

Three Granite Outcrop Plants:

Black-spored quillwort (*Isoetes melanospora*)

Mat-forming quillwort (*Isoetes tegetiformans*)

Little amphanthus (*Amphanthus pusillus*)

Five-Year Review: Summary and Evaluation



Photo Credit: USFWS 2017

**U.S. Fish and Wildlife Service
South Atlantic-Gulf Region
Georgia Ecological Services Field Office
Athens, Georgia**

5-YEAR REVIEW

Black-spored quillwort (*Isoetes melanospora*), Mat-forming quillwort (*Isoetes tegetiformans*), Little amphianthus (*Amphianthus pusillus*)

I. GENERAL INFORMATION

A. Methodology used to complete the review:

This review was completed by the U.S. Fish and Wildlife Service's (Service) lead recovery biologist for each of these species, who is located in the Georgia Field Office, Athens, Georgia. No part of this review was contracted to outside parties. All literature and documents used in this review are on file at the Georgia Field Office and are cited in the Literature Cited section. We used peer-reviewed publications, data and information available on the internet, data from unpublished surveys, and information from personal communications with land managers, biologists, and researchers involved in plant conservation work, as well as the final rule listing these species under the Endangered Species Act (Act) and the recovery plan for these plants. Public notice of this review was given in the *Federal Register* on August 30, 2016 (81 FR 59650), and a 60-day comment period was opened. The draft of this document was distributed for peer review (see Appendix A) and comments received were evaluated and incorporated into this final document as appropriate.

B. Reviewers

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C. Background

1. **Federal Register Notice citation announcing initiation of this review:** August 30, 2016; 81 FR 59650

2. **Species Status:**

Little amphianthus: Declining. Cumulatively, between the three states, there has been 76 known populations of little amphianthus (*Amphianthus pusillus*). Of those populations, 20 are currently considered extirpated, 42 are considered extant, and 14 populations are in an unknown condition because of lack of surveys (9 populations) or an inability to relocate the populations (2 populations). Of the non-extirpated populations, 3 occur in Alabama, 50 occur in Georgia, and 3 occur in South Carolina. Thirteen of the extant populations occur on protected lands (e.g. state, county, and private conservation lands), and two additional populations were introduced into a single pool on protected locations outside of the known historic range of the species (Cobb and Jackson Counties, GA). Since the last 5-year review, we have modified how we define populations. Please refer to section C.1.a. for a description of how we define populations. Of the known extant populations, 24 are listed in poor condition because of either low pool redundancy (the population consists of less than three pools) and/or populations occur at outcrops where there still is active quarrying. Populations

with less than three pools can make the population vulnerable to extirpation events caused by human activities, because pools close together could all be impacted by a single catastrophic event.

Nine new populations of little amphianthus have been documented since the last 5-year review, but five of those populations are classified as poor condition.

- One population, Clover Community Park (York County, SC; Appendix B.), was extirpated in 2018 from construction run-off (Bradley, University of South Carolina, pers. comm. 2018).
- One population, St. Mary's Outcrop (Cobb County, GA), was introduced into a single pool in 1986.
- One population, Rocky Comfort (Warren County, GA), was discovered while a naturalist was documenting the potential travels of William Bartram across Georgia in the 1770's.
- The six remaining new populations were discovered during an extensive survey in 2012 of all known Lithonia gneiss granite outcrops in Georgia by Allison (2013).

Since the last 5-year review, two additional outcrops were listed as extirpated (Sunflower Rock, Heard County, GA, and The Rocks II, Rockdale County, GA). All of the Alabama outcrops where little amphianthus is still extant have seen declines in condition and these populations may be extirpated before the next review, unless conservation efforts prevent their decline.

Black-spored quillwort: Declining. Currently, 11 extant populations of black-spored quillwort populations occur in Georgia. Since the last 5-year review, we have modified the way populations are defined. Please refer to section C.1.a. for a description of our approach to defining populations for this species. Also since the last 5-year review, the black-spored quillwort population in South Carolina has tentatively been reidentified as another undescribed species, which reduces the species overall range to solely occur in Georgia. Additionally, the population Bradley Mountain (reintroduced black-spored quillworts into artificial pools) have been moved to a unique population based on watershed and dispersal limitations with the remaining plants at Arabia Mountain. There are six extirpated populations and the extant populations consist of eight natural populations, two introduced populations, and one reintroduced population. Of the two introduced populations, one is in a single pool at an arboretum and the other is in a single pool on private property (Thompson Mill Forest Arboretum and Siloam). Both of these introduced populations are not considered self-sustaining because the introductions are in less than ideal outcrop habitat, both populations are outside the known historic range of black-spored quillwort, and they were introduced with mat-forming quillwort which could result in hybridization. Five of the black-spored quillwort populations are on protected lands (e.g. state, county, and private conservation lands). Since the last 5-year review, two of the nine extant populations of black-spored quillworts have declined in condition, one has seen improvement in condition, one has been reintroduced and has unknown viability, and the remaining populations have been classified as no change in the population condition. The declining populations (Arabia Mountain and Stone Mountain) are both sites that are currently under conservation and have been considered the best sites for the species throughout its range, but have seen changes in pool community structure that has resulted in declines in the number of quillwort plants that could put the species in jeopardy at these locations.

Mat-forming quillwort: Stable. Historically, mat-forming quillwort was known to occur at 11 granite outcrops across Georgia (Service 1988). In the last 5-year review, there were 9 extant populations comprised of 13 EOs. Please refer to section C.1.a. for a description of our approach to defining populations for this species. There are currently 11 extant populations of mat-forming quillworts, including 2 of unknown condition (the populations have not been visited since the last 5-year review), 2 introduced populations, 1 created population, and 6 additional populations. Of the two introduced populations, one is in a single pool at an arboretum and the other is in a single pool on private property (Thompson Mill Forest Arboretum and Siloam). Both of these introduced populations are not considered self-sustaining because the introductions are in less than ideal outcrop habitat, both populations are outside the known historic range of mat-forming quillwort, and they were introduced with black-spored quillwort which could result in hybridization. Since the last 5-year review, one new population was found (Rocky Comfort), one population was created (Greensboro South), and one population has improved in its condition status (Forty Acre Rock, GA). Three of the natural, extant populations and one introduced population occur on protected lands (e.g. state, county, and private conservation lands).

3. Recovery Achieved: 2 for little amphianthus (25-50%) of species recovery objectives achieved and 1 for both black-spored and mat-forming quillwort (1= 0-25% of species recovery objectives achieved).

4. Listing History

Original Listing

FR notice: 53 FR 3560

Date listed: February 5, 1988

Entity listed: All three plants are listed as species.

Classification: Threatened (little amphianthus) Endangered (black-spored and mat-forming quillworts)

5. Review History:

Recovery Plan: July 1993

Each year, the Service reviews and updates listed species information for inclusion in the required Recovery Report to Congress. Through 2013, we did a recovery data call that included status recommendations such as “Stable or Declining” for these plants. We continue to show that species status recommendation as part of our 5-year reviews. The most recent evaluation for these plants was completed in 2018.

Five-year Reviews: 1991, 2008

The Service conducted a five-year review for all three plants in 1991 (56 FR 56882) and again in 2008. In the 1991 review, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors or threats as they pertain to the individual species. The 2008 review detailed more information on the status of specific populations and threats to the species throughout its range. No change in listing classification was recommended for these three plants in either review.

6. Species' Recovery Priority Number at start of review (48 FR 43098): 5 for black-spored quillwort (*I. melanospora*), 5 for mat-forming quillwort (*I. tegetiformans*), and 8 for little

amphianthus (*Amphianthus pusillus*). The 5 means degree of threat is high and recovery potential is low. The 8 means a moderate degree of threat and high recovery potential.

7. Recovery Plan

Name of plan: Recovery Plan for Three Granite Outcrop Plant Species. Date issued: July 7, 1993.

II. REVIEW ANALYSIS

A. Application of the 1996 Distinct Population Segment (DPS) policy

The Act defines species as including any subspecies of fish or wildlife or plants, and any distinct population of a species of vertebrate wildlife. This definition limits listing DPS to only vertebrate species of fish and wildlife. Because the species under review are plants, the DPS policy is not applicable.

B. Recovery Criteria

1. **Do the species have a final, approved recovery plan containing objective, measurable criteria?** Yes

2. **Adequacy of recovery criteria.**

a. **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 recovery criteria are more than 26 years old. The baseline status for all three species is stable or declining.

b. **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 relevant factors are covered. However, there are newer threats to the all three outcrop species. As alternative energy becomes more popular, energy developers will look for land not appropriate for development or agricultural uses. This activity has already targeted granite outcrop habitat in Rockdale County, GA, and may target additional granite flat rocks to establish solar farms. In recent years, the film industry has been using granite outcrop habitats in DeKalb County, GA, for film sets. This additional threat brings additional foot and vehicle impacts to the outcrops and foreign materials to the outcrop (e.g. paper products used to simulate snow) that could be an indirect impact to nearby pools (Brian McKnight, Stone Mountain Memorial Association, pers. comm. 2017).

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 states that:

“Reclassification of *Isoetes melanospora* or *Isoetes tegetiformans* to threatened will be considered if 10 viable and geographically distinct populations (separate outcrops), averaging at least two pools each, are protected. Delisting will be considered for little

amphianthus if 20 such populations (including at least two populations each in Alabama and South Carolina) are permanently protected for that species to such a degree that the species no longer qualifies for protection under the Endangered Species Act. Viability of populations will be assessed through periodic monitoring for a period of not less than 10 years. A viable population has the reproductive capability to sustain itself” (Service 1993, p. 14).

Little amphianthus. Currently, a total of 15 extant little amphianthus populations are protected. Two of these populations were introduced and may not be self-sustaining and only ten populations may have a condition ranking (fair, good, or excellent) that indicates a likely capability to sustain itself into the future. No protected populations occur in Alabama and of the two protected populations in South Carolina, it is unknown if management of the habitat is compatible with little amphianthus.

Black-spored quillwort. Only three populations of black-spored quillwort meet the recovery criteria of having two or more occupied pools that have been present 10 years or longer (Arabia Mountain, Stone Mountain, and Camp Meeting Rock).

Mat-forming quillwort. For mat-forming quillwort, although three populations meet the recovery criteria of having two or more pools, only one population, Heggie’s Rock, has had mat-forming quillworts documented in two or more pools for over a 10-year period.

Summaries of current population classifications and status can be found in Table 1. Comparatively, in our 2008 5-year review, we had only six populations in conservation status for little amphianthus, three for black-spored quillwort, and two for mat-forming quillwort. Threats from quarrying, farm animals, dumping, vehicular traffic, and recreational impacts have been largely abated for these populations. However, ongoing active management is required. Prior to the recovery plan, five major outcrops had some form of conservation management (Service 1993). Since the previous 5-year review, the new outcrop harboring mat-forming quillwort and little amphianthus (Rocky Comfort, Warren County, GA) was found and protected under a conservation easement in 2018. Details on the status of all populations are listed in Appendix 2. Below is a list and short account of each protected population that still harbors extant populations of at least one federally listed granite outcrop species. By definition of the 1993 Recovery Plan, all of the below outcrops with little amphianthus present, meets the recovery criteria for the species.

Cobb County, Georgia (little amphianthus)

St. Mary’s Outcrop. This outcrop is part of the Kennesaw National Battlefield Park. Little amphianthus was introduced into a single pool at this location in 1986. Cobb County is outside of the known range for the species. This population is not included in recovery calculations because it is outside of the known range of little amphianthus and the long-term persistence of the species at this location is unknown.

Columbia County, Georgia (mat-forming quillwort and little amphianthus)

Heggie’s Rock. This outcrop is owned by the Nature Conservancy and Columbia County and is one of the best-preserved granite outcrops in the state. This outcrop is host to both little amphianthus and mat-forming quillwort. This population of mat-forming quillwort

has more than 2 pools that have been present for more than 10 years.

DeKalb County, Georgia (black-spored quillwort and little amphianthus)

Arabia Mountain. This outcrop is owned by DeKalb County and protected as part of Davidson-Arabia Nature Preserve / Arabia Mountain National Heritage Area. This outcrop is managed for public use and hosts populations of little amphianthus and black-spored quillwort. At least 5 natural pools and 5 artificial pools contain black-spored quillwort and over 30 pools of little amphianthus make this one of the best locations for both species throughout their ranges. The larger historic pools at this location have had increases in competitive grass species several (*Bulbostylis* and *Juncus* spp.) and have resulted in declines of black-spored quillworts coverage in those pools. It is unknown if the artificial pools are self-sustaining. Currently, this granite outcrop meets the recovery criteria for both species.

Bradley Mountain (Little Arabia Mountain). This outcrop is partially owned by DeKalb County and protected as part of Davidson-Arabia Nature Preserve / Arabia Mountain National Heritage Area. Part of the outcrop is privately owned and not protected. The protected part of the outcrop is managed for public use and hosts populations of little amphianthus and black-spored quillwort. This population consists of at least 11 natural pools with little amphianthus and an additional 5 created pools contain black-spored quillwort and little amphianthus. The artificial pools were created in 2014, so recovery criteria for black-spored quillwort at this location has not been met.

Stone Mountain. This outcrop is owned by DeKalb County and outcrop is managed by Stone Mountain Memorial Association. This outcrop is host to populations of amphianthus and black-spored quillwort, most of which occurs within a fenced area to protect the pools from the extensive recreational traffic on the outcrop. In 2017, 5 pools contained black-spored quillwort and 18 pools contained little amphianthus. Abundance of black-spored quillwort have been declining in these pools in recent years (2017-2019). Despite the decline, this population of black-spored quillwort currently meets the recovery criteria of having 2 or more pools for over 10 years. However, the rapid decline of several, larger, historical quillwort pools since 2015 (changing from 75-80% cover to < 10% plant cover) caused by apparent competition from several grass species (*Bulbostylis* and *Juncus* spp.) has resulted in this population meeting the recovery criteria, but is not considered a stable population.

Douglas County, Georgia. (little amphianthus)

Clinton Nature Preserve. This granite outcrop is owned and protected by Douglas County. The property is managed as a horse park and recreational area. There is a very small population of little amphianthus, limited to a single pool, at this outcrop that was last checked in 2007. The status of this population is unknown.

Gwinnett County, Georgia. (black-spored quillwort and little amphianthus)

Baker's Rock (No Business Creek Outcrop). Most of this outcrop was deeded to the city of Snellville in 2007. In 2013, access to the outcrop was limited to protect the sensitive species. Little amphianthus and black-spored quillwort occur in a single pool at this outcrop. This population currently does not meet the recovery criteria for black-spored quillwort.

Heard County, Georgia (black-spored quillwort and little amphianthus)

Camp Meeting Rock. Part of the outcrop is owned and protected by Chattahoochee Valley Land Trust and is managed by the Nature Conservancy as a nature preserve. The 110-acre easement was purchased as part of Section 7 mitigation for Georgia Department of Transportation's impacts to Rock Chapel Park during construction improvements to State Route 124, which resulted in the extirpation of the little amphianthus population (Service 1999). This outcrop is host to a large population of little amphianthus (7-30 pools, depending on year) and black-spored quillwort (2 pools). This population meets the recovery criteria for black-spored quillwort.

Henry County, Georgia (little amphianthus)

Wolf Rock. A portion of this outcrop is protected as greenspace by Henry County. Because of the limited protections and the high recreational use of the outcrop, the single pool harboring little amphianthus has an uncertain future.

Jackson County, Georgia (black-spored quillwort, mat-forming quillwort, and little amphianthus)

Thompson Mill Forest Arboretum. This outcrop is outside of the known range of all three granite outcrop species. All three species have been introduced into a single pool on an outcrop on the property. The long-term viability of these species is unknown. This population is not included in recovery calculations because it is outside of the known range of all three species and the long-term persistence of the species are unknown. The outcrop is owned and managed by a state-owned arboretum.

Putnam County, Georgia (mat-forming quillwort and little amphianthus)

Eatonton Outcrop. This outcrop lies along the shore of Lake Oconee, where some granite outcrop habitat was likely inundated with the creation of the reservoir. This outcrop harbors both little amphianthus and mat-forming quillwort. The exposed part of the outcrop is owned and managed by the Georgia Department of Natural Resources within the Lawrence Shoals Recreation Area and part of the larger Lake Oconee Wildlife Management Area. This outcrop is host to a moderate little amphianthus population (8-11 pools) and 2 pools of mat-forming quillwort. The two pools of mat-forming quillwort are very small and have not been documented for 10 years or more, so do not meet the recovery criteria for the species.

Rockdale County, Georgia (black-spored quillwort and little amphianthus)

Bald Rock. This outcrop is owned, at least in part, by the City of Conyers, Georgia. The outcrop was partially fenced in 1990's as part of the Georgia International Horse Park in preparation for the 1996 Olympics. The area within the fence harbors approximately five pools with little amphianthus. A large portion of the outcrop outside of the fence was converted to a small solar field. It is unknown what impacts this may have on the pools within the fence that currently contain little amphianthus. Poaching of plants inside the fence at this outcrop, where there was evidence of soils and plants from several pools removed in 2012 that impacted the population (Allison 2013).

Warren County, Georgia (mat-forming quillwort and little amphianthus)

Rocky Comfort. This outcrop was found in 2012 and was protected under a conservation easement held by the Oconee Land Trust in 2018. The outcrop harbors two pools with

mat-forming quillwort and five pools with little amphianthus. This population does not currently meet the recovery criteria for documented self-sustaining populations for a 10 year period.

Lancaster County, South Carolina (little amphianthus)

Forty Acre Rock. This outcrop is part of the Forty Acre Rock Heritage Preserve and managed by the South Carolina Department of Natural Resources. This is the largest outcrop in South Carolina, and in 2012 was host to 22 pools with little amphianthus. The taxonomic status of the *Isoetes* species previously considered black-spored quillwort or a black-spored quillwort hybrid at this outcrop is uncertain. This outcrop is no longer considered a part of the black-spored quillwort population or recovery (J. Matthews, Univ. of North Carolina Charlotte, pers. comm. 2018; SCDNR 2013).

York County, South Carolina (little amphianthus)

Hill Top Lane. This outcrop is owned by York County. It is host to five pools harboring little amphianthus. Currently, management of this outcrop appears compatible with little amphianthus, but it is unknown if similar management or use will continue in the future.

C. Updated Information and Current Species Status

1. Biology and Habitat

Black-spored quillwort. A perennial fern ally, this plant's distinguishing characteristics include a sporangium wall that is unpigmented and completely covered by a transparent membrane (velum), dark, tuberculate megaspores and short (2 to 7 cm [0.79 to 2.76 in] long), spiraled leaves (Boom 1979, 1982). Linear, bunched leaves arise from a bulbous base. Immature plants may have distichous leaves (Rury 1978). Spores are produced within a cavity (sporangium) in the base of the leaf. Each sporangium may produce either dozens of larger female spores (megaspores) which are black or hundreds of smaller male spores (microspores). Spores are intermittently produced from May through June. Black-spored quillwort may hybridize with Piedmont quillwort, *Isoetes piedmontana*, in habitats where they co-occur (Boom 1980). The hybrids appear ecologically intermediate between the two species. The more common granite outcrop quillwort, *Isoetes piedmontana*, has incomplete velum coverage, white megaspores, and longer leaves (up to 16.7 cm [6.57 in] long; Heafner and Bray 2005). Black-spored quillwort is restricted to shallow, flat bottomed depressions on granitic outcrops in the Piedmont region of Georgia. Depressions are entirely rock rimmed and generally occur near the summit, with most water accumulating from direct rainfall, rather than run-off from surrounding areas, and little flowing water to provide nutrient input.

Mat-forming quillwort. A perennial fern ally, this plant is similar to the black-spored quillwort in size and reproductive features (Heafner and Bray 2005; Rury 1978). Mat-forming quillwort plants are prolific; forming interconnected clumps by means of numerous cauline, adventitious buds, and differ from all other North American species in having non-dichotomizing roots at maturity (Boom 1982; Rury 1978). Two forms of unbranched roots include a stout, coiled root that emerges from the leaf base and a slender, uncoiled root emerging from the base of the elongated stem. Narrow linear leaves arise in two rows (rather than a spiral) 3 to 7 cm (1.18 to 2.76 in) long and 1 mm (0.04 in) wide. Spores are produced in a cavity of the flared leaf base (sporangium). The

sporangium has unpigmented walls and is completely covered by a transparent membrane (velum). Each sporangium may produce either dozens of larger female spores (megaspores) or hundreds of smaller male spores (microspores). Intermittent spore production occurs from May to October. Mat-forming quillwort is restricted to shallow, flat bottomed depressions on granitic outcrops in the Piedmont region of Georgia. Depressions are entirely rock rimmed and generally occur near the summit with most water accumulating from direct rainfall, rather than run-off from surrounding areas, and little flowing water to provide nutrient input.

Little amphianthus – In 2008, the phylogeny of the genus *Amphianthus* was updated. Based on chloroplast DNA sequences, little amphianthus was transferred to the genus *Gratiola* and given the new name *Gratiola amphiantha* (Estes and Small 2008) (see the taxonomy section for greater detail). This small annual plant is a member of the family Plantaginaceae. This small, fibrous-rooted winter annual normally begins germination in late autumn and peaks in late winter or early spring. Light is required for germination (Lunsford 1938), therefore, buried seeds may serve as a seed bank (Service 1993). Habitat has been typified as high light intensity, shallow soils low in nitrogen and organic matter. Soil depth may range from 0.3 to 6.6 cm (0.12 to 2.6 in) and organic matter from 1.1 % to 29% (Hilton and Boyd 1996). The species has both submerged lanceolate leaves less than 1 cm (0.39 in) in length arranged in a basal rosette and ovate floating leaves 4 to 8 mm (0.16 to 0.31 in) long and 3 to 5 mm (0.12 to 0.2 in) wide. The floating leaves are opposite and attached to the stem near the submerged leaves by long, delicate stems.

Little amphianthus begins flowering in February or March and continues until the habitat is desiccated by a spring drought that kills the plants (usually occurs March-May; McVaugh and Pyron 1937; Service 1993). The plant's white flowers are 4 to 5 mm (0.16 to 0.20 in) in length and are borne in the axils of both the floating and submerged leaves. Floating flowers are open, and submerged flowers are closed except when exposed to air (Lunsford 1938; Rayner 1985). The species can self-pollinate resulting in reduced genetic variation within populations (Service 1993). Little amphianthus produces capsules 2 to 3 mm (0.08 to 0.12 in) broad and 1 mm (0.04 in) long; when mature, the capsules dehisce (or open at certain points) along the sutures, releasing seeds that remain dormant until suitable moisture and light conditions for germination are met. The entire life cycle for little amphianthus often lasts only 3 to 4 weeks (Garris 1980; Kral 1983; Rayner 1985).

Ideal moisture and light conditions are required for successful seed germination and growth. Also, the dormancy period for the seeds is unknown (Garris 1980; Lunsford 1938; Rayner 1985). Little amphianthus has a substantial seed bank that may be 18 times greater than the germinating plants in a given year (Boyd and Bartig 1992). Pool occupancy and density appears to be variable depending on amount and timing of moisture at each location. Seed banks may allow the species to withstand periodic drying or poor reproductive years (Frings and Davenport 2017). Randall (1986) speculates that this plant produces seeds predominately by self-pollination, a genetic factor that may limit its ability to adapt to habitat alteration.

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

Population definition. In the last 5-year review, elemental occurrences (EOs) were used to define some populations in Georgia for each of the three species. Previously, a populations could have been defined as a single EO or more than one EO. For this document, each EO was assessed and grouped into logical populations based on likely dispersal pathways, e.g. water flow that could carry seeds or spores from pool to pool or connected exposed granite outcrop for terrestrial dispersal of seeds or spores by insects or animals. These populations were given names based on those used by the state wildlife resource agencies, the Recovery Plan, nearby geographic or place name features, and referenced by the population name rather than the EO number. We believe that this method of referencing populations will reduce confusion in the future of understanding changes in population and species status through time. Population numbers from the Recovery Plan (Service 1993) can be found in Appendix B.

Little amphianthus. Initially little amphianthus was thought to be a very narrow endemic with populations only known from DeKalb County, GA; however, the historical distribution of little amphianthus was increased to include much of “the granite belt of Georgia from the Alabama line to the South Carolina line” (McVaugh and Pyron 1937). McVaugh and Pyron (1937) continued to express that the species would likely be found in additional localities with the right habitat. Since the last 5-year review, surveys across much of the granite outcrop habitat in the range of little amphianthus and black-spored quillwort in Alabama and Georgia was made by the state wildlife resource agencies (Allison 2013), faculty at Samford University (Frings and Davenport 2017), and the Service to assess those species. Additional assessments of some habitats in the range of mat-forming quillwort was conducted by the Natural Conservancy and the Service. This work has revealed year-to-year variation in pool occupancy and density of little amphianthus.

Historically, little amphianthus was known from 57 populations in 17 Georgia counties, 4 populations in two Alabama counties, and 3 populations in 3 South Carolina Counties. With the additional surveys, a total of 76 populations have occurred throughout its range (including those that have been extirpated), which has included 66 populations in 20 Georgia counties, 6 populations in 3 Alabama counties, and 4 populations in 3 South Carolina counties (Figure 1). Two of the Georgia counties (Newton and Oglethorpe) have since lost their populations.

Of the total populations, 20 have been extirpated and there are currently 56 extant populations. Of those extant populations 14 are in an unknown condition. Thirty-three populations are small populations occupying 1-5 pools. Of the 14 extensive populations (15 or greater pools), one is located in Lancaster County, SC and the others are located in Columbia, DeKalb, Greene, Hancock, Heard, Rockdale, and Walton Counties, GA. Pools often occur at different elevations allowing seed dispersal from higher elevations to lower elevations as water flows through the habitat. The number of individual plants in the pools range from a dozen to several thousand. Populations each consisting of three or fewer pools continue to exist in Randolph (2 populations) and Chambers Counties (1 population) in Alabama. Frings and Davenport (2017) suggest that little amphianthus is at risk of being extirpated from Alabama because of the extremely small number of individual plants and small

number of occupied pools in their populations. Artificially established populations are not treated in these numbers because they are currently not considered to be self-sustaining.

Black-spored quillwort. This plant, was known from 16 populations in central Georgia at the time the Recovery Plan was written (Service 1993). At that time only 11 populations were considered extant. At the time of the last 5-year review, six populations were considered extant, an additional two populations were introduced and not considered self-sustaining, and three more populations were classified as hybrids (see Attachment 2 in Service 2008). Black-spored quillwort was first discovered by Canby in 1869 on Stone Mountain, DeKalb County, GA.

Currently, the plant exists at 11 populations in Georgia (Butts, DeKalb, Greene, Gwinnett, Heard, Jackson, and Rockdale Counties; Figure 2). The taxonomic status of the population previously considered black-spored quillwort at Forty Acre Rock Heritage Preserve, SC, is currently under review by taxonomic experts. The *Isoetes* population is still extant at the site, but experts believe that this population is not black-spored quillwort but a currently undescribed species of quillwort (J. Matthews, Univ. of North Carolina Charlotte, pers. comm. 2018; SCDNR 2013). Of the 11 extant populations, 2 populations have been introduced outside of the known range of black-spored quillwort (Greene and Jackson Counties, GA) and 2 populations are in an unknown condition (both Butts County populations). At one population, this plant is located in remnant quarry pools. In at least one population, there is a concern that the black-spored quillwort may be hybridizing with Piedmont quillwort (Highway 36). The largest populations (Arabia Mountain, Bradley Mountain, and Stone Mountain) contains plants at five or more pools. Other black-spored quillwort populations are confined to one to four pools each. This plant co-occurs in pools with little amphianthus at all populations where it is still extant. Efforts to maintain historical pools at Stone Mountain have included habitat modifications in 2017 and 2018 to remove expanding *Juncus* sp. And *Bulbostylis capillaris* from the pools. Unusually wet spring and early summer weather and increased organic materials in the pools appears to have resulted in rapid growth and domination of grass species in the black spored quillwort pools and has resulted in declines of both black-spored quillwort populations.

Since the last 5-year review, recovery efforts have included creating artificial pools, modifying natural pools, and re-introduction of black-spored quillwort at extirpated location (Bradley Mountain) and the creation of additional pools at Arabia Mountain and Stone Mountain. It will take several years to understand the viability of black-spored quillwort at the created and modified pools.

Mat-forming quillwort. Mat-forming quillwort was first described by Rury (1978) from material he collected from a single vernal pool at Heggie's Rock in Columbia County, GA. Populations are confined to porphyritic (igneous rock with crystals embedded in it) granite outcrops in Columbia, Greene, Hancock, Heard, Putnam, and Warren Counties, GA (Rury 1985; Service 1993). Individual pools may contain few genetic individuals since mat-forming quillwort is a colony-forming species (Bridges 1986). At the writing of the recovery plan for this species, mat-forming quillwort was

known from 10 populations in Georgia (Service 1993). At the last 5-year review there were nine extant populations (11 EOs), including 2 introduced populations) and 3 extirpated populations (see Attachment 3 in Service 2008).

Since the last 5-year review, recovery efforts have included creating artificial pools, modifying natural pools, and introductions of mat-forming quillwort at one new location (Greensboro South; the establishment of a new population) and the modifications of natural pools at Heggie's Rock. The best habitat for mat-forming quillwort is the type locality, Heggie's Rock. The protections have minimized human impacts to the population, and some of the natural pools at have been deepened, supported with additional plants, and managed through the removal of organic material buildup and later successional plants. It will take several years to understand the viability of mat-forming quillwort at the created and modified pools.

Currently, there are 11 extant populations, 3 of which are protected and within the known range of the species, and 1 additional population is protected but occurs outside of the historical range of the species (Figure 3). Four populations are in active quarries (Anderson Farm, Crater Rock, Greensboro South, and Veazy Outcrop). The Anderson Farm and Crater Rock populations are in an unknown condition because of access limitations, but pools containing mat-forming quillwort are in future quarry plans. Five of the extant populations contain only one to three pools with mat-forming quillwort. For the rest of these populations, the plant has been observed in four to seven pools. In the introduced populations (Siloam and Thompson Mill), and at least one other population (Veazy Outcrop), there is a concern that the mat-forming quillwort may be hybridizing with other quillwort species that co-occur in the same pools.

b. Genetics, genetic variation, or trends in genetic variation:

Black-spored quillwort. Van De Genachte (1996) showed that black-spored quillwort had much more genetic diversity than would have been expected for a species with a restricted range and isolated populations. Safeguarding efforts may be required to preserve the genetic integrity of black-spored quillwort. Hybridization between black-spored quillwort and Piedmont quillwort may have occurred in the past (Matthew and Murdy 1969; Rury 1978; Van De Genachte 1996), but has not been rigorously proven. If it is shown to occur, the genetic integrity of black-spored quillwort may be threatened by hybridization and subsequent introgression. In disturbed or altered habitats, more adaptable hybrids may displace black-spored quillwort, which requires a highly specialized microhabitat.

Mat-forming quillwort. Mat-forming quillwort has little allozyme diversity, typical for a colonial species (Van De Genachte 1996). Due to limited genetic diversity, mat-forming quillwort may have limited ability to adapt to environmental change. However, this provides opportunity for repopulating additional pools or restoring extirpated populations with artificially created pools. Van De Genachte (1996) showed that hybridization may also occur between mat-forming quillwort and Piedmont quillwort. The ability of both black-spored quillwort and mat-forming quillwort to hybridize with other quillwort species may be problematic for those

populations where both species were introduced into single pools in the 1980's. Neither species will be viable in those pools if hybridization occurs.

Mat-forming quillwort has been collected from Heggie's Rock and Veazy Outcrop and have been cultivated at the Atlanta Botanical Garden and the Georgia Botanical Garden. The Atlanta Botanical Garden still has several holdings from these populations (Byrd, R. Atlanta Botanical Gardens, pers. comm. 2018). Mat-forming quillwort has also been cultivated by the North Carolina Botanical Garden, as part of the Center for Plant Conservation's National Collection of Endangered Plants.

Little amphianthus. Genetic analysis of amphianthus, suggested that there was very little variation and strong indication of self-fertilization. A few protected populations may capture much of the global genetic diversity of little amphianthus. Therefore, priorities of which population to seek preservation for should be based on factors other than just the presence of little amphianthus. Little amphianthus is not known to be in active cultivation, but several individual plants do occur at the South Carolina Botanical Garden. Because of its limited annual duration and apparently narrow requirements for germination of its seed, greenhouse cultivation of amphianthus is more difficult to maintain than cultivation of either of the quillwort species in this review. Although soil containing seeds and plants have been successfully been introduced to natural pools or created pools and resulted in little amphianthus growth and reproduction (Cruse-Sanders and Richards 2017; Monroe 2016).

c. Taxonomic classification or changes in nomenclature:

The Integrated Taxonomic Information System (2019) was checked while conducting this review, and according to this resource, there are no proposed changes in the taxonomic classification or in nomenclature for black-spored or mat-forming quillwort.

Little amphianthus has been removed from its monophyletic genus *Amphianthus* and reclassified as *Gratiola amphiantha*, in the Order Lamiales, tribe Gratioleae, and Family Plantaginaceae (Estes and Small 2008). In order for us to correct a listed species taxonomic name under 50 CFR 17.11, it requires us to complete a direct final rule in the Federal Register. We intend to make this simple name change, but have been prevented in doing so by other higher priorities for listed species.

d. Spatial distribution, trends in spatial distribution or historic range: The range of mat-forming and little amphianthus has not changed; however, we have changed the range of black-spored quillwort given current taxonomic assessment of the population of *Isoetes* at the Forty Acre Rock, SC population (see Figures 1, 2, and 3). It is unlikely that the range of the three species will have additional significant changes relative to what is known today, however, the number of populations is likely to change with some populations being extirpated from ongoing threats and other unknown populations being discovered. Over 100 granite outcrops were assessed in DeKalb, Gwinnett, Heard, Newton, Rockdale, Walton Counties, Georgia, from 2010 to 2012 (Allison 2013). Some of these outcrops were known to harbor federally listed species. Of these 100 outcrops (all within the range of black-spored quillwort and little amphianthus), no new populations of black-spored quillwort was found and only

seven new populations of little amphianthus were discovered. One additional little amphianthus population was discovered outside of this work during the same period (Rocky Comfort, Warren County, GA). This appears encouraging that there is potential for new little amphianthus discovery, but this work covered most of the significant granite outcrops within approximately half of the range of little amphianthus in Georgia. As all of the outcrops continue to be monitored, time will tell if during more favorable sampling conditions additional populations might be found. Most conserved properties receive some level of monitoring; however, outcrops that are in private holdings receive sporadic monitoring at best and most of the information is not current. Access to all privately-owned populations has not always been granted. Due to limited monitoring, the current status (extent of decline or stability) of all population of the three outcrop plants cannot be accurately assessed.

- e. **Habitat ecosystem conditions:** These endemics are vulnerable because of the limited amount of potential habitat and specialized microhabitat requirements. These species are found on granitic outcrops in the Piedmont physiographic region of the southeastern United States generally in eroded depressions or, rarely, quarry pools formed on flat- to doming granite outcrops. Generally similar in appearance, outcrops may differ geologically as igneous, quartzitic, gneissic, or porphyritic granite (McVaugh 1943; Wharton 1978; Wyatt and Allison 2000). These taxa generally occur in shallow flat-bottomed pools on the crest or flattened slopes of unquarried outcrops (Garris 1980; Rayner 1985; Rury 1985). Pools might be several meters in diameter and are circular or irregularly shaped due to the coalescence of adjacent pools (Lunsford 1938; McVaugh 1943); typically, these pools average 0.5 to 1 square meter. The depressions generally have an intact rim that restricts drainage with an accumulation of a few centimeters of mineral soil that is low in nutrients, particularly nitrogen (Lammers 1958). Following heavy rains, pools retain water for several weeks before completely drying out with summer droughts. Both *Isoetes* are able to go dormant when pools dry out, then resume growth whenever water is replenished, regardless of season (Service 1993; Wyatt and Allison 2000).

2. Five-Factor Analysis

As documented in the recovery plan, quarrying continues to be the primary threat destroying granite outcrops, and populations of all three species have been lost (Service 1993). Environmental conditions on the remaining outcrops are still being modified by cattle eutrophication, littering, trash dumping, fire building, vandalism, and off-road vehicles.

- a. **Present or threatened destruction, modification or curtailment of its habitat or range:** A detailed treatment of threats to each population and their current status can be found in Appendix B.

Quarrying. The greatest threat to these species is the destruction of habitat due to quarrying activities. Quarrying continues to destroy granite outcrops and habitats of all three plants. Of the 24 documented local extinctions of the listed species, 11 can be attributed to this cause. Little amphianthus populations may have been extirpated at up to three additional sites that are now being quarried. The numerous exposures of

granites and gneisses in the Piedmont, particularly in Georgia, have been quarried extensively, and an unknown number of undocumented populations of the listed species were doubtless unknowingly destroyed. Quarrying has impacted 31% of the known populations of little amphianthus and resulted in the extirpation of 11 populations. Half of the extirpated populations of little amphianthus has been attributed to quarrying. Of the black-spored quillwort populations, 38% have been impacted by quarrying and 66% of the extirpations have been attributed to quarrying activities. Half of the mat-forming quillwort populations have been impacted by quarrying activities, and the two known extirpated populations have been attributed to quarrying activities.

Populations of the listed species (and other granite outcrop organisms) may also be impacted by accumulation of rock dust when quarry operations are undertaken nearby (Service 1993). As late as 1979, black-spored quillwort could be found in two pools at Bradley Mountain. Areas near these pools (within several hundred feet) were quarried after 1980 and prior to 1990. Although the depressions themselves are extant, the endangered quillwort has not been seen in them since. The microhabitat of black-spored quillwort may have been altered by the accumulation of quarry dust and from impacts related to quarry vehicles. Although the recovery plan addressed the need to study effects of quarry dust on vernal pool vegetation, no studies have been conducted.

Farm animals / grazing. For some populations, the habitat supporting these species has been degraded through conversion to pasture (Service 1993). Excessive animal wastes have resulted in eutrophication of pools, promoting excessive algal growth that competes with these species for dissolved carbon dioxide and light. Addition of organic matter to the habitat increases soil depth, with concomitant reduction in potential water depth. The added nutrients have resulted in increased competition from other plant species (Patrick and Moffett 2015). Increased soil depth and organic matter may benefit these species in the short term, but soon result in the invasion of more aggressive native species, such as *Callitriche heterophylla* (two headed waterstarwort), *Eleocharis obtuse* (blunt spike rush), *Ranunculus pusillus* (low spearwort), and various *Juncus* spp. (rush spp.), as well as exotic weeds, such as *Poa annua* (annual bluegrass).

Bald Rock is now in Rockdale County ownership in Georgia and has fencing around the extant pools and appears protected from the threats of farm animals and grazing impacts. Forty Acre Rock, GA, is slowly recovering from grazing impacts. Clinton Nature Preserve has a single little amphianthus pool threatened by animal waste (horseback riding). It is unknown if any improvements have been made.

Dumping. Because granite outcrops are regarded by many as worthless, they are frequently subjected to dumping of waste materials. This leads, in some cases, to destruction of the microhabitat through covering over or filling in of pools, or through eutrophication. This impact has been noted in several of the outcrops throughout the range and is a major threat to outcrop pools in Alabama (Frings and Davenport 2017).

Development. With the expansion of Atlanta and other urban centers in Georgia,

development has become a newer threat to this habitat. The Lithonia Rock outcrop was buried under an estimated 1 to 2 meters of fill and houses were placed on top (Eric Van De Genachte, The Nature Conservancy, pers. comm. May 2006). As Atlanta continues to expand and land becomes a scarce and valuable commodity, property that was previously economically unsuitable for development becomes more suitable. Development resulting in substantial habitat destruction for this plant can be expected to continue to grow as a threat.

Vehicular traffic. One persistent threat to even protected outcrops is human use. Vehicular traffic is a serious problem for many populations. This can be due to recreational traffic, such as off-road vehicles, motorbikes, or even automobiles. Even more destructive are the heavy vehicles used in logging operations. Outcrops have consistently been used for logging decks (e.g. Anglin Farm and Culverton South), and all-terrain vehicle, and motor bike recreation (e.g. Anderson Farm, Old Sparta Road, Mountain Rock, Philadelphia Road, Rock of Ages, The Rocks II, both Forty Acre Rock, Georgia and South Carolina, Penton Creek, and others). Almost all of the outcrops have been impacted in the past or are currently impacted by heavy equipment, all-terrain vehicles, motor bikes, and other traffic. At one outcrop in DeKalb County, Georgia, a solitary pool supporting a dense growth of black-spored quillwort and sparse little amphianthus was destroyed when the adjacent Hayden Quarry Road was paved, because heavy equipment operators used the outcrop as a convenient place to turn around. A unique example of vehicle-related extirpation occurred in Walton County, Georgia, at an outcrop formerly used as a storage site for explosives. These were stored in tractor-trailers on the outcrop. As part of the site preparation, many depressions, including all little amphianthus pools, were filled with concrete to provide a smoother surface.

Movie Industry. One new impact since the last 5-year review to granite outcrop habitat is the movie industry. Although not known to directly impact pools of *Isoetes* because of their more protected locations, the granite outcrops at both Arabia Mountain and Stone Mountain have hosted movie and television production activities. The associated traffic, set building, and prop use have likely impacted some pools of little amphianthus at Arabia Mountain which are found throughout the property. Staff at Arabia Mountain have so far limited these uses to areas previously impacted by past quarrying events, but those areas still host pools with little amphianthus and black-spored quillwort. If the industry continues to seek out these habitats for shooting locations, there may be a potential continued threat to granite outcrop species.

Miscellaneous threats. Since the last 5-year review, we have documented an additional new impact to granite outcrop habitats, e.g. solar farms. Although this activity currently has impacted only one granite outcrop (Bald Rock), if the prevalence of this activity increases, its impacts may be more substantial in the future.

- b. Overutilization for commercial, recreational, scientific, or educational purposes:** Not a commonly known factor for these taxa (see factor e for further detail on impacts of recreational use of granite outcrop habitats). We have only had one known occurrence of poaching, at Bald Rock, where soil and accompanying little

amphianthus plants and seed bank were removed from several pools (Allison 2013).

- c. **Disease or predation:** Invasive fire ants (*Solenopsis invicta*) have been hypothesized to be an additional threat to granite outcrop plants and dispersers. Fire ants have become well established throughout the range of the listed granite outcrop species, but based on best available information their impact is unclear. Fire ants may impact little amphianthus directly by consuming seeds and damaging the plants themselves, and indirectly by impacting insects that play a role as pollinators or in seed dispersal (Tschinkel 2006 and references therein).

d. Inadequacy of existing regulatory mechanisms:

State protective measures. Under the provisions of Georgia's Wildflower Preservation Act, little amphianthus, black-spored quillwort, and mat-forming quillwort are legally protected species (The Wildflower Preservation Act of 1973; O.C.G.A. 12-6-3). This law protects State listed plant species by regulating their removal from State-owned lands (Patrick et al. 1995; O.C.G.A. 12-6-173). It further requires that any removal of State-protected plants from private land be with the written permission of the landowner, and it also regulates any traffic in these plants by requiring both transport tags and permits to sell or collect in Georgia. However, state law does not protect plants from trampling and other destructive impacts that do not involve purposeful removal and transfer of plants. Whenever federally listed plant species are involved, provisions of this law (or any other State law or regulation, including State criminal trespass laws), are enforceable by Federal agents under Section 9 of the Endangered Species Act of 1973, as amended.

The Georgia Wildflower Preservation Act has not had a significant effect on stopping or slowing down habitat loss, the primary threat to the listed species. This legislation also does not protect plants from recreational damage. Recreational overuse of publicly owned sites results in damage to pool habitat through trampling, alteration of pool microhabitats, ATV use, and added organic materials is not always addressed by current ordinances. For certain populations (e.g. Arabia Mountain), existing ordinances against damage to pools, littering, spray-painting, fire building, off-road vehicles, etc., have proved difficult to enforce, are not fully effective, and have limited support by state and local law enforcement.

Of the three States where little amphianthus occurs, only Georgia has a native plant conservation law. However, the three federally listed outcrop endemics are recognized as species of concern by conservation agencies in all three States where they occur.

An additional Georgia State law affording some protection to these and other listed species is the Georgia Environmental Policy Act of 1991 (GEPA; O.C.G.A. 12-16-1). Modeled after the National Environmental Policy Act (NEPA), this 1991 law established requirements and procedures for assessing the environmental effects of all proposed State government actions that "may significantly adversely affect the quality of the environment."

In Georgia, Surface Mining Permits are issued to prospective operators by the Department of Natural Resources, Environmental Protection Division (EPD), only

after surface mine land use plans are reviewed. The Georgia Surface Mining Act of 1968 has as one of its stated purposes to "advance the protection and restoration of land water, and other resources affected by mining" (O.C.G.A. 12-4-70). The law, however, contains no language explicitly mentioning protected species. At the least procedures need to be developed to ensure that information compiled by the Game and Fish Division of the Georgia Department of Natural Resources is available for consideration by EPD during its evaluation of permit applications.

The preceding paragraph focuses on Georgia because that State has both the preponderance of populations of the listed species and is the leading producer of granite aggregate in the United States. The same principles apply, however, to the mining regulatory process in Alabama and South Carolina.

- e. Other natural or manmade factors affecting its continued existence:** In some cases, other environmental factors are suspected to have led to the decline of certain populations of these species. As these species require high light intensities (Lammers 1958), excessive tree growth is suspected to be a problem for a few populations, due to shading and additional organic inputs into the pools. A few pools appear to be moving toward a later stage of succession due to excessive soil accumulation. This excessive soil accumulation results in increases in various grass species (e.g. *Juncus* spp.) and other species that can dominate the habitat, increase organic inputs into the pool, and outcompete quillworts and little amphianthus in the pools.

Black-spored quillwort is susceptible to damage or even killed when subjected to abnormally low temperatures (below ca. -12° C [10° F]). When the largest population was visited on January 2, 1984, many, if not most, of the quillworts had shed their outermost leaves. Many of these plants were evidently killed by record cold temperatures of December 1983. During a less severe freeze in December 1937, sufficient to freeze these same pools solid, freeze damage was also observed (Johnson 1938) but did not result in high mortality. Little amphianthus is also sometimes killed by freezes but, being an annual, can recover population size more rapidly.

Climate change. The granite outcrop endemic species have evolved to endure periods of high temperatures with hot, dry conditions during large portions of the summer (Edwards et al. 2013). Timing of rainfall may be an additional concern for these species in the future. Added nutrients in pools in combination with rainfall in late spring through the summer can increase competition with other species and all three listed outcrop species. If the pools hold water longer into the spring and do not undergo the extreme drying events that these species have evolved with, it provides opportunities for native and non-native species to take over the pools. These conditions have occurred in several of the historic black-spored quillwort pools at Stone Mountain and to a lesser extent Arabia Mountain and have required physical manipulation of the habitat to remove native and non-native species. A shift in climate, with increasing summer temperatures may however, favor granite outcrop endemics that have evolved to withstand extreme heat and drying conditions (Caspary 2011).

Recreational impacts. Many populations exhibit signs of recreational overuse or

abuse. Although those populations that are publicly owned are protected from quarrying, they are subjected to excess foot traffic, littering, human modification of pools, or vandalism, such as spray painting.

As populations increase, protected lands that are used for recreation will likely see additional traffic. Outcrops, such as Arabia Mountain and Forty Acre Rock, SC, may see increased threat related to increased visitation. At Stone Mountain, the remaining pools supporting black-spored quillwort and little amphianthus have benefited from fencing. Eatonton Outcrop is located on the edge of a recreational lake and is currently managed as a Wildlife Management Area; but evidence of some trash dumping, painting, and fire building can be found on the outcrops and within pools. At Heggie's Rock, fencing has reduced access to the site and provided protection to both mat-forming quillwort and little amphianthus populations there from vehicular traffic (Malcolm Hodges, The Nature Conservancy, pers. comm. June 2019).

Hybridization. At outcrops where black-spored quillwort presumably once occurred with Piedmont quillwort, black-spored quillwort has seemingly been out competed by hybrids between these two species (Matthews and Murdy 1969). These "populations" exhibited extreme variability in the extent of velum development. Analysis of these hybrids is complicated because the distinguishing characteristics of black-spored quillwort and Piedmont quillwort are found in the subterranean portion of the plants; each individual plant can be identified only by removing it from the substrate.

In addition to historic hybridization impacts, hybridization events may also have occurred at attempted transplant sites, both Siloam outcrop and Thompson Mills Forest. New evidence shows mat-forming quillwort may also suffer from hybridization (see Genetics).

Several attempts have been made at conducting transplants using both quillwort species, with mixed results. Some pools within populations (e.g. Arabia Mountain, Bradley Mountain, Greensboro South, and Heggie's Rock) have appeared successful, but long-term monitoring will assess the viability of the populations. Past introductions of both quillwort species into a single pool at Thompson Mill Arboretum and Siloam Outcrop may be problematic because of hybridization between quillwort species. A protocol and monitoring program should be established with any future introductions or transplants to ensure population stability and to limit the potential hybridization of black-spored quillwort with other quillworts (see section IV).

- D. Synthesis** These species are found exclusively in a distinctive granite outcrop habitat whose distribution is well known, at least in Georgia (mapped by the State Geological Survey due to their economic importance as a source of stone), and most populations were discovered prior to publication of the recovery plan. A few populations have been placed in conservation; however, the majority of the populations occur on privately owned property and face imminent threats from quarrying, development, farm animals, dumping, vehicular traffic, and recreational impacts. Very little new research has been conducted on these species.

Little amphianthus. Since the last 5-year review, nine new populations of little amphianthus

have been found, three have been extirpated, seven populations have declined in condition, and two populations have improved their condition. In total, 76 populations have been known for this species since its description, 20 (26%) have been extirpated, 15 are in conservation, and 41 are on private property.

Black-spored quillwort. Since the last 5-year review, no new populations have been found, but one population was reintroduced onto a site that was previously extirpated. Additionally, one population improved in condition, two populations have declined in condition, and one population was reidentified as another species. In total, there have been 17 populations of black-spored quillwort (18 counting the misidentified population at Forty Acre Rock, SC). Of the 17 populations, 6 (35%) have been extirpated and 5 are in conservation. An additional introduced population in conservation exists, but both black-spored quillwort and mat-forming quillwort were planted into a single pool, which may result in hybridization. Two additional populations may also be hybrid populations.

Mat-forming quillwort. Since the last 5-year review, one new population has been found, one population has been introduced, and one population has improved its condition. In total, there have been 13 known populations of mat-forming quillwort. Of these 13 populations, 2 (15%) have been extirpated, and 3 natural populations are in conservation. Of the populations currently considered extant four occur on sites that are owned by mining companies. If these additional populations are lost, it would result in a total of six (46%) extirpated populations. An additional introduced population in conservation exists, but both black-spored quillwort and mat-forming quillwort were planted into a single pool, which may result in hybridization.

As a whole, all three taxa are experiencing continuing threats. Extirpated populations will likely require reintroductions, as natural recolonization is unlikely given the current patchiness of these populations (Loehle 2006). Although more populations are in conservation than at the time of the last 5-year review, a small proportion of the total populations have been placed into public ownership or conservation. The majority of populations that occur on privately owned property face imminent threats. Since the recovery plan, the available habitat for all three species is declining in condition. Therefore, based on the threats described above and the status of each of the three plants, little amphianthus continues to meet the definition of threatened and black-spored and mat-forming quillworts continue to meet the definition of endangered under the Act.

III. RESULTS

- A. **Recommended Classification:** No change in status for these plants.
- B. **New Recovery Priority Number:** No changes to the recovery number for all three species are recommended at this time.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS:

Before any future efforts to move any of the three plants, we along with partners need to develop a protocol and monitoring schedule prior to moving plants. Any protocol must consider how to limit the potential of hybridization of black-spored quillwort with other *Isoetes*. Little amphianthus cannot reasonably be expected to be kept in cultivation, therefore, an effort to

maintain seed stock from the various pools should be established. The implications of seed storage should be studied to evaluate germination success and techniques. The recovery plan suggested that the effects of quarry dust should also be investigated. Management plans for each of the protected populations should be developed to ensure that future uses of the property (e.g. film industry use and increasing pressures for expanding populations).

Studies should be conducted to assess the status of the introduced populations and the viability of plants in the artificial pools. Because most natural pools of both quillworts are larger than the artificially-created pools, these pools may be less resilient to drying out and may not hold water long enough for the species to persist when facing variability in water availability. Efforts may be beneficial to create and research differing pool sizes and depths to understand their impacts on species viability.

Conservation priorities need to be developed that protect and/or enhance each of these listed plants as well as other community associates of the granite outcrop. At outcrops with conservation potential, the landowners need to be contacted to seek conservation easements or fee simple acquisition. The Service and State Heritage programs should continue to contact private landowners to request their cooperation in plant conservation. Status surveys need to be continued for these species in all three States.

The Implementation schedule in the recovery plan needs to be updated.

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Table 1. Summary of federally listed granite outcrop species populations in Alabama (AL), Georgia (GA), and South Carolina (SC). Populations were classified as Protected¹ or Unprotected (or unknown) and each population's status was classified as Extant², Unknown³, Extirpated, or Introduced⁴.

Population Protection	Population Status	<i>Amphianthus pusillus</i>	<i>Isoetes melanospora</i>	<i>Isoetes tegetiformans</i>
Protected ¹	Extant ²	11 (9 GA and 2 SC)	5 (GA)	3 (GA)
	Unknown ³	2	-	-
	Extirpated	2	-	-
	Introduced ⁴	2	1	1
Unprotected	Extant	29	2	4
	Unknown	12	2	2
	Extirpated	18	6	2
	Introduced ⁴	0	1	1
Total		76	17	13

¹. Populations are listed as protected if they occur on land that is under federal, state, or county control, or under a conservation easement and are managed in a way that is compatible for persistence of the federally protected granite outcrop species.

². Populations are considered extant if they have been assessed and found present since the last review (2007-2008) and are within the known range of the species.

³. Unknown populations are those populations where the species was present in the last review (2007-2008), but have not been assessed since that time.

⁴. Introduced populations are those populations that have been introduced either outside of the species range. If the species was introduced within the species range, these populations were included in the totals as either Extant, Unknown, or Extirpated.

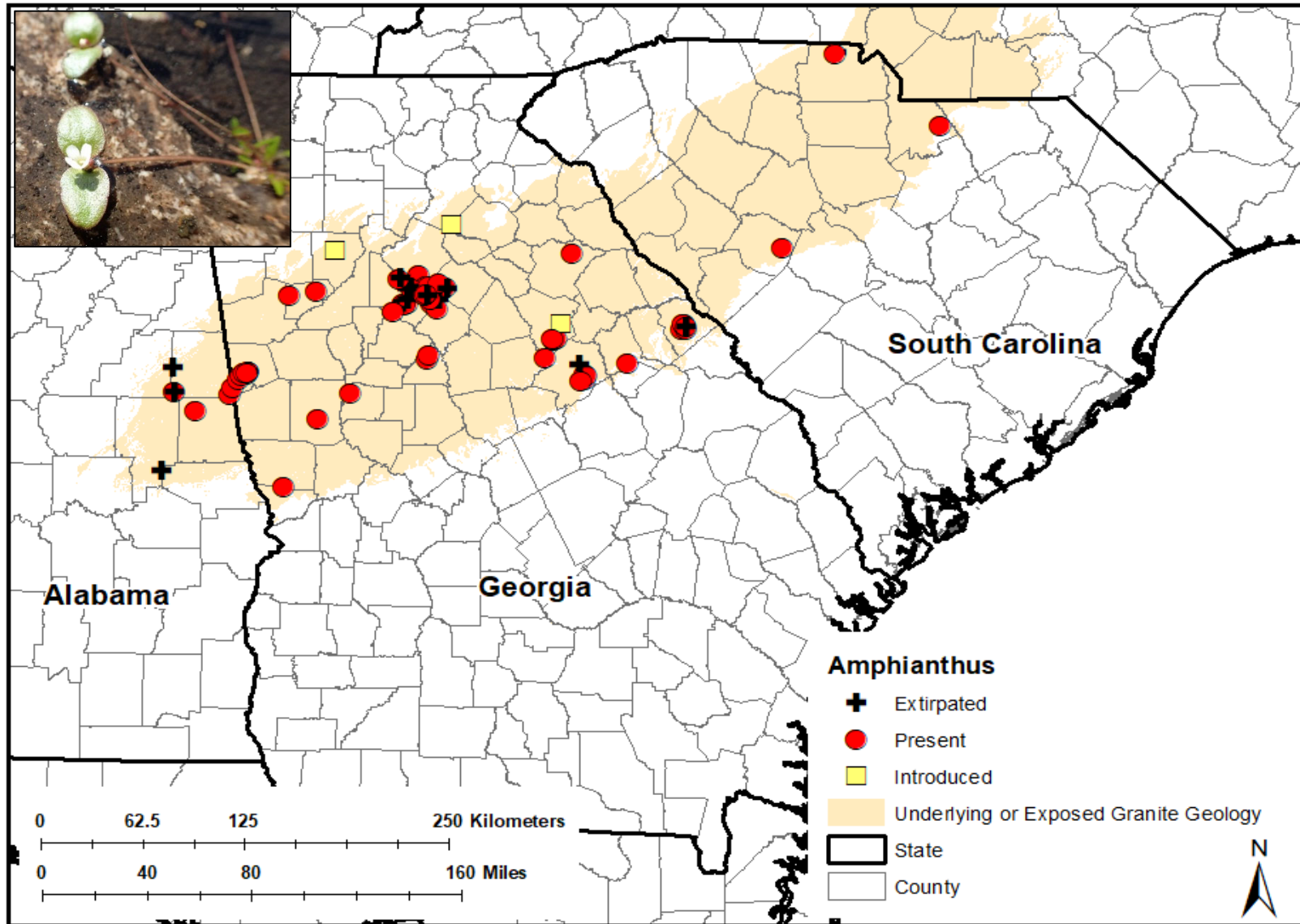


Figure 1. Distribution of little amphianthus (*Amphianthus pusillus*) populations in Alabama, Georgia, and South Carolina. Each population is identified by a single cross (extirpated), red circle (present), and yellow square (introduced population). The tan background indicates the area of potential exposed granite outcrop. Data sources: U.S. Fish and Wildlife Service, GADNR, SCDNR, D. Frings.

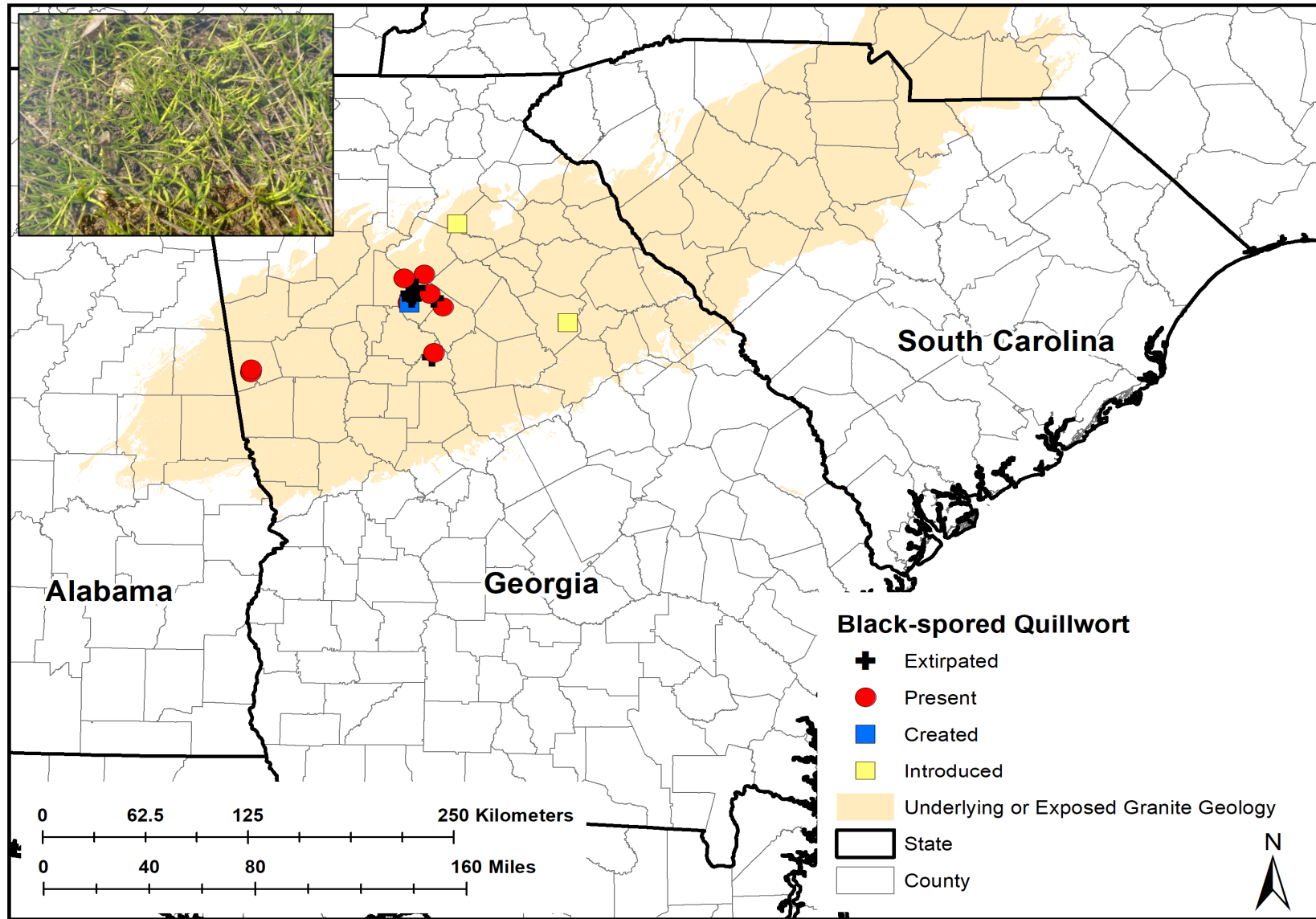


Figure 2. Distribution of black-spored quillwort (*Isoetes melanospora*) populations in Alabama, Georgia, and South Carolina. Each population is identified by a single cross (extirpated), red circle (present), blue square (created/reintroduced populations) and yellow square (introduced population). The tan background indicates the area of potential exposed granite outcrop. Data sources: U.S. Fish and Wildlife Service and GADNR.

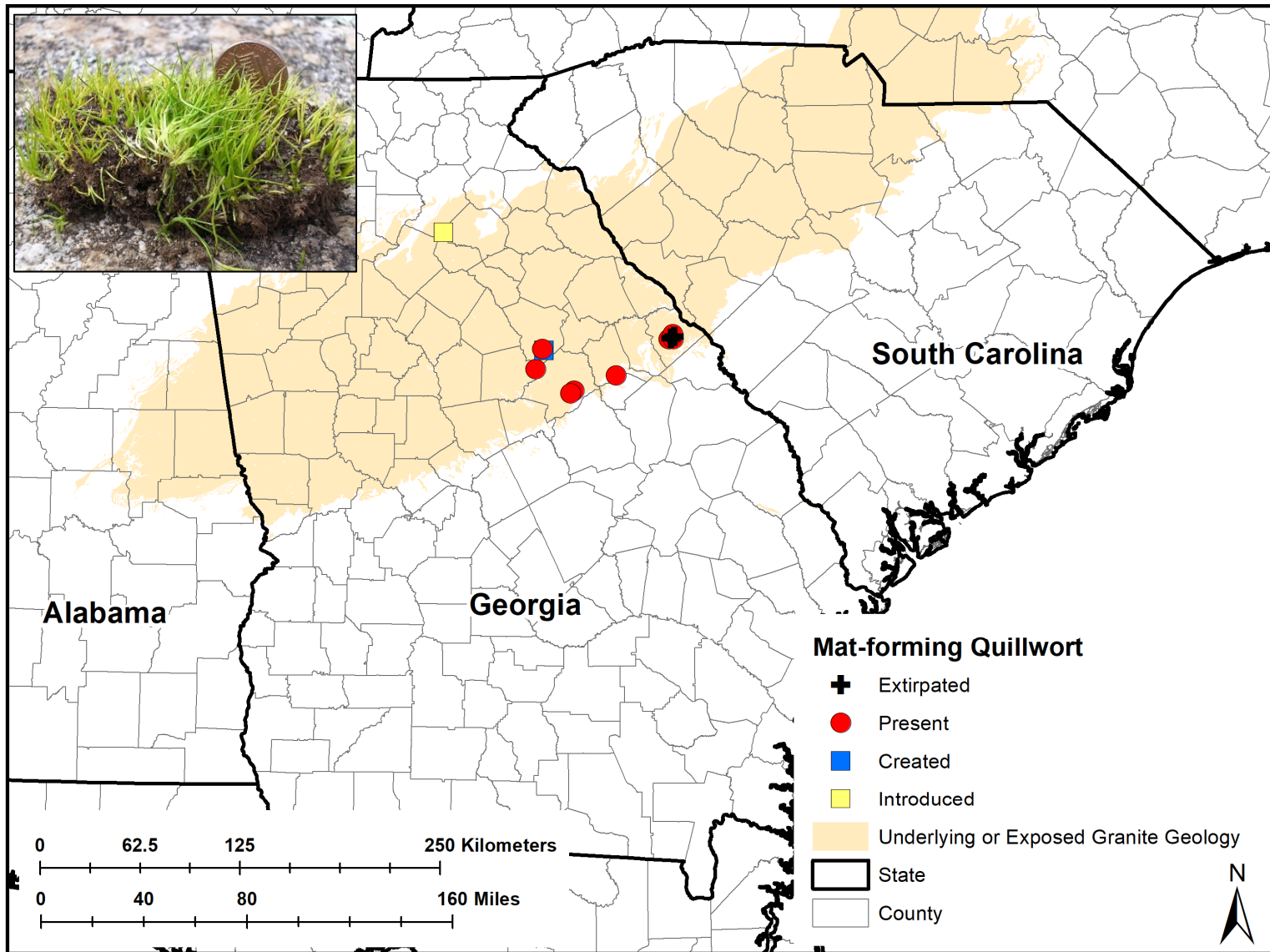


Figure 3. Distribution of mat-forming quillwort (*Isoetes tegetiformans*) populations in Alabama, Georgia, and South Carolina. Each population is identified by a single cross (extirpated), red circle (present), blue square (created population) and yellow square (introduced population). The tan background indicates the area of potential exposed granite outcrop. Data sources: U.S. Fish and Wildlife Service and GADNR.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of
Black-spored quillwort (*Isoetes melanospora*)
Mat-forming quillwort (*Isoetes tegetiformans*)
Little amphianthus (*Amphianthus pusillus*)

Current Classification: Black-spored quillwort - Endangered
Mat-forming quillwort - Endangered
Little amphianthus - Threatened

Recommendation resulting from the 5-Year Review for all three plants:

No change is needed

Review Conducted By: Carrie A. Straight, Georgia Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve: Donald W. [Signature]

Date: 9/11/2019

APPENDIX A:
Summary of peer review for the granite outcrops 5-year review of
Black-spored quillwort, (*Isoetes melanospora*),
Mat-forming quillwort, (*Isoetes tegetiformans*), and
Little amphianthus, (*Amphianthus pusillus*)

A. Peer Review Method: See B. below.

B. Peer Review Charge: On June 16, 2019, emails were sent to April Punsalan (South Carolina Ecological Services Office) and Shannon Holbrook (Alabama Ecological Services Office). They were asked if there was any information in addition to the text provided and to review any information specific to their state. An additional independent peer review was sent to David Frings. All reviewers were asked to comment on biological and population-level information but not on status of the species.

C. Summary of Peer Review Comments/Report:

A summary of email comments is provided below. The complete set of emails is available at the Georgia Ecological Services Field Office, U.S. Fish and Wildlife Service.

April Punsalan, South Carolina Ecological Services Office. Ms. Punsalan provided grammar and clarity edits to the document and provided information that little amphianthus did occur at the South Carolina State Botanical Gardens.

Shannon Holbrook, Alabama Ecological Services Office. Shannon did not have any comments on the documents.

David M. Frings, Assistant Director of Master of Science in Environmental Management, Department of Biological and Environmental Sciences, Samford University.

E. Response to Peer Review:

In a response to comments from Cooperating Field Offices and peer review, we addressed grammar and clarity comments as needed throughout text, added bullet points to text in section C.2. for ease of readability, added text to address little amphianthus in the South Carolina Botanical Garden, and clarified the use of site vs population throughout the text for consistency. Mr. Frings provided four comments that were not related to grammar and were not rhetorical comments. We provided additional sentences or information to provide clarity related to those comments that pertained to population conditions. We added text further detailing conditions of the populations at Stone Mountain and Arabia Mountain for black-spored quillwort and text detailing condition of amphianthus in each state throughout the species' range.

Appendix B. Granite outcrops and conditions of three federally listed granite outcrop species, little amphianthus (*Amphianthus pusillus*), black-spored quillwort (*Isoetes melanospora*), and mat-forming quillwort (*Isoetes tegetiformans*). Abbreviations for the table include: species: AP = little amphianthus, IM = black-spored quillwort, IT = mat-forming quillwort, Status: UN = Unknown, NA = Not Applicable (no records of this species at this outcrop or outside of range), PR = Present, CR = Created, IN = Introduced, EX = Extirpated.

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Eastern Populations (mat-forming quillwort range)											
Anderson Farm (Benton Branch)	GA	Columbia	Not protected	UN	NA	UN	This large, doming porphyritic granite outcrop is currently part of an active quarry and is part of their future quarry plans. In 2007, amphianthus occurred in over 20 pools and 2 pools contained mat-forming quillwort. Mat-forming quillwort covered a relatively small area (four square meters) in 2002. The primary impacts to the site noted in 2007 include quarrying, ATV traffic, excess organic materials, and exotic species. The site has not been visited since 2007, permission to access the area was denied by the land owner in 2014. Because this outcrop is part of an active quarry, the prospects of long-term survival of both amphianthus and mat-forming quillwort are considered poor.	Recovery Plan #7 (AP), #1 (IT) fair (AP) good (IT)	poor (AP, IT / 2003)	unknown or poor (AP, IT / 2007)	unknown
Crater Rock	GA	Columbia	Not protected	UN	NA	UN	In 1996 and again in 2007 mat-forming quillwort was found in four pools along with Amphianthus on this granite flat rock. This outcrop hosts a large population of amphianthus, almost 30 pools in 2007. The outcrop is owned and managed by an active quarry. In 2007, quarrying activities were close to occupied pools. Access to assess the population and discuss conservation options was denied in 2014 so the current status is unknown. Because this outcrop is part of an active quarry, the prospects of long-term survival of both amphianthus and mat-forming quillwort are considered poor.	Recovery Plan #8 (AP), #2 (IT) good to poor (AP, IT / 2007)	good (AP, IT / 2002)	unknown or poor (AP, IT / 2007)	unknown
Crescent Rock	GA	Columbia	-	-	-	-	This outcrop is part of the Heggie's Rock complex is discussed as part of that outcrop in this review.				discussed as part of Heggie's Rock

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Heggie's Rock	GA	Columbia	Protected	PR	NA	PR	Heggie's Rock is a porphyritic granite outcrop and the type locality for mat-forming quillwort. Mat-forming quillwort occupies three pools at this outcrop. Amphianthus typically occupies over 20 pools across the outcrop in an average year. In 2015, Amphianthus occurred in over 50 pools. This outcrop is part of a recolonization effort, around 2007 two pools were created with artificial rims and planted with materials from Mt. Gemini. Three additional pools were manipulated or created between 2015 and 2017. Each pool was either inoculated with soil from nearby populations or plants propagated at Atlanta Botanical Gardens. In 2017, two of these pools still have mat-forming quillwort plants. A full assessment of habitat condition in 2015 revealed the habitat was in excellent condition. Future concerns for this outcrop includes continued advancing succession of the pool habitat and competition of space with amphianthus and Isoetes. One main entrance onto the outcrop has been fenced and gated reducing vehicular traffic on the site. Outcrop owned by The Nature Conservancy and Columbia County and managed as a nature preserve, and much of the outcrop habitat has been fenced. This site is the type locality for mat-forming quillwort (Rury 1978).	Recovery Plan #10 (AP) and #3 (IT), and also includes Crescent Rock #9 (AP)	excellent (AP, IT / 2006)	excellent (AP, IT / 2017)	no change
Little Heggie's Rock	GA	Columbia	Not protected	PR	NA	NA	Little Heggie's Rock is a large porphyritic granite outcrop northwest of Heggie's Rock. Little amphianthus occurs in several pools (9 in 2007 to 16 in 2015) in the northeast portion of the outcrop. In 2015 several pools contained over 100 plants. This outcrop has recreational use, vehicle and golf cart traffic, and fire pits in the pools. The outcrop is considered in good condition despite the recreational activities because of the condition of the pools containing little amphianthus. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #12 (AP)	unknown (AP)	good (AP / 2015)	no change
Little Kiokee (Hwy 232 Northeast)	GA	Columbia	Not protected	UN	NA	NA	This small porphyritic granite flat rock occurs between Heggie's Rock and Lost Rock in Columbia county. Amphianthus was recorded in a single pool along with <i>Isoetes piedmontana</i> . In 2007, the outcrop was surveyed and little amphianthus was found in two pools, one of which only contained six plants. This tiny population of amphianthus is threatened by increased organics and exotics. The status of this population is unknown because it has been over 10 years since its last assessment. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #11 (AP)	unknown (AP)	poor (AP / 2007)	unknown

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Lost Rock (Little Kiokee Creek Quarry / Claussen Quarry)	GA	Columbia	Not protected	NA	NA	EX	Most of this granite flat rock has been destroyed by quarrying activities prior to 1986. Mat-forming quillwort has been extirpated from the outcrop. Some mat-forming quillwort was salvaged from this location and transplanted at Thompson Mill Forest. No past surveys have found little amphianthus at this location. Attempts were made to access the property in 2014 to verify condition of habitat, but permission to access property was denied by the property owner.	Recovery Plan #13 and #14 (AP) poor or extirpated (AP)	extirpated (AP / 1986)	extirpated (AP)	no change
Mt. Gemini	GA	Columbia	Not protected	EX	NA	EX	This outcrop is a large porphyritic granite outcrop. Mat-forming quillwort was known from two pools at the northern summit that was destroyed quarrying activities in the 1990's. Some plants from this outcrop were transplanted by the property owner to a portion of Heggie's Rock that they also owned. Material from Mt. Gemini was also taken to Atlanta Botanical Garden for ex situ safeguarding and propagation for future planting (2007-2017) at Heggie's Rock. There are no known remaining populations of amphianthus at this site.	Recovery Plan # 15 (AP) poor or extirpated (AP); extirpated (IT / pre-1990)	extirpated (AP, IT / pre-1990)	extirpated (AP, IT)	no change
Greensboro South	GA	Greene	Not protected	PR	NA	CR	This porphyritic granite flat rock outcrop has been actively quarried in the past and is currently an active quarry. Amphianthus was found in 1987 and 2007 but a complete survey of the outcrop since then has not been conducted. As part of a recolonization effort since the last 5-year review, seven artificial pools were either deepened or created between 2012 and 2014. Each pool was either inoculated with soil or stocked with mat-forming quillwort propagated at Atlanta Botanical Gardens from material taken at Veazy Outcrop. In 2017, four of these pools still had mat-forming quillwort. The future status viability of these created pools is currently unknown, but as of 2017, their condition was classified as good.	Recovery Plan #25 (AP) good to poor (AP)	good to poor (AP)	good (IT/ 2017), unknown (AP)	introduced (upgrade) (IT); unknown (AP)
Old Sparta Road	GA	Greene	Not protected	PR	NA	NA	This is a small granite flat rock has four to five documented little amphianthus pools. The outcrop and pools have been impacted by exotics and invasive species, dumping of deer carcasses, and ATV traffic. One pool with amphianthus is located on the edge of power line road. In 2011, all of the pools had a much lower density of amphianthus resulting in a poor ranking of the condition of this population. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #26 (AP) good to poor (AP)	poor (AP / 2004)	poor (AP / 2011)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Siloam	GA	Greene	Not protected	PR	UN (INT)	UN (INT)	This small granite flat rock was used for experimental introductions of black-spored quillwort, mat-forming quillwort, and amphianthus. Amphianthus naturally occurred in a single pool in 1979. Two pools were modified in 1981 and soil from Veazy Outcrop, potentially containing mat-forming quillwort spores and amphianthus seeds, was added to the modified pools. Black-spored quillwort was transplanted into pools on this site from populations destroyed in DeKalb and Newton Counties. Additionally, black-spored quillwort was planted from the Ellis Farm Quarry in 1982 and two plants were planted from the Hayden Quarry in 1983. From the early 1980's to the early 2000's, the population of amphianthus was over 1000 plants. In 2007, the landowner buried the site with fill material, planted it in fescue, and put the property up for sale. Most pools were filled and resulted in the extirpation of the granite outcrop plants in those pools. During an assessment in 2017, one pool still contained <i>Isoetes</i> (unknown species) along with amphianthus. The condition of this outcrop is now poor with limited survival potential because of eutrophication and sedimentation from the fill material and competition with grasses in the single remaining pool. Because this outcrop is within the range of amphianthus, it is included in the populations where the species is present.	Recovery Plan #27 (AP) good (AP)	not self-sustaining (AP / 2007)	poor, not self-sustaining (AP / 2017)	no change
Veazy Outcrop (Greensboro North)	GA	Greene	Not protected	PR	NA	PR	This large porphyritic granite flat rock has portions of abandoned and active quarrying. Mat-forming quillwort was known to occur in at least seven pools. In 2002, mat-forming quillworts occurred in four pools and in 2008 they occupied five pools intermixed with Piedmont quillwort. In 2008, amphianthus occurred in over 30 pools across the outcrop. In 2011, much of the outcrop was in similar condition to 2008 with 5 mat-forming quillwort pools and over 25 amphianthus pools. The outcrop showed signs of ATV traffic, vehicle/equipment traffic, invasive species, organic debris, and historic quarrying debris. Based on observations in 2011, the condition of the amphianthus populations remains poor to fair at the site and the condition of mat-forming quillwort remains very good to excellent. The amphianthus and quillworts both occupy areas of the outcrop that has undergone past quarrying activities and may have more limited future impacts than those seen at other active quarries. Under a partnership with Plum Creek Timber and Atlanta Botanical Garden, personnel removed vouchers of mat-forming quillwort from this location for propagation. These vouchers were planted in seven artificially created pools at Greensboro South.	Recovery Plan #24 (AP), #4 (IT) excellent to poor (AP, IT)	poor to fair (AP / 2006); excellent (IT / 2006)	poor (AP / 2011) very good to excellent (IT / 2011)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Culverton South	GA	Hancock	Not protected	PR	NA	NA	Culverton South is a granite flat rock with four to five amphianthus pools. The outcrop has been degraded by off-road vehicles, exotic species, and heavy equipment from logging activities. In 2015, survey of the habitat revealed the population was in fair condition cause by threats to the outcrop pools. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #29 (AP) good (AP)	unknown	fair (AP / 2015)	decline
Forty Acre Rock, GA (Boone Farm Outcrop)	GA	Hancock	Not protected	PR	NA	PR	This porphyritic granite outcrop is a large flat rock located in pasture. In 1980 and 2007, records listed more than a dozen pools with Amphianthus. In 2015, amphianthus was documented in over 50 pools. Mat-forming quillwort was very scarce in 1980, was not located in 1986 or 1987, but was found in a single large pool in 1996. In 2007 and 2015, mat-forming quillwort occurred in three pools. Past cattle grazing and nutrient inputs have impacted pool habitat. The surrounding landscape was converted from pasture to pine plantation. This conversion likely resulted in an improvement of habitat (e.g., reduced exotics, trampling, added nutrients to the pools) resulting in a fair to good overall classification of the granite outcrop habitat. Organics, trampling, vehicle / ATV traffic, and increased competition from invasive species still threaten the amphianthus and mat-forming quillwort populations at this outcrop.	Recovery Plan #30 (AP), #5 (IT) good to poor (AP); fair (IT)	poor (AP, IT / 2002)	fair to good (AP, IT / 2015)	upgrade
Galilee Rock	GA	Hancock	Not protected	UN	NA	NA	Galilee Rock is a granite flat rock that has been disturbed by past human activities. Amphianthus occurs in only a few pools (three in 2007). The habitat is dominated by exotic species associated with livestock and is impacted by vehicular traffic. This outcrop has not been visited since 2007. The condition in that year was ranked as fair because the pool habitat was dominated by invasive exotics and vehicular traffic disturbed the pool habitat. The status of this population is unknown because it has been over 10 years since its last assessment. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #31 (AP) fair to poor (AP)	fair (AP / 2007)	fair (AP / 2007)	unknown
Granite Hill	GA	Hancock	Not protected	EX	NA	NA	This granite flat rock outcrop habitat is disturbed with evidence of heavy traffic, paint on exposed rock. The population of amphianthus was discovered in 1989. A visit in 2007 did not reveal any amphianthus or remaining habitat and the population was listed as extirpated. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #32 (AP) fair (AP)	extirpated (AP)	extirpated (AP)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Pinkston Creek	GA	Hancock	Not protected	PR	NA	PR	This large granite outcrop had seven pools with mat-forming quillwort and over 60 amphianthus pools when it was visited in 2015. The site has minimal invasive species within the pools. The surrounding habitat is used for hunting and by the timber industry. The site overall is in good to excellent condition and both the amphianthus and mat-forming quillwort populations are classified as in excellent condition.	Recovery Plan #6 (IT), #33 (AP) excellent (AP, IT)	excellent (AP, IT / 2006)	excellent (AP, IT / 2015)	no change
Rocky Flats	GA	Hancock	Unknown	UN	NA	NA	This site was described in the 1993 Recovery Plan, but the outcrops location could not be discovered in 2008 and is still unknown as of this writing. Based on the description and size this outcrop might be Rock of Ages. Coordination with the past author of the Recovery Plan and the Georgia Department of Natural Resources failed to identify where this granite outcrop is located.	Recovery Plan #34 (AP) good (AP)	unknown (AP)	unknown (AP)	unknown
Thompson Mill Forest Arboretum	GA	Jackson	Protected	INT	INT	INT	This outcrop is a small flat rock within an arboretum. Black-spored quillwort was introduced to this site from salvaged material from Ellis Farm Quarry, Newton County, Georgia. In the same year, mat-forming quillwort and amphianthus were introduced to this site from material salvaged from Claussen Quarry, Columbia County, Georgia. All species were introduced into a single pool in this state-owned arboretum. The population condition is listed as poor because of the introductions into a single pool and although the outcrop falls within appropriate granite habitat and is on the edge of the known range of all three species. This outcrop has not been visited since 2001.	Not in the Recovery Plan	not self-sustaining (AP, IM, IT / 2001)	poor, not self-sustaining (AP, IM, IT / 2001)	no change
Echols Mill Granite Outcrop	GA	Oglethorpe	Not protected	EX	NA	NA	This granite flat rock is part of a large quarry. A survey around 1965 revealed three pools with less than 200 amphianthus plants. Amphianthus at this were extirpated from quarrying activities before 1993. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #47 (AP) extirpated (AP)	extirpated (AP)	extirpated (AP)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Eatonton Outcrop (Old Forty Acre Rock)	GA	Putnam	Protected	PR	NA	PR	This large doming granite outcrop was likely partially inundated by Lake Oconee. The exposed part of the outcrop is owned and managed by the Georgia Department of Natural Resources. In the remaining outcrop habitat, amphianthus has been found in eight to eleven pools near the top of the dome with some pools having over 1000 individuals. Mat-forming quillwort occurs in two pools. The patches of mat-forming quillwort are still small in each pool with no single patch being larger than 10x10 cm. In 2015, one pool had five separate patches of Isoetes and the other pool had a single patch. During a visit in 2017, many dead pine trees were observed, likely killed by drought in previous year(s). These dead pine trees have added organic material to the existing pools. Excess organic material may alter the pool communities to favor more grass species and other later successional species. The minimal threats and good population numbers have resulted in a good classification of both the amphianthus and mat-forming quillwort populations.	Recovery Plan #14 and #49 (AP), #7 (IT)	good (AP, IT / 2006)	good (AP, IT / 2017)	no change
Rocky Comfort	GA	Warren	Protected	PR	NA	PR	This moderate-sized flat rock outcrop was found in 2012. It is a small outcrop, but has two pools with dense mats of mat-forming quillwort and five pools with amphianthus. In 2015, an assessment of the outcrop revealed habitat and populations in good condition with limited human impacts. There is no signs of vehicular traffic or trash dumping. The outcrop is surrounded by woodland and pine plantation. The site is protected under a conservation agreement help by the Oconee Land Trust as of 2018.	Not in the Recovery Plan	new in 2012	good (AP, IT / 2012)	new in 2012 (good)
Forty Acre Rock, SC	SC	Lancaster	Protected	PR	NA	NA	This outcrop is the largest outcrop in South Carolina and has populations of little amphianthus. In an assessment from 2012, amphianthus was reported in 22 pools and was in good condition. Although the outcrop is protected by the state and managed as a nature preserve, the outcrop is impacted from human use, ATVs, and graffiti. In the past sedimentation in the pools was a concern, but a water control structure reduced sedimentation onto the outcrop and into occupied pools. There are also concerns about invasive species, which has increased with sedimentation and flooding events. The taxonomic status of the population previously considered black-spored quillwort at Forty Acre Rock Heritage Preserve is currently under review by the taxonomic experts. This <i>Isoetes</i> population is still extant at the site, but because of uncertainties of what species this is, it will not be discussed further in this document (J. Matthews, pers. comm. 2018; SCDNR 2013).	Recovery Plan #55 (AP)	unknown (AP)	good (AP / 2012), (IM not addressed)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Flat Rock (Lorick Outcrop / Batesburg)	SC	Saluda	Not protected	UN	NA	NA	This site has not been visited since 1993. The condition of the outcrop and the amphianthus population is unknown. Past threats included vehicular traffic and quarrying.	Recovery Plan #56 (AP) fair (AP)	unknown (AP)	unknown (AP)	no change
Clover Community Park	SC	York, SC	Not protected	EX	NA	NA	This outcrop is owned by the city of Clover, South Carolina. This population is classified as not protected, because it is unknown if management activities are compatible with the granite outcrop plants. There was a population of amphianthus and <i>Isoetes</i> (unknown species) at this site, but run off from a construction site in the spring of 2018 caused the pools to fill with sediment and the federally listed species are likely extirpated from this site (Bradley, pers. comm. 2018).	Not in the Recovery Plan	not addressed	extirpated (AP / 2018)	decline (extirpated)
Hill Top Lane, SC	SC	York, SC	Protected	PR	NA	NA	This granite flat rock outcrop is owned by York County, South Carolina. In a survey conducted by Keith Bradley in 2017, 161 amphianthus plants were found occupying five pools (Bradley pers. com. 2018). The current management of the outcrop appears to be compatible with amphianthus, but future management of the site is unknown. The limited size of the outcrop and threats associated with surrounding urban land use have resulted in a fair condition classification for this population. We have no records of black-spored quillwort or mat-forming quillwort occurring at this site.	Recovery Plan #57 (AP) fair to good (AP)	unknown (AP)	fair (AP / 2017)	no change
Western Populations (black-spored quillwort range)											
Penton Creek Outcrop	AL	Chambers	Not protected	PR	NA	NA	This biotite granite gneiss outcrop hosts approximately three pools for little amphianthus. A portion of this outcrop has been quarried in the past. This outcrop is impacted by trash dumping, ATV use, and quarrying. Little amphianthus is limited to three pools with total plant populations in 2012, 2013, and 2016 ranging from 559-2017 individuals. Periodic surveys from 2010 to 2018 revealed one pool had variable numbers with amphianthus with plants being absent in some years and low numbers in other years (Frings and Davenport 2017). The condition of this outcrop was classified as poor, because of the limited number of pools and threats to the outcrop. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #1 (AP) fair (AP)	unknown (AP)	poor (AP / 2018)	decline

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Almond Outcrop (Bald Rock)	AL	Randolph	Not protected	PR	NA	NA	Almond outcrop is a larger trondjhemite outcrop. Little amphianthus limited to three pools all of which are approximately one meter in diameter. The pools were checked in 2012, 2013, and 2016 with the total count of little amphianthus plants ranging from 1270 to 1655 (Frings and Davenport 2017). In 2018, the three pools were visited again and the total numbers appeared lower than estimates from 2012-2016. According to Frings and Davenport (2017) threats to these pools include trash dumping, ATV traffic, and vehicle traffic. Because of the limited number of pools and threats to the outcrop, the condition of the population is considered poor. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #2 (AP) fair (AP)	unknown (AP)	poor (AP / 2018)	decline
Blakes Ferry Outcrop	AL	Randolph	Not protected	EX	NA	NA	Although on protected lands, this granite outcrop is not managed in a compatible way for the protection of federally listed species. This outcrop was partially inundated by the completion of Harris Dam and creation of Harris Reservoir in 1983. It is storied that materials quarried from the outcrop were used in creation of dam. Amphianthus was documented to occur here in described in the 1930's. The outcrop is now part of Flat Rock Park and the outcrop habitat has been extirpated because of overuse from vehicular traffic and recreation (Frings and Davenport 2017). There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #3 (AP) fair (AP)	unknown (AP)	extirpated (AP / 1995)	no change
Wehadkee Creek	AL	Randolph	Not protected	PR	NA	NA	This granite outcrop was impacted by past quarrying. Little amphianthus limited to two pools near the rim of an abandoned quarry (Frings and Davenport 2017). Because of the limited number of pools and threats to the outcrop, the condition of the population is considered poor. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #4 (AP) fair (AP)	unknown (AP)	poor (AP / 2016)	decline
Wolfpen Creek	AL	Randolph	Not protected	EX	NA	NA	This large monadnock outcrop once had documented pools with little amphianthus, but no occurrences have been documented since 1984 (Frings and Davenport 2017). This population of amphianthus is considered extirpated.	Not in the Recovery Plan	extirpated (AP / 1984)	extirpated (AP / 1984)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Thornton Road	AL	Tallapoosa	Not protected	EX	NA	NA	This outcrop is a flat expanse near a road. Records of this granite outcrop are only known from herbarium specimens. Amphianthus was last known to occur at this site in 2006. Population appears to be extirpated because of dumping (Frings and Davenport 2017). There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Not in the Recovery Plan	unknown (AP)	extirpated (AP / 2006)	no change
Highway 36 Outcrop	GA	Butts	Not protected	UN	UN	NA	At this small granite flat rock, the quillworts currently present may be hybrids between Piedmont quillwort (<i>Isoetes piedmontana</i>) and black-spored quillwort. Past surveys documented black-spored quillwort occurring in a single pool that is visible from the highway in 1986. Amphianthus has been found in two pools and is in competition with populations of exotic species and quillworts. The last known survey of this outcrop was in 2007. The status of the population of black-spored quillwort and amphianthus at this outcrop is currently unknown. This outcrop is threatened by exotic species and disturbance from the road.	Recovery Plan #6 (AP), IT not addressed	hybrid? (IM / 2007) poor (AP / 2007)	hybrid? (IM / 2007); poor (AP / 2007)	unknown
Mountain Rock	GA	Butts	Not protected	UN	UN	NA	This granitic gneiss outcrop is composed of two sections. The southern exposed rock (the "mountain") was in good condition, but the northern exposed outcrop has more disturbance from ATV and motorbike traffic. In 2007, black-spored quillwort and amphianthus were found in a single pool on the southern rock. Aerial imagery from the area shows the land around both the northern and southern exposed outcrop has been clear-cut and numerous ATV trails lead around and into portions of both areas. The status of this population is unknown, but with only one occupied pool the long-term stability of this population is unlikely for both the black-spored quillwort and amphianthus.	Recovery Plan #5 (AP), #1 (IM) excellent (AP) good (IM)	excellent (AP / 2002) good (IM / 2003)	poor (IM, AP / 2007)	unknown

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
St. Mary's Outcrop (Kennesaw Mountain)	GA	Cobb	Protected	INT	NA	NA	This persistent, but very small population was introduced in 1986 from plants cultivated from an unknown granite outcrop. This pool is located on the St. Mary's gneiss outcrop south of Kennesaw Mountain's peak. Amphianthus only occurs in one pool that is approximately one meter in diameter. The population is periodically assessed and numbers of plants range from approximately 20-500 plants. The population is within Kennesaw Mountain National Battlefield Park, but is near a subdivision with evidence of foot traffic and in 2018 records indicated the outcrop area harboring amphianthus was impacted by vehicular traffic (Ranger pers. comm. 2018). This population is classified as poor because of limited long-term survival and threats to a single pool. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Not in the Recovery Plan	not treated	poor / not self- sustaining ? (AP / 2018)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Arabia Mountain	GA	DeKalb	Protected	PR	PR	NA	<p>This outcrop is a large granite monadnock. Amphianthus is found in over 30 natural pools and several quarry pools. Quarrying in some areas has created artificial pools that have provided habitat for amphianthus and at least one of which contains black-spored quillwort. Black-spored quillwort occurred in six natural pools only five of which could be relocated in 2017. As part of a recolonization effort, five pools were created in 2013. Each pool was either inoculated with soil from nearby populations or plants propagated at the State Botanical Garden in Athens, Georgia. In 2017, two of these pools still have black-spored quillwort plants. A wet spring and summer in 2018 resulted in a lot of competition in the natural Isoetes pools with grass species. This competition appears to have resulted in a decline of black-spored quillwort. If changes in timing of drought continues to occur, grasses may continue to increase in these pools requiring more active management to reduce competition. In the past, the lower and middle slopes of portions of the outcrop were quarried. The site is now owned by DeKalb County and is part of the Davidson-Arabia Nature Preserve and Arabia Mountain National Heritage Area. Current threats include foot-traffic, pool disturbance (rearranging rocks), trash, fire creation in pools, and invasive plants. In the last several years, granite outcrops, specifically Arabia Mountain and Stone Mountain have been sought out for television and movie sets. Additional threats from the film industry to the granite outcrop pools come from vehicle and foot traffic, equipment, and other materials. Although management of both locations attempts to minimize impacts to pools with listed species the timing and potential of changes to pool habitat is a concern for both amphianthus and black-spored quillwort. Based on current threats and occupied pools, the current population of amphianthus and black-spored quillwort is in good to excellent in condition. This site is the type locality for black-spored quillwort (Engelmann 1882).</p>	Recovery Plan #16 (AP), #2 (IM)	excellent (AP, IM / 2006)	good to excellent (AP, IM / 2017)	decline

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Bradley Mountain (Little Arabia Mountain)	GA	DeKalb	Protected	PR	CR	NA	This large doming gneiss outcrop is visible from Arabia Mountain. A survey in 2017 revealed 11 natural pools and 5 created pools with amphianthus and 5 created pools with sparse densities of black-spored quillwort. The natural populations of black-spored quillwort appear to be extirpated from this outcrop in the 1980s or 1990's. Isoetes was known to occur in two pools in 1979 and several attempts (1985, 1986, 2007, and 2012) were made to find the historic pools with no success. As part of a recolonization effort, five artificial pools were created in 2014. Each pool was either inoculated with soil from nearby populations or plants propagated at the State Botanical Garden in Athens, GA. Based on the added pools with Isoetes and current threats to the outcrop, e.g. trash dumping, vehicular traffic, recreational use foot traffic, and invasive species, the outcrop condition was changed to good for amphianthus and fair for black-spored quillwort. If the pools with black-spored quillwort can survive and expand in the future, this condition may be upgraded, but it is currently too early to assess viability.	Recovery Plan #17 (AP) fair (AP)	fair (AP / 2002); extirpated (IM / 2002)	good (AP / 2017) fair (IM / 2017)}	upgrade / reintroduced (unknown viability)
Hayden Quarry Rd.	GA	DeKalb	Not Protected	EX	EX	NA	This gneiss flat rock outcrop straddles Hayden Quarry Road. The amphianthus and black-spored quillwort populations were represented by a single pool with a limited number of plants found in the middle of the road. The road was paved and the outcrop was used by heavy equipment to turn around. The pool with amphianthus and black-spored quillwort was destroyed and the populations extirpated sometime during road paving in 1982 or 1983.	Not in the Recovery Plan	extirpated (AP, IM / 1983)	extirpated (AP, IM)	no change
Lithonia Rock	GA	DeKalb	Not protected	NA	EX	NA	This large gneiss flat rock outcrop was once quarried. Black-spored quillwort occurred in at least two quarry pools. Records in 1989 documented plants transplanted to a created pool from a larger pool near the entrance to the outcrop. The outcrop was eventually converted to a subdivision. Using aerial imagery, the date of extirpation occurred sometime between January 2004 and March 2005.	Recovery Plan #3 (IM) fair (AP)	extirpated (IM / 2004)	extirpated (IM)	no change
Little Rock Chapel Mountain (Rock Chapel Mountain East)	GA	DeKalb	Not protected	PR	NA	NA	This large doming gneiss monadnock was a historic quarry as part of the Rock Chapel Mountain complex. This outcrop may be included in future expansion of quarrying at Rock Chapel Mountain. The four pools found in 2012 with amphianthus are within an area planned for future quarry expansion and, therefore, were classified as a poor condition. Some areas of the outcrop are already impacted by quarrying activities. Other threats include dumping, fire building, graffiti and vandalism, invasive species, recreational activities, and vehicular traffic. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #18 (AP) poor (AP)	possibly extirpated (AP / 2007)	poor (AP / 2012)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Little Stone Mountain (Pine Mountain)	GA	DeKalb	Not protected	NA	EX	NA	This outcrop is a large gneiss monadnock where the pool habitat has been completely destroyed from quarrying activities and associated vehicular traffic. The pool habitat at the summit, where black-spored quillwort would have been found, was likely destroyed before 1930. Black-spored quillwort was recorded as occurring in shallow depressions on the summit. Specimens were collected in 1897 and cataloged at the Biltmore Herbarium. There is no record of amphianthus occurring at this outcrop.	Not in the Recovery Plan	extirpated (IM / pre-1930)	extirpated (IM)	no change
McDaniel Mill Road	GA	DeKalb	Not protected	PR	NA	NA	A 2012 survey of this granite flat rock revealed a very small population with amphianthus found in a single pool. Much of the outcrop has been quarried. Areas surrounding the outcrop have been developed, and the outcrop is close to a road, which may make it vulnerable to increased future impacts related to human activities. The limited pools and the surrounding land use resulted in a poor classification for the condition and future of this population. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Not in the Recovery Plan	new in 2012	poor (AP / 2012)	new in 2012 (poor)
North Rock Chapel Mountain	GA	DeKalb	Not protected	EX	NA	NA	Little amphianthus was last known occurring on this small gneiss outcrop in 1984 where one or two pools were occupied. The outcrop is north of the quarry at Rock Chapel Mountain and was likely part of that population until the pools there were impacted by quarrying. Although no amphianthus pools were located in 2007 and 2012, North Rock Chapel Mountain has some habitat still available that could harbor outcrop endemics. Until occurrences are found of amphianthus this outcrop will be considered extirpated. Other threats include dumping, fire building, graffiti and vandalism, invasive species, recreational activities, and vehicular traffic. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #19 (AP) poor (AP)	possibly extirpated (AP / 2007)	extirpated (AP / pre-2007)	no change
Rock Chapel Mountain	GA	DeKalb	Not protected	EX	EX	NA	This outcrop was a large gneiss monadnock with an active crushed stone quarry. The population of both black-spored quillwort and amphianthus are considered extirpated. Outcrop was part of an active quarry and pools containing listed plants were likely destroyed before 1940. The last record of known occurrences of <i>Isoetes</i> was in 1938 and of amphianthus was in 1939. Lunsford (1939) visited the site and noted the largest pool was drained by active quarrying.	Not in the Recovery Plan	extirpated (AP, IM / pre-1940)	extirpated (AP, IM)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Rollaway	GA	DeKalb	Not protected	EX	NA	NA	This gneiss flat rock outcrop was documented to have amphianthus in the early 1960's. Quarrying activities and storage of stone blocks have destroyed the pools where amphianthus once occurred. The outcrop was surveyed in 1983, 1984, and 2011 with no evidence of amphianthus. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop. A hybrid black-spored quillwort X Piedmont quillwort population was documented at this location (Service 1993).	Not in the Recovery Plan	extirpated (AP / pre-1983)	extirpated (AP)	no change
Stephenson-Rock Chapel / SR 124 (Rock Chapel Park)	GA	DeKalb	Not protected	EX	NA	NA	Little amphianthus once occurred within two pools at this gneiss flat rock. The habitat was impacted by the widening of Highway 124 and the relocation of utility lines in the late 1990's early 2000's. The pools with amphianthus were destroyed as a result of those activities. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop. This location is presumed to be the type locality of little amphianthus (McVaugh 1937, Estes and Small 2008, Allison 2013).	Recovery Plan #20 (AP) fair (AP)	extirpated (AP / early 2000's)	extirpated (AP)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Stone Mountain	GA	DeKalb	Protected	PR	PR	NA	<p>This outcrop is a large granite monadnock. The black-spored quillwort currently occurs in pools on the top of the monadnock. A fenced enclosure was placed around a portion of the outcrop in 1996 to protect the existing black-spored quillwort and most of the amphianthus pools. In 1999, black-spored quillwort was found in a single pool with less than 150 plants. The habitat has been slowly recovering as foot-traffic and recreational use of the enclosed area has been minimized. As part of a maintenance and expansion effort, a total of six pools were manipulated to manage for black-spored quillwort. Two pools were jackhammered to create additional habitat in the early 2000's. Four additional pools were inoculated with soil from nearby populations or plants propagated at on-sight. In two historic pools, efforts have been made to remove invasive <i>Juncus</i> spp. and common hairsedge (<i>Bulbostylis capillaris</i>). In 2017, 5 pools still had black-spored quillwort plants and 18 pools contained amphianthus. A wet spring and summer in 2018 resulted in a lot of competition in the quillwort pools with grass species. This competition appears to have resulted in a drastic decline of black-spored quillwort in all pools where it occurs. Continued management of those pools may be required to maintain black-spored quillwort in all of the pools. The outcrop is currently managed by Stone Mountain Memorial Association. In the last several years granite outcrops, specifically Arabia Mountain and Stone Mountain, have been sought out for television and movie sets. Additional threats from the film industry to the granite outcrop pools come from vehicle and foot traffic, equipment, and other materials. Although management of both locations attempts to minimize impacts to pools with listed species the timing and potential of changes to pool habitat is a concern for both amphianthus and black-spored quillwort. Because of these concerns, the population condition is classified as fair to good.</p>	Recovery Plan #21 (AP), #4 (IM) fair (AP)	good (AP / 2006) (IM / 2002)	fair to good (AP, IT / 2017)	decline
Stone Mountain Flatrock	GA	DeKalb	Protected	EX	NA	NA	<p>This outcrop is a monzonite granite flat rock located near the base of Stone Mountain. Amphianthus on this outcrop have been extirpated from past quarrying and use. The outcrop is currently managed by Stone Mountain Memorial Association. This outcrop has been assessed periodically since 1978 with no indication of amphianthus. Impacts to the habitat have occurred through quarrying, inn construction, tourism traffic, and vehicle traffic. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.</p>	Not in the Recovery Plan	extirpated (AP / pre-1978)	extirpated (AP)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Clinton Nature Preserve	GA	Douglas	Protected	UN	NA	NA	Amphianthus is known to occur in one pool at this county-owned granite flat rock. The pool has been threatened in the past by quarrying and development. On-going threats include recreational use as a horse park, invasive species, and potential indirect impacts from widening of the utility right-of-way with a co-located pipeline. The status of this population has not been assessed since 2007. Because of the limited number of pools and threats, the condition of this population is classified as poor to possibly extirpated.	Recovery Plan #22 (AP) poor (AP)	possibly extirpated (AP / 2002)	poor to possibly extirpated (AP / 2007)	unknown
Pope Road	GA	Douglas	Not protected	UN	NA	NA	The Pope Road outcrop is a medium-sized granite flat rock. Amphianthus was known to occur in two pools in 1979 and a single pool in 2007. A portion of the site has been quarried in the past and was used as a dumpsite. Waste rock from quarry was used to block vehicular access at entry. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop. Although the outcrop has not been surveyed since 2007, the limited number of pools and threats the condition of this population is classified as poor to possibly extirpated.	Recovery Plan #23 (AP) fair (AP)	possibly extirpated (AP / 2007)	poor to possibly extirpated (AP / 2007)	unknown
Baker's Rock (No Business Creek Outcrop)	GA	Gwinnett	Protected	PR	PR	NA	The outcrop is a large gneiss flat rock that harbors a single pool with a small population of amphianthus with less than 100 plants. Black-spored quillwort population is also small and co-occurs in a single pool with amphianthus. This outcrop has undergone quarrying in the past (Snell's Quarry was active in the late 1800's through the 1920's), which has impacted habitat. Current threats to the outcrop include vehicular traffic, invasive species, trash dumping, nearby development, and recreational use. Most of the outcrop was deeded to the city of Snellville in 2007 and in 2013 access to the outcrop was limited to protect the sensitive species. Because past recreational use has impacted the pool and only one pool is occupied, the condition of the population is still considered poor despite its protected status.	Recovery Plan #28 (AP) and #5 (IM) poor (AP, IM)	poor (AP / 2000) (IM / 2002)	poor (AP, IM / 2012)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Gray Rock	GA	Harris	Not protected	UN	NA	NA	This granite flat rock outcrop has been degraded by trash dumping (concrete, wood, slash, and junk), vehicular traffic, and exotics. The outcrop was visited in 1993, but not in the proper season for amphianthus, so the excellent classification of the habitat may have been in error. A visit in 2001 lists that the habitat was still intact at the site, but does not document the status of the population. In 2007, amphianthus occurred in three small, degraded pools and was classified as in poor condition. The writing of the last 5-year review may have occurred before this status was determined. This outcrop has not been visited since 2007 and, therefore, remains classified as in poor condition. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #35 (AP) excellent (AP)	excellent (AP / 2003)	poor (AP / 2007)	no change
Alford Road	GA	Heard	Not protected	PR	NA	NA	This outcrop is a small, long outcrop north of Camp Meeting Rock. The outcrop is degraded by vehicular traffic, invasive species, and adjacent development with road frontage that may threaten the outcrop. Amphianthus occurs in two pools at this outcrop. Because of the limited number of pools, this population is classified as poor.	Not in the Recovery Plan	new in 2012	poor (AP / 2012)	new in 2012
Camp Meeting Rock	GA	Heard	Protected	PR	PR	NA	This large granite flat rock outcrop has a small population black-spored quillwort where it is found in two pools. This outcrop is host to a large population of little amphianthus with a variable number of pools from year-to-year ranging from 7 to over 30 pools. Part of the outcrop is owned and protected by Chattahoochee Valley Land Trust and is managed by the Nature Conservancy as a nature preserve. The 110-acre easement was purchased as part of Section 7 mitigation for Georgia Department of Transportation's impacts to Rock Chapel Park during construction improvements to State Route 124. A past threat to the outcrop included quarrying. Current threats to the outcrop include Chinese privet and other invasive species, adjacent development (increasing human impacts), dumping, and vehicular traffic. The classification of this outcrop is excellent because of its protected status and large number of pools for amphianthus and two pools of black-spored quillwort.	Recovery Plan #38 (AP), #6 (IM) excellent (AP) good (IM)	excellent (AP / 2006) good (IM / 2006)	excellent (AP, IM / 2012)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Flat Rock North (Allen/Aubrey Outcrop)	GA	Heard	Not protected	PR	PR	NA	This outcrop supports a small population of black-spored quillwort (two pools) and large population of amphianthus (approximately 30 pools). According to records, one pool may contain hybrid quillwort species. The outcrop is located near a state highway and shows evidence of vehicle traffic, invasive species, human activities (dumping), and past quarrying. The classification of this outcrop is listed as good to excellent, because of its large number of pools for amphianthus and two pools of black-spored quillwort.	Recovery Plan #39 (AP) good (AP)	good (AP / 2003)	good to excellent (AP, IM / 2012)	upgrade
Flat Rock Northeast	GA	Heard	Not protected	PR	NA	NA	This small outcrop shows evidence of human activities with dumping. There are at least two pools with amphianthus at the outcrop. Threats to this outcrop include human impacts (e.g., broken glass, dumping, and vehicular traffic). The outcrop also had evidence of past quarrying. The classification of this outcrop was designated as poor due to the limited number of pools and threats. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Not in the Recovery Plan	new in 2012	poor (AP / 2012)	new in 2012 (poor)
Little Wehadkee Creek (Big Oak Rock)	GA	Heard	Not protected	PR	NA	NA	This small outcrop straddles the Georgia-Alabama boundary. Amphianthus occurs in three pools on the Georgia portion of the outcrop. A small area of trees separates the Alabama portion of the outcrop, which may not have been surveyed in the past. Area has been impacted by vehicular traffic, invasive species, dumping, and some past quarrying. The classification of this outcrop was designated as poor due to the limited number of pools and threats. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Not in the Recovery Plan	new in 2012	poor (AP / 2012)	new in 2012 (poor)
Mile Post Six	GA	Heard	Unknown	UN	NA	NA	This site was described in the 1993 Recovery Plan, but the outcrops location could not be discovered in 2008 and is still unknown as of this writing. The status of the population was listed as fair in 2002 with the habitat intact. Coordination with the past author of the Recovery Plan and the Georgia Department of Natural Resources failed to identify where this granite outcrop is located.	Recovery Plan #40 (AP) good to fair (AP)	fair (AP / 2002)	unknown	unknown

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Mount Carrie Church (Whitewater Creek / Lipham Road)	GA	Heard	Not protected	PR	NA	NA	This outcrop is a long granite flat rock that is split into three areas by GDNR, Whitewater Creek to the southeast, Mount Carrie Church in the middle portion, and Lipham Road to the northeast because of parcel ownership. We will continue to treat these three outcrops as a single population. Whitewater Creek is smaller with approximately 4 amphianthus pools and the Lipham Road area is larger with approximately 13 amphianthus pools. The pools within the Mount Carrie Church area have been extirpated. Areas close to the road are degraded by exotics, vehicular traffic, a logging deck, and dumping. Both the Whitewater Creek and main Mount Carrie's Church outcrops have recent nearby logging activities with visible access roads and activities surrounding the outcrops. These activities likely resulted in additional threats to the amphianthus at the site. Pools on the eastern portion of the outcrop have more plants and fewer impacts. The status of the outcrop is listed as fair because of its size, but it still has relatively light to medium ongoing threats. Pools near the road that bisects the outcrop have been extirpated. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #43 (AP) fair (AP)	fair (AP / 2002)	fair (AP / 2012)	no change
Rusty Rock	GA	Heard	Not protected	EX	NA	NA	Much of this granite flat rock is degraded habitat from extensive quarrying activity. A small portion on the southern end of the site still harbored a remnant granite outcrop habitat, but no evidence of amphianthus occurred when the site was last checked in 2012. This outcrop was heavily quarried and the amphianthus population was likely extirpated around 1998. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #41 (AP) fair to extirpated (AP)	extirpated (AP / 1998)	extirpated (AP)	no change
Straylott Road Outcrops	GA	Heard	Not protected	PR	NA	NA	Two outcrops have been combined because of their proximity to each other to form the Straylott Road Outcrops. Amphianthus occurs on Straylott Road NE (GDNR elemental occurrence 70) and Straylott Road North / Big Rock (GDNR elemental occurrence 34). Surveys documented at least two pools occupied by amphianthus in each of the areas, totaling eight amphianthus pools. Impacts to the outcrop from vehicle traffic, dumping, invasive species, and cattle grazing. Conditions at this outcrop are similar to those described from the last survey in 2007, therefore the status is listed as good. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #36 and #37 (AP) fair to good (AP)	good (AP / 2003)	good (AP / 2012)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Straylott Road South	GA	Heard	Not protected	PR	NA	NA	This outcrop is part of the Straylott Road outcrops. We have kept the Straylott Road South outcrop separate from the others because of the distance between the outcrops and a large roadway that divides them. Amphianthus occurs on Boggy Rock / Straylott South / "The Domer" (GDNR elemental occurrence 57). The proximity of this outcrop with the Straylott Road North and NE have resulted GDNR to combine all of the outcrops into a single resource. Surveys in 2012 documented four pools occupied by amphianthus. Impacts to the outcrop from vehicle traffic, dumping, invasive species, and cattle grazing. Conditions at this outcrop are similar to those described from the last survey in 2007; therefore, the status is listed as good. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #36 and #37 (AP) fair to good (AP)	good (AP / 2003)	good (AP / 2012)	no change
Sunflower Rock	GA	Heard	Not protected	EX	NA	NA	This granite flat rock outcrop is considered extirpated, which was attributed to dumping and burning of refuse on the outcrop. A survey in 1979 of the outcrop documented amphianthus. Visits in 2007 and 2012 failed to find any amphianthus pools. Continued threats to the outcrop include adjacent development, dumping, recreational impacts (fire building), invasive species, and vehicular traffic. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #42 (AP) good (AP)	good (AP / 2003)	extirpated (AP / 2007)	decline (extirpated)
Vista Rock	GA	Heard	Not protected	PR	NA	NA	This outcrop is currently a small gneiss outcrop surrounded by pasture and successional pine. Aerial imagery reveals what was likely a much larger outcrop to the southeast that has been extensively quarried. Amphianthus was documented in eight pools in 2011 and three pools in 2012. Recent aerial imagery indicates that a new road leads to the outcrop and newly clear-cut land borders the outcrop. These new land use changes could indicate an imminent threat to the outcrop. It is unknown what impacts might occur to this outcrop and if amphianthus or mat-forming quillwort will persist in these pools in the future. These concerns lead to the classification of both populations as poor.	Not in the Recovery Plan	new in 2012	poor (AP / 2012)	new in 2011/2012 (poor)

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Wolf Rock	GA	Henry	Protected	UN	NA	NA	Amphianthus occurs in a single pool on this flat to gently-sloping granite outcrop, which had 35 plants in 2007. This pool was heavily degraded with sedimentation and eutrophication. The outcrop showed signs of heavy ATV traffic and broken glass. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop. Although a portion of this outcrop is protected as greenspace by Henry County, viability of amphianthus is uncertain. The population of amphianthus was classified as in poor condition because of the limited number of pools and the threats.	Recovery Plan #44 (AP) poor (AP)	poor (AP / 2007)	poor (AP / 2007)	unknown
Wright Branch N	GA	Meriwether	Not protected	UN	NA	NA	This large granite outcrop supports approximately three amphianthus pools. Amphianthus has persisted at the site since 1980 when it was documented as occurring in a single pool. In 2007 and 2011, amphianthus occurred in three pools. These three pools are in close proximity to each other and would be vulnerable to any threats in their immediate vicinity. The outcrop is threatened by off road vehicle traffic and invasive species. Because of the number of pools and the threats, the population on this outcrop is classified as fair. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #45 (AP) fair (AP)	fair (AP / 2002)	fair (AP / 2011)	no change
Ellis Farm Quarry	GA	Newton	Not protected	EX	EX	NA	This granite flat rock outcrop was part of an active crushed stone quarry. This outcrop formerly had at least two pools with black-spored quillwort and up to four pools (two natural and two created from quarrying activities) with approximately 200 amphianthus plants. These pools were protected by a power line right-of-way. The pools were extirpated when the power lines were relocated before 1988. Some black-spored quillwort was salvaged from this outcrop and planted at Thompson Mill and Siloam outcrops.	Not in the Recovery Plan	extirpated (AP, IM / 1988)	extirpated (AP, IM)	no change
Geezer Rock	GA	Newton	Not protected	EX	NA	NA	This outcrop is a small gneiss flat rock. Population of amphianthus at this outcrop is considered extirpated. Competition and increased exotics, invasive species, and organics / eutrophication of pools were identified as the cause. In 1981, there was evidence (piles of hay present on the outcrop) that the outcrop used for grazing and feeding cattle. Competition from <i>Callitiche heterophylla</i> , <i>Poa annua</i> , and other disturbance-adapted species likely added to the threats to amphianthus at this site. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #46 (AP) poor or extirpated (AP)	extirpated (AP / pre-1993)	extirpated (AP)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Concord Flat Rock	GA	Pike	Not protected	PR	NA	NA	This granite flat rock outcrop is bisected by Concord Road. In 2007, amphianthus occurred in ten pools. In 2011, only two pools contained amphianthus. The outcrop has experienced past quarrying. Current threats include exotics, eutrophication of pool habitat and vehicle/ATV use of the outcrop. Because of threats to the outcrop and the past documentation of limited pools, the population is classified as fair to good. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #48 (AP) good (AP)	good (AP / 2002)	fair to good (AP / 2011)	no change
Bald Rock	GA	Rockdale	Protected	PR	NA	NA	Bald Rock is a large gneiss flat rock that is surrounded by successional pine forest and a solar field. Amphianthus occurs in 4-8 pools at this site with as many as 800 plants in a productive year. The site is owned by the City of Conyers and was partially fenced in 1990's as part of the Georgia International Horse Park in preparation for the 1996 Olympics. The area outside the fence is impacted by foot and bike traffic as well as activities associated with a solar field. There were five pools containing amphianthus in 2012 and 2017. Inside the fence, evidence of plant collection/poaching was noticeable in 2012. All five amphianthus pools had portions of soil removed from the pool that impacted the amphianthus populations (Allison 2013). The amphianthus pools appeared to be in good condition in 2017 despite the past poaching events. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #50 (AP) good to poor (AP)	unknown (AP)	good (AP / 2017)	no change
Gleaton Rd	GA	Rockdale	Not protected	NA	EX	NA	The Gleaton Road outcrop is a large gneiss flat rock. There are no known occurrences of amphianthus at this granite flat rock outcrop. Black-spored quillwort appears extirpated with the last known occurrence before 1995. The site was visited in 2000, 2000, 2012, and 2014 with no black-spored quillwort or amphianthus found. Grazing was likely an early impact to the outcrop with trampling, eutrophication, and invasive species. Later, increased shade and succession reduced the quality of habitat for black-spored quillwort and amphianthus. The northern third of the outcrop has been grazed by cattle and horses and the southern two-thirds has ATV traffic and very little available pool habitat. Ongoing threats include adjacent development, invasive species, road frontage, and vehicular traffic and past threats include light quarrying at the site.	Recovery Plan #7 (IM) poor (IM)	extirpated (IM / 1995)	extirpated (IM)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Highway 138	GA	Rockdale	Not protected	PR	NA	NA	In 2012, this gneiss flat rock was surveyed and amphianthus occupied 23 pools. Population has been impacted by grazing cattle and invasive species. Pools nearest the highway have the largest threats from invasive species, human disturbance, trash dumping, and roadway impacts. Some areas were covered by logging slash and topsoil. Because of these threats and the nearness to the roadway, the population was classified as in fair condition. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Not in the Recovery Plan	new in 2012	fair (AP / 2012)	new in 2012 (fair)
Jessamine Rock	GA	Rockdale	Not protected	PR	NA	NA	In 2012 Amphianthus found in 12 pools at this granite flat rock. Some areas near an old road are degraded mostly because the area was used for dumping logging slash. Vehicular traffic was also a threat to the population, but may be reduced since the closure of the access road to the outcrop. The seclusion of this outcrop and limited apparent on going threats resulted in the classification of these populations as in good condition. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Not in the Recovery Plan	new in 2012	good (AP / 2012)	new in 2012 (good)
Panola Mountain State Conservation Park	GA	Rockdale	Protected	EX	NA	NA	Panola Mountain is a large doming coarse-grained granite monadnock. Records of amphianthus at this site date back to 1939. Repeated searches on the outcrop since 1939 did not reveal any federally listed outcrop species; therefore, amphianthus is considered extirpated from the site. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Not in the Recovery Plan	extirpated (AP / 1939)	extirpated (AP)	no change
Philadelphia Road	GA	Rockdale	Not protected	PR	PR	NA	In the 1990, this flat gneiss outcrop had at least 5 pools with black-spored quillwort and 20 pools with amphianthus. In following years, there were a variable number of black-spored quillwort plants present in a single large pool from 0 in 2007 to 40 individuals in 2012. In 2007 and 2012, amphianthus was only known from this single large pool. Invasive species are a serious threat to the outcrop pools. Vehicular traffic and associated dumping has taken a toll on the species, but the dumping has mostly been cleaned up and the site fenced in conjunction with a nearby road construction. The main ongoing threats comes from invasive species and apparent motorbike trail through the outcrop. The condition of the amphianthus population is classified as poor, and the condition of the black-spored quillwort population is considered fair.	Recovery Plan #51 (AP), #8 (IM) poor (AP)	poor (AP / 2002); fair (IM / 2002)	poor (AP / 2012); fair (IM / 2012)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
The Rocks I	GA	Rockdale	Not protected	PR	NA	NA	This granite outcrop is very extensive and much of the outcrop is in good condition. In 2007, amphianthus was found in two pools and in 2012 in three pools. Exotic species, heavy off-road vehicle / ATV use, and successional changes to the outcrop habitat all threaten the outcrop and the amphianthus population. Some areas, especially in the northwest, have been disturbed by past grazing, dumping, and other impacts. The future outlook for the amphianthus pools at this outcrop is unknown, but the limited number of pools where amphianthus has been found resulted in a classification of fair for this population. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #52 (AP) fair (AP)	fair (AP / 2006)	fair (AP / 2012)	no change
The Rocks II	GA	Rockdale	Not protected	EX	NA	NA	This very large gneiss flat rock once had amphianthus at the summit. The first observations of amphianthus may have been around 1836 and the last observation was likely around 1937. A single pool of amphianthus may have been present until 2007. No occupied pools were found in 2012 and amphianthus. Because of heavy impacts to the one pool from dumping and vehicular traffic, amphianthus is considered extirpated at this site. Extirpation attributed to off-road vehicle and motorbike use and years of trash dumping. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Not in the Recovery Plan	unknown	extirpated (AP / 2012)	decline (extirpated)
Anglin Farm	GA	Walton	Not protected	PR	NA	NA	Anglin Farm outcrop is a gneiss flat rock in a landscape dominated by even aged pines and in the past some pasture. The population of little amphianthus at this site includes approximately four to five pools. Impacts to the site include vehicular traffic, dumping, logging activities (slash, storage, and parking), and horse grazing. In recent years clearing and the construction of a residence nearby have increased the threats to this outcrop. The areas between the exposed outcrop is predominantly loblolly pine. As these pines continue to grow and expand, they may increase organics to the pool habitat and increase shading, which could decrease overall pool quality. Both of these may contribute to decline of amphianthus in the future. Currently the amphianthus population is classified as fair. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #53 (AP) fair (AP)	unknown (AP)	fair (AP / 2012)	no change

Population	State	County	Status	AP	IM	IT	2019 population notes	1993 Recovery plan / condition	2008 5-year condition (species / yr)	2019 5-year condition (species / yr)	2019 status change
Preacher Moon Road (Southwest)	GA	Walton	Not protected	PR	NA	NA	The Preacher Moon Road outcrop is a series of exposed gneiss flat rocks surrounded by a matrix of pine, pasture, and agricultural land. In 2012, amphianthus was found in 14 pools. Some damage to pools on this outcrop, caused by vehicular traffic, invasive species, and dumping of tires and other waste. Evidence of an old barbed-wire fence, with posts supported by old tires, indicated a likely past use of the outcrop for grazing cattle. Indications of vehicular traffic is a serious on-going threat to the outcrop resulting in fair to good classification. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Not in the Recovery Plan	new in 2012	fair to good (AP / 2012)	new in 2012 (fair to good)
Rock of Ages	GA	Walton	Not protected	PR	NA	NA	This large gneiss flat rock straddles a small stream, Rocky Branch. Amphianthus has only occurred in a single pool, which has been impacted from motorbike and/or mountain bike damage. Encroaching development, dumping, exotic species, and heavy recreational use has resulted in poor conditions at portions of this outcrop. Based on aerial imagery from 1993 to 2012, the outcrop is surrounded on almost all sides by increasing development, which will likely contribute to increased human impacts to the outcrop. Past impacts to the site include quarrying and associated activities. Overall, the outcrop condition is good, but because of amphianthus being limited to one pool, and increasing threats caused by surrounding development, its condition is classified as poor. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Recovery Plan #54 (AP) fair (AP)	fair (AP / 2006)	poor (AP / 2012)	decline
Walnut Grove (Morrison Outcrop)	GA	Walton	Not protected	EX	NA	NA	This medium-sized gneiss outcrop once had two pools with amphianthus. In the 1970's, pools on much of the outcrop were filled with asphalt. This outcrop was used for driving, parking, and storage for explosives. This activity included the filling of pools that once harbored amphianthus. There are no known records of black-spored quillwort or mat-forming quillwort occurring on this outcrop.	Not in the Recovery Plan.	extirpated (AP / 1970)	extirpated (AP)	no change