 and Appendix B) were updated to reflect the correct number of extant and extirpated populations and the five-factor analysis (Section 2.3.2.1) was expanded to address the threats presented by herbicide use within managed utility rights-of-way.

The suggestions for revised population boundaries (provided by NCNHP) were adopted. The five factor analysis was revised to address protections from Registry and Dedication Agreements with NCNHP. However, the USFWS did not concur with NCNHP's interpretation that the Clean Water Act and/or North Carolina state statute or regulation affords significant additional

protections to *S. fasciculata* in the absence of that species' federal status. The Clean Water Act only offers protection of this species when it grows on federal land because intentional take of plants is not prohibited by the Endangered Species Act unless growing on federal land. North Carolina state statute does not protect the species or its habitat from destruction in conjunction with development projects or otherwise legal activities. The recommendation to address this issue in the five factor analysis was not adopted.

Appendix B: Tables

Table B.1. *Sagittaria fasciculata* populations and the number of colonies they are estimated to contain. Also noted are the corresponding Natural Heritage Program (NHP) element occurrence records (EORs) located within the boundary of each population recognized by USFWS.

State	County	Population name	Colonies (total)	Colonies extant (presumed)	Protected colonies	NHP EORs
Extant						
NC	Henderson	French Broad – East Flat Rock	2	2	0	NC*001
NC	Henderson	French Broad – Highland Lake Inn	1	1	1	NC*008
NC	Henderson	French Broad – Mud Creek	2	2	1	NC*002, 003
NC	Henderson	French Broad – Bat Fork Creek	1	1	1	NC*004
NC	Henderson	French Broad – Mills River	1	1	0	NC*007
SC	Greenville	Enoree River - mainstem	15	15	3	SC*001, 003, 004, 005, 006, 008, 009, 018, 019, 020, 022, 023, 024
SC	Greenville	North Enoree River	3	2	1	SC*016, 023
SC	Greenville	South Tyger – Beaverdam Creek	3	2	0	SC*014, 025
SC	Greenville	South Tyger – Clear Creek	1	1	1	SC*015
SC	Greenville	Reedy River	9	8	1	SC*002, 010, 011, 012, 013, 021, 027, 028
SC	Greenville	Enoree River – below Cane Creek	2	2	0	SC*007
Extirpated						
NC	Henderson	French Broad – Memminger Creek	1	0		NC*006
SC	Greenville	Enoree River – Beaverdam Creek	2	0	0	SC*007

Table B.2. Protected colonies of *Sagittaria fasciculata*.

Population name	Colony name	Landowner	Protection type	NHP EORs
French Broad River – Highland Lake Inn (NC, Henderson County)				
	Highland Lake Inn/CMLC easement	Highland Lake Inn	Conservation easement	NC*008
French Broad River – Bat Fork Creek (NC, Henderson County)				
	Bat Fork Bog	NCPCP	Fee title by a state natural resource agency; also a Dedicated Nature Preserve[†]	NC*004
French Broad River – Mud Creek (NC, Henderson County)				
	Ochlawaha Bog	NCPCP, CMLC	Fee title by a state natural resource agency; also a Dedicated Nature Preserve[†] and a Registered Heritage Area [¥]	NC*003
Enoree River – mainstem (SC, Greenville County)				
	Bunched Arrowhead Heritage Preserve	SCDNR	Fee title by a state natural resource agency	SC*005, 006, 019
	Blackwell Heritage Preserve – West	SCDNR	Fee title by a state natural resource agency	SC*018
	Blackwell Heritage Preserve – East	SCDNR	Fee title by a state natural resource agency	SC*022
North Enoree River (SC, Greenville County)				
	Bellvue Springs Heritage Preserve	SCDNR	Fee title by a state natural resource agency	SC*016
South Tyger River – Clear Creek (SC, Greenville County)				
	Clear Creek Heritage Preserve	SCDNR	Fee title by a state natural resource agency	SC*015
Reedy River (SC, Greenville County)				
	Furman University	Furman University	Voluntary registry	SC*010

[†] Dedicated Nature Preserves represent a permanent land allocation agreement approved by the North Carolina Council of State, signed by the Department of Administration and the Department which administers the state agency's lands, which provides standards for management and restoration of the lands.
[¥] Registered Heritage Areas represent voluntary agreements between the landowner and the NC Department of Environment and Natural Resources (NCDENR) which express the intentions of the owner not to permit changes damaging to the natural values of the site and recommending a management prescription specific to the area. Unlike Dedicated Nature Preserves, this form of protection is not legally binding and non-regulatory.