Species Status Assessment Report
for the
Georgia rockcress
(*Arabis georgiana)*

Version 1.0

Photo by Michele Elmore, U.S. Fish and Wildlife Service

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VERSION UPDATES

EXECUTIVE SUMMARY

Arabis georgiana (Georgia rockcress) is a perennial plant of the mustard family (Brassicaceae) endemic to Alabama and Georgia. The natural habitat for Georgia rockcress is steep river bluffs with shallow soils over rock, exposed rock outcroppings, as well as sandy eroding riverbanks. Georgia rockcress possesses a thick rootstock that may live for many years but is considered a short-lived perennial. The species is a poor competitor and relies on shallow soils or regular disturbance to reduce competition as well as to create canopy gaps for sufficient light. This species was listed in 2014 by the U.S. Fish and Wildlife Service (Service) as "Threatened" under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543) (Act), due to ongoing threats from development that either destroys or degrades habitat and facilitates the invasion of nonnative species (79 FR 54627). Georgia rockcress is composed of at least three octoploid genetic groups within its range: North Georgia, South Georgia, and Alabama groups. Negative influences on viability of this species include development (quarrying, residential development, timber harvest, road building, recreation, and hydropower dam construction), as well as forest succession. It is uncertain how climate change will affect the species. Current and potential future positive influences could include land acquisition, easements, and voluntary agreements with private landowners, and management activities like targeted tree removal, prescribed fire, invasive species control, and population augmentation or introduction.

The assessment of the current and future condition of Georgia rockcress was based on element occurrence (EO) data from the Alabama Natural Heritage Program and Georgia Department of Natural Resources (GDNR). The population delineation resulted in 24 populations from 37 natural EOs, of which 17 populations are currently extant. To characterize the current condition, we used the EO condition ranks that were based on population size, habitat suitability, degradation, and protection. The species was assessed in terms of its resiliency (the ability of populations to withstand stochastic events), redundancy (the ability of a species to withstand catastrophic events by having multiple, widespread populations), and representation (the ability of a species to adapt to environmental change over time). Currently there are three populations with excellent resilience, six populations with good resilience, five populations with fair resilience, three populations with poor resilience, five historical populations, and two extirpated populations. Historical populations are those that have not been located during the most recent surveys but are not yet considered extirpated. Only six extant populations are protected currently, with most of those not receiving management as part of a formal plan. Populations are at least partially degraded by invasive species or a legacy of previous land uses which create the continual threat of establishment and worsening of invasive species coverage. There has been a loss of redundancy compared to the historical distribution of Georgia rockcress. The nine populations exhibiting excellent or good resilience are fairly well-distributed throughout the species' range, improving the likelihood of species persistence following catastrophic events

(e.g. flooding or wildfire). Representative units for this species correspond to a North Georgia, South Georgia, and Alabama group according to genetic analysis.

The same four factors used to assess current resilience of Georgia rockcress populations were used to assess future resilience under three future plausible scenarios. All scenarios were projected 20 and 40 years into the future and classified each population into one of six categories (ranked from best to worst: Excellent, Good, Fair, Poor, Extant, Extirpated). In the Status Quo Scenario, management activities are maintained where they presently occur, and do not increase in frequency, extent, or type. For the Status Quo Scenario population conditions remain similar to current in the short-term (2040 projection) followed by a decline in the long-term (2060 projection) associated with the potential insufficiency of actions and decline in available resources (e.g., funds, personnel, partnering agencies, etc.). In the Focused and Expansion Scenarios, conservation activities increase in scope, including some easements and/or conservation agreements, but vary by what populations are included in these efforts. The Focused Conservation Scenario targets populations for protection, restoration, and conservation management that are protected and already have excellent or good resilience and represents a future where conservation and restoration on all protected land is not feasible. The Expansion Scenario focuses on all protected areas, increasing conservation at some unprotected sites, and searching for new populations. Targeted populations in both of the increased conservation scenarios increase in resilience by one rank every 20 years for most condition factors. Non-targeted populations in all scenarios tend to decrease by one rank every 20 years for most condition factors (i.e. move from Excellent to Good condition or moving from Fair to Poor).

While the number of extirpated populations increases over time in all scenarios compared to current conditions, certain approaches increase the proportion of resilient populations (i.e. populations classified as Excellent or Good within those that remain extant (Figure EX1). The trajectory of resilience for non-target populations within each scenario decreases, leading to overall declines in the number of extant populations. However, the increased conservation measures applied to populations in some conservation scenarios led to increases in the number of resilient populations. In the Status Quo Scenario, four populations are expected to be resilient by 2040, and only two remain resilient by 2060. In general, fourteen extant populations (those of any rank other than extirpated) remain by 2040, reduced to eight by 2060 as populations become extirpated in the Status Quo Scenario; over half (67 percent) of the populations are extirpated in the 2060 projection. The increase in resilience in the Focused Scenario is largely attributed to safeguarding populations; however, in 2060, half (50 percent) of the populations are extirpated, and the number of resilient populations (11 in 2040, 10 in 2060) is not much improved compared to the current condition (n = 9). In the Expansion Scenario, resilient populations increase to 15 in 2040 and 17 in 2060. Populations still become extirpated in this scenario, but this is limited to a total of eight extirpated by 2040 and ten by 2060. In 2060, 27 percent of populations are extirpated. In all scenarios, extirpations are associated with unprotected private lands subject to forest succession and/or the spread of invasive species.

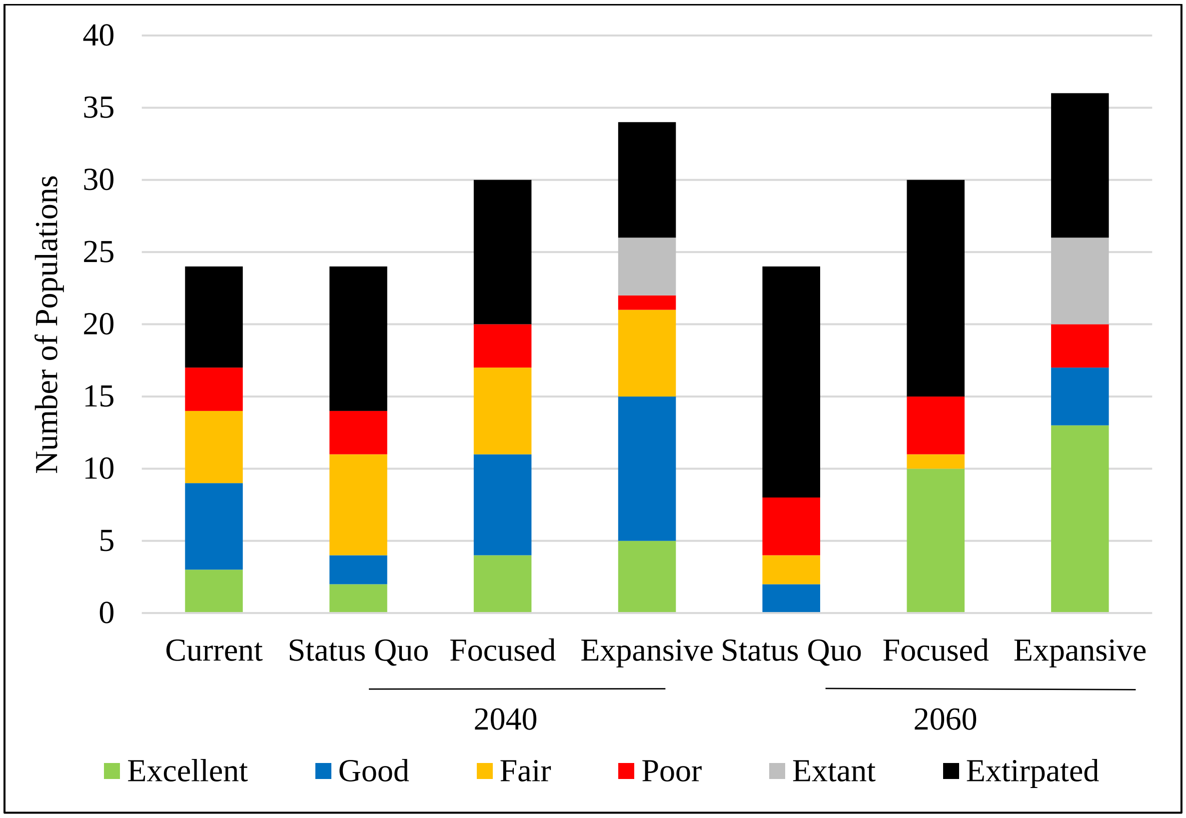

Figure EX1. Current and expected future resilience in 20 and 40 years under three scenarios.

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1 INTRODUCTION AND ANALYTICAL FRAMEWORK

The Species Status Assessment (SSA) framework (Service 2016, entire) is intended to support an in-depth review of a species' biology and threats, an evaluation of its biological status, and an assessment of the resources and conditions needed to maintain long-term viability. The SSA forms the scientific basis for decisions under the U.S. Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1543; Act). It is a living document, to be easily updated as new information becomes available, and to support all functions of the Endangered Species Program from Candidate Assessment to Listing to Consultations to Recovery (Smith et al. 2018, entire).

Arabis georgiana (hereafter, Georgia rockcress) is a short-lived perennial plant of the mustard family (Brassicaceae) endemic to Alabama and Georgia. The natural habitat for Georgia rockcress is steep river bluffs with shallow soils over rock, exposed rock outcroppings, as well as sandy eroding riverbanks. In 2014, this species was listed by the U.S. Fish and Wildlife Service (Service) as "Threatened" under the Act, (79 FR 54627) due to ongoing threats from development that either destroys or degrades habitat and facilitates the invasion of nonnative species that outcompete Georgia rockcress. This SSA for Georgia rockcress is intended to provide the biological support for a 5-Year Status Review of the species and the development of a Recovery Plan. Importantly, the SSA does not result in any decisions or actions by the Service. Rather, this SSA provides a review of the available information strictly related to the biological status of Georgia rockcress. Any future decisions will be made by the Service after reviewing this document and all relevant laws, regulations, and policies, and the results of any proposed decisions will be announced in the *Federal Register*, with appropriate opportunities for public input.

For the purpose of this assessment, we define **viability** as a description of the ability of a species to sustain populations in the wild beyond a biologically meaningful time frame. Viability is not a specific state, but rather a continuous measure of the likelihood that the species will sustain populations over time (Service 2016, p. 9). Using the SSA framework (Figure 1-1), we consider what the species needs to maintain viability by characterizing the status of the species in terms of its **resiliency**, **redundancy**, and **representation** (together the 3R's) (Wolf et al. 2015, entire).

- **Resiliency** describes the ability of populations to withstand stochastic events (i.e., arising from random factors), and is positively related to population size and growth rates.

- **Redundancy** describes the ability of a species to withstand catastrophic impacts by assessing the number and distribution of populations (i.e., species with more populations spread over a larger area are more likely to withstand catastrophes).

- **Representation** describes the breadth of genetic and environmental diversity within and among populations, which influences the ability of a species to adapt to changing environmental conditions over time.

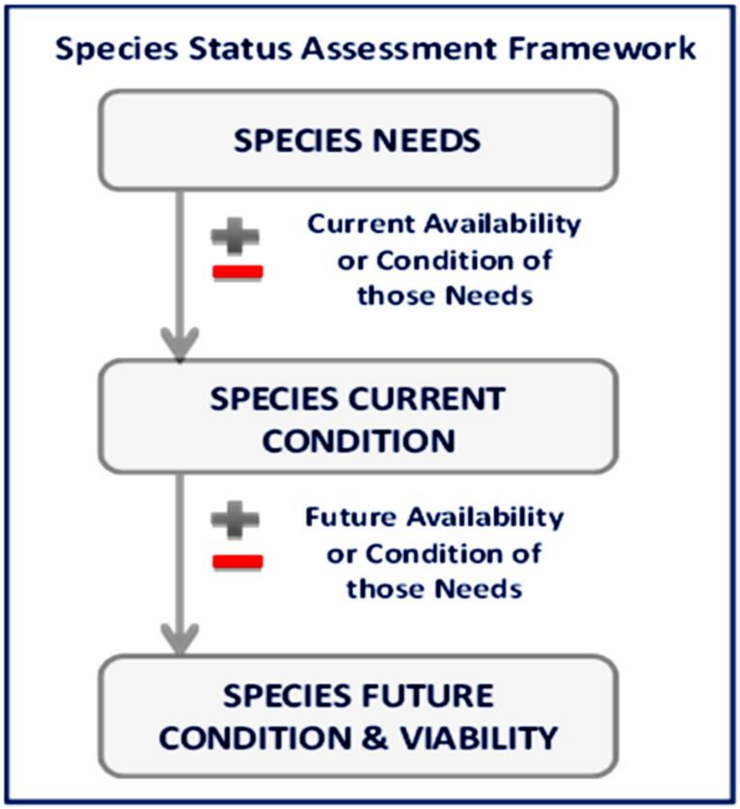

Figure 1-1. Species Status Assessment Framework

To evaluate the biological status of Georgia rockcress, we assessed a range of conditions to allow us to consider the 3R's for this species. This SSA report provides a synthesis of the species biology and natural history and assesses risks, stressors, and influencing factors in the context of determining the viability of the species. The format for this SSA includes Georgia rockcress biology and ecology (Chapter 2), resource needs from the individual to species level (Chapter 3), influences on viability (Chapter 4), current condition (Chapter 5), and future condition (Chapter 6).

2 BIOLOGY AND ECOLOGY

2.1 Taxonomy

Arabis is a polyphyletic genus of herbaceous plants in the mustard family (Brassicaceae). Reclassifications are ongoing, having been triggered by phylogenetic analyses in the 1990s

(Koch and Grosser, 2017, p. 225). There are currently approximately 70 *Arabis* species distributed across the northern hemisphere (except Mexico and northern Africa; Koch et al., 2010, p. 1040). A recent revision by Al-Shehbaz (2003, entire) moved most of the North American *Arabis* species to *Boechera*. Currently, the Integrated Taxonomic Information System, the federal entity that maintains and reviews data for taxonomic classifications, includes 17 *Arabis* species and two varieties: *A. aculeolata, A. alpina, A. blepharophylla, A. caucasica , A. crucisetosa, A. eschscholtziana, A. furcata, A. georgiana, A. hirsuta, A. mcdonaldiana, A. modesta, A. nuttallii, A. olympica, A. oregana, A. patens, A. procurrens, A. pycnocarpa, A. pycnocarpa* var. *adpressipilis,* and *A. pycnocarpa* var. *pycnocarpa*. North American *Arabis* species are sympatric in some areas, with *A. pycnocarpa* and *A. eschscholtziana* the most widespread and variable (Figure 2-1; Koch et al. 2010, p. 1041).

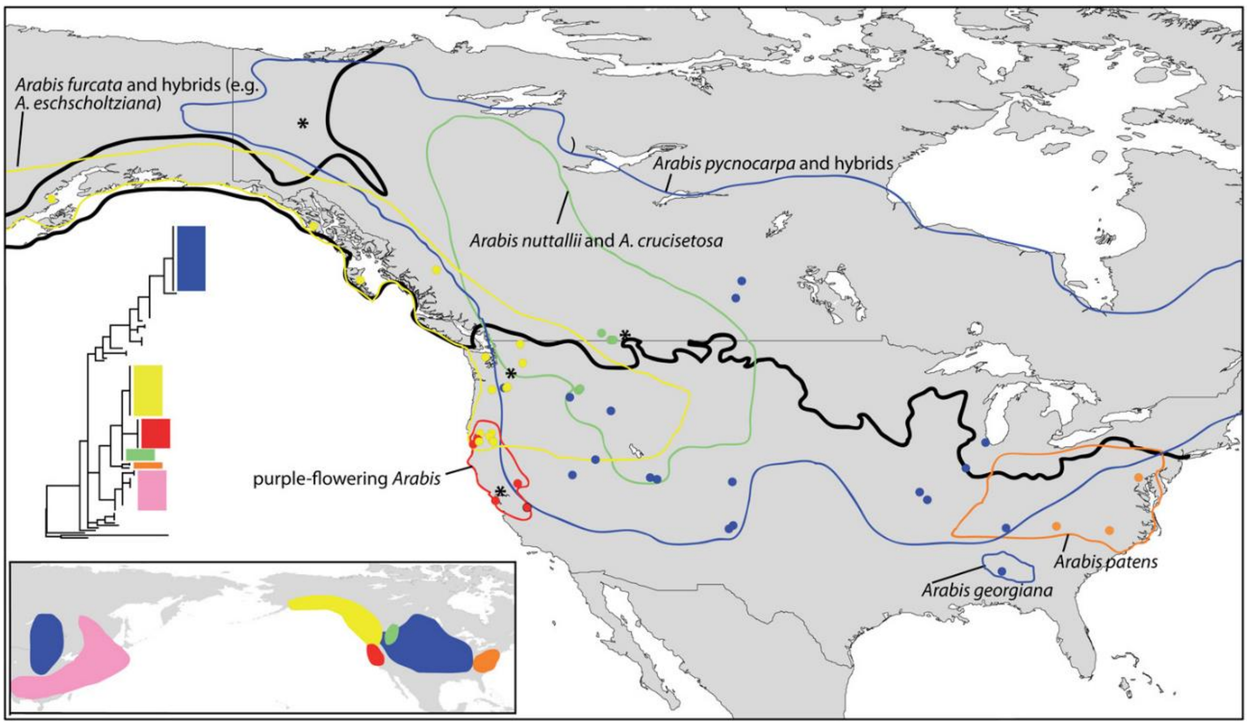

Figure 2-1. Distribution of North American *Arabis* phylogenic groups (Koch et al. 2010, p. 1044). Points in the same color belong to the same clade, and the distribution area of each species group is encircled in the same color. The glacier boundary during the last maximum glaciation (18,000 years ago) is indicated as black solid line. An overview of the phylogenetic tree is shown to the left, along with the distribution of accessions of the five North American groups, and their Asian members.

Georgia rockcress (*Arabis georgiana*) was first collected along the Chattahoochee River near Columbus, Georgia, by Samuel Boykin in 1841 and Alvan Chapman collected the species later in the 19th century presumably from the mountains of northwestern Georgia (Patrick et al. 1995,

p. 18). Roland Harper was the first to describe the Georgia rockcress as a distinct species in 1903 after seeing it along the Chattahoochee River in Stewart County, Georgia (Harper 1903, p. 88). On a subsequent trip, Harper (1906, p. 532) documented Georgia rockcress in Elmore County, Alabama. In his description, Harper (1903, p. 88) noted the species seemed closely related to *Arabis patens*. However, the siliques (seedpods) were noticeably longer and more erect and the leaves and stem were also partly glabrous (smooth). Recent genetic barcoding work has confirmed Georgia rockcress is a distinct species (Garcia 2012, p. 31) that seems to have arisen through hybridization in the Pleistocene (over 12,000 years ago). East Asian ancestors of *Arabis pycnocarpa* hybridized with North American purple-flowering *Arabis*, resulting in at least four new taxa: *A. eschscholtziana*, *A. olympica*, *A. georgiana* and *A. oregana*. These taxa occur near or within the range of the five North American phylogenetic groups, with Georgia rockcress occurring in the contact zone of *A. patens* and *A. pycnocarpa* in Georgia and Alabama (Figure 2-1; Koch and Grosser 2017, p. 229).

The currently accepted taxonomic ranking for Georgia rockcress is described below*.

Kingdom	Plantae
Subkingdom	Viridiplantae
Infrakingdom	Streptophyta
Superdivision	Embryophyta
Division	Tracheophyta
Subdivision	Spermatophytina
Class	Magnoliopsida
Superorder	Rosanae
Order	Brassicales
Family	Brassicaceae – mustards
Genus	*Arabis* L. – rockcress
Species	*Arabis georgiana* R.M. Harper – Georgia rockcress

*Retrieved 08/07/2019 from the Integrated Taxonomic Information System (ITIS) on-line database, http://www.itis.gov.

2.2 Species Description

Georgia rockcress is a perennial herb up to 90 centimeters (cm; 35.4 inches (in)) tall. The basal leaves are oblanceolate (lance-shaped but broadest above the middle and tapering toward the base), rounded at the apex, toothed on the margins, 4 to 8 cm (1.6 to 3.1 in) long, and with or without long, tapered petioles. The basal leaves form a basal rosette and usually persist through the fruiting season with green lower surfaces. The basal leaves may persist throughout the year but may wither early in drought years (Patrick et al. 1995, p. 17). The stem leaves are alternate, lanceolate (lance-shaped) to narrowly elliptic, 1 to 5 cm (0.4 to 2.0 in) long, and somewhat clasping around the stems. The upper surfaces of the stem leaves have stiff, branched hairs when young and are relatively smooth when mature (Figure 2-2). All leaves tend to be finely hairy. The flowers are borne in a terminal inflorescence (cluster at the tip of the stem) that is somewhat loosely branched. There are four, white petals that measure 6 to 10 millimeters (mm; 0.2 to 0.4 in) long (Figure 2-3). The fruit stands erect as a slender (1 mm; 0.04 in), relatively long (5 to 7 cm; 2.0 to 2.8 in) pod that splits in two, leaving behind a thin, papery, lengthwise partition. Seeds are brownish (when mature), oblong, about 2 mm (0.08 in) long, and are borne in single rows on each side of the partition. Flowering occurs from March to April, with fruiting beginning in May and into early July (Allison 1995, p. 4; Patrick et al. 1995, pp. 17-18; Chafin 2007, pp. 47-48; Schotz 2010, p. 3). Georgia rockcress is most closely related to *A. pycnocarpa*, but has vegetative differences in the 3-rayed trichomes (hair-like structure) on lower surfaces of basal leaves, and reproductive features such as narrower fruits and longer petals that help to differentiate it (Figure 2-2; Al-Shehbaz, 2010, entire).

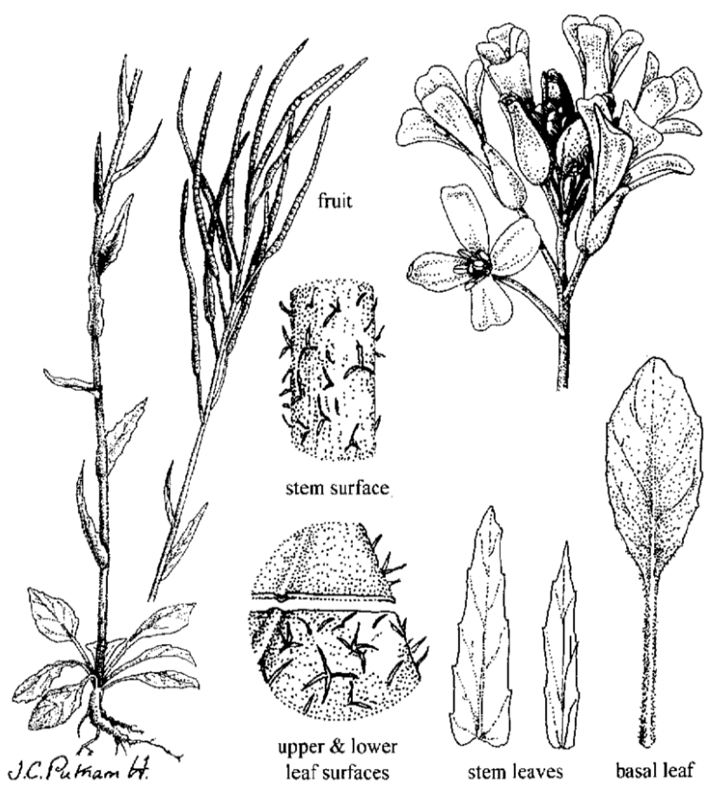

Figure 2-2. Botanical illustration of Georgia rockcress by Jean C. Putman (Chafin 2007, p. 48).

Figure 2-3. Georgia rockcress basal and stem leaves (left) and flowers and fresh seed pods (right). Photo credit Michele Elmore.

2.3 Life History and Demography

The life stages of a perennial plant such as Georgia rockcress consist of the dispersing and germinating seed, basal rosette, vegetative plant, and reproductive plant (Figure 2-4). Georgia rockcress possesses a thick rootstock that may live for many years (Schotz 2010, p. 9), but is reported to be short-lived perennial by Garcia (p. 16). Trends in *Arabis* evolution indicate species tend to shift from perennial to biennial growth forms with a decrease in elevation (alpine to montane, respectively; Koch et al. 2017, p. 1041); Georgia rockcress may be intermediate in this trait.

No studies of dispersal are known for Georgia rockcress. The degree to which Georgia rockcress reproduces from seed is not well understood, however the species reproduces easily when grown from seed in garden plots (Elmore 2010, p. 2). Seeds fall from the fruit while the fruit remains attached to the parent plant. It is likely that gravity is a primary dispersal agent for this species, which limits most dispersal events to a meter (about 3 feet) or less; a few meters may be possible during high wind events. Surface water runoff likely plays a secondary role in dispersal. Water action could move seeds an additional few meters (about 10 feet) down slope (Schotz 2010, p. 9 - 10). Longer-distance dispersal via large waterways such as rivers is undocumented, but likely.

Given the propensity of Georgia rockcress to grow in steeply sloped locations with thin soil, seed bank development is not likely extensive. No studies of seed bank presence or longevity are known. Seeds do not seem to need a long period of after-ripening before germination, requiring only the onset of cool temperatures in the fall and winter (Allison 1995, p. 9), suggesting that germination is typically fairly good in any given year (Schotz 2010, p.10).

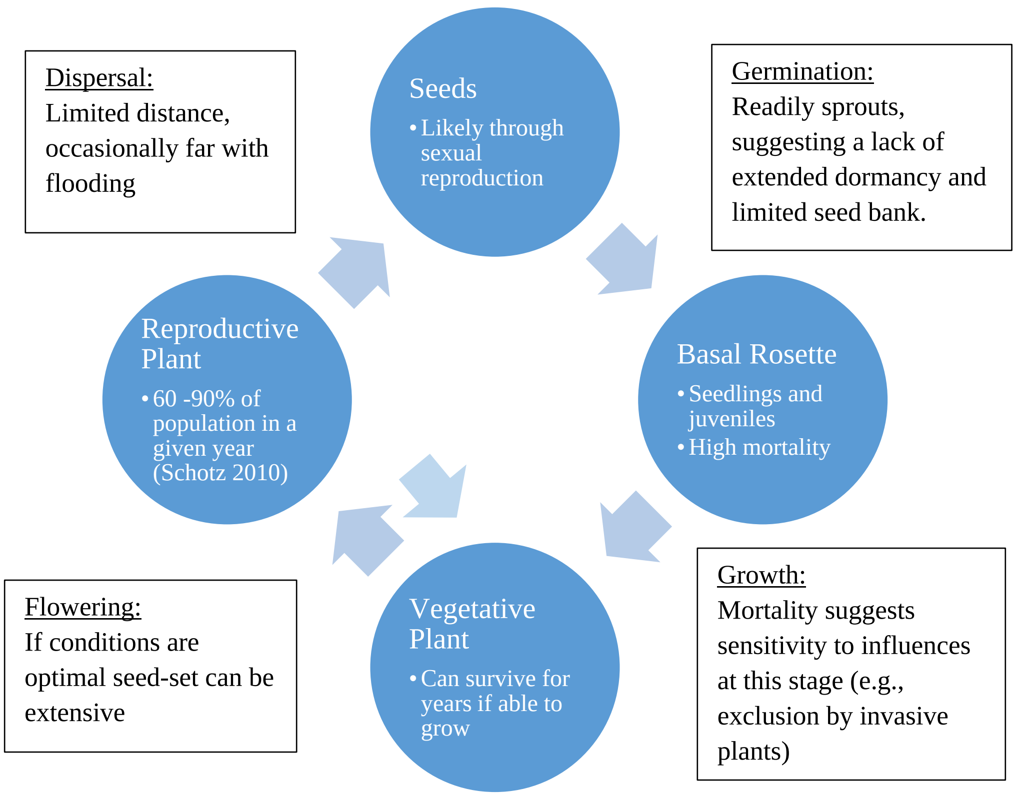

Figure 2-4. Georgia rockcress perennial life cycle with life history and demography.

Georgia rockcress can likely survive for several years by vegetative means. Experts indicate that under cultivation, plants seem to be able to survive for three to four years. The plants do not need to flower every year, as long as they develop new growth for photosynthetic activity. How long the plants can continue to survive under conditions that suppress flowering is unknown (Schotz 2010, p.9).

Reproduction in Georgia rockcress appears to be exclusively sexual, but research on its reproductive biology has not been conducted (Allison 1995, p. 12). *Arabis* species exhibit various mating strategies, ranging from pollination (sexually via fertilization) to apomixis (asexually, directly from unreduced, diploid gametes). Pollination can be an insect-mediated exchange between flowers of the same or different plants or self-pollination (Schotz 2010, p. 9). However, Georgia rockcress exhibits flowering characters indicative of species primarily relying on sexual reproduction (Allison 1995, p. 9). Several types of insects have been observed visiting the flowers, including Diptera such as midges and syrphid flies, and Lepidoptera such as skippers; however, Georgia rockcress shows no preference for specific pollinators (Schotz 2010, p. 9 -10).

Georgia rockcress population size can vary greatly from year to year. Abundance in short-lived species is influenced by seed production in past years, germination rates, and environmental conditions (e.g., temperature, and rainfall (Bush and Lancaster 2005, p. 1)). Georgia rockcress can reproduce within six months of germinating (Garcia 2012, p. 12). Field observations indicate that juvenile mortality is high; a classic type III survivorship curve with high reproductive output and few individuals surviving to a reproductive stage may best describe the survival strategy for this species (Garcia 2012, p. 35). However, Georgia rockcress appears to be successful in maintaining itself when ecological conditions are suitable (Schotz 2010, p. 10). Plants in captivity can be productive, with 21.3 grams of seed, (approximately 3000 seeds/gram, 63,900 seeds) produced from an uncertain number of individuals (approximate maximum 2250) in 2009 (Elmore 2010, p. 2 - 3).

The typical age distribution of Georgia rockcress is uncertain. The surface area occupied by the root crown of each individual probably increases each year (depending on resource availability and plant utilization ability), providing a gauge for identifying age classes within an occurrence. There is no known way to precisely age an individual or to compare age class distribution between different occurrences. During 2010 surveys, most occurrences contained roughly 60-90% reproductive (i.e., flowering and fruiting) plants, with seedlings, juveniles and senescent (non-reproductive) plants comprising the remainder. The average plant density in Alabama occurrences was 2.2 plants per ft^2 (23.7 plants per m^2), ranging from about 1.1 to 3.8 plants per ft^2 (11.8 to 40.9 plants per m^2) (Schotz 2010, p.9).

2.4 Habitat

Georgia rockcress often occurs along major river courses and grows in a variety of dry mesic to mesic soils, including shallow soil accumulations on rocky bluffs, ecotones of sloping rock outcrops, and sandy loam along eroding riverbanks. These conditions result in micro-disturbances, such as sloughing soils with limited accumulation of leaf litter or canopy gap dynamics, possibly with wind-thrown trees, which provide small patches of exposed mineral soil in a patchy distribution. It is occasionally found within limestone or dolomitic glades. Georgia rockcress will not persist in heavily shaded conditions. This species is adapted to high or moderately high light intensities, generally with a mature canopy providing partial shading; the habitat supports a relatively closed to open canopy typified by *Juniperus virginiana* (eastern red cedar), *Ostrya virginiana* (American hophornbeam), *Quercus muehlenbergii* (chinquapin oak), *Fraxinus americana* (white ash), *Acer barbatum* (southern sugar maple), and *Cercis canadensis* (eastern redbud) with a rich diversity of grasses and forbs characterizing the herb layer, which might include: *Carex cherokeensis* (Cherokee sedge), *Bromus purgans* (hairy woodland brome), *Chasmanthium sessiliflorum* (longleaf woodoats), *Piptochaetium avenaceum* (blackseed speargrass), *Pellaea atropurpurea* (purple cliffbreak), *Melica mutica* (two-flower melic grass), *Poa autumnalis* (autumn bluegrass), *Delphinium alabamicum* (Alabama larkspur), *Myosotis macrosperma* (largeseed forget-me-not), *Desmodium ochroleucum* (cream ticktrefoil), *Dodecatheon meadia* (shooting star), *Solidago auriculata* (eared goldenrod), *Symphyotrichum shortii* (Short's aster), and many more (Schotz 2010, pp. 1, 6 - 8).

This species occurs on soils that are circumneutral to slightly basic (or buffered) (pH between 6.5 and 7.5) in the Ridge and Valley, Piedmont, and Southeastern Plain ecoregions. Georgia rockcress occurs in locations between 24 – 98 meters in elevation (Schotz 2010, p. iii) that are underlain or otherwise influenced by limestone or granite-gneiss. The soils at these locations are well drained, with low to moderate water retention capacity (Schotz 2010, pp. 4–6).

Climatological data collected from 1981 to 2020 by the National Climatic Data Center of the United States (NOAA 2021, entire) were compiled for the northern and southern limits of the Georgia rockcress range in Alabama and Georgia. These data include a tight range of average maximum daytime summer (June through August) temperatures, from 88.5 to 92.8°F (31.4 to 33.8 °C). Winters are mild with occasional low temperatures below freezing; the average daily winter temperature is between 33.7 and 39.5°F (1° and 4.2°C) from December to February, the coldest part of the year. The average annual precipitation ranges between 47.8 and 54.6in (1.2 and 1.4m). Droughts are rare and dry spells are not severe (Schotz 2010, pp. 6 - 7).

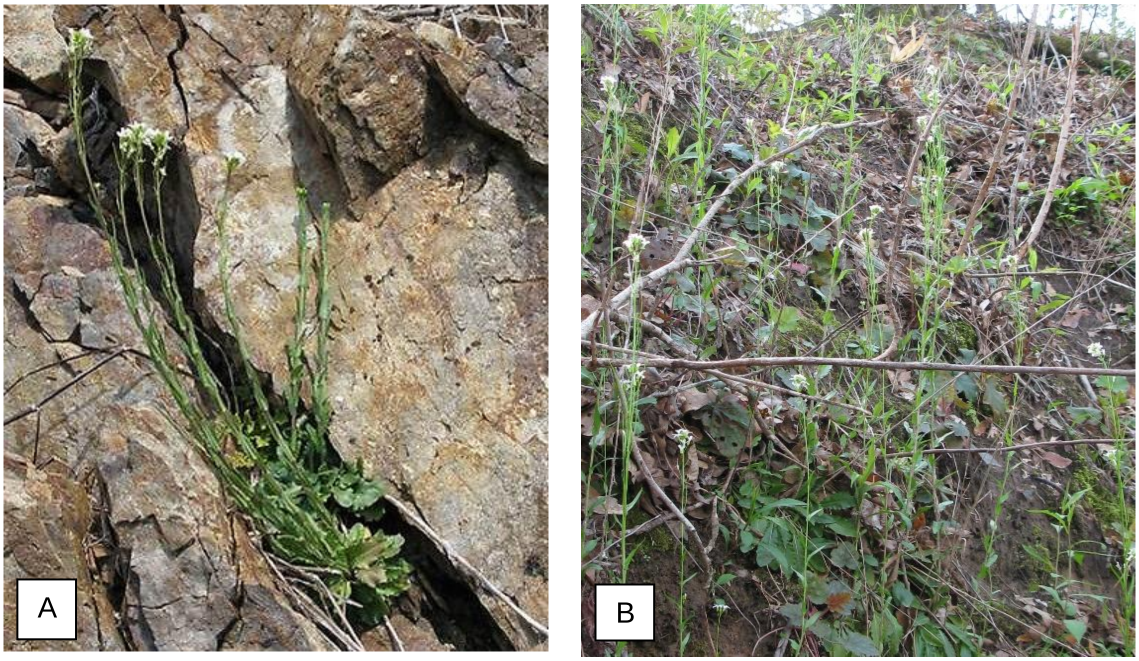

Figure 2-5. Georgia rockcress growing in varied habitats: a) steep rock terrace b) sandy riverbank. Photo credit Michele Elmore.

2.4.1 Critical Habitat

Under the Act and its implementing regulations, the Service was required to identify the physical or biological features essential to the conservation of Georgia rockcress in areas occupied at the time of listing, focusing on the physical and biological features essential to the species conservation, in order to designate critical habitat (79 FR 54635). We identified primary constituent elements, which are specific elements of the physical or biological features that provide for a species' life-history processes and are essential to the conservation of the species. These elements primarily occur within the Ridge and Valley, Piedmont Ecoregions, and Southeastern Plains of Alabama and Georgia (Figure 2-6). See Section 4.5 for more detail on critical habitat units.

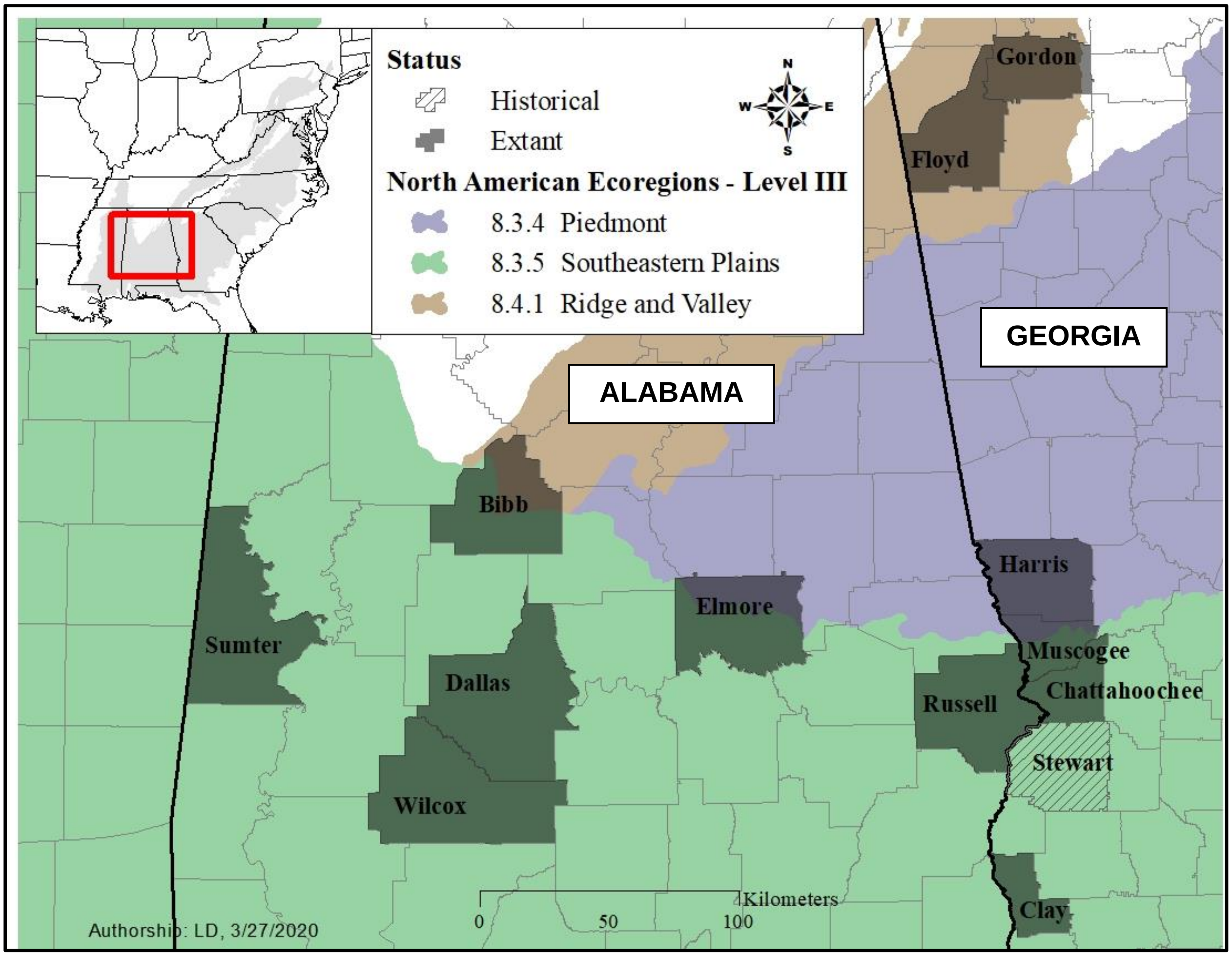

Figure 2-6. County occurrences (extant and extirpated/historical) of Georgia rockcress within level three ecoregions in Alabama and Georgia.

The primary constituent elements for Georgia rockcress were determined to be (79 FR 54635):

- A mature, mixed-level canopy with spatial heterogeneity, providing mottled shade and often including species such as eastern red cedar, America hophornbeam, chinquapin oak, white ash, southern sugar maple, and redbud with a rich diversity of grasses and forbs characterizing the herb layer;

- Well-drained soils that are buffered or circumneutral generally within regions underlain or otherwise influenced by limestone or granite-gneiss;

- Large river bluffs with steep and/or shallow soils that are subject to localized disturbances that limit the accumulation of leaf litter and competition;

- Surrounding habitat to impede the invasion of competitors

2.5 Historical Range and Distribution

The known historical range of Georgia rockcress is within the Ridge and Valley, Piedmont and Southeastern Plains ecoregions of Alabama and Georgia (Figure 2-6; Patrick et al. 1995, p. 17 - 18). Fairly extensive searches have been conducted for this species in the aforementioned ecoregions, focusing on suitable habitat in both Alabama and Georgia (Allison 1995, pp. 1-31; Allison 1999, pp. entire), but unsurveyed habitat remains. Allison (1995, pp. 18-31) conducted the first comprehensive survey and compiled existing data on known occurrences. As part of this effort, he searched for Georgia rockcress occurrences at 205 locations within potential habitat over nine counties in Georgia and discovered only four previously unknown occurrences. A total of eight of nine occurrences were relocated, and these remained occupied in 2005 (Allison 1995, pp. 18-28; Moffett 2007, p. 2). A historical occurrence from Stewart County, Georgia, has not been relocated despite repeated searches, including the most recent attempt in 2005 (Moffett 2007, p. 1). In 2018 an additional historic?? Georgia occurrence was confirmed from an herbarium specimen collected in 1870. An attempt to find this occurrence was not successful; it has likely been extirpated due to human recreational use and modification of cave entranceway and spring run (Georgia Department of Natural Resources data; Moffett in litt, 2019). Allison (1999, entire) described 22 extant Georgia rockcress occurrences in Alabama during early survey work. Not all of these occurrences have been relocated. Schotz (2010, p. 7) visited a total of 44 occurrences in Alabama (16 historically occupied and 28 potential), and of the 16 historically occupied occurrences, 14 were still extant and two appeared to be extirpated but have been classified as historical. In addition, one new occurrence was discovered from among the potential occurrence locations, for a total of 15 extant occurrences in Alabama and 28 (24 extant) occurrences range-wide. The region between the Alabama occurrences and Georgia occurrences within the Southeastern Plains may have suitable habitat that remains to be surveyed. Today there are a total of 37 occurrences of which 26 are considered extant.

At the time of listing (2014), 18 extant populations were documented to occur across Alabama and Georgia (79 FR 54627). Multiple occurrences can make up a population. Population delineation assessed in this SSA and how they relate to the populations described at the time of listing is explained in detail in Chapter 5 (Current Condition). At listing, twelve populations occurred solely in Alabama; five occurred solely in Georgia; and one extended into both States. Of the 12 populations in Alabama, six occurred in the Ridge and Valley ecoregion (all in Bibb County), and six occurred in the Southeastern Plains region (Dallas (2), Elmore, Wilcox, Monroe and Sumter counties). Of the five populations found solely in Georgia, three occurred in the Ridge and Valley ecoregion (Floyd and Gordon counties); one occurred in the Piedmont ecoregion (Harris/Muscogee counties); and one occurred in the Southeastern Plains ecoregion (Clay County). The one population that extended into both States (Russell County, AL/Chattahoochee County, GA) also occurred in the Southeastern Plains ecoregion (Allison 1995, pp. 13-14; Allison 1999, entire; Moffett 2007, p. 1; Schotz 2010, pp. 48-50).

2.6 Genetics

Georgia rockcress is composed of at least three octoploid genetic groups: a North Georgia group, a South Georgia group (referred to as Middle Georgia in the listing 79 FR 54627), and an Alabama group (Garcia 2012, entire; Koch and Grosser 2017, p. 232). One standard for assessing genetic differences is using Nei's genetic distances (D_{nei}), which are relative values (ranging from 0 to 1) that can estimate the separation among populations with 0 indicating no separation (no genetic difference) and larger values indicating longer separation. Garcia (2012, p. 33 – 34) calculated D_{nei} for the Georgia rockcress genetic groups and found North Georgia and South Georgia genetic clusters had the closest relationship (0.47) suggesting the lowest amount of time since these populations were isolated from one another. The South Georgia and Alabama genetic clusters were intermediate at 0.48 while the North Georgia and Alabama populations were the most distant from one another (0.68; Figure 2-7). Further work by Garcia (2012, p. 38) using a variable microsatellite locus revealed significant genetic structuring across populations likely based more on geographic location than on population size. However, this information must be considered cautiously as it is based on data from one variable microsatellite locus.

The genetic cluster analysis could be an indication that these three groups were once larger more connected populations which have become separated over time. If this is true, then the clusters likely reflect a fitness advantage within particular regions due to potential adaptation to local climactic patterns. The low degree of inbreeding in Georgia rockcress does not support the interpretation of genetic clusters forming due to genetic drift (Garcia 2012, p. 39).

Any threats that remove or further deteriorate populations can also have a detrimental effect on the existing genetic diversity of the species. Most Georgia rockcress populations have low population sizes, which can increase the threat to genetic diversity from inbreeding (Speilman et al. 2004). The fixation index (F) is a measure of inbreeding, and ranges from -1 (strong heterozygosity) to 1 (strong homozygosity), with values near zero representing the Hardy-Weinberg principle (genetic equilibrium). The F values for the North Georgia, South Georgia and Alabama groups were -1.00, -0.58, and -1.00 respectively (Garcia 2012, p. 34) indicating inbreeding does not seem to be occurring within any of the clusters currently. While the South Georgia genetic group contains the largest populations (Goat Rock Dam and Fort Benning) and is important to the conservation of this species, the smaller populations, which have stronger heterozygosity, in the North Georgia and Alabama genetic groups are more vulnerable to localized extirpation and represent important conservation elements for this species.

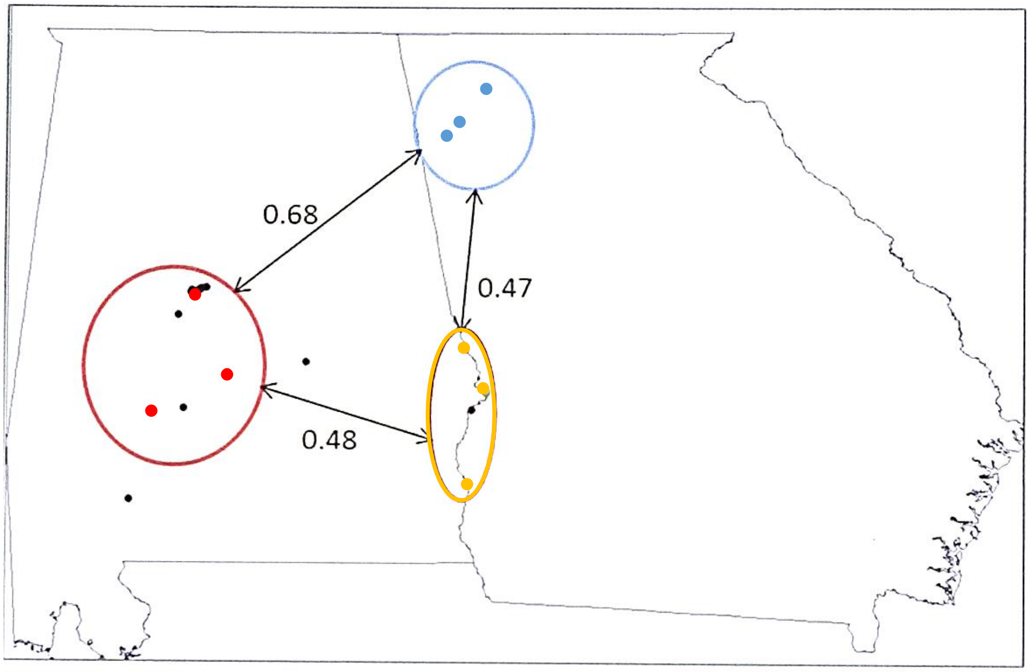

Figure 2-7. Genetic clusters for populations of Georgia rockcress, from Garcia 2012 (p. 66). The clusters are circled: North Georgia (blue; upper circle), South Georgia (yellow; lower right oval) and Alabama (red; left circle). Unbiased Nei genetic distances between populations are included. Populations indicated by colored points were sampled for genetic analysis of population structure.

3 RESOURCE NEEDS FOR VIABILITY

In this chapter we review the resources that the Georgia rockcress needs for viability at the individual, population, and species level. In Chapter 4 we will describe factors that positively and negatively influence these resource needs. Assessments of the current and future conditions of these population and species resource needs are the subject of Chapters 5 and 6.

3.1 Individual Level

At the individual level, Georgia rockcress plants require suitable habitat to flourish during each of their life stages, which include a dispersing and germinating seed, basal rosette, vegetative plant, and reproductive plant. Habitat characteristics and requirements are discussed in detail in the next section as they relate to the population scale, but individual plants have similar needs, briefly: small-scale disturbances with slightly increased light, limited competition for water, and exposed well-drained mineral soils within regions underlain or otherwise influenced by, limestone or granite-gneiss for seed germination (Alison 1995, p. 7; Moffett 2007, p. 5; Schotz 2010, p. 1). In addition to suitable habitat, individual plants depend on pollinators (likely generalist species) to successfully reproduce. Individual plants are susceptible to mortality from lack of sufficient resources (e.g., poor habitat, competition, etc.), herbivory or disease, and natural or anthropogenic disturbance (e.g., extreme rain or drought, forest fires, and development).

3.2 Population Level

For resilient populations to persist, the needs of individuals (suitable habitat and pollinators) must be met at a broader scale, both spatially and temporally. Populations of Georgia rockcress are healthiest in areas receiving full or partial sunlight in river bluffs or glades (Figure 2-5) underlain by calcareous soils (Schotz 2010, p. 8). This species seems to be able to tolerate moderate shading, but it exists primarily as vegetative rosettes in heavily shaded areas (Moffett 2007, p. 5). Those populations occurring in forested areas will decline as the forest canopy closes (Allison 1999, p. 4) and will likely result in extirpated populations if individuals do not have the conditions to flower and set seed. Habitat area must be large enough to support sufficient Georgia rockcress individuals for cross-pollination that will maintain both healthy population sizes and genetic variation within populations. Population sizes also must be large enough to withstand stochastic environmental, demographic, and anthropogenic events or changes. Because Georgia rockcress is immobile, occupies a narrow range, and resilience of the seed bank is uncertain, populations are likely highly vulnerable to high-intensity long-lasting or repeated disturbances – though some populations may need low to moderate-intensity disturbance to reduce shading (e.g., fire, flooding or wind-thrown canopy). In addition, populations with small number of individuals are vulnerable to local extinctions from unfavorable habitat conditions such as extreme shading or localized catastrophic events.

3.3 Species Level

For a species to be viable, there must be adequate redundancy (suitable number and distribution of populations to allow the species to withstand catastrophic events) and representation (genetic and environmental diversity to allow the species to adapt to changing environmental conditions). Redundancy improves with increasing numbers of populations (natural or reintroduced) that are distributed across the species range. Natural large-scale disturbances, such as fire and catastrophic flooding, are unlikely to occur on the steep river bluffs occupied by some Georgia rockcress populations. However, populations occurring on upper or lower river terraces may be vulnerable to fire and/or flooding. Representation improves with the persistence of populations spread across the range of genetic and/or ecological diversity within the species. Long-term viability will require resilient populations to persist into the future; for Georgia rockcress, this will mean maintaining habitat free of human destruction and degradation (such as the pervasive threat of invasive species or changes in land use) in perpetuity, addressing any existing or new threats that are revealed to be impacting the species, and increasing redundancy across the species range.

4 FACTORS INFLUENCING VIABILITY

In this chapter, we provide information on negative and positive influences on viability of Georgia rockcress, including habitat loss and degradation from a variety of sources, climate change, and conservation and management (Figure 4-1). Over-collection and over-browsing (e.g., deer) were influences that we considered, but were not elaborated on in the following chapter because it is not believed to be a significant threat to Georgia rockcress at this time.

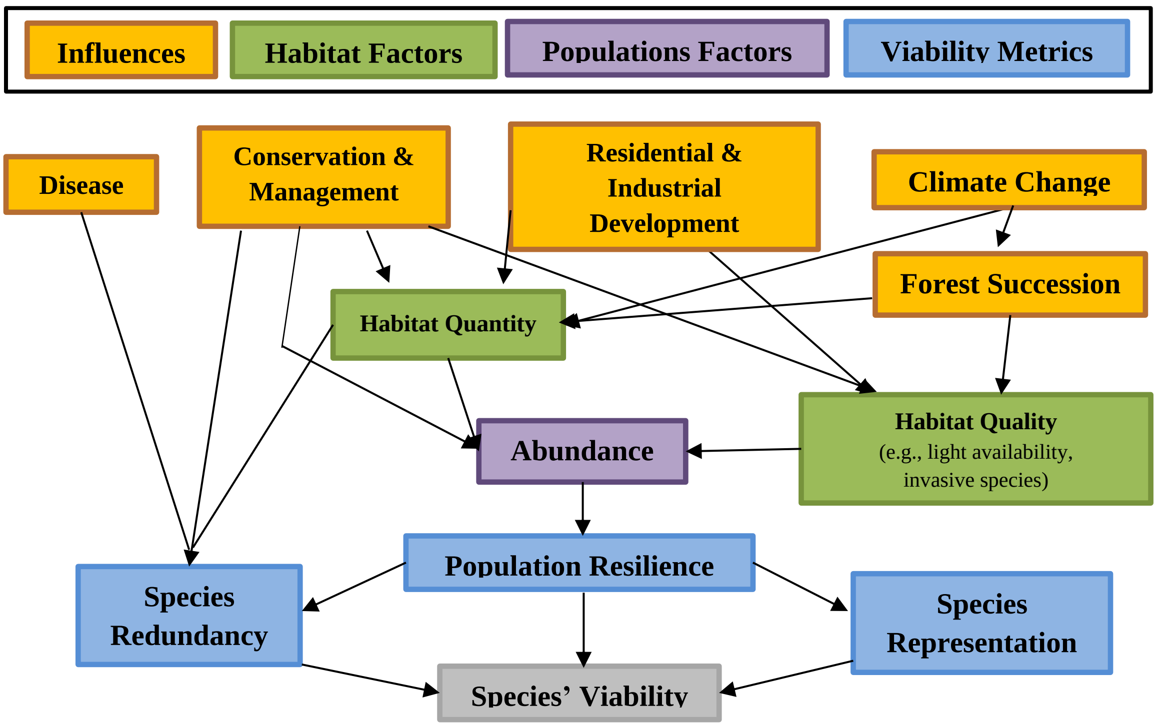

Figure 4-1. Simplified influence diagram illustrating how various impacts influence habitat and population factors that in turn influence the viability of the species.

4.1 Habitat Loss and Degradation

Historically, suitable habitat for this species was destroyed by development, including quarrying, residential development, timber harvest, road building, recreation, and hydropower dam construction. One or more of these activities pose ongoing current threats to all known occurrences as either direct effects, or as an indirect but persistent threat of invasive species spreading into formerly disturbed areas. Given the typically low abundance of Georgia rockcress where it occurs, activities that destroy even a small amount of habitat can have a serious impact on this species, including genetic diversity of the species. In addition, forest succession could extirpate small patches of Georgia rockcress, which illustrates the need for management of lands where Georgia rockcress occurs.

Currently, the primary threat to Georgia rockcress is the ongoing invasion of nonnative species into occupied habitat. Residential and industrial development through quarrying, construction of buildings and roads, timber harvest, recreation sites (such as campsites or mowing of fields) and other activities open the canopy, provide a source of invasive seed and plant material, destroy soil profiles and disrupt hydrology. These changes fragment Georgia rockcress, creating more edge habitat and promote the invasion of nonnative species (Honu and Gibson, 2006, entire). Edges function as sources of propagules for disturbed habitats and represent complex environmental gradients with changes in light availability, temperature, humidity, wind speed, and soil moisture, with plant species responding directly to environmental changes (Meiners et al. 1999, entire). Edge effect, including any canopy break due to timber harvest, fields, or maintained rights-of-way, may penetrate as far as 175 meters, resulting in changes in community composition (Fraver 1994, p. 830; Meiners et al. 1999, p. 266; Gehlhausen et al. 2000, p.32; Honu and Gibson 2006, p. 264).

4.1.1 Invasive Species

Georgia rockcress requires full sun to partial shady conditions with exposed mineral soil. Because the species is a poor competitor, nonnative invasive species are a significant factor influencing the viability of the species. An invasive species is any organism that is not native to an ecosystem that causes harm. Competition from invasive species, exacerbated by adjacent land use changes, likely contributed to the loss of the type locality in Stewart County, Georgia (Allison 1995, p. 8), and one of the Bibb County, Alabama, occurrences and several other occurrences in this general area (Allison 2002, pers. comm.; Alabama Natural Heritage Program 2004, p. 3). Loss of these EOs reduces the area occupied by the species, the abundance of individuals in a population and fragments populations which can result in smaller, isolated and less resilient populations. Additional occurrences are also currently being negatively affected by competition with invasive plants. According to Moffett (2007, entire), most of the habitat in Georgia is being impacted by the presence of invasive plant species, primarily *Lonicera japonica* (Japanese honeysuckle), *Ligustrum sinense* (Chinese privet), and *Microstegium vimineum* (Nepalese browntop). Japanese honeysuckle was observed growing on individual plants of Georgia rockcress at several occurrences (Allison 1995, pp. 8-9). There was also an instance of plants growing in a mat of Nepalese browntop declining in number from 27 individuals in 1995 (Allison 1995, p. 19) to 3 in 2006 (Moffett 2007, p. 6). Allison (1995, pp. 18 - 28; Allison 1999, entire) considered 40 percent of Georgia rockcress occurrences in Georgia to be imminently threatened by the nearby presence of nonnative invasive plants. By 2007, Moffett (2007, entire) reported all Georgia rockcress occurrences in Georgia were threatened by invasive species. Schotz (2010, p. 20 - 55) reported the majority of occurrences in Alabama were also impacted by invasive species. Experts indicate that propagation activities (See Section 4.5.1 Conservation Horticulture) have likely also been hampered by shading from invasive privet species.

Human disturbance at almost all Georgia rockcress occurrences has created conditions suitable for the future or continued spread of invasive species, especially Japanese honeysuckle. This plant is a gap adaptor that can easily invade disturbed areas to 90 meters into a forested habitat (Honu and Gibson 2006, p. 264). Other nonnative and arguably invasive plants that threaten Georgia rockcress include *Melia azedarach* (Chinaberry or bead-tree), *Pueraria montana var. lobata* (kudzu), *Albizia julibrissin* (mimosa), *Ligustrum japonicum* (Japanese privet), and *Lygodium japonicum* (Japanese climbing fern) (Alison 1995, entire; Moffett 2007 p. entire; Schotz 2010 pp. 20 -55). While edge habitats are subject to invasion of nonnative species, a more limited group of invasive plants can then spread into closed-canopy habitats; species with a rosette form, like Georgia rockcress, are more susceptible to exclusion by invasive plants due to competition for light from the taller invasive species (Meiners et al. 1999, p. 266). Georgia rockcress is not a strong competitor and is usually found in areas where growth of other plants is restrained due to the shallowness of the soils or the dynamic status of the site (e.g., eroding riverbanks; Allison 1995, p. 8; Moffett 2007, p. 5). However, invasive species are colonizing these riverbank sites, and the long-term survival of at least five occurrences is questionable (Allison 1995, p. 18 - 28). This species is only able to avoid competition with invasive species where the soil depth is limited (e.g., rocky bluffs; Allison 1995, p.8, Moffett 2007, p. 5).

4.1.2 Quarrying

Quarrying destroys bluff habitat by removing the canopy and soil. One of the occurrences of Georgia rockcress in Floyd County, Georgia, appears to be a surviving remnant of a once larger occurrence; the primary habitat at this locality has been extensively quarried (Allison 1995, p. 10). Another occurrence in Monroe County, Alabama, is adjacent to an area that was once quarried (Schotz 2010, pp. 45-47). It is possible that other undocumented occurrences on rocky bluffs in the Piedmont and Ridge and Valley ecoregions were destroyed by quarrying (Allison 1995, p. 10).

4.1.3 Urbanization

Urbanization includes residential and commercial development and associated roads. Urbanization can directly affect Georgia rockcress by destroying habitat but also can create indirect effects from changes in microclimate, introduction of invasive species, and runoff from impervious surfaces. Twelve Georgia rockcress occurrences have nearby roads. Because these occurrences are relatively small, even a single road corridor can have substantial impact on the occurrence. Five occurrences have been impacted by housing, and two are impacted by commercial buildings, with transmission lines bisecting two sites. Five occurrences have bluff habitat that has been impacted by housing development (Schotz 2010, pp. 20-57; Allison 1999, pp. 3-8). Commercial development has the same impact as housing; at least two occurrences have been directly impacted by such construction (Schotz 2010, pp. 20-57; Moffett 2007, pp. 5-8; Allison 1999, pp. 3-8; Allison 1995, pp. 18-28). Impervious surfaces associated with housing and commercial development have increased runoff and provided access for dumping of trash on some sites. Two historical occurrences in Alabama were directly adjacent to a paved road, though the exact collection site of herbaria material is assumed (Schotz 2010, p. 57).

4.1.4 Timber Harvest

Six Georgia rockcress occurrences have been impacted by timber management. Timber operations that remove the forest canopy promote early successional species and result in the decline of Georgia rockcress (Schotz 2010, p. 10). Seven occurrences have been impacted by timber harvest activities (Schotz 2010, pp. 20-57; Moffett 2007, pp. 5-8; Allison 1999, pp. 3-8; Allison 1995, pp. 18-28). While the impacts are to the bluff habitat that surrounds these occurrences, these disturbances eliminate potential habitat for expansion of occurrences and fragment the occurrences. Timber harvest can also influence the microclimate and facilitate spread of invasive species (see discussion of invasive species in section 4.1.1., above).

4.1.5 Recreation

Recreation can cause habitat degradation by denuding vegetation that can lead to hard-packed, exposed mineral soil (Moffett 2007, pp. 3–4). Trash and dumping can also degrade the habitat. Four Georgia rockcress occurrences have impacts from recreation, two are on or near maintained fields, one of which is maintained for recreation (Schotz 2010, pp. 20-57; Allison 1999, pp. 3-8). The other two populations are impacted by foot traffic and camping along the river bluffs where the species occurs.

4.1.6 Hydropower Dam Construction

Potential habitat adjacent to three populations has been inundated by construction of hydropower dams. Rock bluffs along rivers have also been favored sites for hydropower dam construction, which may have inundated other undiscovered populations. The construction of Goat Rock Dam in Harris County, Georgia, destroyed a portion of suitable habitat for Georgia rockcress, and the current plants there may also represent a remnant of a once much larger occurrence (Allison

1995, p. 10). Two occurrences in Wilcox and Dallas counties, Alabama, occur on the banks of William "Bill" Dannelly Reservoir, where habitat was likely inundated (Schotz 2010, pp. 41 and 56).

4.2 Forest Succession

Although timber harvest may impact Georgia rockcress under certain circumstances, Georgia rockcress plants occurring in forested areas will also decline as the forest canopy closes without proper forest management. Allison (1999, p. 4) attributed the decline of a habitat at one Georgia rockcress occurrence in Bibb County, Alabama to canopy closure. Georgia rockcress grows best in high to moderately-high light conditions under open to partial forest canopy, but the accumulation of leaf litter within well-developed canopies also seems to negatively impact Georgia rockcress germination (GPCA unpublished data, 2015) and could remain an ongoing problem for natural propagation. In addition, the small number of individuals at the majority of Georgia rockcress occurrences makes the species vulnerable to local extirpations from unfavorable habitat conditions, such as extreme shading. Prescribed fire has been used at lands managed by Georgia Power (GP) and The Nature Conservancy (TNC) to keep the canopy open. Wildfire at other occurrences may have also helped to limit woody plant encroachment in the long-term, following short-term impacts on Georgia rockcress from mortality.

4.3 Disease and Predation

No significant disease or predation affecting Georgia rockcress has been reported during targeted surveys. Rust fungi are known to infect occurrences of many other *Arabis* species and may occasionally affect Georgia rockcress as well. Some evidence of significant herbivory or other predation was observed. Deer and other native fauna graze on the leaves and flowering stems on an occasional basis, occasionally with significant impacts to propagation activities. Experts suggest the majority of plants lost in the first two years following outplanting of propagated material appear to have been due to deer browsing, suggesting fencing may be important in establishing new populations.

Moth damage to Georgia rockcress could be extensive, but there is no record of such effects to date. Cabbage butterflies (*Pieris rapae*), an exotic species known to specifically prefer plants in the mustard family (Brassicaceae) as a food source, were witnessed in the vicinity of some occurrences, but it is unknown whether this species causes damage to Georgia rockcress (Schotz 2010, p.9). Similarly, diamondback moth (*Plutella xylostellac*) is an invasive species that feeds on mustard species. The impact of diamondback moth is not well documented outside of an agricultural setting. As a highly mobile and invasive Brasicaceae feeder, diamondback moth has a demonstrated tendency to outbreak (Phillips et al. 2014, p. 1 – 2) and therefore presents some risk to Georgia rockcress. Diamondback moth is a threat to the recovery of two endemic mustard species in Canada, where it can reduce mean seed output by 60% across the entire species range (25 and 190 km; Squires et al. 2008, p. 203- 204). Monitoring for insect damage and presence of diamondback moth at Georgia rockcress occurrences would help resolve the significance of this threat.

4.4 Climate Change

In the future, changing climatic conditions will likely impact Georgia rockcress. The Intergovernmental Panel on Climate Change (IPCC) concluded that warming of the climate system is unequivocal (IPCC 2014, p. 2). The climate in the southeastern United States has warmed about 2 degrees F (1.1 degrees C) from a cool period in the 1960s and 1970s, and is expected to continue to rise by 4 to 8 degrees F (2.2 to 4.4 degrees C) by 2100 (Carter et al. 2014, p. 398-399). In Alabama and Georgia, soils have become drier regardless of the increase in annual rainfall in most areas, likely because most rain arrives in heavy downpours (EPA 2016a, p. 1; EPA 2016b, p. 2), which results in runoff and less water infiltration. Spring rainfall is likely to increase over the next 40 to 50 years, but droughts are likely to be more severe as periods without rain may be longer and very hot days will be more frequent, especially in the summer months (EPA 2016a, p. 2; EPA 2016b, p. 2; Runkle et al. 2017, p. 3).Warmer temperatures and changes in rainfall are unlikely to substantially reduce forest cover in Alabama and Georgia, although the composition of trees in the forests may change to favor oak and pine. More droughts would reduce forest productivity, and climate change is also likely to increase the damage from insects and disease (EPA 2016a, p. 2; EPA 2016b, p. 2).

Species that are dependent on specialized habitat types (e.g., riparian slopes, limestone glades) or are limited in distribution (e.g., Georgia rockcress) may be the most susceptible to the impacts of climate change (Byers and Norris 2011, p. 5; Anacker et al. 2013, p. 197). There is evidence that some terrestrial plant occurrences have been able to adapt and respond to changing climatic conditions (Franks et al. 2014, entire). Both plastic (phenotypic change such as leaf size or phenology) and evolutionary (shift in allelic frequencies) responses to changes in climate have been detected. Given enough time, plants can alter their ranges, resulting in range shifts, reductions, or increases (Kelly and Goulden 2008, entire; Loarie et al. 2008, p. 3-5), but the ability of Georgia rockcress to do this is uncertain given the taxon’s habitat needs and limited dispersal.

Whether or how Georgia rockcress might respond to a changing climate is uncertain. Severe drought would be expected to have an effect on the plant community, including the mature canopy and canopy gap dynamic, and increased storm intensity could accelerate erosion-related disturbances; however, the information currently available on the effects of global climate change and increasing temperatures does not make sufficiently precise estimates of the occurrence and magnitude of the effects. In addition, we are not currently aware of any climate change information specific to the habitat of Georgia rockcress that would indicate which areas may become important to the species in the future. A changing climate could alter the distribution of nonnative species that could compete with Georgia rockcress. The impact of increased periods of drought on Georgia rockcress is unknown. While drought during critical periods could impact the survival and reproduction of Georgia rockcress, there could be a positive effect by making Georgia rockcress habitat less hospitable for other species that might compete with it.

4.5 Conservation and Management

When Georgia rockcress was listed, the Service designated seventeen critical habitat units, five of which have two sub-units each (Appendix A). are currently occupied by the species and contain all physical and biological features and primary constituent elements that are essential to the conservation of the species (see Section 2.4.1). Units that are federal, state, or privately-owned through a conservation partner, such as TNC or GP, are classified as protected (Table 4-1). Protected properties enact regulations that limit human access to specific low impact uses that are compatible with the persistence of the natural environment. At four sites population monitoring and/or management is implemented. Georgia Power Company limits human activity near Georgia rockcress and is an active member of the Georgia Plant Conservation Alliance (GPCA; See Conservation Horticulture Section 4.5.1), but this protected status could change in the future.

Table 4-1. Designated critical habitat units (CHU) for Georgia rockcress (79 FR 54635). Land ownership is indicated as private, state, or federal. In instances where private land is managed, we note those CHUs whose management is implemented by The Nature Conservancy (TNC) or Georgia Power Company (GP). Potential conservation partner agencies are indicated with asterisks. Area estimates reflect all land within critical habitat unit boundaries.

Unit #	Critical Habitat Unit (CHU)	County/State	Land Ownership	Protected?	Size in Acres (Hectares)
1	Fort Tombecbee	Sumter/AL	State*	Yes	14 (6)
2	Marshalls Bluff	Monroe/AL	Private	No	27(11)
3	Prairie Bluff	Wilcox/AL	Private	No	32 (13)
4	Portland Landing	Dallas/AL	Private	No	31(12)
5	Durant Bend	Dallas/AL	Private	No	28 (12)
6	Murphy’s Bluff	Bibb/AL	Private	No	26(11)
7A	Creekside Glades	Bibb/AL	Private	No	26 (11)
7B	Little Schulz Creek	Bibb/AL	Private	No	28 (12)
8A	Cottingham Creek Bluff	Bibb/AL	Private (TNC, partial)*	Yes	55 (22)
8B	Pratts Ferry	Bibb/AL	Private	Yes	28 (11)

Unit #	Critical Habitat Unit (CHU)	County/State	Land Ownership	Protected?	Size in Acres (Hectares)
9A	Fern Glade	Bibb/AL	Federal *	Yes	34 (14)
9B	Sixmile Creek	Bibb/AL	Private (TNC)*	Yes	31 (13)
10A	Browns Dam Glade North	Bibb/AL	Private (TNC)*	Yes	35 (14)
10B	Browns Dam Glade South	Bibb/AL	Private (TNC)*	Yes	37 (15)
11	Limestone Park	Bibb/AL	Private	No	15 (6)
12	Fort Toulouse State Park	Elmore/AL	State*	Yes	17 (7)
13	Fort Gaines Bluff	Clay/GA	Private	No	42 (17)
14A	Goat Rock North	Harris/GA	Private (GP)*	Yes	17 (7)
14B	Goat Rock South	Harris, Muscogee/GA	Private (GP, partial)*	Yes and No	59 (24)
15	Blacks Bluff Preserve	Floyd/GA	Private (TNC)*	Yes	92 (37)
16	Whitmore Bluff	Floyd/GA	Private	No	43 (17)
17	Resaca Bluff	Gordon/GA	Private	No	13 (5)
Total					*732 (297)*

* Current or potential conservation partner agencies

Georgia rockcress is listed as threatened by the State of Georgia (Patrick et al. 1995, p.17; Chaffin 2007, p. 47). This State listing provides legal standing under the Georgia Wildflower Preservation Act of 1973 (O.C.G.A. 12-6-170), which prohibits the removal of this and other wildflower species from public land and regulates the taking and sale of plants from private land (e.g., CHUs 13 - 17). This law also triggers the Georgia Environmental Protection Act in the event of potential impacts to an occurrence by State activities on State-owned land (Moffett 2007, p.4). However, the greater problem of habitat destruction and degradation is not addressed by this law (Patrick et al. 1995, p.17); there is no protection from projects like road construction, construction of reservoirs, installation of utility lines, quarrying, or timber harvest that may also degrade or fragment habitat. In Alabama, there is no protection or regulation for either direct or indirect impacts to Georgia rockcress (Schotz 2010, p. 2).

The majority of land on which Georgia rockcress occurs is privately owned, although some significant occurrences are located on public land (Table 4-1). Conservation efforts by TNC in Bibb County, Alabama, have included acquisition of both Georgia rockcress CHUs at Browns Dam Glade (10A and 10B), the Six Mile Creek occurrence (CHU 9B), and a small portion of the Cottingham Creek Bluff unit (CHU 8A). Blacks Bluff Preserve in Georgia (CHU 15) is also owned by TNC. Private lands not owned by a conservation partner could be acquired through fee-simple purchases or enter into a conservation agreement (easement or management agreement). Both acquisitions and conservation agreements would help facilitate habitat management to improve condition for Georgia rockcress (i.e., invasive species, targeted tree removal).

Two occurrences are federally owned, and two are owned by the State of Alabama (Table 4-1). Fern Glade (CHU 9A) occurs on the Service's Cahaba National Wildlife Refuge (CNWR). The CNWR developed a habitat management plan in 2007 that includes management of invasive species for the benefit of species including Georgia rockcress (CNWR 2007, pp. 67 - 69). Also, all plants at Fort Benning, located along the banks of the Chattahoochee River in Russell County, Alabama, and Chattahoochee County, Georgia, are under federal ownership. The Department of Defense worked with TNC to develop monitoring and conservation protocols for the Fort Benning occurrences (Elmore 2010, entire). Fort Benning has updated their Integrated Natural Resources Management Plan (INRMP) to address Georgia rockcress (INRMP 2014, p. 89), therefore these occurrences are not included under the critical habitat designation (79 FR 54635). The Fort Benning INRMP excludes timber harvest except for ecological restoration in occupied habitat (INRMP 2014, p. 45) and establishes a monitoring effort coupled with management of invasive species (feral hog) and provisions for the use of prescribed burning (INRMP 2014, p. 886 - 887). The State of Alabama owns Fort Tombecbee (CHU 1) in Sumter County and Fort Toulouse State Park (CHU 12) in Elmore County, though there are no management plans or other conservation actions for Georgia rockcress on these protected properties.

The majority of the Goat Rock plants (CHU 14A & B) in Georgia are located within GP lands, which receive some protection from their shoreline management plan. Vegetative management buffers prohibit disturbance and protect Georgia rockcress, but there is no regular removal of invasive species. This management plan was developed during Federal Energy Regulatory Commission (FERC) licensing (FERC 2004, p. 7; Moffett 2007, p. 7), and is updated every five years with the next update scheduled for 2021 (FERC 2016, entire). Georgia Power Company has worked with the GPCA to conduct periodic invasive species removal in and around the known Georgia rockcress habitat. The southernmost portion of the Goat Rock occurrence is owned by a different private landowner.

In total, at least some portion of six critical habitat units are owned by current or potential conservation partner agencies (Table 4-1). The Black's Bluff CHU within TNC lands, as well as GP lands, and Fort Benning have management plans that benefit Georgia rockcress (

Table 4-2). These lands are afforded varying degrees of protection. While none of these lands are likely to be developed, they could be subject to other impacts including recreation, road construction, incompatible timber harvest, and continued pressure from invasive plant species.

Table 4-2. Habitat management for Georgia rockcress.

Property	Years	Habitat Management
Black's Bluff Preserve	? – 2019	Prescribed fire (Hodges in litt., 2019)
Goat Rock North and South	~ 2010, 2018	Prescribed fire to create outplanting sites; invasive species treatment and removal at and adjacent to occurrences (Moffett 2007, p. 7; GPCA unpublished data, 2018).
Ft. Benning	2014 – present	Feral hog exclusion through fencing (INRMP 2014, p.886)

Going forward, management activities that could address the threats to Georgia rockcress habitat include (but are not limited to):

- Continue public outreach to provide education and explore opportunities to work on private property;
- Develop and implement management strategies for the species to include aspects like invasive species control and selective tree removal;
- Conserve and manage existing populations and habitat;
- Look for opportunities to protect existing occurrences through acquisition, or conservation agreement (easement or management agreement);
- Develop and implement management strategies for the Georgia rockcress, initially with state lands in Alabama, but also with other potential conservation partners;
- Continue working with the GPCA for safeguarding. Begin working with the Alabama Plant Conservation Alliance (APCA) to build up safeguarding capacity; and
- Search for new and historical occurrences and conduct regular surveys and monitoring at all accessible sites.

4.5.1 Conservation Horticulture (Safeguarding)

Although rare plants and endangered plant communities almost always receive less publicity, less protection, and lower levels of funding than do animals, the threat to their survival may be greater. Plants receive less than 5 percent of recovery funding from federal and state agencies, yet the majority of species listed under the ESA are plants (Negron-Oritz 2014, p. 36). The GPCA, is a statewide network of public and private conservation organizations and agencies formed in 1995. The mission of the GPCA is to "study and conserve Georgia's flora through multidisciplinary research, education, and advocacy; facilitate the recovery of rare, threatened, and endangered plants of Georgia and the southeast US through collaborative efforts in our state; support the development and implementation of the Georgia State Wildlife Action Plan (SWAP), as well as other plant, wildlife, and habitat conservation plans by member agencies and organizations; and communicate the importance of preserving biodiversity worldwide" (GPCA 2008, entire; Ceska, in litt., 2018). The GPCA has developed a prioritized list of critically endangered plant species coordinated by the Georgia Department of Natural Resources (GDNR as part of the SWAP.

The Georgia rockcress is a priority SWAP species (GDNR 2015 pp. 77, 110, 121, 138, 176) and was selected by the GPCA as a top priority species for conservation action. In order to "safeguard" this species from any catastrophic event that may extirpate Georgia rockcress several safeguarding projects have been initiated and include long-term seed storage, *ex-situ* propagation at GPCA member facilities, and *in-situ* augmentation, reintroduction, and introductions (Table 4-3). A captive propagation plan is being developed consistent with the USFWS captive propagation policy and ongoing activities are described in more detail below.

<u>Long-term seed storage at North Carolina Botanical Garden</u>

1. Whitmore's Bluff and Resaca Bluff seed collected in 2011
2. Black's Bluff seed collected in 2012
3. Resaca Bluff, date collected uncertain

<u>*Ex-situ* propagation at GPCA member facilities.</u> While facilities have obtained and propagated material from different occurrences over time, collections are kept separate as much as possible to help maintain pure genetic stock.

1. Black's Bluff – Chattahoochee Nature Center
2. Whitmore's Bluff – Chattahoochee Nature Center
3. Resaca Bluff – Georgia State Botanical Garden (SBG) and Atlanta Botanical Garden
4. Goat Rock – von Schmeling Madison Farm

<u>*In-situ* augmentation, reintroduction, and introductions.</u> The long-term viability of this type of safeguarding is currently unknown but the efforts supplement the *ex-situ* propagation work on-going at GPCA member facilities. The goal is to maintain plant material in the wild and is considered a conservation effort of last resort to prevent extinction of a species or genotype. *In-situ* safeguarding may be used to recover or bolster existing populations, but additional research and monitoring will need to be conducted to evaluate measures of success. To-date *in-situ* reintroduction and introductions work by GPCA have focused on the North Georgia populations (particularly Black's Bluff) due to the vulnerability of these populations. These restoration efforts are being reviewed by the Service to set goals and measures for determining if and how the reintroduced populations will contribute to recovery. A summary of known augmentations, introductions, and reintroductions are provided below.

1. Goat Rock augmentation

   In 2008, 103 two-year-old plants were outplanted into 5 plots within the natural occurrence on GP property. The plants were grown *ex-situ* at GPCA facilities and sourced from Goat Rock. Some monitoring occurred during the years following the outplanting and recruitment was documented (Garcia 2012, p. 31), but it is unknown whether these outplantings were successful in expanding the distribution within the Goat Rock occurrence. A study by Garcia (2012, pp. 1 - 2) assessed difference between "restored" (the augmented plots) and natural plots and concluded overall reduced fitness (flowering, fruiting) of restored plots versus natural plots, but could not determine the cause of the reduced fitness. In addition, Garcia (2012, p. 31) noted the increase in abundance at Goat Rock between 2005 and 2010 could also be attributed to a shift in age structure or to a more thorough surveying effort in 2010.

   In 2009, over 60,000 seeds sourced from Goat Rock material were direct sown into about 12 plots. This was conducted as an experiment to determine if direct sowing could be a viable alternative method to augment occurrences. Success of this effort is not known. While GPCA safeguarding work began with the Goat Rock occurrence, emphasis was shifted to the North Georgia occurrences (Black's Bluff, Resaca Bluff, and Whitmore's Bluff) because these sites were considered the most vulnerable due to dwindling abundance at all occurrences. The safeguarding efforts for the North Georgia occurrences are described below.

2. Black's Bluff reintroduction and introduction

   Reintroduction: Seeds were collected from the last fertile plant at the Black's Bluff population in 2007, and by 2009 the original natural occurrence at Black's Bluff was presumed extirpated (Elmore 2010; Moffett in. litt., 2019). Therefore, the GPCA and TNC agreed to reintroduce Georgia rockcress back to Black's Bluff Preserve (CHU 15; Figure 4-2). The SBG grew Georgia rockcress *ex-situ* from the seeds collected from the last naturally occurring reproductive plant at Black's Bluff Preserve, propagated the plants, and provided material for a reintroduction. Black's Bluff Preserve material was reintroduced along several rock outcrops within TNC lands but adjacent to the critical habitat unit (CHU 15). A total of 100 plants were outplanted in the spring of 2010 with 10 plants in each of 10 plots (Goldstrohm 2010, p. 1). By the following spring 84 plants were surviving (Goldstrohm 2011a, p. 1), however, by early fall only 31 were found to be surviving. However, as many as 48 had produced seed. It was noted that in most cases plants died after producing seed, but it is unclear how many of the 31 surviving plants had produced seed (Goldstrohm 2011b, p. 3). By 2013 only five plants from the original outplanting remained but some plots continued to show signs of recruitment (Goldstrohm 2013 p. 1). In 2014, nine plants were observed in several of the original outplanting plots, and these were likely recruited from seed of outplanted individuals (Goldstrohm 2014a p. 1). Four new outplanting plots were established with 44 plants in 2014. Plants appeared to have persisted from the 2010 outplanting; 300 plants were documented in the area of the first outplanting in 2017 (GPCA unpublished data, 2018).

In 2011, direct seeding occurred to further supplement the reintroduction (Figure 4-3). Three different sites were selected as candidates for seeding activities. Each consisted of 10 micro-sites having approximately 500 seeds dispersed. This made an approximate total of 15,000 seeds sown (Goldstrohm 2011b pp. 1 - 3). In 2012 one seeded site was considered "surviving" but by 2013 no seeded plots contained plants (Goldstrohm 2013 p. 1). However, in 2014, one seeded site showed seven plants, and one additional seeding site was established (Goldstrohm 2014a, p. 1). Leaf litter was noted as hindering germination (GPCA unpublished data, 2015), but in 2018 (GPCA unpublished data, 2018) it was noted that direct seeding seemed to be more successful when sown on moss (*Bryoandersonia illecebra*) clumps.

<u>Introduction:</u> In 2015, another introduction occurred at Black's Bluff approximately 1200 m from the reintroduction site to limit gene flow with the reintroduction site (Hodges, M. in litt., 2019). It included seed from Black's Bluff Preserve (CHU 15) plus seed from two other locations within the Ridge and Valley Ecoregion: Whitmore's Bluff (CHU 16) and Resaca Bluff (CHU 17; Table 4-1). GPCA's goal for mixing the material from the three North Georgia occurrences to increase overall vigor of an in-situ safeguarding occurrence (GPCA unpublished data, 2015) and was supported by the results of Garcia (2012) showing that all three natural occurrences were of the same genotype, or genetic group. Plants at this safeguarding location started reproducing in 2019. The first generation recruits are referred to by the GPCA as "Coosa/Oostanaula Hybrids". The CNC has sold greenhouse-grown Georgia rockcress plants at their annual spring native plant sale through a process permitted by the Georgia Department of Natural Resources that involves an in-state transport tag (Moffett 2007, p. 3), but stopped selling this species in 2009.

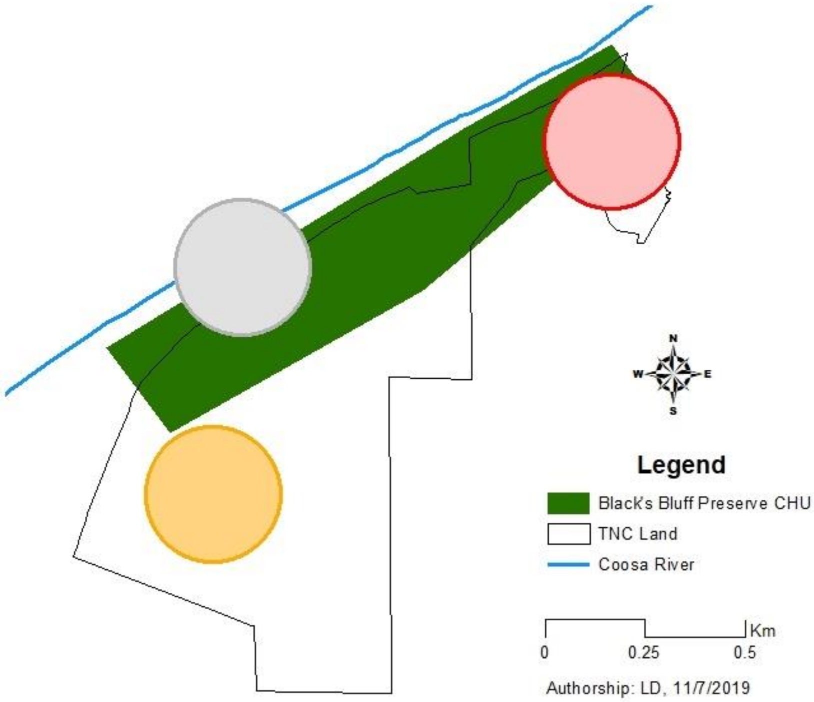

Figure 4-2. *In-situ* safeguarding initiatives at The Nature Conservancy's (TNC) Black's Bluff Preserve. The yellow area outlines (lowest circle) the reintroduction area for plant material originating from the Black's Bluff Preserve CHU. The red area (upper right circle) outlines the general location of an introduction involving plant material from Black's Bluff, Whitmore's Bluff, and Resaca Bluff. The grey area (center circle) indicates the location of the extirpated natural population. The introduction and reintroduction locations are approximately 1.2 km apart to limit gene flow.

Figure 4-3. Photos of *in-situ* safeguarding direct seeding and outplantings at The Nature Conservancy's (TNC) Black's Bluff Preserve. Top photos are direct seeding and bottom are outplanted plants. Photo credit Bill Goldstrohm.

3. <u>Resaca Bluff augmentation</u>
   Population augmentation has occurred at two locations within the Resaca Bluff CHU. The material used for this initiative was collected at Resaca Bluff. In 2014, 29 plants were outplanted into two areas within the natural occurrence (Goldstrohm 2014b, p. 1). It was noted that the augmentation efforts may have contributed to the increase in abundance observed in 2018 (Patrick and Moffett in litt., 2018). The general location of both the naturally occurring and augmented plants is shown in Figure 4-4.

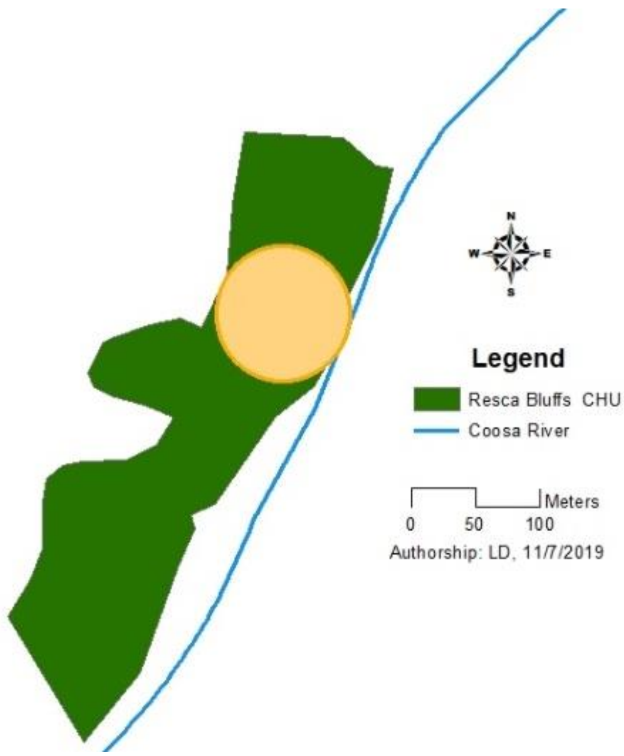

Figure 4-4. Augmentation loaction of existing plants at Resaca Bluff. The yellow area indicates the location of both naturally occurring individuals and augmentation outplantings in close proximity (< 1 km).

Table 4-3. Summary of GPCA safeguarding actions at three Georgia rockcress occurrences

Occurrence	Type	Material	Year	Number outplanted	Survival
Goat Rock	Augmentation	Plants	2008	103	Some monitoring occurred during the years following the outplanting and recruitment was documented (Garcia 2012, p. 31).
	Augmentation	Seeds	2009	60,000	Survival is unknown.
Black's Bluff	Reintroduction	Plants	2010	100	Spring 2011, 84 plants were surviving (Goldstrohm 2011a, p. 1); Fall 2011 only 31 were found to be surviving, but as many as 48 had produced seed (Goldstrohm 2011b, p. 3); In 2013 only 5 plants from the original outplanting remained but some plots continued to show signs of recruitment (Goldstrohm 2013 p. 1). In 2014, 9 plants were observed in several of the original outplanting plots and these were mostly considered recruitment from seed (Goldstrohm 2014a p. 1); In 2017 300 plants were reported in the area of the first outplanting
Black's Bluff	Reintroduction	Plants	2014	44	
Black's Bluff	Reintroduction	Seeds	2011	15,000	In 2012 one seeded site was considered "surviving" but by 2013 no seeded plots contained plants (Goldstrohm 2013 p. 1). In 2014, one seeded site showed seven plants and one additional seeding site was established (Goldstrohm 2014a, p. 1) in 2018 (GPCA unpublished data, 2018) it was noted that direct seeding seemed to be successful when sown on moss (*Bryoandersonia illecebra*) clumps.
Black's Bluff	Introduction	Seeds from Black's Bluff, Whitmore's Bluff, Resaca Bluff	2015	unknown	Plants at this safeguarding location started reproducing in 2019. F1 recruits are referred to as "Coosa/Oostanaula Hybrids."
Resaca Bluff	Augmentation	Plants	2014	29	Augmentation efforts may have contributed to the increase in abundance observed in 2018 (Patrick and Moffett in litt., 2018).

5 CURRENT CONDITION

The population is the basic unit of resilience, which is then scaled up to redundancy and representation at the species level, examining the distribution of the species and appropriately defining and delineating populations is a crucial initial step to assess species viability. After delineating populations and units of representation, we then assessed the resilience of each population by synthesizing the best available information about population and habitat conditions. Population resilience was then scaled up to describe current redundancy and representation for Georgia rockcress range-wide.

5.1 Previous Viability Assessments

Long-term quantitative monitoring data are unavailable for this taxon, but both the Georgia Natural Heritage Inventory Program (GNHIP) and Alabama Natural Heritage Program (ANHP) have recorded qualitative estimates of element occurrence size and quality in the recent past. An element occurrence (EO) is the basic conservation unit used by GNHIP and ANHP in tracking species and communities of special concern. NatureServe defines an EO as "an area of land and/or water where a species or ecological community is or was present" (NatureServe 2004, p. 1). The terms element occurrence and occurrence are used interchangeably throughout this document. Evaluations are used to rank each occurrence with respect to size and viability, condition of the habitat, and degree of threat. As a short-lived perennial plant, numbers of Georgia rockcress can naturally fluctuate greatly from year to year based on a variety of factors such as seed production in past years, germination rates, and environmental conditions (e.g., temperature, rainfall; Bush and Lancaster 2005, p. 1). Because of these factors, habitat condition is often used to evaluate viability rather than population numbers. EOs have previously been ranked into the following categories: A (excellent estimated viability), B (good estimated viability), C (fair estimated viability), D (poor estimated viability), E (verified extant but not assessed), H (not observed within the past 20 years), or X (occurrence is considered extirpated). We have also included a ranking of I (*in-situ*) to indicate occurrences established (or populations reestablished after extirpation) for safeguarding purposes. Although more recent survey work (e.g., post 2010) has been completed at some occurrences, these data have not yet been incorporated into an assessment of viability. These data will be discussed further in Section 5.3.

Georgia rockcress is rare throughout its range. Allison (1995, pp. 18-28) described nine occurrences from Georgia during the first state-wide survey for the species. In a state-wide survey of Alabama, Allison (1999, pp. 2-4) originally documented this species at 18 occurrences in Bibb County, along with the Fort Toulouse occurrence in Elmore County and the Prairie Bluff occurrence in Wilcox County. Allison found this species typically had a limited number of individuals restricted over a small area (1999, pp. entire), but no formal viability assessment was completed as part of these surveys.

More than a quarter of Georgia rockcress occurrences have not been relocated or have been extirpated following the initial survey work completed by Allison in the 1990s. Almost immediately following the initial surveys, one of the Bibb County occurrences could not be relocated during a visit in 2001 (Allison 2002, pers. comm.). Six occurrences described by Allison (1999, p. 2-7; Table 5-1) were not revisited as part of the Alabama viability assessment (Schotz 2010, entire), and so are considered historical because they are not tracked by ANHP. Because these six occurrences in Table 5-1 do not have EO numbers as they were digitized for the purposes of this SSA. The six occurrences in Table 5-1 appear to be unique and could be added to the ANHP database following verification of their validity. In addition, two historical Alabama occurrences with specimens assumed to have been collected along County Road 26 were not relocated (Schotz 2010, pp. 13 and 57). Therefore, Georgia rockcress is listed as historical at these eight occurrences in Alabama (Table 5-2).

In Georgia, the number of extant occurrences remained the same during the most recent state survey (Moffett 2007, entire) used to inform viability ranking by the GNHIP, but the species has been extirpated from its type locality near Omaha, Georgia, in Stewart County after several failed attempts to relocate the record (Moffett 2007, p. 2). In 2018, a new occurrence was confirmed from a museum specimen collected from Cave Spring, Georgia, but no individuals were found during a recent site visit. While it is likely extirpated, we treat the Cave Spring occurrence as historical in this SSA. Another Georgia occurrence, Black’s Bluff Preserve, had declined to one reproductive individual by 2007 (Moffett 2007, p. 5) and was extirpated 2009 (Elmore 2010, p. 1). Safeguarding efforts by the GPCA preserved seed stock from the original Black’s Bluff occurrence. GPCA members have propagated plants and increased seed which has been outplanted at the Black’s Bluff Preserve, referred to as “*in-situ* safeguarding” occurrences. Table 5-2 lists the status of the 37 natural Georgia rockcress occurrences, of which 11 are presumed unoccupied (historical or extirpated; 30 percent).

Table 5-1. Occurrences from Allison (1999, p. 2-7) that are currently considered historical. Historical occurrences are those that have not been relocated and their viability is unknown. The occurrence numbers refer to Table 5-3 and Figure 5-1 in Section 5.2.

Occurrence Name	ID	Description
4 Mile Creek	24	At least 20 plants scattered along sandy riverbank. Location approximate but separate from Limestone Park occurrence.
Pratt Glade West	23	At least 20 plants on dolomite outcrop on north side of Pratt Creek.
Mouth of Little Shultz Creek	A	At least 6 plants on shaded limestone outcrop, along north side of Little Shultz Creek north of Little Schultz Creek Confluence occurrence.
Double Glade South	B	At least 20 plants on margin of dolomite glade near road, along east side of Little Cahaba River, west of Fern Glade occurrence.
Columbine Bluff	C	A few plants on a vertical rock face, along south side of Little Cahaba River, east of Fern Glade occurrence.
Cow Glade	D	Approximately five plants on sandy riverbank of dolomite outcrop above north bank of Little Cahaba River, east of Brown's Dam Glades occurrence.

Table 5-2. Status ranks for 37 natural and two safeguarding occurrences (EOs) of Georgia rockcress from past surveys. The most recent viability assessment completed for Georgia occurrences was in 2007, and Alabama occurrences were assessed in 2010. *In-situ* safeguarding occurrences (the reintroduction and introduction) are included in a separate heading but are not included in the resilience assessment for current condition.

Occurrence Rank	Viability	**Georgia** (Moffett 2007)	**Alabama** (Schotz 2010)	Total
A	Excellent	5	2	7
A/B	Excellent or Good	1	0	1
B	Good	0	5	5
B/C	Good or Fair	1	0	1
C	Fair	1	5	6
C/D	Fair or Poor	0	0	0
D	Poor	0	2	2
E	Extant	0	4	4
X	Extirpated	2	0	2
H	Historical	1	8	9
Total Natural EOs		***11***	***26***	***37***
I	*In-situ* safeguarding	2	0	2

5.2 Delineating Populations

Populations were delineated from spatial EO data to distinguish discrete groupings of the species that were likely to interact with each other via gene flow, primarily seed dispersal. Georgia rockcress EOs range from more than 2,000 plants to as few as 1 plant for the EOs at specific points in time. Georgia rockcress populations are composed of 1 or more EOs. We used the same criteria to delineate populations that ANHP used to delineate EOs for Alabama's natural heritage database, which is consistent with NatureServe methodology (Appendix B). A default separation distance of 1 km was used between EOs (and thus populations for this SSA) unless circumstances warranted grouping occurrences that were more distant from each other, or limited landscape connectivity necessitated separating nearby occurrences. For example, seed dispersal in Georgia rockcress is believed to occur within drainages via sheet flow of water, so occurrences distributed within the same drainage along an elevation gradient might be demographically connected via seed dispersal even if occurrences are greater than 1 km from each other. NatureServe (2004) suggests that populations of riparian species be grouped if the water flow distance between them is 3 km or less of predominantly suitable habitat.

This population delineating strategy resulted in 24 populations of which 17 populations are currently extant. EOs (37 total natural, 26 extant) were grouped into populations similar to those defined at the time of listing; however, in this SSA 17 extant populations were estimated versus 18 extant at the time of listing due to delineation methods described here and not because extant populations described at the time of listing have been extirpated. Creekside Glades and Little Schultz Creek were grouped into a population previously, but we assessed these populations to be too distant by land and not actually connected by Little Shultz Creek. The Little Shultz Creek occurrence is 160 meters upstream of the confluence of the Cahaba River and Little Shultz Creek (Schotz 2010, p. 32), and seed from Creekside Glades would be unlikely to travel past the rocky bluff on which the Little Shultz Creek population occurs. Therefore, we grouped the Little Shultz Creek occurrence with the Cottingham Creek Bluff/Pratts Ferry occurrence upstream because of water-based connectivity along the Cahaba River. The Fern Glades and Sixmile Creek occurrences likely formed a continuous population with Brown's Dam Glades in the recent past because two other occurrences were between them along the Cahaba River, but this connectivity has been sufficiently interrupted by habitat fragmentation and the extirpation of the two occurrences to identify the populations as separate. Safeguarding occurrences were listed as such, but did not constitute their own populations regardless of sufficient separation distance (Table 5-3, Figure 5-1).

It is possible that EO delineations might be reviewed and changed in the future, especially if plants at historical or new occurrences are encountered in future surveys, or further genetic analyses are conducted (Garcia 2012, entire). For this SSA however, we used the current EO delineations as much as possible because those delineated units are the units at which population and habitat monitoring results have been aggregated for the existing natural heritage databases. Population names are largely consistent with the *Federal Register* listing (79 FR 54627), with nomenclature from Allison (1999, pp. 2 - 7), Schotz (2010, p. 13), and Moffett (2007, p.10) used for historical or extirpated populations where possible. For clarification, Resaca Bluff has been referred to as Oostanaula or Truck Stop in some documents or databases. Fort Toulouse National Historic Park will be referred to as Fort Toulouse. The population that is an amalgamation of several occurrences that could be referred to as Cottingham Creek Bluff/Pratt's Ferry and Little Schultz Creek by other document standards will be referred to as Pratt's Ferry. We will refer to Little Cahaba- 4 Mile Creek as 4 Mile Creek.

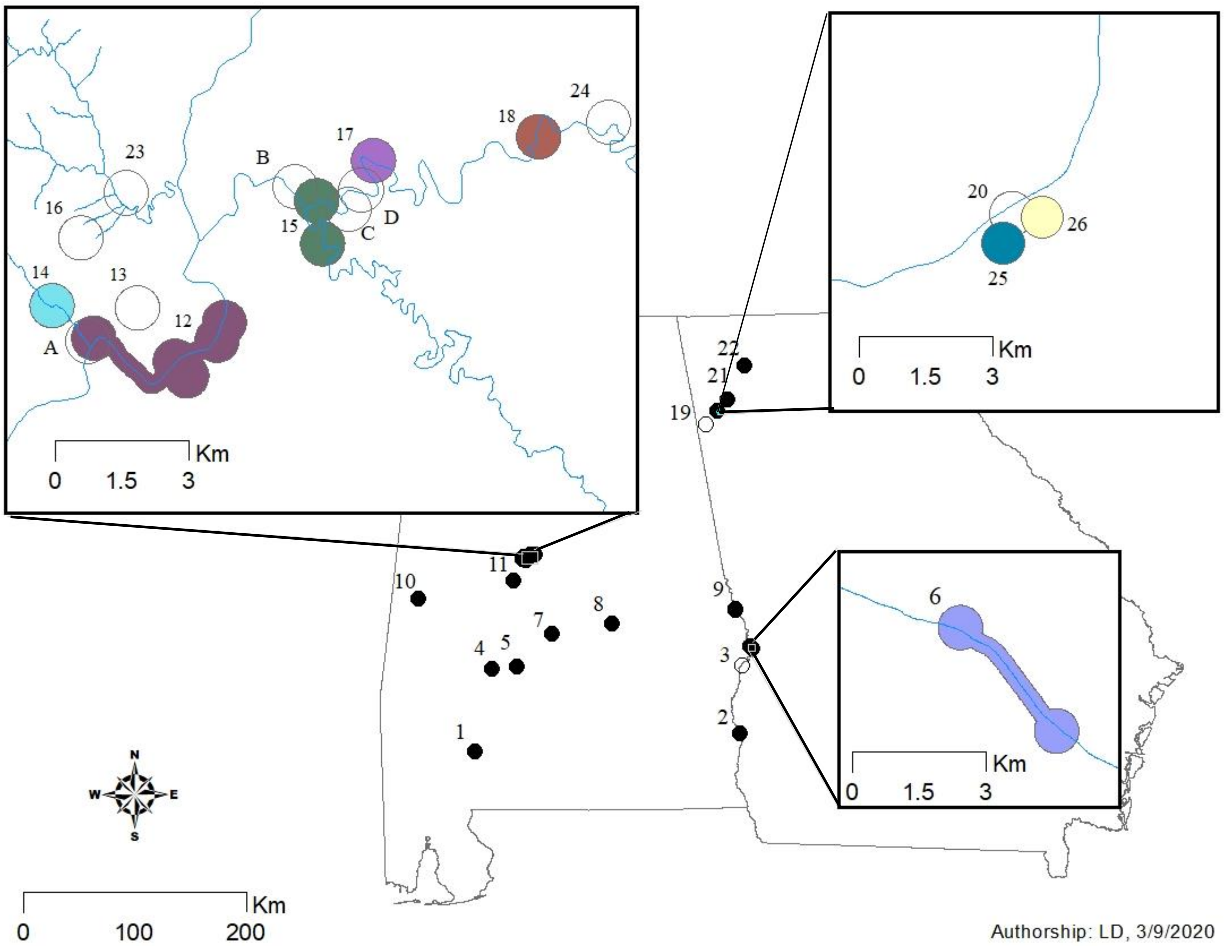

Figure 5-1. Populations of Georgia rockcress in Alabama and Georgia. Location data were buffered in this figure to enhance visibility. Historical and extirpated populations are circled and numbered, while extant populations (n =17) are colored and numbered (with the exception of 25 and 26, which are extant safeguarding populations (n=2)). Historical occurrences from Allison 1999 (Table 5-1) that overlap with extant populations are identified with letters. Inset maps highlight population clusters, and/or populations linked by water connectivity.

Table 5-3. List of Georgia rockcress populations and the occurrences that comprise them. The associated river system, county/state, and extant status for each population is also included. Population and occurrence numbers relate to Figure 5-1.

Population	Population Number	River System	County/ State	Extant	EOs and EO numbers
Marshalls Bluff	1	Alabama	Monroe/AL	Yes	1 (AL EO 6)
Fort Gaines Bluff	2	Chattahoochee	Clay/GA	Yes	1 (GA EO 7)
Omaha – Type Locality	3	Chattahoochee	Stewart/GA	No	1 extirpated (GA EO 6)
Prairie Bluff	4	Alabama	Wilcox/AL	Yes	1 (AL EO 4)
Portland Landing	5	Alabama	Dallas/AL	Yes	1 (AL EO 19)
Fort Benning	6	Chattahoochee	Chattahoochee/ GA, Russell/AL	Yes	2 total; Ft. Benning (GA EO 8, AL EO 21)
Durant Bend	7	Coosa	Dallas/AL	Yes	1 (AL EO 20)
Fort Toulouse	8	Coosa	Elmore/AL	Yes	1 (AL EO 17)
Goat Rock	9	Chattahoochee	Harris, Muscogee/GA	Yes	4 total (GA EO 2, EO 1, EO 3, EO 4); Goat Rock North, Goat Rock Dam (Powerplant Bluff), Goat Rock Dam (Powerlines), and Goat Rock South.
Fort Tombecbee	10	Tombigbee	Sumter/AL	Yes	1 (AL EO 22)
Murphy's Bluff	11	Cahaba	Bibb/AL	Yes	1 (AL EO 18)
Pratts Ferry	12	Cahaba	Bibb/AL	Yes	6 total. 5 extant: Cottingham Creek Bluff/Pratt's Ferry (AL EO 6, EO 9, EO 10, EO 14), and Little Schultz Creek Confluence (EO 13). 1 historical: occurrence A (no EO)
Pratt's Ferry	13	Cahaba	Bibb/AL	No	1 historical (AL EO 8)
Creekside Glades	14	Cahaba	Bibb/AL	Yes	1 (AL EO 2)
Fern Glades	15	Little Cahaba	Bibb/AL	Yes	4 total. 2 extant: Fern Glades (AL EO 3), and Sixmile Creek (AL EO 15). 2 historical: occurrences B and C (no EOs)
Pratt's Ferry (EO9) (2.3 miles NW)	16	Cahaba	Bibb/AL	No	1 historical (AL EO 9)
Brown's Dam Glades	17	Little Cahaba	Bibb/AL	Yes	2 total. 1 extant: Brown's Dam Glades (AL EO 5). 1 historical: occurrence D (no EO)
Limestone Park	18	Little Cahaba	Bibb/AL	Yes	1 (AL EO 12)
Cave Spring	19	Coosa	Floyd/ GA	No	1 historical (GA EO 11)
Black's Bluff Preserve	20 (25 and 26*)	Coosa	Floyd/GA	No	3 total. 1 extirpated (GA EO 9), *1 introduction (26, no EO) and 1 reintroduction (25, no EO) by GPCA.
Whitmore's Bluff	21	Coosa	Floyd/GA	Yes	1 (GA EO 10)
Resaca Bluff	22	Oostanaula	Gordon/GA	Yes	1 (GA EO 5)
Pratt Glade West	23	Cahaba	Bibb/AL	No	1 historical: occurrence 23 (no EO)
4 Mile Creek	24	Little Cahaba	Bibb/AL	No	1 historical: occurrence 24 (no EO)
Populations = 24 (17 extant)					**Occurrences = 37 natural (26 extant), 2 safeguarding.**

5.3 Population Resilience Factors and Ranking

We assessed population resilience using the condition factors and framework employed by GNHIP and ANHP. We assessed the resilience of each population by synthesizing the best available information about population and habitat conditions from survey data. *In-situ* safeguarding occurrences will not be assessed for resiliency as the occurrences are not yet considered self-sustaining. Factors influencing the viability of this species (Chapter 4) were incorporated as condition factors for assessing the resilience. These factors included the population factor of population size and three habitat factors: suitability degradation, and protection. These factors relate to those used by Schotz (2010, p. 19), ANHP, and GNHIP to assess the viability of EOs and are summarized below.

Table 5-4. Georgia rockcress viability ranking scheme adapted from Schotz 2010 (p. 19).

Condition Factors	Metrics
Population Size (Quality; Schotz 2010). Metrics focus on plant abundance, productivity, and vigor.	• Phenology: whether plants are vegetative, flowering, and/or fruiting • Approximate number of plants • Vigor: based on general appearance of plants, i.e., number of plants, amount of flowering and fruiting; rated as excellent, good, marginal, or poor
Suitability (Viability; Schotz 2010). Metrics focus on habitat quality, incorporating habitat quantity to conceptualize persistence of a population.	• Light: open, partial, filtered, and/or dense shade • Moisture: mesic, dry-mesic, or dry soils • Occupied and surrounding available habitat area
Degradation (Condition; Schotz 2010). Metrics focus on habitat loss from anthropogenic disturbance, and competition with invasive species.	• Degree of development: minimal, low, moderate, or high human modification • Invasive plant presence: minimal, low, moderate, or high by an associated % coverage for conceptualization
Protection (Defensibility; Schotz 2010). Metrics focus on how effectively anthropogenic disturbance and degradation can be limited.	• Degree of conservation through ownership: Private property without easement, private property with easement, or owned by conservation partner agency, state, or federal land. • Difficult to access/build (bedrock, elevation, slope).

The condition factors listed above are combined to derive an overall resilience rank for each population. The ranking for each condition factor is provided on a scale from A to D, with A meaning excellent, B good, C fair, and D poor. The overall population resilience rank is an average of these factors. The ranking process for each condition factor is described in the following sections.

5.3.1 Population Size

Schotz (2010, p. 8) documented fewer than 3,000 plants from all known sites in Alabama, but this was a large increase compared to population sizes in the 1990s (Table 5-5). In 2010, populations from Alabama ranged between 16 and 229 plants in Bibb County, 42 to 498 in Dallas County, 47 from Elmore County, 414 from Monroe County, 842 from Russell County, 4 from Sumter County, and 551 from Wilcox County. Subsequent surveying has not been conducted in Alabama.

Repeated surveying in Georgia indicates population sizes can fluctuate greatly in a short period of time. Moffett (2007, p. 8) found approximately 2,140 plants from all known populations in Georgia. Previously, the combined size of the Georgia populations was 323 plants, most of which were confirmed to be reproductive (Allison 1995, pp. 18-28). Regardless of the increase in plants compared to the previous survey, Moffett (2007, pp. 1-2) noted that the overall status of the three populations in northern Georgia (Black's Bluff Preserve, Whitmore's Bluff, and Resaca Bluff) was poor, as these populations tended to be small, and declining in size and vigor. In 2009, plants could not be relocated at Black's Bluff (Elmore 2010, p. 1), resulting in a designation of extirpated (Moffett, M. in litt., 2019). Only one plant was seen at Whitmore's Bluff in 2014, where 25 to 50 had been documented in 2007 (Elmore 2010, p. 1; Table 5-5). The recent population estimates at Resaca Bluff of 125 individuals is considered conservative according to experts, though it was noted that most plants were shaded by Chinese privet.

Some Georgia population sizes have remained fairly stable or even increased through time. The largest population in Georgia is the multi-occurrence Goat Rock population in Harris and Muscogee counties with approximately 1,000 flowering stems in 2007 (Moffett 2007, p. 2). The number of reproductive individuals (174) decreased in 2010 surveys (Garcia 2012), but the total number of plants more than doubled. Resaca Bluff experienced an increase in both the abundance and reproductive individuals (125) in a recent 2018 estimate, likely due to population augmentation (Patrick and Moffett 2018, p. 1). Fort Gaines experienced a slight decrease in population size, but an increase in the number of reproductive individuals (84) in 2010 (Garcia 2012). Fort Benning supported a vigorous population in 2007, with an estimated 1,000 plants (Moffett 2007, p. 2). The Fort Benning population increased in all age classes in 2010 (Garcia 2012) and 2014 (Parker 2019, p. 4). However, Fort Benning decreased greatly in 2019 likely due to stochastic events (Table 5-5). Fort Benning experienced heavy rains and flooding during the fall and winter of 2017-2018. It is believed that portions of the riverbank sluffed off and much of the sub-population on the Alabama side of the river was lost, while the Georgia sub-population riverbank remained stable. Fort Benning will continue to monitor the area to determine if the population recovers or fertile plants were missed during the most recent survey (Parker 2019, entire).

Table 5-5. Abundance estimates for populations of Georgia rockcress. The respective data source/survey year is listed under each data year column. Years where data were not reported/collected for a population are indicated with "n/a". Populations/times with unknown population abundances are denoted with a "U". Data from the Black's Bluff Introduction and Black's Buff Reintroduction populations are omitted, as the viability of these populations will not be assessed.

Extant Natural Populations (County)	**1992-1993 or 1997-1998**	**2006**	**2008-2010**	**2014**	**2018**	**2019**
	Allison (1995), Allison (1999)	Moffett (2007)	Schotz (2010), Garcia (2012)	Incidental: Goldstrohm 2014b, Patrick and Moffett in litt., 2018, Allison in litt. 2019, and Parker 2019		
Georgia **(**Fertile / Vegetative / Total Plants).						
Whitmore's Bluff (Floyd)	63 / U / U	30 / 20 / 50	6 / 6 / 12	0 / 1 / 1	n/a	n/a
Resaca Bluff (Gordon)	51 / U / U	23 / 9/ 32	28 / 14 / 42	n/a	125 / U / U	n/a
Goat Rock (Harris and Muscogee)	53 / U / U	870 / 129 / 999	174 / 2146 / 2320	n/a	n/a	n/a
Ft. Benning (Chattahoochee/GA and Russell/AL)	U / U / 144	573/499/1234	834 / 894 / 1728	1371 / 1911 / 3282	n/a	230 / 673 / 903
Ft. Gaines (Clay)	12 / U / U	55 / 87 / 142	84 / 28 / 112	n/a	n/a	n/a
Alabama **(**Fertile / Vegetative / Total Plants).						
Marshalls Bluff (Bibb)	n/a	n/a	226 / 188 / 414	n/a	n/a	n/a
Prairie Bluff (Wilcox)	Small (10?)	n/a	317 / 234 / 551	n/a	n/a	n/a
Portland Landing (Dallas)	n/a	n/a	326 / 172 / 498	n/a	n/a	n/a
Durant Bend (Dallas)	n/a	n/a	33 / 9 / 42	n/a	n/a	n/a
Fort Toulouse (Elmore)	U / U / 24	n/a	29 / 18 / 47	n/a	n/a	n/a
Fort Tombecbee (Sumter)	n/a	n/a	4 / 0 / 4	n/a	0	n/a
Murphy's Bluff (Bibb)	U / U / 15	n/a	14 / 2 / 16	n/a	n/a	n/a
Pratts Ferry (Bibb)	U / U / 198	n/a	180 / 86 / 266	n/a	n/a	n/a
Creekside Glades (Bibb)	U / U / 12	n/a	45 / 26 / 71	n/a	n/a	n/a
Fern Glades (Bibb)	U / U / 35	n/a	83 / 57 / 140	n/a	n/a	n/a
Limestone Park (Bibb)	U / U / Scarce (5?)	n/a	31 / 19/ 50	n/a	n/a	n/a
Brown's Dam Glades (Bibb)	5 / U / U	n/a	49 / 22 / 71	n/a	n/a	n/a

Previous viability assessments have focused on how robust an occurrence is by assessing the size and productivity of the occurrence and the vigor of the individuals (Schotz 2010, p. 19). In addition to occurrences, population size is an important part of resilience. Short-lived perennial plants like Georgia rockcress often have widely fluctuating population sizes (Bush and Lancaster 2004, p. 1), and a given year's population strongly influences the seed bank for future years. Large populations with larger seed banks or more vegetative individuals will be better able to persist through environmental and demographic stochastic events (e.g., drought years that reduce seed production). Large populations will also be more likely to withstand short periods of poor habitat conditions (e.g., increasing invasive species cover) because of their robust seed bank. However, even large populations will not be able to withstand continually poor conditions over several years that reduce reproduction and limit the ability of vegetative individuals to put on new growth or extend beyond the average life of the plant, the exact length of which is unknown but is likely around four to five years (von Schmeling, H. in litt., 2019). Although no studies have examined the long-term viability of Georgia rockcress seed, they do not seem to enter extended dormancy, which indicates that there is likely a limited seed bank for recovery from stochastic events (Allison 1995, p. 9). Seed stored by the GPCA for safeguarding has shown about a 50% decline in viability during germination trials after 8 years of storage (GPCA, unpublished data, 2018).

The size of the reproductive population was used in the resilience assessment even though it represents only a snapshot in time. Population sizes naturally fluctuate (Figure 5-2) and the trend in populations sizes (increasing, decreasing, stable) would provide more context to population resilience than population sizes alone, but trend data were not available for all populations (Table 5-5). Most populations are not surveyed annually or even every few years, surveys often report uncertainty in the extent of an occurrence and reported abundances from surveys vary in the detail of information collected (e.g., extent of coverage from invasive plants). Only reproductive plant population size during the most recent survey contributed to current population resilience.

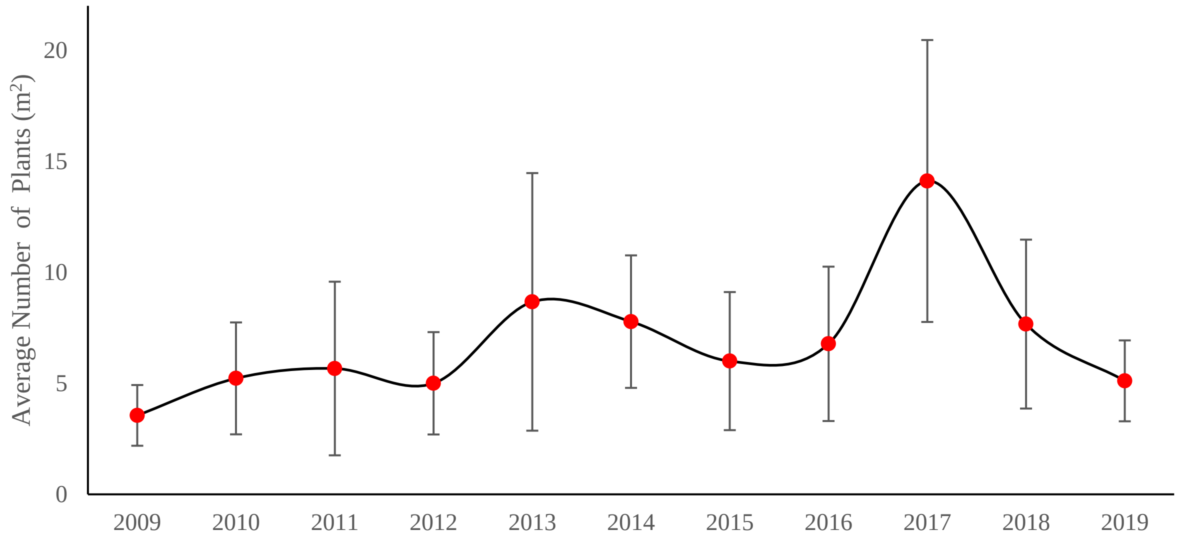

Figure 5-2. Annual monitoring data (2009 – 2019; FERC 2015) from the Goat Rock population of Georgia rockcress, summarized as average number of plants per 1m^2 (10.8 ft^2) plot (n = 9) +/- standard error. Monitoring has been completed annually since 2009 by Georgia Power Company.

We categorized populations into four condition classes based on abundance (Table 5-6). The condition of each population size class was ranked as excellent (A), good (B), fair (C), and poor (D). The population size threshold between good and excellent condition of 100 individuals was chosen because it is the population size used by Schotz (2010, p. 17) to rank EOs as having "excellent viability" and likely to persist for the next 20 to 30 years (NatureServe 2008). This is a generic population size limit, but also corresponds to a maximum population size of flowering plants found in populations that typically do not exceed several hundred (Moffett 2007, p. 9, Schotz, 20 -55), though some larger populations can exceed 1000 plants including non-reproductive individuals.

The other threshold population sizes for Georgia rockcress were chosen with guidance from past range-wide assessments (Moffett 2007, p. 9; Schotz 2010, p. 17 - 55), as well the NatureServe (2008) guidelines. Populations with fewer than 100 but greater than 51 individuals were considered to be in good condition, as there is evidence from survey data of populations with fewer than 100 individuals persisting for decades (e.g., Fern Glades and Sixmile Creek population; (Table 5-5).

Fair condition ranged from 10 to 49, with Georgia rockcress populations below 10 ranked as poor. There are also examples of moderately-sized populations persisting for decades (e.g., Fort Toulouse National Historic Park), but smaller populations (e.g., Whitmore's Bluff) are at great risk of extirpation as evidenced by the recent loss of the natural occurrence at Black's Bluff.

There are presently no empirical estimates of minimum viable population sizes for Georgia rockcress. If these data becomes available in the future, it should be used in future updates of this SSA to refine the population size categories and their implications for population resilience (Table 5-6). Small population sizes are often correlated with low habitat quantity, which is discussed in the next section.

Table 5-6. Strategy for assigning condition ranks to populations of Georgia rockcress based on population size.

Fertile Plants	Condition	Rank
> 100	Excellent	A
50 – 99	Good	B
10 – 49	Fair	C
< 10	Poor	D

5.3.2 Suitability

Habitat quantity is an important component of population resilience. Habitat quantity influences population size; populations on larger areas of suitable habitat can support higher population sizes than those with smaller areas. Georgia rockcress has specialized habitat needs (e.g., well-drained exposed soils, limited shading) and does not compete well with other species. Populations of Georgia rockcress that are confined to very small areas can be eradicated by activities such as road construction, residential or commercial development, herbicide application, and forest succession or encroachment because these threats are likely to affect the entire occurrence (see examples in Section 4.1). The majority of the extant populations of Georgia rockcress are fairly small, ranging from 0.004 to 1.3 acres (0.0016 to 0.5 hectares) for occurrences with known occupied extents (Table 5-7). However, the availability of unoccupied, suitable habitat nearby occurrences is also important, as this species can readily colonize exposed soil (Allison 1995, p. 22). Habitat condition included the estimated area occupied by each population, and the suitability of conditions during surveys (Allison 1995 p. 18 - 28, Schotz 2010 pp. 17 - 55).

Table 5-7. Habitat suitability for Georgia Rockcress populations. Data for Georgia populations is from Allison 1995 (pp. 18 - 28), and Schotz 2010 (pp. 17 -55) for Alabama. The critical habitat areas were designated in 2014 (79 FR 54635). See Table 5-8 for a discussion of light and moisture characteristics for different suitability ranks.

Populations (State)	**Area Occupied In Acres *(Hectares)***	**Critical Habitat Area in Acres *(Hectares)***	**Light**	**Moisture**
Whitmore's Bluff (GA)	0.1 *(0.04)*	43 *(17.4)*	hardwood community (partial to filtered)	Dry-mesic
Resaca Bluff (GA)	Uncertain, along riverbank	13 *(5.2)*	hardwood community (partial to filtered)	Dry-mesic
Goat Rock (GA)	Uncertain, Small openings	76 *(30.7)*	Sparse woods (open to filtered)	Dry-mesic
Ft. Benning (GA/AL)	AL side at 1.1 (*0.45*) in 2010	61 *(24.6)**	Partial to filtered	Mesic
Ft. Gaines (GA)	0.004 (*0.0016*)	42 *(17)*	Well-developed hardwood community (filtered)	Dry-mesic
Marshalls Bluff (AL)	0.05 *(2)*	27 *(11)*	Open to partial	Dry-mesic
Prairie Bluff (AL)	1.3 *(0.5)*	32 *(13)*	Open to partial	Mesic
Portland Landing (AL)	0.5 *(0.2)*	31 *(12.5)*	Open to partial	Mesic
Durant Bend (AL)	0.04 *(0.016)*	28 *(11)*	Partial to filtered	Mesic
Fort Toulouse (AL)	Unknown	17 *(7)*	Filtered	Mesic
Fort Tombecbee (AL)	0.008 *(0.003)*	14 (*5.6*)	Filtered	Dry-mesic
Murphy’s Bluff (AL)	0.01 *(0.004)*	26 (*10.5*)	Partial	Mesic
Pratts Ferry (AL)	Unknown	111 *(45)*	Open to filtered	Dry-mesic to mesic
Creekside Glades (AL)	0.025 (*0.01*)	26 *(10.5)*	Open to partial	Dry-mesic
Fern Glades (AL)	0.04 (*1.6*)	65 *(26)*	Partial	Dry-mesic to mesic
Limestone Park (AL)	0.04 (*1.6*)	15 *(6)*	Open to partial	Dry-mesic
Brown’s Dam Glades (AL)	Unknown, small	72 *(29)*	Open to partial	Dry-mesic

* Fort Benning has designated suitable habitat specifically for Georgia rockcress conservation within a management plan (INRMP 2014, pp. 882,884-885).

Habitat suitability was ranked based on size, light, and soil moisture combinations (Table 5-8). Where area occupied or area available (critical habitat area) conflicted with habitat suitability (light or moisture) in ranking a given population, precedence was given to the habitat suitability for assigning ranks. Soil moisture conditions were largely consistent between ranks, so light availability or forest characteristics were often the deciding factor in this case. For example, the Fort Gaines occurrence is D for area occupied but ranks higher based on habitat suitability (light/forest is C, moisture is A-C). It is therefore assigned a habitat quantity rank of C based on light (Table 5-8).

Table 5-8. Strategy for assigning suitability condition ranks to populations of Georgia rockcress based on habitat quantity and quality.

Suitability	Condition	Rank
Open to lightly shaded, dry-mesic soils, > 1.0 acres occupied, > 20 acres available. Sparse woods.	Excellent	A
Partially open canopy, dry-mesic soils, < 0.25 acre – 1.0 acres occupied, >20 acres available. Hardwood community	Good	B
Filtered light, dry-mesic soils, 0.005– 0.25 acres occupied, >20 acres available. Well- developed hardwood forest	Fair	C
Dense shade, hydric soils, < 0.005 acres occupied, < 20 acres available. Mixed hardwood or conifer forest.	Poor	D

5.3.3 Degradation

The impacts on habitat supporting the population (pristine or degraded) and the potential for recovery or restoration of that habitat are considered in our assessment of habitat degradation (Schotz 2010, p. 19). Populations with few forbs and woody plants as competitors received higher ranks than those with more than ten percent coverage of invasive species. Some of these populations in degraded habitats may have relatively large population sizes, especially where large open areas are maintained by periodic disturbance (e.g., mowing). However, Georgia rockcress in these habitats are highly vulnerable to changes in land management that could increase invasive species that out-compete Georgia rockcress. Habitat degradation metrics were assessed qualitatively by surveyors during site visits (Allison 1995 p. 18 - 28, Allison 1999 p. 2-7, Moffett 2007 p. 9, Schotz 2010 17 – 55, Garcia 2012) and summarized for the listing in 2014. More recent data was incorporated where available. Table 5-9 is adapted from the listing rule, re-evaluating past survey data to better correspond to our ranking assessment.

The impact of anthropogenic disturbance and invasive species is considered relative to Georgia rockcress abundance. Populations with low abundance (< 49 individuals) can only have excellent condition when there is minimal to no degradation (< 10 % coverage of invasive species and/or anthropogenic disturbance) and will have poor condition when degradation is increased any amount (≥10 % coverage of invasive species and/or anthropogenic disturbance). Populations with fair abundance (50 to 99 individuals) can have excellent condition (< 10 % coverage of invasive species and/or anthropogenic disturbance), moderate condition (≥10 % to 30% coverage of invasive species and/or anthropogenic disturbance) or poor condition. This ranking scheme is used to represent the higher risk of extirpation for small populations once degradation occurs.

Larger populations ($\geq$ 50 individuals) have poor condition once degradation is > 70% (Table 5-9). Where there is a conflict between the anthropogenic disturbance and invasive species metrics, the worse condition rank of the two was used for the degradation condition ranking.

Table 5-9. Degradation of Georgia rockcress habitat from anthropogenic factors and invasive plants at the time of listing (2014), updated to reflect the current population delineation and recent survey data (2010 and beyond) where possible.

Population	**County/ State**	**Anthropogenic Impact**	**Invasive Plant Impact (See Table 5-10)**
Fort Tombecbee	Sumter/AL	High. Threats from road with bridge, housing, commercial development. Degradation from timber harvest and livestock grazing.	None
Marshalls Bluff	Monroe/AL	Low. Threats from adjacent abandoned quarry and road, no plans to expand. Largely forested.	None
Prairie Bluff	Wilcox/AL	Low. Threats from nearby road, housing, foot paths, and hydropower, but largely forested. Possibility for further residential development.	Low
Portland Landing	Dallas/AL	Low. Threats from nearby timber harvest, hydropower. Largely forested.	Moderate
Durant Bend	Dallas/AL	Low. Threats from nearby timber harvest.	Moderate
Murphy's Bluff	Bibb/AL	Low. Threats from road and bridge, potential for nearby timber harvest.	Moderate
Creekside Glades	Bibb/AL	Low. Threats of nearby housing, utility lines, and clearcutting.	None
Pratts Ferry	Bibb/AL	Low. Threats from adjacent abandoned quarry, road with bridge, and timber harvest. Possibility of degradation from future timber harvest	Low
Fern Glade	Bibb/AL	Low. Degradation from unpaved road, threats from nearby timber harvest.	Moderate
Browns Dam Glade	Bibb/AL	Low. Degradation from unpaved road. Camping not permitted.	Low
Limestone Park	Bibb/AL	Low. Threats from adjacent road, housing, maintained field, recreation.	None
Fort Toulouse	Elmore/AL	Moderate. Threats from recreation, degradation from field maintenance.	Moderate
Fort Gaines Bluff	Clay/GA	Low. Possible degradation from future timber harvest	Moderate (High adjacent to occupied habitat)
Fort Benning	Chattahoochee /GA, Russell/AL	Low. Threats of adjacent roads, potential indirect impacts from adjacent timber harvest, potential degradation from fire.	Low (Garcia 2012)
Goat Rock	Harris, Muscogee/GA	Low. Potential degradation from hydropower and utility lines created suitable open habitat. Threats from roads and foot paths.	Low (GPCA unpublished data, 2015; GPCA unpublished data, 2018)
Whitmore Bluff	Floyd/GA	High. Threats from timber harvest and housing. Degradation from recreation.	High
Resaca Bluff	Gordon/GA	Moderate. Threats from road with bridge, commercial development, and trash dumping. Limited degradation from camping and foot paths.	High

Table 5-10. Strategy for ranking degradation condition in populations of Georgia rockcress.

Degradation	Condition	Rank
Minimal to no degradation: < 10% coverage of invasive species and/or anthropogenic disturbance.	Excellent	A
Low degradation: 10 to 30% coverage of invasive species and/or anthropogenic disturbance in larger populations (e.g. $\geq$ 100 reproductive plants).	Good	B
Moderate degradation: 31 to 70% coverage of invasive species and/or anthropogenic disturbance in larger populations (e.g. $\geq$ 100 reproductive plants); or smaller populations (50 - 99) with $\geq$ 10 to 30% coverage of these degrading factors.	Fair	C
High degradation: 71 to 100% coverage of invasive species and/or direct anthropogenic disturbance; small populations (< 49) with $\geq$ 10% coverage of these degrading factors; or larger populations (50-99) with > 31 % coverage of these degrading factors	Poor	D

5.3.4 Protection

The protection of a population from threats is another factor included in resilience ranking. Populations that occur on protected lands (e.g., public land, including private lands with conservation agreements) were assigned to a higher rank than unprotected lands. By doing so, the importance of populations on unprotected lands to the viability of the species is not discounted, nor is it implied that private owners are managing the land poorly or are impacting Georgia rockcress (Table 5-11). Large, pristine populations of Georgia rockcress can be supported on private lands (e.g., Durant Bend; Schotz 2010, p. 14); however, even large populations can collapse quickly from poor management or habitat destruction. Lands that are not protected for conservation have a higher risk of changes in management or land use that could impact Georgia rockcress populations (Table 5-12).

Table 5-11. Land ownership of Georgia rockcress populations, and a description of their protection status and/or landscape context.

Population	County/State	Ownership and Description
Fort Tombecbee	Sumter/AL	State (along the crest and steep banks of a stream)
Marshalls Bluff	Monroe/AL	Private (no conservation agreement, on a high elevation rocky bluff)
Prairie Bluff	Wilcox/AL	Private (no conservation agreement, along bluffs and ravines)
Portland Landing	Dallas/AL	Private (no conservation agreement, unstable erodible sandy soils)
Durant Bend	Dallas/AL	Private (no conservation agreement, eroding riverbank and adjacent forest)
Murphy's Bluff	Bibb/AL	Private (no conservation agreement, along a crest)
Creekside Glades	Bibb/AL	Private (no conservation agreement, associated with small dolomite glades)
Pratts Ferry	Bibb/AL	Private (no conservation agreement, on bouldery limestone woodland) and TNC
Fern Glade	Bibb/AL	Federal (CRNWR) and private (protected: TNC)
Brown's Dam	Bibb/AL	Private (TNC) on glades and open rocky areas
Limestone Park	Bibb/AL	Private (no conservation agreement, on rocky limestone outcrops)
Fort Toulouse	Elmore/AL	State (sandy soils of upper slopes and crest)
Fort Gaines	Clay/GA	Private (no conservation agreement, on high, steep, eroding riverbank)
Goat Rock	Harris/GA Muscogee/GA	Private (protected according to FERC licensing, though no formal conservation agreement: GP), southern most occurrence private (no conservation agreement). Gneiss crevices and steep bluffs.
Whitmore Bluff	Floyd/GA	Private (no conservation agreement, bluff with minimal rock crevices)
Resaca Bluff	Gordon/GA	Private (no conservation agreement, low bluff)
Fort Benning	Chattahoochee/GA, Russell/AL	Federal (on bluff line and associated steep forested slopes)

Table 5-12. Strategy for assigning condition ranks to populations of Georgia rockcress based on degree of protection.

Protection	Condition	Rank
Federal land. Also, state land or private protected land with extreme/unstable slopes and/or extensive rock features.	Excellent	A
Private property with extreme/unstable slopes and/or extensive rock features, without conservation agreement. State, or private protected land with moderate eroding slopes and/or some rock features	Good	B
Private property with moderate eroding slopes and/or some rock features, without conservation agreement. State, or private protected land with mild slopes.	Fair	C
Private property with mild slopes, without conservation agreement	Poor	D

5.3.5 Combined Population Resilience Ranking

Overall population resilience is determined by a combination of the population and habitat factors. Therefore, population size, habitat suitability, and protection ranks for populations were combined to inform resilience ranks. A description of the overall population resilience ranks is included in Table 5-13.

Table 5-13. Population resilience ranking criteria for Georgia rockcress populations, adapted from Schotz (2010, p. 17).

Resilience Rank and Criteria
A (Excellent): 100 or more flowering stems associated with basal rosettes indicating successful reproduction. Soils are well-drained with few forbs and woody plants as competitors, under open to lightly shaded conditions in glades and bluffs. Less than ten percent coverage of invasive species and/ or anthropogenic disturbance.
B (Good): 50 to 99 flowering stems associated with basal rosettes indicating successful reproduction. Soils are well-drained with few forbs and woody plants as competitors, under open to lightly shaded conditions in glades and bluffs. Less than ten percent coverage of invasive species and/ or anthropogenic disturbance. A larger occurrence may have up to thirty percent coverage of invasive species and/ or anthropogenic disturbance. Restorable to A-ranked criteria.
C (Fair): 10 to 49 flowering stems associated with basal rosettes indicating successful reproduction. Soils are well-drained with few forbs and woody plants as competitors, under open to lightly shaded conditions in glades and bluffs. Less than ten percent coverage of invasive species and/ or anthropogenic disturbance. Highly impacted A- or B-sized (by population) occurrences with up to seventy percent coverage of invasive species and/ or anthropogenic disturbance qualify as C-ranked. Good potential for restoration to B-ranked criteria.
D (Poor): 1 to 9 flowering stems or basal rosettes. Occupies highly degraded habitat (e.g., anthropogenic disturbance) completely covered or soon to be completely covered with invasive species resulting in competition, with a closed canopy that limits light availability. Limited to no potential for restoration.
H (Historic): Population has not been observed within the past 20 years.
E (Extirpated): Population is considered extirpated.

5.4 Current Resilience

In the following section, we report the results of the resilience assessment. Each population was rated as currently being in excellent (A), good (B), fair (C), or poor (D) condition for each of the resilience factors of population size, and habitat suitability, degradation and protection. These categories were then converted to numerical ranks 4, 3, 2, and 1, respectively. The average of the factor ranks was then used to generate an overall resilience score, and all factors were evenly weighted. Resilience was rounded down for values ≤ 0.5, as a conservative measure. For example, if a population was B for population size, C for habitat suitability, B for degradation, and C for protection, it would average a BC or 2.5 ranking on average. However, according to the rounding rule, this hypothetical population would be down-ranked to account for uncertainty (e.g., older or less precise) information within our dataset to obtain a final rank of C or 2. The gradient from excellent (A) to poor (D) resilience as an average of condition factors represents the increasing ability of a population to persist in the face of stochastic natural and man-made conditions and events. Generally speaking, populations with excellent (A) or good (B) resilience were considered to be resilient, with fair (C) and poor (D) resilience populations considered to lack resilience at present.

5.4.1 Excellent Resilience

Three populations received a rank of A based on their combined EO resiliency ranks (population size, habitat quantity, habitat quality, conservation and management; Table 5-14). According to NatureServe's viability ranking criteria, if current conditions prevail, these populations are "very likely to persist for the foreseeable future (i.e., at least 20-30 years) in their current condition or better" (Hammerson et al. 2008). One population is on federal land (Fort Benning). Most of the Goat Rock population occurs on Georgia Power Company (GP) land and subject to a management plan according to Federal Energy Regulatory Commission (FERC) requirements, while the southern-most portion of the population occurs on other private land. The GP property is not formally protected; however, GP has been an active partner with the GPCA to conserve this species. A conservation agreement for this species could maintain or improve the long-term resilience at this site. Regular management activities at Fort Benning and Goat Rock will likely be needed to maintain the resilience of these populations. The Goat Rock population is near the 30% threshold between A and B rank for habitat degradation for large populations, so consistent management will be especially important for maintaining resilience at this population. Garcia (2012, p. 31) noted some recruitment for the GPCA augmentation efforts (restored plots) at the Goat Rock population, it is unknown if the augmentation efforts have influenced abundance due to limited long-term monitoring data. At a lower population level, the condition of the population would be C (fair) instead of B (good) regarding invasive species coverage contributing to habitat degradation.

Even though the Alabama sub-population of the Fort Benning population has been drastically reduced (natural flooding presumed; five vegetative individuals remained in 2019), the upstream sub-population in Georgia remains robust. The Alabama occurrence has a good natural recovery potential (e.g., recolonization from upstream, existing seedbank, and/or from remaining individuals). Marshalls Bluff is a high priority population to protect, either through acquisition or agreements with the landowners to better maintain resilience – the excellent landscape context of this population has elevated its conservation and management rank beyond what might be expected otherwise (Table 5-14).

Table 5-14. Populations with excellent resilience. Unit refers to the representative unit the population belongs to (see Section 5.5). The condition ranks used to calculate resilience are (1) population size, (2) suitability, (3) degradation, and (4) protection. The resiliency estimate is indicated under the column denoted by ‘R’.

Population Name	Unit	1	2	3	4	R	Last Survey	Protected?	Notes
Marshalls Bluff	Alabama	A	A	A	B	A	2009	No	226 flowering plants, natural habitat with native plant communities
Fort Benning	South Georgia	A	A	A	A	A	2019	Yes	230 flowering plants, natural habitat with native plant communities on federal land. 2017/2018 flood likely cause of AL sub-population reduction.
Goat Rock	South Georgia	A	A	B	A	A	2010	Yes (GP) and No	174 flowering plants, subject to past augmentation. Private land not owned by GP contains 19 fertile and 244 vegetative individuals. Moderate invasive species impacts.

5.4.2 Good Resilience

Six populations received a resilience rank of B (“Good”; Table 5-15). According to NatureServe’s viability ranking criteria, if current conditions prevail, these populations are “likely to persist for the foreseeable future (i.e., at least 20-30 years) in their current condition or better” (Hammerson et al. 2008.). The majority of the Pratt’s Ferry reproductive plant population (151 of 180 plants) occurs within TNC lands. Half of these populations are protected by TNC but are not benefitted by a management plan. Even though the majority of populations with good resilience are protected, regular management activities will likely be needed to maintain resilience. The amount of degradation or the suitability of the habitat (e.g., canopy conditions) could be improved with appropriate management under protection to increase overall resiliency, depending which of these factors is worse. The resiliency of unprotected populations could likely increase with protection alone.

Table 5-15. Populations with good resilience. Unit refers to the representative unit the population belongs to (see Section 5.5). The condition ranks used to calculate resilience are (1) population size, (2) suitability, (3) degradation, and (4) protection. The resiliency estimate is indicated under the column denoted by 'R'.

Population Name	Unit	1	2	3	4	R	Last Survey	Protected?	Notes
Brown's Dam Glades	Alabama	C	C	A	A	B	2010	Yes (TNC)	49 flowering plants, natural habitat with native plant communities and some invasive plants and trampling.
Fern Glades	Alabama	B	B	B	A	B	2010	Yes (CRNWR and TNC)	44 flowering plants, natural habitat with native plant communities and some invasive plants.
Pratt's Ferry	Alabama	A	A	B	B	B	2010	Yes (TNC) and No	151 flowering plants, natural habitat with native plant communities and invasive plants, nearby logging potential.
Durant Bend	Alabama	B	B	B	C	B	2008	No	33 flowering plants, natural habitat with native plant communities and invasive plants, logging potential
Portland Landing	Alabama	B	B	B	C	B	2010	No	326 flowering plants, natural habitat with native plant communities and invasive plants.
Prairie Bluff	Alabama	A	A	B	D	B	2010	No	317 flowering plants, natural habitat with native plant communities and invasive plants.

5.4.3 Fair Resilience

Five populations received a resilience rank of C ("Fair"; Table 5-16). According to NatureServe's viability ranking criteria, persistence for these populations is uncertain under current conditions, the population may persist under current conditions dependent on appropriate protection or management, or these populations are likely to persist but in worse condition (e.g., lower population size, worse habitat quality) than the current condition (Hammerson et al. 2008). The majority of these populations are on private land unmanaged by a partner agency (e.g., TNC). Resaca Bluff has been augmented, and recent reports indicate the population may be experiencing a temporary increase in abundance at present. Conditions at Fort Gaines are similar to Resaca Bluff; however, the population size is smaller and access to the site to monitor conditions is currently limited. Creekside Glades has good habitat suitability and fair landscape context as it is associated with glades. The only population that is protected, does not have a management plan; Fort Toulouse resiliency could be improved via a conservation and management partnership.

Table 5-16. Populations with fair resilience. Unit refers to the representative unit the population belongs to (see Section 5.5). The condition ranks used to calculate resilience are (1) population size, (2) suitability, (3) degradation, and (4) protection. The resiliency estimate is indicated under the column denoted by 'R'.

Population Name	Unit	1	2	3	4	R	Last Survey	Protected?	Notes
Creekside Glades	Alabama	C	B	C	C	C	2010	No	22 flowering plants, natural habitat with native plant communities, dry-mesic soil and open to partial light. Nearby clear-cut.
Fort Toulouse	Alabama	C	C	C	B	C	2010	Yes	29 flowering plants, natural habitat with native plant communities, mesic soil and filtered light. Extensive invasive plants.
Resaca Bluff	North Georgia	A	C	D	D	C	2019	No	125 flowering plants, natural habitat with native plant communities and invasive plants. Human activity and trampling present. Augmented.
Limestone Park	Alabama	C	C	B	C	C	2010	No	31 flowering plants, natural habitat with native plant communities, dry-mesic soil, open to partial light.
Fort Gaines	South Georgia	B	C	C	D	C	2010	No	84 flowering, few (22) vegetative plants. Natural habitat with native plant communities. Invasive species adjacent to population. Routine monitoring not achievable.

5.4.4 Poor Resilience

Three populations received a resilience rank of D ("Poor"; Table 5-17). These populations face a high risk of extirpation within 20-30 years (Hammerson et al. 2008, n.p.). The potential for conservation and management for the Fort Tombecbee population could be improved, as the land is owned by University of West Alabama and The Archaeological Conservancy which could be approached as conservation partners. The conservation potential of Whitmore's Bluff is limited; seed from the Whitmore's Bluff population has been collected and out-planted as part of the Black's Bluff Introduction safeguarding site. The Murphy's Bluff population has experienced active logging in the surrounding area, and logging is not typically conducive to maintaining Georgia rockcress populations unless it is selective to promote the regeneration of hardwood species (FERC 2016, p. 3).

Table 5-17. Populations with poor resilience. Unit refers to the representative unit the population belongs to (see Section 5.5). The condition ranks used to calculate resilience are (1) population size, (2) suitability, (3) degradation, and (4) protection. The resiliency estimate is indicated under the column denoted by 'R'.

Population Name	Unit	1	2	3	4	R	Last Survey	Protected?	Notes
Murphy's Bluff	Alabama	D	D	C	C	D	2010	No	14 flowering plants, natural habitat with native plant communities and invasive plants. Partial light and mesic soil. Potential for timber harvest.
Fort Tombecbee	Alabama	D	D	C	C	D	2010	Yes	4 flowering plants, natural habitat with native plant communities. Filtered light, dry mesic soil. Canopy closure and dense understory where canopy reduced. Some livestock grazing.
Whitmore's Bluff	North Georgia	D	C	D	D	D	2014	No	1 vegetative plant, natural habitat with native plant communities and invasive plants. Degraded from residential development.

5.4.5 No Resilience

Nine populations have no resilience. These populations received a rank of X or H, and are either currently extirpated (X: n = 2) or have not been located during the most recent surveys but are not yet considered extirpated (H: n = 5; Table 5-18). Black's Bluff has been subject to safeguarding initiatives involving a reintroduction and introduction. Repeated surveys have not relocated the Omaha population which was last seen in 1901 and now deemed extirpated. However, the Cave Spring population was last seen in 1870 has not received the same survey effort and is listed as historical. Future surveys could examine historical locations to determine if they have been recolonized. Many of the occurrences were very small (e.g., 5 plants) when they were described and may have represented locations with a lack of or marginal suitable habitat.

Table 5-18. Georgia rockcress populations that have been extirpated or were not found during the most recent surveys. Unit refers to the representative unit the population belongs to (see Section 5.5). The rank is indicated under the column denoted with 'R'.

Site	Unit	Last Survey	R	Protected?	Notes
Black's Bluff	North Georgia	2010 (one fertile plant seen in 2007)	X	Yes	Safeguarding activities have preserved the genetics of the last individual from this population.
Omaha-Type Locality	South Georgia	2005 (seen in 1901)	X	No	Shady woods atop high bank. At least three searches (1988, 1992 2005) failed to find plants at this site.
Cave Spring	North Georgia	2018 (collected in 1870)	H	Yes	Exposed limestone of cave entrance, presumably at Rolater Park. Impacted by recreational use and modification of cave entrance and spring run.
4 Mile Creek	Alabama	1997 (found in 1996)	H	No	Described by Allison (1999, p. 2 -7). See Current and Historical Conditions Table 5-1 for more details.
Pratt Glade West	Alabama	1997 (found in 1992)	H	No	Described by Allison (1999, p. 2 -7). See Current and Historical Conditions Table 5-1 for more details.
2.3 miles NW Pratt's Ferry	Alabama	2010 (seen in 1975)	H	No	The population has not been observed during subsequent site visits. The Alabama Natural Heritage Program assumes the specimen was collected along County Road 26.
Pratt's Ferry Road	Alabama	2010 (seen in 1975)	H	No	The population was not relocated in connection with the most recent survey, as well as during subsequent attempts since the time of the original collection. The Alabama Natural Heritage Program assumes the specimen was collected along County Road 26.

5.4.6 Current Resilience Summary

Overall, nine populations (38 percent) currently exhibit excellent or good resilience (Table 5-19), indicating that they are likely to persist in their current condition or better for the foreseeable future (at least 20-30 years). Five populations (24 percent) have fair resilience, indicating that they will likely require conservation actions in order to remain in the current condition for the foreseeable future; otherwise they will be expected to decline. Roughly a third of the populations fall in the bottom two categories with either poor resilience (14 percent) and face a high risk of extirpation, or no resilience (extirpated or historical; 24 percent). Seven of the 17 extant populations (41 percent) are protected but only 3 (18 percent) of those (Black's Bluff, Goat Rock and Fort Benning) receive management as part of a formal plan. Populations are usually at least partially degraded by invasive species or a legacy of previous land uses which create the continual threat of establishment and worsening of invasive species coverage. The species has been able to flourish where land is managed consistent with Georgia rockcress persistence (e.g., soils remain thin, or invasive plants are limited/reduced). Population augmentation has occurred at Resaca Bluff and Goat Rock. However, it is difficult to know to what degree this work has increased resiliency.

Table 5-19. Summary of Georgia rockcress populations in each resilience category.

Resilience	**All Populations**
Excellent	3
Good	6
Fair	5
Poor	3
No Resilience (Historical)	5
No Resilience (Extirpated)	2
Total	*24*

5.5 Delineating Representative Units

Georgia rockcress spans three ecoregions within its limited range: the Ridge and Valley, Piedmont, and Southeastern Plains. However, genetic studies have shown that Georgia rockcress is composed of at least three genetic groups that correspond to separation by distance (Garcia 2012), not ecoregion (Figure 5-3). The genetic clustering indicates that occurrences within each grouping were linked in the recent past through gene flow and would thus have similar evolutionary potential in a changing future. Given the genetic evidence, we have delineated representative units for this species that correspond to a North Georgia, a South Georgia (referred to as Middle Georgia in the *Federal Register* listing (79 FR 54627)), and an Alabama group (Garcia 2012, p. 33). While there is suitable habitat between the Alabama and South Georgia group, it has not been adequately surveyed. There may be intervening occurrences that have not yet been discovered that, with future genetic testing, would support different genetic clusters (e.g. Alabama and South Georgia combined, or more than three clusters). While the Fort Tombecbee, Fort Toulouse, and Marshalls Bluff populations were not included in the genetic analysis, they are connected to the Alabama representative unit by major water systems, ecoregion, and proximity, and so are included with the Alabama representative unit in this SSA.

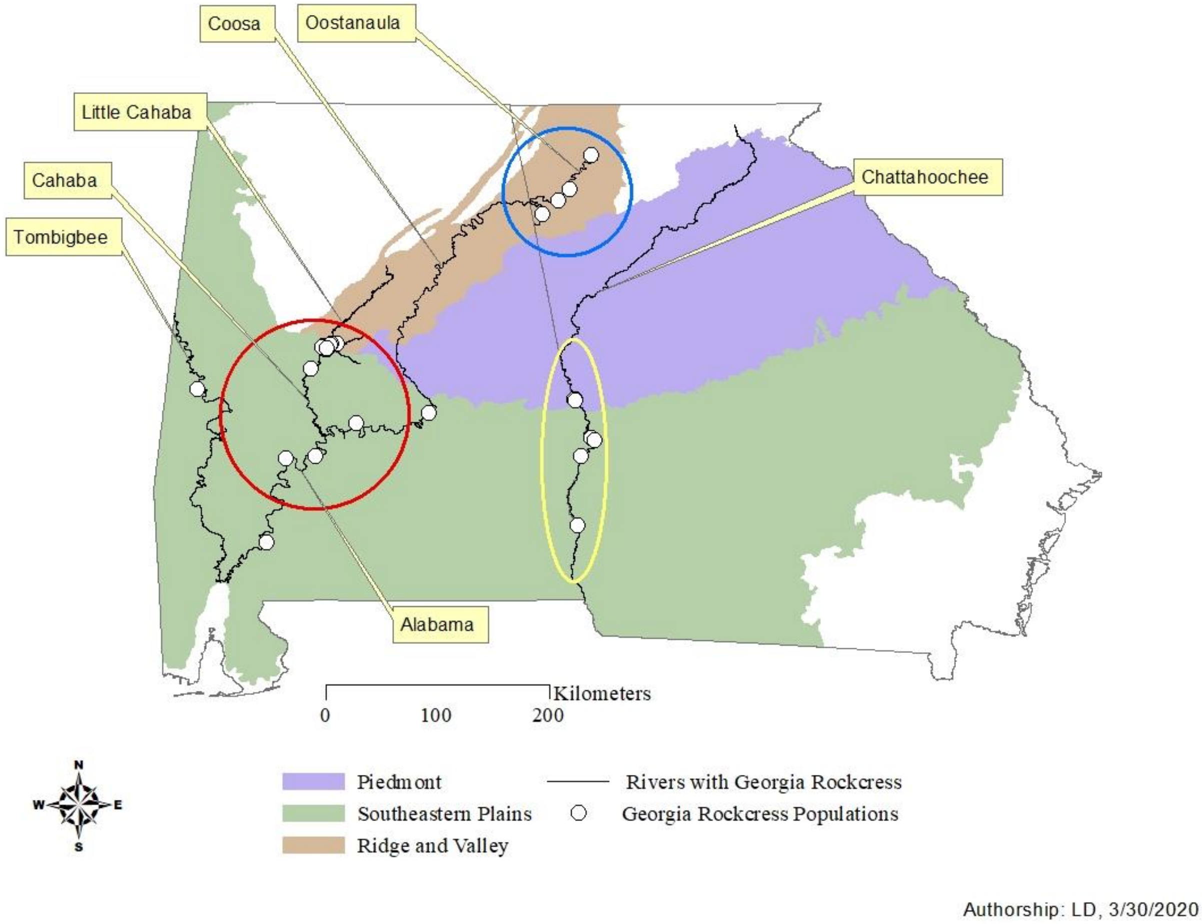

Figure 5-3. Representative units for Georgia rockcress in Alabama and Georgia. The river systems that contain Georgia rockcress populations are included, as well as the level three ecoregions. The genetic clusters used to delineate representative units are: North Georgia (upper right circle; blue), South Georgia (lower right oval; yellow) and Alabama (lower left circle; red).

5.6 Current Redundancy and Representation

Georgia rockcress is endemic to Alabama and Georgia. Populations of Georgia rockcress are restricted to small patches of suitable habitat associated with large river bluffs with steep and/or shallow soils that are subject to localized disturbances that limit the accumulation of leaf litter and competition, underlain with granite, sandstone, or limestone. The habitat specificity for this species has resulted in limited and fragmented suitable habitat resulting in low redundancy; therefore, Georgia rockcress may be at a higher risk for extinction from habitat loss or degradation associated with localized events (manmade or natural).

There has been a loss of redundancy compared to the historical distribution of Georgia rockcress. While populations remain across the known historical range, there has been a reduction in the number of populations and the occurrences that comprise them within this extent. Over a 15- to 20-year period of surveying, seven populations were either confirmed extirpated or were not relocated (Table 5-19). Extirpations were attributed to development (i.e., houses, commercial facilities, lawns) and habitat degradation. Of the extant populations, only those with resilience contribute to redundancy. Populations ranked as excellent (A) or good (B) were considered resilient. Populations with fair or poor resilience are considered to lack resilience and do not contribute to redundancy; this approach is a conservative measure given that populations have not been thoroughly surveyed since 2010 (Schotz 2010, Garcia 2012). In total, over half (67%) of the Georgia rockcress populations are considered to lack resilience currently (Table 5-20).

The nine populations exhibiting resilience (good or excellent resilience) are fairly well-distributed throughout the species' range, improving the likelihood of species persistence following catastrophic events (Figure 5-4). Man-made or natural catastrophic events that affect one population (e.g., development, flooding, or fire) are unlikely to impact the others. Six of the resilient populations occur completely or partially on protected lands (public land, including private lands with voluntary conservation agreements or agency stewardship). These populations are less susceptible to many of the types of catastrophes that could impact this species because they are less likely to experience changes in land use and management than those on privately owned lands.

Resilient Georgia rockcress populations do not occur within all representative units. The North Georgia representative unit contained four known populations; however, none are currently resilient (Table 5-20). The Cave Spring and Black's Bluff populations of North Georgia are historical and extirpated, respectively. Fortunately, safeguarding efforts have established a reintroduction site within the population boundary of the recently extirpated Black's Bluff population, using Black's Bluff material propagated *ex-situ* from one plant (Moffett 2007, p. 6). Plant material collected from Black's Bluff has also been used in an introduction to a new site

1.2 km away from the reintroduction site and includes material from Resaca Bluff and Whitmore's Bluff (Hodges, M. in litt., 2019). These safeguarding initiatives are vital for conserving the adaptive potential of this representative unit, though the *in-situ* populations are not assessed as contributing to resiliency of natural populations in the SSA. The extirpation of the Omaha type locality, and the inability to reliably monitor at Fort Gaines makes maintaining representation in the South Georgia unit particularly difficult. A catastrophic event (e.g. flooding) could eliminate redundancy within the South Georgia unit. For example, Fort Benning experienced heavy rains and flooding during the fall and winter of 2017-2018. It is believed that portions of the riverbank sluffed off and much of the population on the Alabama side of the river was lost, while the plants on the Georgia side of the riverbank remained stable. Fort Benning will continue to monitor the area to determine if the population recovers or fertile plants were missed during the most recent survey (Parker 2019, entire). It is important to note that Goat Rock plays a vital role in the conservation of the species in the South Georgia unit, as the flood risk at Goat Rock is mitigated by the presence of a dam at this population. In general, there appears to be a strong need to resurvey most, if not all, Georgia populations.

Table 5-20. Summary of Georgia rockcress population resiliency by representative unit. Excellent and good resilient populations are grouped under 'Resilient'. Extirpated, historical, poor, and fair resilience populations are combined in the 'Other' category.

Representative Unit	**Populations**		**Total**
	Resilient	**Other**	
North Georgia	0	4	*4*
South Georgia	2	2	*4*
Alabama	7	9	*16*
Total	*9*	*15*	*24*

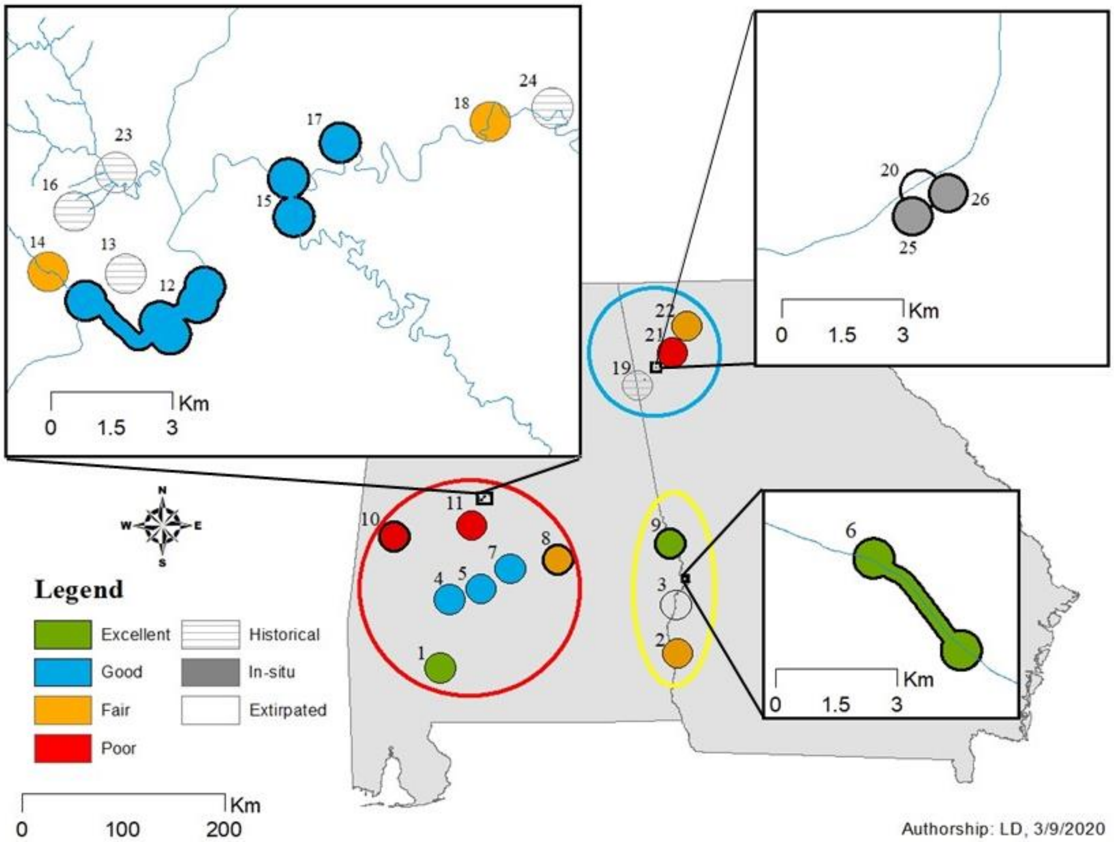

Figure 5-4. Distribution of Georgia rockcress populations in Alabama and Georgia, and their resiliency scores. Populations are buffered to increase visibility. Populations occurring partially or completely on protected lands are bordered in bold. Representative units are indicated by red (lower left circle; Alabama), yellow (lower right oval; South Georgia), or blue (upper right circle; North Georgia) circled areas. Details for population resilience can be found in Tables 5.14 through 5.17.

The Alabama representative unit contains many small historical occurrences, which suggests suitable habitat is available for Georgia rockcress. Searching for populations within and adjacent to the Alabama unit could yield new or rediscovered populations for the Alabama or even the South Georgia unit. Genetic analysis would be needed to determine if new populations are facilitating gene flow between the two representative units within the Southeastern Plain Ecoregion. While the number of historical populations and occurrences in Bibb County is high, these locations could be indicative of naturally small patches of habitat. Where feasible, acquisition or easements at historical locations combined with management could improve connectivity within or between populations (e.g., Fern Glades (15) and Brown's Dam Glades (17); Figure 5-4). Approximately half of the extant populations in the Alabama representative unit are currently resilient. Five of the populations in this unit are on protected lands (three are resilient) (Figure 5-4), but not all of these populations benefit from management actions. The population with the highest resilience occurs on private land (Marshalls Bluff). A conservation easement here would help maintain the unique contribution to redundancy of Marshalls Bluff, given its distance from the Bibb County population cluster. This cluster occurs within the Alabama representative group and is identified in the inset map of Figure 5-4. The potential for conservation and management for the Fort Tombecbee population could also be improved, as the land is owned by University of West Alabama which could be approached as a conservation partner. At minimum, access would likely be granted to collect material for safeguarding. Fort Tombecbee is assumed to be part of the Alabama representative unit but it is not as well connected (e.g., distance, river system) as the other populations that comprise the Alabama group. In general, there appears to be a strong need to resurvey most, if not all, of the populations in Alabama. Some populations initially described by Allison (1999, pg. 2 - 7) could not be relocated in 2015 due to accessibility limitations (Rickard, J. in litt., 2019), even though some of these populations had been assessed recently (Schotz 2010, entire).

6 FUTURE CONDITION

In the previous chapters, we reviewed Georgia rockcress ecological and resource needs (Chapter 2 and 3), factors influencing the historical, current, and future viability of the species (Chapter 4), and the current condition of the species (Chapter 5). We now consider what the species' future conditions are likely to be. We apply our future projections to the concepts of resiliency, representation, and redundancy to describe the future viability of Georgia rockcress.

To assess the future condition of Georgia rockcress populations, we projected the current resilience factors (population size, habitat suitability, degradation, and protection) forward under three scenarios that differ by what type of management is employed and where it occurs (Figure 6-1). All scenarios were projected 20 and 40 years into the future, based on expert input, the lifespan of the species, and time scale at which positive and negative influences on viability operate. More detailed descriptions for each scenario can be found in Section 6.2.

- In Conservation Scenario 1 (Status Quo), management activities are maintained where they occur, and do not increased in frequency, extent, or type.
- In Conservation Scenarios 2 (Focused) and 3 (Expansive), conservation activities increase in scope compared to Status Quo. Note that any future *in situ* conservation effort (reintroductions, introductions and/or augmentations) should be carefully designed, if implemented, to conserve genetic integrity.
    - The Focused Scenario increases the frequency and type of management including augmentation within protected areas, but typically limits these activities to

populations that currently have excellent or good resilience. Reintroductions or introductions will also occur.

- The Expansion Scenario increases the frequency and type of management including augmentation within all protected areas and also expands to certain unprotected private lands. Reintroductions or introductions will occur, as well as surveys for new Georgia rockcress populations.

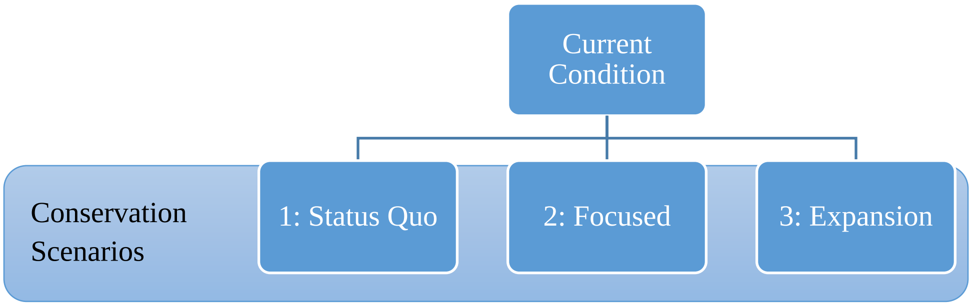

Figure 6-1. Conceptual diagram of the future condition assessment for Georgia rockcress. Resilience factors from the current condition are projected into the future under three management-based scenarios. The resilience factors for a given population may increase, decrease, or remain stable in the future compared to their current condition rank.

6.1 Resilience Factors

The same four factors used to assess current resilience of Georgia rockcress populations were used to assess resilience under three future scenarios. These resilience factors were population size and habitat suitability, degradation, and protection. To project these condition factors into the future, metrics that would change predictably were selected. The metric for projecting population size was consistent with the current condition (number of fertile individuals), but protection focused mainly on land ownership. Habitat suitability focused on assessing changes in canopy extent. Habitat degradation focused on anthropogenic disturbance from urbanization and the associated spread of invasive species. Methods for projecting resilience factors into the future are described below.

6.1.1 Population Size

The future size of Georgia rockcress populations depends on management activities that maintain or improve habitat, as well as augmentation. Habitat conditions include canopy coverage and prevalence of degrading factors at a given population. Change in population size were determined in relation to the current condition, where rankings for this factor ranged from excellent (A), good (B), fair (C) or poor (D) depending on the abundance of reproductive individuals (Section 5.3.1).

Population size is expected to change depending on whether or not a population benefits from or is targeted for management within each respective future scenario. Target and non-target populations are identified in Section 6.2. In general, non-target populations in all scenarios decrease population size by one rank in both the short and long-term projections (Table 6-1). The lack of management at non-target populations is expected to impact habitat conditions (suitability, degradation) that in-turn reduces abundance. Populations benefiting from the continuation of current management practices under the Status Quo scenario will remain in stable condition in the short-term (20-year) projection but decline by one rank in the long-term (40-year) projection which is described further in Section 6.2.1. In both the Focused and Expansion Scenarios, increased conservation and management actions at target populations will continually improve the Georgia rockcress population size through time. The effects of augmentation are variable according to management (or lack thereof) and will be determined for each population on a case-by-case basis. Populations receiving augmentation will be noted within the description of each future scenario.

Table 6-1. Change in Georgia rockcress population size condition rank under a continuation of current conservation effort (Status Quo), or increased effort (Focused and Expansion). Populations that do not benefit from conservation actions are included under 'Non-target Populations'.

Condition Factor	All Scenarios: Non-target Populations		Status Quo Target Populations		Focused and Expansion Target Populations	
	2040	2060	2040	2060	2040	2060
Population size*	Decrease by 1	Decrease by 1	Stable	Decrease by 1	Increase by 1	Increase by 1

* Some populations will be augmented, and rank changes will be determined on a case-by-case basis.

6.1.2 Suitability

The suitability of Georgia rockcress habitat can be altered through canopy conditions that increase or decrease light availability. Light availability can be increased through management (e.g., selective tree removal) or decreased as succession progresses. Light availability and/or canopy condition varies depending on management actions in scenarios, but can either decrease, remain stable, or increase compared to the current condition (Table 6-2). As in the current condition, excellent (A) conditions occur in open to lightly shaded areas created by sparse woods, good (B) conditions consist of partially open canopy in hardwood communities, fair (C) conditions occur within well- developed hardwood forests with filtered light, and poor (D) conditions are found within the dense shade of well- developed mixed hardwood or conifer forest. In the future, canopy and soil moisture could change in response to climate change, succession, or management. However, the degree to which climate change could limit canopy development and exacerbate desiccation of soils is uncertain at present and is not quantitatively assessed here. Non-target populations decrease in rank through time as forest succession occurs and no management occurs to mitigate it. Status Quo management serves to limit the increase in canopy condition but does not halt the progression. Selective tree removal in Conservation Scenarios 1 and 2 increases light availability for Georgia rockcress.

Table 6-2. Change in Georgia rockcress habitat suitability condition rank under a continuation of current conservation effort (Status Quo), or increased effort (Focused and Expansion). Populations that don't benefit from conservation actions are included under 'Non-target Populations'.

Condition Factor	All Scenarios: Non-target Populations		Status Quo Target Populations		Focused and Expansion Target Populations	
	2040	2060	2040	2060	2040	2060
Suitability	Decrease by 1	Decrease by 1	Stable	Decrease by 1	Increase by 1	Increase by 1

6.1.3 Degradation

We examined future loss and degradation of Georgia rockcress habitat by projecting future urbanization. Areas are lost to residential and commercial development through time, in a predicable manner. We used the Slope, Land cover, Exclusion, Urbanization, Transportation, and Hillshade (SLEUTH; Jantz et al. 2010, entire) model to determine areas expected to be urbanized in the future. The SLEUTH model has previously been used to assess probabilities of urbanization across the southeastern United States in 10-year increments, and the resulting GIS data are freely available (Belyea and Terrando 2013, entire). For our future projections, we used the SLEUTH raster data sets from 2040 and 2060 (20 and 40 years into the future), and examined the area expected to be urbanized with 80% or higher probability.

Both critical and buffer habitat are important to Georgia rockcress viability. Buffer habitat serves to minimize edge effects on critical habitat, excluding or greatly slowing the spread of invasive species that outcompete Georgia rockcress. The 2016 National Land Cover Dataset (Dewitz 2019, entire) was used to identify and remove water, planted/cultivated, or developed areas which do not function as critical or buffer habitat for populations, leaving only vegetated area within population boundaries (as defined by the population delineation, Section 5.2). Removing non-vegetated areas resulted in a more accurate depiction of future habitat loss and degradation for Georgia rockcress. We then calculated the proportion of vegetated area within each population that is expected to be urbanized in the future (Table 6-3).

We categorized the percent vegetated habitat loss from urbanization for each population to have a low, moderate, or high risk of development. Development risk is correlated with the risk of invasion and spread of invasive species. Therefore, we developed a future degradation condition rank based on both the expected future development and the current presence of invasive plants:

(1) Minimal Degradation is 0 to 30% vegetated cover loss; invasive plants absent
(2) Low Degradation is 0 to 30% of vegetated cover loss; invasive plants present
(3) Moderate Degradation is 31 to 70% of vegetated cover loss; invasive plants present
(4) High Degradation is 70 to 100% of vegetated cover loss; invasive plants present

Table 6-3. Proportion of Georgia rockcress population area urbanized in 20-year (2040) and 40-year (2060) projections using the SLEUTH model. Degradation condition ranging from minimal to high is listed in parentheses for each population and projection time period.

Population (acres vegetated in 2020)	% Area Urbanized	
	2040	2060
Fort Tombecbee (95)	17 (minimal)	32 (moderate)
Fort Gaines (132)	2 (low)	7 (low)
Goat Rock (244)	0 (low)	5 (low)
Whitmore’s Bluff (160)	9 (low)	12 (low)
Resaca Bluff (48)	15 (low)	78 (high)
Marshalls Bluff (141)	0 (minimal)	0 (minimal)
Creekside Glades (181)	0 (minimal)	0 (minimal)
Limestone Park (111)	0 (minimal)	0 (minimal)
All other populations (824 to 96)	0 (low)	0 (low)

Each population’s future degradation condition was determined generally as follows (Table 6-4):

(1) Minimal Degradation results in negative impacts after 20 years for all non-target populations as well as all populations under Status Quo management. The future condition of targeted populations under the Focused and Expansive Scenarios are not impacted.
(2) Low Degradation results in immediate negative impacts for non-target populations. Target populations under Status Quo management are impacted after 20 years. The future condition of targeted populations under the Focused and Expansive Scenarios are not impacted.
(3) Moderate Degradation results in negative impacts at all populations. Only the most rigorous conservation and management activities under the Focused and Expansive Scenarios mitigate impacts of urbanization for target populations.
(4) High Degradation results in impacts to all populations with impacts being most severe for non-target populations. It is assumed that populations with Moderate and High Degradation in future projections will become invaded by invasive species, if they are not present currently.

Table 6-4. Change in Georgia rockcress degradation condition (increase or decrease in degradation category) under a continuation of current conservation effort (Status Quo), or increased effort (Focused and Expansion). The condition of populations that don't benefit from conservation actions is included under 'Non-target Populations'.

Condition Factor		All Scenarios: Non-target Populations		Status Quo Target Populations		Focused and Expansion Target Populations	
		2040	2060	2040	2060	2040	2060
Degradation	Minimal	Stable	Decrease by 1	Stable	Decrease by 1	Increase by 1	Increase by 1
	Low	Decrease by 1	Decrease by 1	Stable	Decrease by 1	Increase by 1	Increase by 1
	Medium	Decrease by 2	Decrease by 2	Decrease by 1	Decrease by 1	Stable	Stable
	High	Decrease by 3	Decrease by 3	Decrease by 2	Decrease by 2	Decrease by 1	Decrease by 1

6.1.4 Protection

The protection of Georgia rockcress populations could be altered by a change in ownership or the creation and implementation of a management plan. The landscape context (e.g., slope, rocky features) that provides some protection for populations is unlikely to be altered through time. However, private lands could enter into conservation agreements or be acquired through fee-simple purchase. Change in future condition was determined in relation to the current condition, where populations were ranked as excellent (A), good (B), fair (C) or poor (D) as described in Section 5.3.4. Any change in the protection status of a population will be described within the future scenarios. The condition rank will be described for each population that benefits from increased protection. Generally, protection is expected to either increase or remain stable for any given population (Table 6-5).

Table 6-5. Change in Georgia rockcress protection condition under a continuation of current conservation effort (Status Quo), or increased effort (Focused and Expansion). The condition of populations that don't benefit from conservation actions is included under 'Non-target Populations'.

Condition Factor	All Scenarios: Non-target Populations		Status Quo Target Populations		Focused and Expansion Target Populations	
	2040	2060	2040	2060	2040	2060
Protection	Stable		Stable		Increase*	

* For new conservation agreements. The amount increased depends on site conditions.

6.2 Future Resilience

We projected future resilience of Georgia rockcress under three conservation scenarios. In the Status Quo Scenario, management activities are maintained where they occur, and do not increase in frequency, extent, or type. In the Focused and Expansion Scenarios, conservation activities increase in scope compared to Status Quo. The Focused Conservation Scenario increases the frequency and type of management including augmentation within protected areas, but typically limits these activities to populations that currently have excellent or good resilience. Reintroductions or introductions will also occur. The Expansion Scenario increases the frequency and type of management including augmentation within all protected areas and also expands to certain unprotected private lands. Reintroductions or introductions will occur, as well as surveys for new Georgia rockcress populations. A general summary of how the condition of resilience factors will change in the future within each scenario is included in Table 6-6. A summary of scenario inputs for future condition rank increases, decreases, or stability of Georgia rockcress populations in 20 and 40-year projections in included in Table 6-7.

Table 6-6. Summary of change in Georgia rockcress resilience factor rank under a continuation of current conservation effort (Status Quo), or increased effort (Focused and Expansion). The condition of populations that do not benefit from conservation actions is included under 'Non-target Populations'.

Condition Factor		All Scenarios: Non-target Populations		Status Quo Target Populations		Focused and Expansion Target Populations	
		2040	2060	2040	2060	2040	2060
Suitability		Decrease 1	Decrease 1	Stable	Decrease 1	Increase 1	Increase by 1
Protection		Stable		Stable		Increase by 1*	
Population size**		Decrease 1	Decrease 1	Stable	Decrease 1	Increase 1	Increase by 1
Degradation	Minimal	Stable	Decrease 1	Stable	Decrease 1	Increase 1	Increase by 1
	Low	Decrease 1	Decrease 1	Stable	Decrease 1	Increase 1	Increase by 1
	Medium	Decrease 2	Decrease 2	Decrease 1	Decrease 1	Stable	Stable
	High	Decrease 3	Decrease 3	Decrease 2	Decrease 2	Decrease 1	Decrease by 1

* For newly protected populations. Change in rank described in each scenario. ** Some populations will be augmented

Future resilience was calculated as in the current condition, as an average of the resilience factor condition ranks. The highest condition rank that can be assigned is excellent (A), and condition cannot increase above this. Unlike the current condition, condition factors may be projected to decline lower than poor (D), to extirpated (X). Where factors were projected to reach extirpation, the numerical rank for the calculation of resilience would be 0.

In certain instances, populations will be considered extirpated in the future. If the resilience factor of population size is projected to decrease in condition from poor (D) to extirpated (X), then the population is expected to become extirpated regardless of other condition factor ranks. This decision rule reflects the importance of population size and the precarious nature of populations at low abundance. Similarly, if both habitat suitability and degradation are expected to decrease in condition from poor (D) to extirpated (X), then the population is expected to become extirpated as it is very likely no suitable habitat would be remaining. It is unlikely a population could persist under such conditions, so a rank of extirpated would be assigned regardless of other condition factors. Where resilience cannot be assessed, as in the case of newly discovered populations, resilience is listed as extant (E) to indicate the presence of Georgia rockcress of unknown viability.

Table 6-7. Scenario inputs for future condition rank increases (+), decreases (-) and stability (0) for resilience at Georgia rockcress populations in 20 and 40-year projections, with current resilience included as reference. The Status Quo Scenario is denoted as SQ, Focused as F, and Expansion as Ex. Non-target populations are denoted as NT. Projection ranks include excellent (A), good (B), fair (C) or poor (D).

Population	Scenario	Projection (Current / 2040 / 2060)			
		Population Size	Suitability	Degradation	Protection
Goat Rock	SQ	A / 0 / -1	A / 0 / -1	B / 0 / - 1	A / 0 / 0
	F and Ex	A / +1 / +1	A / + 1/ +1	B / + 1/ +1	A / 0 / 0
Fort Benning	S Q	A / 0 / -1	A / 0 / -1	B / 0 / - 1	A / 0 / 0
	F and Ex	A / + 1/ +1	A / + 1/ +1	A / + 1/ +1	A / 0 / 0
Fort Tombecbee	SQ and F	D / -1 /-1	D / -1 / -1	C / 0 / -1	C / 0 / 0
	Ex	D / +1/ +1	D / +1 / +1	C / +1 / +1	C / 0 / 0
Pratts Ferry	SQ	A / -1 / -1	A / -1 / -1	B / -1 / -1	B / 0 / 0
	F and Ex	A / +1/ +1	A / +1/ +1	B / +1 / +1	B / + / 0
Fern Glade	SQ	B / -1 / -1	B / -1 / -1	B / -1 / -1	A / 0 / 0
	F and Ex	B / +1/ +1	B / +1 / +1	B / +1 / +1	A / 0 / 0
Brown’s Dam	SQ and F	C /-1 /-1	C / -1 / -1	A / -1 / -1	A / 0 / 0
	Ex	C /+1/+1	C / +1 / +1	A / +1/ +1	A / 0 / 0
Fort Toulouse	SQ and F	C/-1 /-1	C / -1 / -1	C / -1 / -1	B / 0 / 0
	Ex	C / +1 / +1	C / +1 / +1	C / +1/ +1	B / 0 / 0
Marshalls Bluff	SQ and F	A / -1 / -1	A / -1 / -1	A / 0 / -1	B / 0 / 0
	Ex	A / +1 / +1	A / +1 / +1	A / +1 / +1	A / 0 / 0
Prairie Bluff	SQ and F	A / -1 / -1	A / -1 / -1	A / -1 / -1	B / 0 / 0
	Ex	A / +1 / +1	A / +1 / +1	A / +1 / +1	A / 0 / 0
Portland Landing *	All: NT	B / -1 / -1	B / -1 / -1	B / -1 / -1	C / 0 / 0
Durant Bend *	All: NT	B / -1 / -1	B / -1 / -1	B / -1 / -1	C / 0 / 0
Murphy’s Bluff	All: NT	D / -1 / -1	D / -1 / -1	C / -1 / -1	C / 0 / 0
Creekside Glades	All: NT	C / -1 / -1	B / -1 / -1	C / 0 / -1	C / 0 / 0
Limestone Park	All: NT	C / -1 / -1	C / -1 / -1	B / 0 / -1	C / 0 / 0
Fort Gaines	SQ and F	B / -1 / -1	C / -1 / -1	C / -1 / -1	D / 0 / 0
	Ex	B / +1/ +1	C / +1 / +1	C / +1 / +1	A / 0 / 0
Whitmore Bluff	SQ and F	D /-1 /-1	C / -1 / -1	D / -1 / -1	D / 0 / 0
	Ex	D / +2 / +2	C / +1/ +1	D / +1 / +1	D / +1 / 0
Resaca Bluff *	SQ	A / -1 / -1	C / -1 / -1	D / -1 / -3	D / 0 / 0
	F and Ex	A / +1 / +1	C / -1 / -1	D / -1 / - 3	D / 0 / 0
Discovered or Rediscovered	Ex	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
Introduction/ Reintroduction	F and Ex	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
Black’s Bluff Reintroduction	F and Ex	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0
Black’s Bluff Introduction	F and Ex	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0	0 / 0 / 0

* Alternate targets in the Expansion Scenario

6.2.1 Conservation Scenario 1: Status Quo

In the Status Quo Scenario, conditions were expected to continue along present trajectories. There were no significant increases or decreases in management (e.g., selective tree removal, invasive species control) at Georgia rockcress populations except for populations where there is ongoing planning and momentum building for increased conservation as described in Section 4.4. This built-in capacity includes *in-situ* work (e.g., augmentation), but the effectiveness of this approach has not been verified and so is not projected to increase resilience. The Status Quo scenario does not include activities listed as possible future conservation actions in Section 4.4, such as planning for new acquisition, easements and/or management agreements.

Under the Status Quo Scenario, there are two populations (Goat Rock, Fort. Benning) where management has been ongoing and is anticipated to continue, resulting in improved resilience. In managed populations, conditions remain stable in the short-term (2040 projection) followed by a decline in the long-term (2060 projection) given the potential insufficiency of actions and decline in available resources (e.g., funds, personnel, partnering agencies, etc.). This slow decline represents the limited and experimental nature of current management, as well as the potential decline in available resources. Protection rank is expected to remain stable, as there are no known plans for acquisition or easements. Degradation condition depends on the current ranking of a population, and the development risk category the population falls within for a given time period. The standard future resilience rules and special cases of populations with ongoing conservation momentum are summarized in Table 6-8. The condition factor ranking and population resilience for the Status Quo Scenario are included in (Table 6-9).

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Table 6-8. Status Quo Scenario description, with future resilience rules and special cases outlined for each Georgia rockcress population.

Population	**Future Resilience**
Currently ranked historical or extirpated	No resilience in future, assume that they are truly extirpated.
Currently ranked *in-situ*	No resilience in future, assume all viability of reintroduction and introduction work remains unknown. Black's Bluff Preserve population remains extirpated.
<u>Target Populations:</u> Goat Rock, Ft. Benning Resaca Bluff	Continuation of current management. Low degradation. *Resaca Bluff:* The effect of past population augmentation is unknown, and therefore not projected to have increased population size. Resaca Bluff is therefore treated the same as non-target populations as described below. Degradation at Resaca is low in 20 years but high in 40 years.
<u>Non-target:</u> All other populations	These lands do not enter into conservation agreements nor are they the subject of fee-simple purchase. Lands that are protected are currently not subject to management plans and remain unmanaged. Invasive species and anthropogenic disturbance proceed unabated according to the low degradation projection, except Ft. Tombecbee which increases to moderate degradation in 40 years.

Table 6-9. Condition factors and resilience ranking for 20 and 40-year projections of the Status Quo Scenario. Resilience is an average of the four condition factors (population size, suitability, degradation, protection) for a given time period. Current resilience is included for reference. Projection ranks include excellent (A), good (B), fair (C), poor (D), or extirpated (X).

Population	Currently Protected	Projection (Current / 2040 / 2060)				
		Population Size	Suitability	Degradation	Protection	Resilience
Goat Rock	Yes and No	A / A / B	A/ A / B	B / B / C	A / A / A	**A / A / B**
Fort Benning	Yes	A / A / B	A / A / B	A / A / B	A / A / A	**A / A / B**
Fort Tombecbee	Yes	D / X / X	D / X / X	C / C / D	C / C / C	**D / X / X**
Pratts Ferry	Yes and No	A / B / C	A / B / C	B / C / D	B / B / B	**B / B / C**
Fern Glade	Yes	B / C / D	B / C / D	B / C / D	A / A / A	**B / C / D**
Brown's Dam	Yes	C / D / X	C / D / X	A / B / C	A / A / A	**B / C / X**
Fort Toulouse	Yes	C / D / X	C / D / X	C / D / X	B / B / B	**C / D / X**
Marshalls Bluff	No	A / B / C	A / B / C	A / A / B	B / B / B	**A / B / C**
Prairie Bluff	No	A / B / C	A / B / C	B / C / D	D / D / D	**B / C / D**
Portland Landing	No	B / C / D	B / C / D	B / C / D	C / C / C	**B / C / D**
Durant Bend	No	B / C / D	B / C / D	B / C / D	C / C / C	**B / C / D**
Murphy's Bluff	No	D / X / X	D / X / X	C / D / X	C / C / C	**D / X / X**
Creekside Glades	No	C / D / X	B / C / D	C / C / D	C / C / C	**C / C / X**
Limestone Park	No	C / D / X	C / D / X	B / B / C	C / C / C	**C / C / X**
Fort Gaines	No	B / C / D	C / D / X	C / D / X	D / D / D	**C / D /X**
Whitmore Bluff	No	D / X / X	C / D / X	D / X / X	D / D / D	**D / X / X**
Resaca Bluff	No	A / B / C	C / D / X	D / X / X	D / D / D	**C / D / X**

6.2.2 Conservation Scenario 2: Focused

It would be ideal to devote conservation resources to raise the resilience of populations in all protected lands, but a more moderated approach may be necessary given available resources (e.g., funds, personnel, partnering agencies, etc.). The Focused Conservation Scenario represents a future where conservation and restoration on all protected land is not feasible. This scenario includes current and proposed future actions that benefit the Georgia rockcress, but limits the number of populations that receive these increased efforts and does not include surveying for new populations.

The types of activities that would benefit Georgia rockcress at target populations of the Focused Scenario are described in Section 4.4 (Conservation and Management) and include proposed future actions such as regular invasive species control, selective tree removal, surveying to monitor populations, land acquisition, conservation agreements, population augmentation, and others. In the future, we anticipate protected lands in Alabama will benefit from management through the APCA. The APCA has been approached as a new conservation partner, and after a period of building capacity, should function in a similar manner to the GPCA which already works with the Service to conserve Georgia rockcress in Georgia. This is a vital partnership for both the success of the Focused and the Expansion Scenario. Any reintroductions or introductions would occur on protected lands (e.g., TNC), though the exact locations cannot be known at this time.

Each population occurring entirely or partly in protected land (federal, state, or partner agency) that currently has either excellent (A) or good (B) resilience was projected to initiate management activities in the Focused Scenario, translating to an increase in resilience by one rank every 20 years for most condition factors except for protection. Protected lands not fitting these criteria include Brown's Dam and Fort Toulouse; these protected lands remained as non-target populations. While it is plausible that some populations might take longer or shorter than 20 years to improve with conservation and restoration actions, we chose that rate as a realistic average because restoration actions take time to translate into population benefits, and it is not likely that all managed populations will be restored simultaneously.

The standard future resilience rules and special cases for targeted populations with ongoing conservation momentum are summarized in Table 6-10. For example, it has previously been noted that Goat Rock does not have a conservation agreement in place. Establishing one will help ensure resilience is maintained in the future but will not improve the protection condition. For target populations, augmentation could alter the population size projection for a given population compared to that outlined in Table 6-6. The condition factor ranking and population resilience for the Focused Scenario are included in (Table 6-12)..

Table 6-10. Focused Conservation Scenario description, with future resilience rules and special cases outlined for each Georgia rockcress population.

Population	**Future Resilience**
Currently ranked historical or extirpated	No resilience in future, assume that they are extirpated.
Currently ranked *in-situ*	Contribute to resilience in future. See Black’s Bluff Preserve Introduction and Reintroduction
<u>Targets:</u> Black’s Bluff Introduction and Reintroduction	Habitat management and safeguarding activities establish two populations with good resilience from the one reintroduced and one introduced occurrence in 2020. They have excellent resilience in 2060. Low degradation.
<u>Targets:</u> Goat Rock, Ft. Benning, Pratt’s Ferry, Fern Glade	Expansion of current management at protected lands (federal, state, partner agency). Establish a conservation agreement at Goat Rock. Pratt’s Ferry unprotected land enters into conservation agreement or easement, improving protection condition. Low degradation.
<u>Target:</u> Resaca Bluff	Augmentation continues and increases population size rank by one in both 2040 and 2060. There is no concurrent habitat management to promote larger population increases with augmentation. Augmentation avoids extirpation. Otherwise, treated the same as non-target populations, as described below. Degradation is low in 20 years but high in 40 years.
<u>Non-target:</u> All other populations	These lands do not enter into conservation agreements nor are they the subject of fee-simple purchase. Lands that are protected are currently not subject to management plans and remain so. Low degradation for all populations except Ft. Tombecbee, which increases from minimal to moderate degradation in 40 years.
<u>New populations:</u> Reintroduced/ Introduced	Four new populations in 2040 and two additional new populations by 2060 (extant resilience, location unknown). One additional introduction or reintroduction in North GA with good resilience in 20 years, transitioning to excellent in 40 years. In AL, 3 new introduced or reintroduced populations of good resilience in 2040, transitioning to excellent in 2060. These initiatives would occur on protected lands.

Table 6-11. Condition factors and resilience ranking for 20 and 40-year projections of the Focused Conservation Scenario. Resilience is an average of the four condition factors (population size, suitability, degradation, protection) for a given time period. Current resilience is included for reference. An inability to project condition is indicated by a dash. Projection ranks include excellent (A), good (B), fair (C), poor (D), or extirpated (X).

Population	Currently Protected	Projection (Current / 2040 / 2060)				
		Population Size	Suitability	Degradation	Protection	**Resilience**
Goat Rock	Yes and No	A / A / A	A / A / A	B / A / A	A / A / A	**A / A / A**
Fort Benning	Yes	A / A / A	A / A / A	A / A / A	A / A / A	**A / A / A**
Fort Tombecbee	Yes	D / X / X	D / X / X	C / D / E	C / C / C	**D / X / X**
Pratts Ferry	Yes and No	A / A / A	A / A / A	B / A / A	B / A / A	**B / A / A**
Fern Glade	Yes	B / A / A	B / A / A	B / A / A	A / A / A	**B / A / A**
Brown's Dam	Yes	C / D / X	C / D / X	A / B / C	A / A / A	**B / C / X**
Fort Toulouse	Yes	C / D / X	C / D / X	C / D / X	B / B / B	**C / D / X**
Marshalls Bluff	No	A / B / C	A / B / C	A / A / B	B / B / B	**A / B / C**
Prairie Bluff	No	A / B / C	A / B / C	B / C / D	D / D / D	**B / C / D**
Portland Landing	No	B / C / D	B / C / D	B / C / D	C / C / C	**B / C / D**
Durant Bend	No	B / C / D	B / C / D	B / C / D	C / C / C	**B / C / D**
Murphy's Bluff	No	D / X / X	D / X / X	C / D / X	C / C / C	**D / X / X**
Creekside Glades	No	C / D / X	B / C / D	C / C / D	C / C / C	**C / C / X**
Limestone Park	No	C / D / X	C / D / X	B / B / C	C / C / C	**C / C / X**
Fort Gaines	No	B / C / D	C / D / X	C / D / X	D / D / D	**C / D /X**
Whitmore Bluff	No	D / X / X	C / D / X	D / X / X	D / D / D	**D / X / X**
Resaca Bluff	No	A / A / A	C / D / X	D / X / X	D / D / D	**C / D / D**
Re/Introduction 1	-	-	-	-	-	**- / B / A**
Re/Introduction 2	-	-	-	-	-	**- / B / A**
Re/Introduction 3	-	-	-	-	-	**- / B / A**
Re/Introduction 4	-	-	-	-	-	**- / B / A**
Black's Bluff Reintroduction	-	-	-	-	-	**- / B / A**
Black's Bluff Introduction	-	-	-	-	-	**- / B / A**

6.2.3 Conservation Scenario 3: Expansion

The Expansion Scenario builds upon the increased conservation actions listed in the Focused Scenario, but each population occurring entirely or partly in protected land was projected to benefit from increased management. These protected target populations include Goat Rock, Ft. Benning, Ft. Tombecbee, Pratt's Ferry, Fern Glade, Brown's Dam, and Fort Toulouse. These targeted populations experience an increase in resilience by one rank for each condition factor every 20 years. In addition, certain unprotected private lands were targeted for conservation agreements (Whitmore Bluff, Marshall's Bluff, Prairie Bluff, Fort Gaines), and surveying for new populations was incorporated. The goal for selecting unprotected lands for conservation agreements was to increase redundancy within the three representative units (Alabama, North Georgia, and South Georgia). A representative unit does not exhibit redundancy unless there are at least two resilient populations present. Our goal was to maintain at least three resilient populations in each representative unit in the future, so that redundancy would remain if one population was lost to a catastrophic event in a given unit.

The Alabama representative unit contains several options for establishing conservation agreements with landowners, while the options in North and South Georgia are limited. In the Alabama unit, we aimed to establish two newly protected populations. Primary candidates for this initiative were Marshall's Bluff and Prairie Bluff, as they have the best resilience of all unprotected lands in the Alabama unit at present. If agreements at these populations are not possible, then Portland Landing and Durant Bend are secondary candidates. The current resilience of a population was not a factor in identifying candidate populations for conservation agreements in North and South Georgia, given the lack of populations in these representative units. We identified Whitmore's Bluff as a primary candidate for a conservation agreement in the North Georgia unit. If this population cannot be protected, then Resaca Bluff is the secondary candidate for the unit given that Black's Bluff is already protected, and Cave Spring is a historical record. The Goat Rock population in South Georgia is largely considered protected at present due to the partnership with GP although the establishment of conservation agreement there would help ensure long-term conservation at this site. The Fort Benning population is already protected, and the Omaha population is extirpated. Therefore, the only option for adding a newly protected population in South Georgia is Fort Gaines, so it is our sole candidate for the unit.

We projected future resilience assuming conservation agreements were obtained at all primary targets. We assume that secondary candidates will function to ensure that in general, two additional resilient populations become protected in the Alabama representative unit, and one additional population becomes protected and eventually achieves resilience in both the North and South Georgia units for a total of at least three resilient population in each unit. It is important to note that there is no secondary target in South Georgia, so reaching the redundancy goal in this unit may not happen within the timeframe expected or at all.

The rate of discovery of new Georgia rockcress occurrences during surveys could be high, especially in regions that have not been surveyed previously. Allison 1999 (p. 2 – 5) discovered or rediscovered 18 small occurrences (approximately 5 plants each) in Bibb County, Alabama, in one year with an uncertain search effort and success rate, while subsequent surveying found one new Alabama occurrence out of 28 sites that were searched (four percent success rate; Schotz 2010, p. 7). Populations could be rediscovered within the known range, or new populations could be found between the Alabama and South Georgia representative units where surveying has been incidental in the past. Recently (2019) surveys along the Cahaba River in Bibb County, Alabama have reported new populations of Georgia rockcress may be present (Keener in litt. 2019), however additional information is needed to confirm this report. As a conservative estimate, we anticipate at least one extensive survey of historical populations and potential habitat in each time period (2020 to 2040, and 2040 to 2060), and projected the discovery or rediscovery of four populations in the 20-year projection, with two more in 40 years.

The standard future resilience rules and special cases of populations with ongoing conservation momentum are summarized in Table 6-12. Augmentation could alter the population size projection for a given population compared to that outlined in Table 6-6. Protection condition typically did not change for most populations. The general future resilience rules and special cases of populations with expanded conservation are summarized in Table 6-12. The condition factor ranking and population resilience for the Status Quo Scenario are included in (Table 6-13). It should be noted that Fort Tombecbee may already be extirpated. Allison (2019 in litt) and Keener (in litt. 2019) searched for Georgia rockcress at this site in 2018 and were unable to locate any plants. It is also possible that this population may have been Arabis patens (Keener in litt. 2019). Immediate attention will be needed at this population to collect seed for any chance of increasing resilience in the future.

Table 6-12. Expansion Conservation Scenario description, with future resilience rules and special cases outlined for each Georgia rockcress population.

Population	Future Resilience
Currently ranked historical or extirpated	No resilience in future, assume that they are truly extirpated.
Currently ranked *in-situ*	Contribute to resilience in future. See Black's Bluff Introduction and Reintroduction
Targets: Black's Bluff Introduction, Black's Bluff Reintroduction	Habitat management and safe-guarding activities establish two populations with good resilience in 20 years from the one reintroduced and one introduced occurrence. These populations have excellent resilience in 40 years.
Targets: Goat Rock, Ft. Benning, Ft. Tombecbee, Pratt's Ferry, Fern Glade, Brown's Dam, Fort Toulouse, Whitmore Bluff Marshall's Bluff, Prairie Bluff, Fort Gaines	Increase of current management (e.g. limit canopy closure and spread of invasive plants). Establish a conservation agreement at Goat Rock, Marshall's Bluff, Prairie Bluff, and Fort Gaines. Marshall's Bluff remains in excellent protection condition, Prairie Bluff and Fort Gaines increase to moderate. The large portion of unprotected land (28 acres) at Pratt's Ferry, as well as the Whitmore Bluff population enter into conservation agreements, improving protection condition. Initiative management (e.g. limit canopy closure and spread of invasive plants) at newly protected populations. Augmentation increases population size by two ranks in each time period for Whitmore Bluff. Low degradation for all populations, except Ft. Tombecbee which increases from minimal to moderate degradation in 40 years. Immediate attention will be needed at Fort Tombecbee to collect seed for any chance of increasing resilience.
Target: Resaca Bluff	Augmentation continues and increases population size rank by one in both 2040 and 2060. There is no concurrent habitat management to promote larger population increases with augmentation. Augmentation avoids extirpation. Otherwise, treated the same as non-target populations, as described below. Degradation is low in 20 years but high in 40 years.
New populations: Rediscovered / Discovered, Reintroduced /Introduced	Four new populations in 2040 and also two in 2060 (extant resilience, location unknown). One additional introduction or reintroduction in North GA with good resilience in 20 years, transitioning to excellent in 40 years. In AL, 3 new introduced or reintroduced populations of good resilience in 2040, transitioning to excellent in 2060. These initiatives would occur on protected lands.
Non-target: All other populations	These lands do not enter into conservation agreements nor are they the subject of fee-simple purchase. Lands that are protected are currently not subject to management plans and remain so. Low degradation for all populations.

Table 6-13. Condition factors and resilience ranking for 20 and 40-year projections of the Expansion Conservation Scenario. Resilience is an average of the four condition factors (population size, suitability, degradation, protection) for a given time period. Current resilience is included for reference. An inability to project condition is indicated by a dash. Projection ranks include excellent (A), good (B), fair (C), poor (D), extant (E), or extirpated (X).

Population	Currently Protected	Projection (Current / 2040 / 2060)				
		Population Size	Suitability	Degradation	Protection	Resilience
Goat Rock	Yes and No	A / A / A	A / A / A	B / A / A	A / A / A	**A / A / A**
Fort Benning	Yes	A / A / A	A / A / A	A /A / A	A / A / A	**A / A / A**
Fort Tombecbee	Yes	D / C / B	D / C / B	C / B / B	C / B / B	**D / C / B**
Pratts Ferry	Yes and No	A / A / A	A / A / A	B / A / A	B / A / A	**B / A / A**
Fern Glade	Yes	B / A / A	B / A / A	B / A / A	A / A / A	**B / A / A**
Brown’s Dam	Yes	C / B / A	C / B / A	A / A / A	A / A / A	**B / B / A**
Fort Toulouse	Yes	C / B / A	C / B / A	C / B / A	B / B / B	**C/ B / A**
Marshalls Bluff	No	A / A / A	A / A / A	A / A /A	B / A / A	**A / A / A**
Prairie Bluff	No	A / A / A	A / A / A	B / A / A	D / C / C	**B / B / B**
Portland Landing	No	B / C / D	B / C / D	B / C / D	C / C / C	**B / C / D**
Durant Bend	No	B / C / D	B / C / D	B / C / D	C / C / C	**B / C / D**
Murphy’s Bluff	No	D / X / X	D / X / X	C / D / X	C / C / C	**D / X / X**
Creekside Glades	No	C / D / X	B / C / D	C / C / D	C / C/ C	**C / C / X**
Limestone Park	No	C / D / X	C / D / X	B / B / C	C / C / C	**C / C / X**
Fort Gaines	No	B / A / A	C / B / A	C / B / A	D / C / C	**C / B / B**
Whitmore Bluff	No	D / B / A	C / B / A	D / C / B	D / C / C	**D / C / B**
Resaca Bluff	No	A / A / A	C / D / X	D / X / X	D / D / D	**C / D / D**
Re/Discovered 1	-	-	-	-	-	**- / - / E**
Re/Discovered 2	-	-	-	-	-	**- / - / E**
Re/Discovered 3	-	-	-	-	-	**- / E / E**
Re/Discovered 4	-	-	-	-	-	**- / E / E**
Re/Discovered 5	-	-	-	-	-	**- / E / E**
Re/Discovered 6	-	-	-	-	-	**- / E / E**
Re/Introduction 1	-	-	-	-	-	**- / B / A**
Re/Introduction 2	-	-	-	-	-	**- / B / A**
Re/Introduction 3	-	-	-	-	-	**- / B / A**
Re/Introduction 4	-	-	-	-	-	**- / B / A**
Black’s Bluff Reintroduction	-	-	-	-	-	**- / B / A**
Black’s Bluff Introduction	-	-	-	-	-	**- / B / A**

6.2.4 Resilience Summary

We assessed the change in resiliency for Georgia rockcress populations, projecting the current condition forward 20 and 40 years under scenarios representing possible future conditions. Future resilience incorporated estimates of population size, and habitat suitability, degradation, and protection condition. Resilience can be altered through conservation and management, which may vary in scope in the future. This variation in frequency, extent, or type of conservation and management is represented by three future scenarios under which resilience was assessed: Status Quo, where these was no significant increases or decreases in management, and two conservation scenarios with increased management that varied in which populations were targeted and the incorporation of surveying for new populations (Table 6-14).

The trajectory of population resilience expected for non-target populations within each scenario declines, leading to overall reduction in the number of extant populations. Increased conservation scenarios (Focused and Expansion) led to improvements in the number of extant populations as well as those with good or excellent resilience in 2040 (hereafter referred to as resilient). Further gains of resilient populations are minimal by 2060 in the Focused and Expansion Scenarios (Table 6-15; Figure 6-2). However, the Status Quo Scenario leads to a decrease in the number of resilient populations over time as current conservation momentum is limited or experimental. Only two populations receive the benefits of management currently (Table 6-8), so the spread of invasive species and canopy closure was anticipated to continue unabated at most populations.

These resilience trends are based on the assumption that populations currently ranked historic (H) or extirpated (X) are extirpated and do not regain resilience in the future. For comparison purposes, this assumption was made. It is possible that some of the new populations in the Expansion Scenario are rediscovered historical populations, but the number of populations we anticipate adding are based primarily on surveying potential habitat not previously known to have been occupied by Georgia rockcress. It is possible that populations might regain resilience, either because they had simply been missed in surveys despite persisting or regrew from a seed bank. If this happens, the number of extant populations would be higher than those expected here, but resilience for those populations will likely remain low without significant conservation action. We also grouped extant (E), poor (P), and fair (C) populations together in our discussion as populations that lack resilience. Populations ranked as extant might be subject to management in the future that would result in excellent or good resilience, but we did not assume this.

Table 6-14. Resiliency for each Georgia rockcress population projected 20 and 40-years into the future under three future management-based scenarios. Resilience ranks include excellent (A), good (B), fair (C), poor (D), extant (E), or extirpated (X).

Population	Representative Unit	Resilience by Scenario and Time Period (Current / 20 / 40 yr)		
		Status Quo	Focused	Expansion
Goat Rock	South Georgia	**A / A / B**	**A / A / A**	**A / A / A**
Fort Benning	South Georgia	**A / A / B**	**A / A / A**	**A / A / A**
Fort Tombecbee	Alabama	**D / X / X**	**D / X / X**	**D / C / B**
Pratts Ferry	Alabama	**B / B / C**	**B / A / A**	**B / A / A**
Fern Glade	Alabama	**B / C / D**	**B / A / A**	**B / A / A**
Brown's Dam	Alabama	**B / C / X**	**B / C / X**	**B / B / A**
Fort Toulouse	Alabama	**C / D / X**	**C / D / X**	**C/ B / A**
Marshalls Bluff	Alabama	**A / B / C**	**A / B / C**	**A / A / A**
Prairie Bluff	Alabama	**B / C / D**	**B / C / D**	**B / B /B**
Portland Landing	Alabama	**B / C / D**	**B / C / D**	**B / C / D**
Durant Bend	Alabama	**B / C / D**	**B / C / D**	**B / C / D**
Murphy's Bluff	Alabama	**D / X / X**	**D / X / X**	**D / X / X**
Creekside Glades	Alabama	**C / C / X**	**C / C / X**	**C / C / X**
Limestone Park	Alabama	**C / C / X**	**C / C / X**	**C / C / X**
Fort Gaines	South Georgia	**C / D /X**	**C / D /X**	**C / B / B**
Whitmore Bluff	North Georgia	**D / X / X**	**D / X / X**	**D / C / B**
Resaca Bluff	North Georgia	**C / D / X**	**C / D / D**	**C / D / D**
Re/Discovered 1	-	-	-	**- / - / E**
Re/Discovered 2	-	-	-	**- / - / E**
Re/Discovered 3	-	-	-	**- / E / E**
Re/Discovered 4	-	-	-	**- / E / E**
Re/Discovered 5	-	-	-	**- / E / E**
Re/Discovered 6	-	-	-	**- / E / E**
Re/Introduction 1	North Georgia	-	**- / B / A**	**- / B / A**
Re/Introduction 2	Alabama	-	**- / B / A**	**- / B / A**
Re/Introduction 3	Alabama	-	**- / B / A**	**- / B / A**
Re/Introduction 4	Alabama	-	**- / B / A**	**- / B / A**
Black's Bluff Reintroduction	North Georgia	-	**- / B / A**	**- / B / A**
Black's Bluff Introduction	North Georgia	-	**- / B / A**	**- / B / A**

Table 6-15. Summary of future resiliency for Georgia rockcress populations in 20 and 40-year projections under three future scenarios.

Resilience Rank	Current	Scenario and Projected Number of Populations (2040 / 2060)		
		Status Quo	Focused	Expansion
Excellent (A)	3	2 / 0	4 / 10	5 / 13
Good (B)	6	2 / 2	7 / 0	10 / 4
Sub-total (resilient)	**9**	**4 / 2**	**11 / 10**	**15 / 17**
Fair (C)	5	7 / 2	6 / 1	6 / 0
Poor (D)	3	3 / 4	3 / 4	1 / 3
Extant (E)	0	0 / 0	0 / 0	4 / 6
Sub-total (not resilient)	**8**	**10 / 6**	**9/ 5**	**11 / 9**
Extirpated (X)	7	10 / 16	10 / 15	8 / 10
Grand Total	**24**	**24 / 24**	**30 / 30**	**34 / 36**

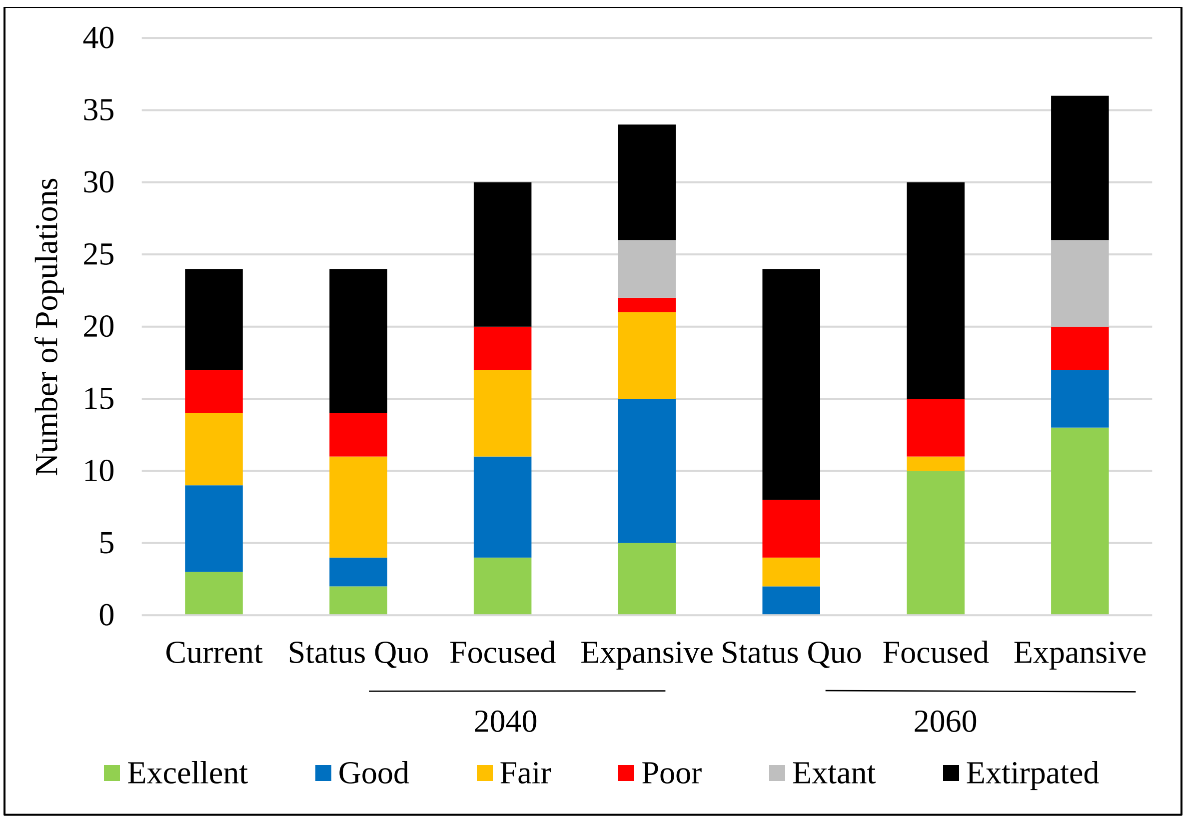

Figure 6-2. Current and expected future resilience in 20 and 40 years under three scenarios.

Conservation Scenario 1: Status Quo

Maintaining the current level of management and conservation in an effort to offset habitat degradation and canopy closure resulted the extirpation of three populations by 2040 and six in 2060 (Table 6-15; Figure 6-2). Of nine currently resilient populations, only four are expected to be resilient by 2040, and only two will remain so in 2060. Of 24 known populations, 20 populations will be either not resilient or extirpated by 2040 and 22 will be either not resilient or extirpated by 2060. Three populations change from fair (C) to extirpated between 2040 and 2060, as their current population size made persistence unlikely (Table 6-9). Over half (16 of 24; 67 percent) of the populations are extirpated in the 2060 projection. Extirpated populations occur on private lands subject to canopy closure and/or the spread of invasive species, and on protected state lands that do not utilize management to limit the impacts of these threats.

Conservation Scenario 2: Focused

Increasing land protection and increasing habitat management practices within protected lands that were resilient in the current condition, as well as establishing and improving populations led to a slight increase in the number of resilient populations of Georgia rockcress (Table 6-15; Figure 6-2). There are 30 populations in the Focused Scenario, which is increased from current conditions by introduced populations. The increase in resilience in this scenario is largely attributed to safeguarding combined with management at reintroduced and introduced sites. In 2060, half (50 percent) of the populations are extirpated, with these losses occurring on unprotected private lands subject to forest succession and/or the spread of invasive species. This is one less extirpated population compared to the Status Quo Scenario. Relocating or establishing new populations on protected lands could be especially useful for preserving the adaptive capacity of a population on private land where conservation agreements are not feasible. However, the number of resilient populations under the Focused Scenario (11 in 2040, 10 in 2060) is not much improved compared to the current condition (n = 9). With the conservation effort described in this scenario, recovery of the species beyond ten resilient populations does not seem possible.

Conservation Scenario 3: Expansion

The Expansion Scenario has great recovery potential for Georgia rockcress. The Expansion Scenario builds upon the Focused Scenario to include conservation and management on all protected lands and certain unprotected private lands, as well as searching for new or historical populations. The total number of populations increased to 34 in 2040 and 36 in 2060 as surveys encounter Georgia rockcress in previously unoccupied or new habitats. With increased management at protected lands, resilient populations increase from nine currently, to 15 in 2040 and 17 in 2060 (Table 6-15; Figure 6-2). This increase in resilience does not include any new populations discovered or rediscovered during surveys, but it is based on successful introductions and reintroductions. It is likely that some new populations could be resilient at the time of discovery. Any management action to improve resilience at new populations would be dependent on the land ownership. It's likely that state, federal, or partner agency lands would be surveyed initially, to ensure the ability to protect a population once it is encountered. We also estimate that the number of populations likely to be discovered is conservative. Populations still become extirpated in this scenario, but this is limited to a total of eight by 2040 and ten by 2060. In 2060, 27 percent of populations are extirpated with these losses occurring on unprotected private lands subject to forest succession and/or the spread of invasive species. It should be noted that Fort Tombecbee is dependent on immediate action to collect seed for the population to recover resiliency as projected. It is possible that the population is already extirpated. Otherwise, this population will likely require augmentation. This site is currently protected as state land would likely be a good site for an introduction from another population in the Alabama representative unit if the original is or becomes extirpated. We project the current population into the future with the understanding that the time it would take to increase resilience at this location would be similar regardless of the approach taken to establish a resilient population (augmentation vs. introduction vs. reintroduction).

6.3 Future Redundancy and Representation

Redundancy for Georgia rockcress is inherently low due to limited habitat availability across its narrow historical range but could be maintained or even improved in the future. The number of extant (i.e., any rank other than X) populations is expected to either decrease, increase temporarily, or increase reliably depending on scenario (Table 6-15, Figure 6-2). Under the Status Quo Scenario, the number of extant populations is expected to decline to 14 in 20 years, and eight in 40 years. In the Focused Scenario, the number of extant populations is expected to initially increase to 20 in 20 years, then decline to 15 in 40 years. The narrow focus of this scenario ensures the persistence of only a small number of populations as threats continue unabated through time. In the Expansion Scenario, the number of extant populations stabilizes at 26 in 20 and 40 years. Across all scenarios, populations that did not receive the benefits of conservation actions became extirpated.

While redundancy of extant populations is expected to decline under all but the Expansion Scenario, redundancy of resilient populations is predicted to stabilize or increase under both increased conservation scenarios. In the Status Quo Scenario, current conservation efforts may not be enough to limit impacts to populations; resilient populations are expected to decrease from 9 currently to 4 in 20 years and 2 in 40 years. In the Focused Scenario there will be 11 and 10 populations with high resilience in 20 and 40 years, respectively. In the Expansion Scenario, there will be 15 and 17 resilient populations in 20 and 40 years.

Table 6-16. Georgia rockcress population resiliency for the Alabama, North Georgia, and South Georgia representation units under three scenarios of Status Quo (SQ), Focused (F), and Expansion (E) in 2040 and 2060. The locations of discovered populations ranked as having extant resilience are not spatially explicit and could not be assigned to a representative unit.

Resilience Rank	Scenario	Representative Unit and Projection (2040 / 2060)		
		Alabama	North Georgia	South Georgia
Excellent (A)	Current	1	0	2
	SQ	0 / 0	0 / 0	0 / 0
	F	2 / 5	0 / 3	2 / 2
	E	3 / 8	0 / 3	2 / 2
Good (B)	Current	6	0	0
	SQ	2 / 0	0 / 0	0 / 2
	F	4 / 0	3 / 0	0 / 0
	E	6 / 2	3 / 1	1 / 1
Fair (C)	Current	3	1	1
	SQ	7 / 2	0 / 0	0 / 0
	F	6 / 1	0 / 0	0 / 0
	E	5/ 0	1 / 0	0 / 0
Poor (D)	Current	2	1	0
	SQ	1 / 4	1 / 0	1 / 0
	F	1 / 3	1 / 0	1 / 0
	E	0 / 2	1 / 1	0 / 0
Extirpated (X)	Current	4	2	1
	SQ	6 / 10	3 / 4	1 / 2
	F	6 / 10	3 / 4	1 / 2
	E	4/ 7	0 / 0	0 / 0

Representation is expected to be greatly impacted under a continuation of current conservation and management. In the Status Quo Scenario, populations predicted to have high resilience (excellent or good category) in the future are concentrated in the southern portion of the species' range in 2040 and restricted to the South Georgia representative unit by 2060 (Table 6-16; Figure 6-3). While it is true that no scenario led to the resilience of unprotected private populations, the Status Quo Scenario also does not ensure the persistence of Georgia rockcress at target populations that benefit from some management. Within the Status Quo there is a severe loss of representation and resilience, with a trend towards extinction. However, increased conservation scenarios suggest that this trend can be stabilized or reversed depending on the approach taken.

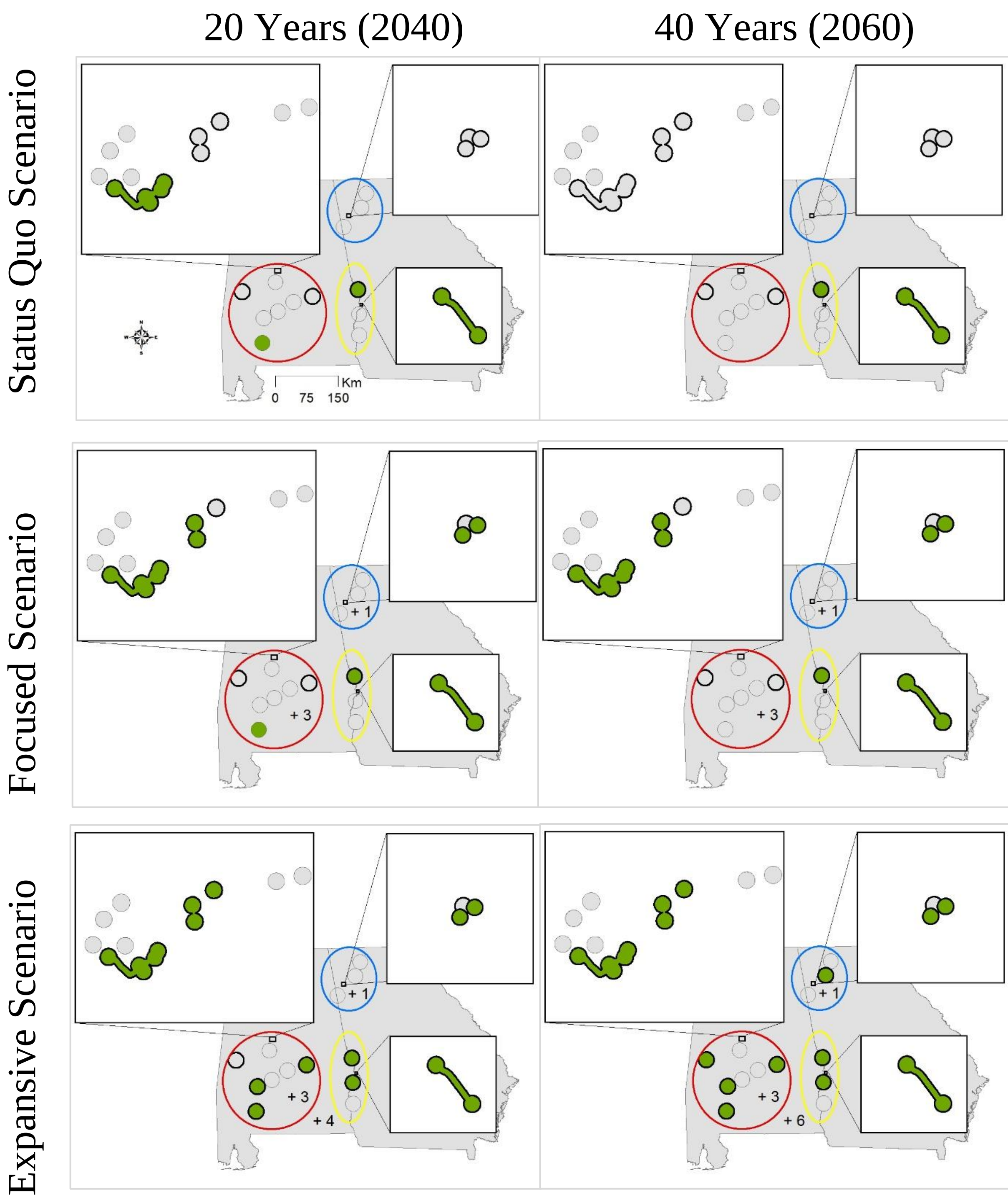

Figure 6-3. Spatial distribution of populations with good or excellent resilience (green) based on conservation scenarios. Populations are buffered to increase visibility. Populations on protected lands are bordered in bold. Representative units are indicated by the red (lower left circle; Alabama), yellow (lower right oval; South Georgia), and blue (upper right circle; North Georgia) circled areas. New populations are indicated only by cumulative number; those outside of a representative unit are discoveries (extant resilience only).

Within the increased conservation scenarios, there are new populations added that increase both redundancy and representation. It is expected that safeguarding activities will broaden in scope, moving from augmentation, reintroductions, and introductions with unknown viability to establishing self-sufficient populations at locations such as Black's Bluff. The success of safeguarding in the future may depends on pairing these activities with regular management. We expect that one more reintroduction or introduction would occur in the North Georgia representative unit, indicated by a + 1 in Figure 6-3. It is likely that this work would involve Whitmore's Bluff seed to either bolster the existing population or establish a safeguarding site that could develop into a population. The historical Cave Spring occurrence could be a good target, as some degree of protection could be achieved through partnership with the city; experts suggest the fenced area surrounding the spring could be investigated for introduction suitability. Similar safeguarding in Alabama may be achieved through partnership with the APCA A successful partnership is indicated by an additional three populations (+ 3; Figure 6-3) within the Alabama representative unit, providing safeguarding for unprotected privately-owned populations that may not persist in the future. The Expansion Scenario contains four new populations that may be discovered or rediscovered by 2040, with an additional two that could be found with follow-ups surveys, for a total of six in 2060. It is uncertain where these populations will be found, and so they are not included with any representative unit. Newly discovered populations are likely to be associated with the area between the Alabama and South Georgia representative unit based on expert opinion (Schotz in litt. 2019). The populations found through surveying will have both unknown location and resilience, and so are simply included as extant (E) in Table 6-15, and are not found within the representation summary (Table 6-16).

The loss of resilient populations within representative units in the Status Quo Scenario indicates a potential decline in the species' adaptive capacity that can be offset through increased conservation and management. Under the Status Quo there is a great loss of resilient populations from representative units resulting in a loss of species level adaptive capacity. Given the reductions in resiliency and the extirpation of populations at 2040 and 2060, the species' representation is predicted to be greatly reduced from current levels in this scenario. However, these losses are offset under the Focused Scenario where resilient populations are maintained in all representative units, with the Expansion Scenario maintaining or increasing representation in all units with the potential to expand the species range.

Viability for the species in the future will depend on increased conservation actions to combat the declining trend for the species. This SSA will follow the species through its life cycle under the Act, through recovery planning, consultations, and all policy-related decision-making until recovery and eventual delisting. This SSA will be updated as new information becomes available, including but not limited to information about seedbank viability, responses of the species to fires and other disturbances, the efficacy of population augmentation and introductions, and updating future scenario projections.

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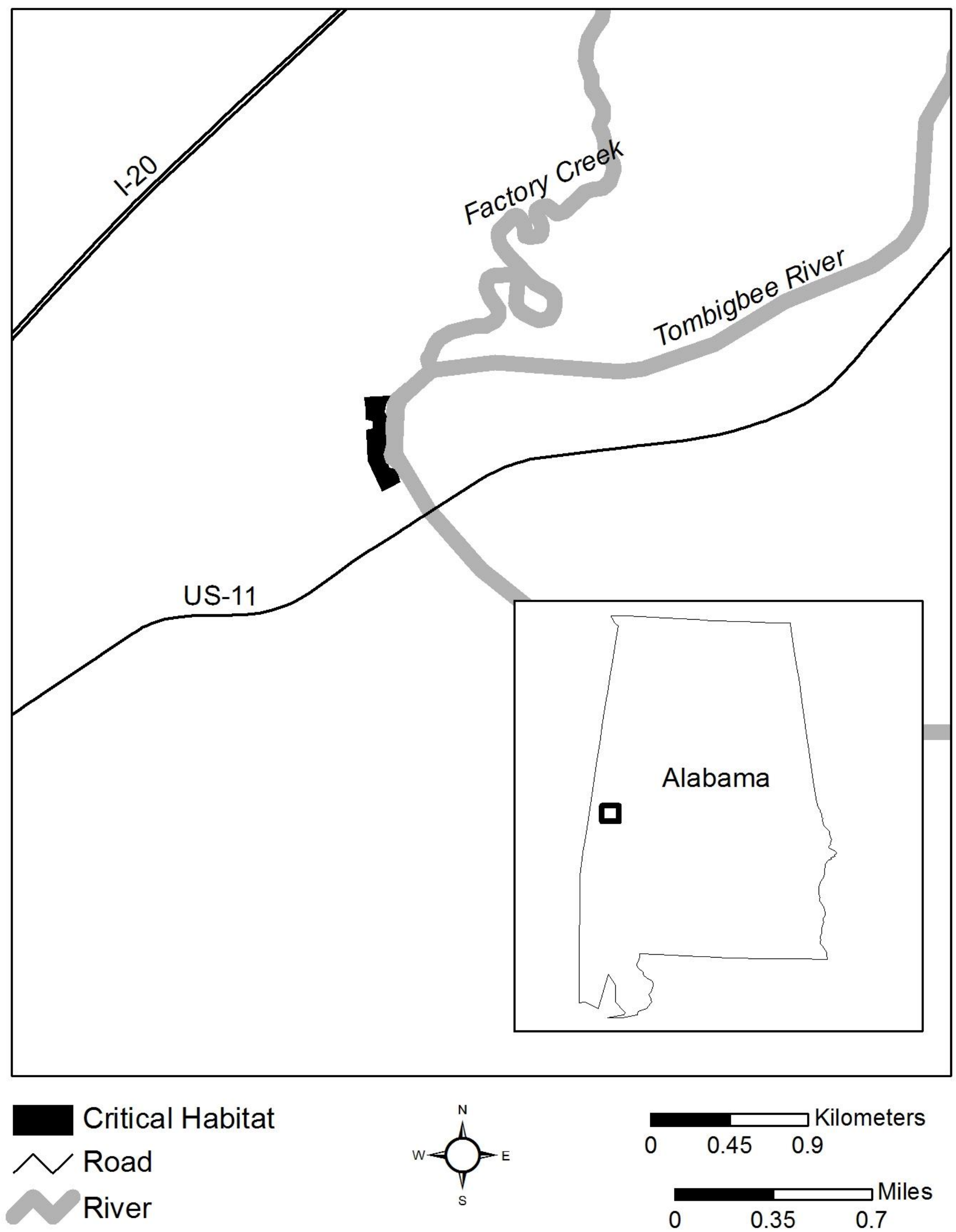
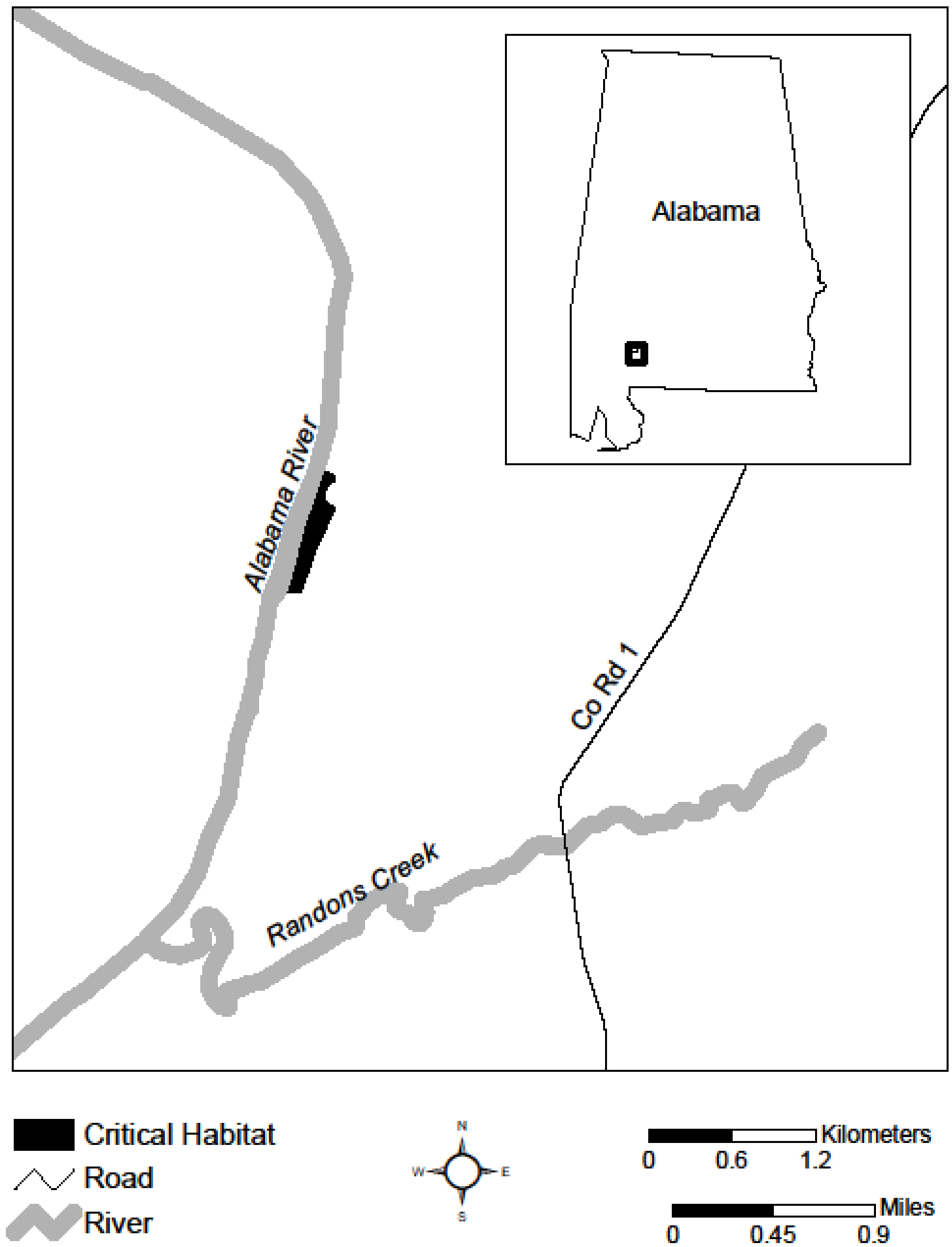
APPENDIX A – Critical Habitat Units for Georgia Rockcress (79 FR 54635).

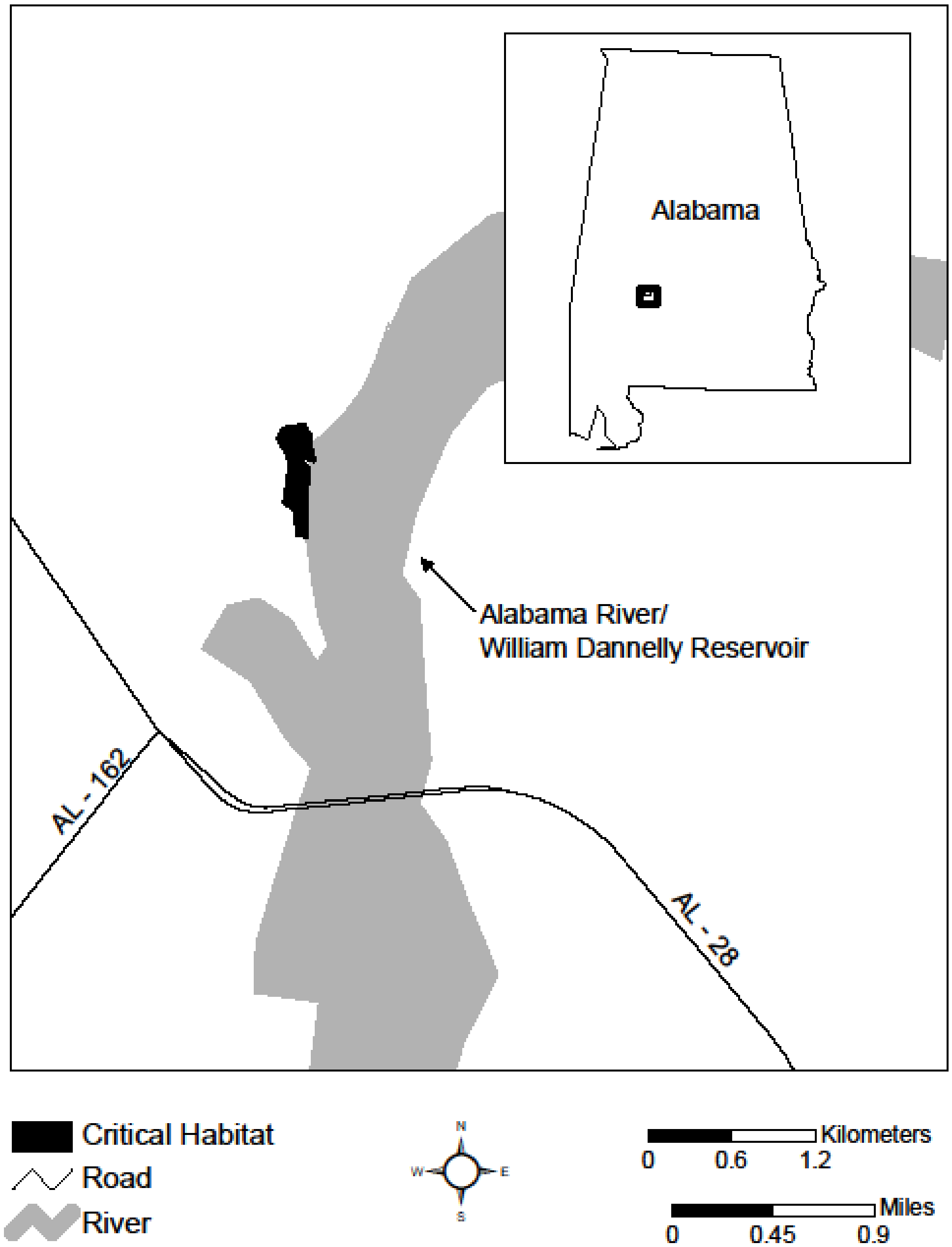
Unit 1: Fort Tombecbee
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Sumter County, AL



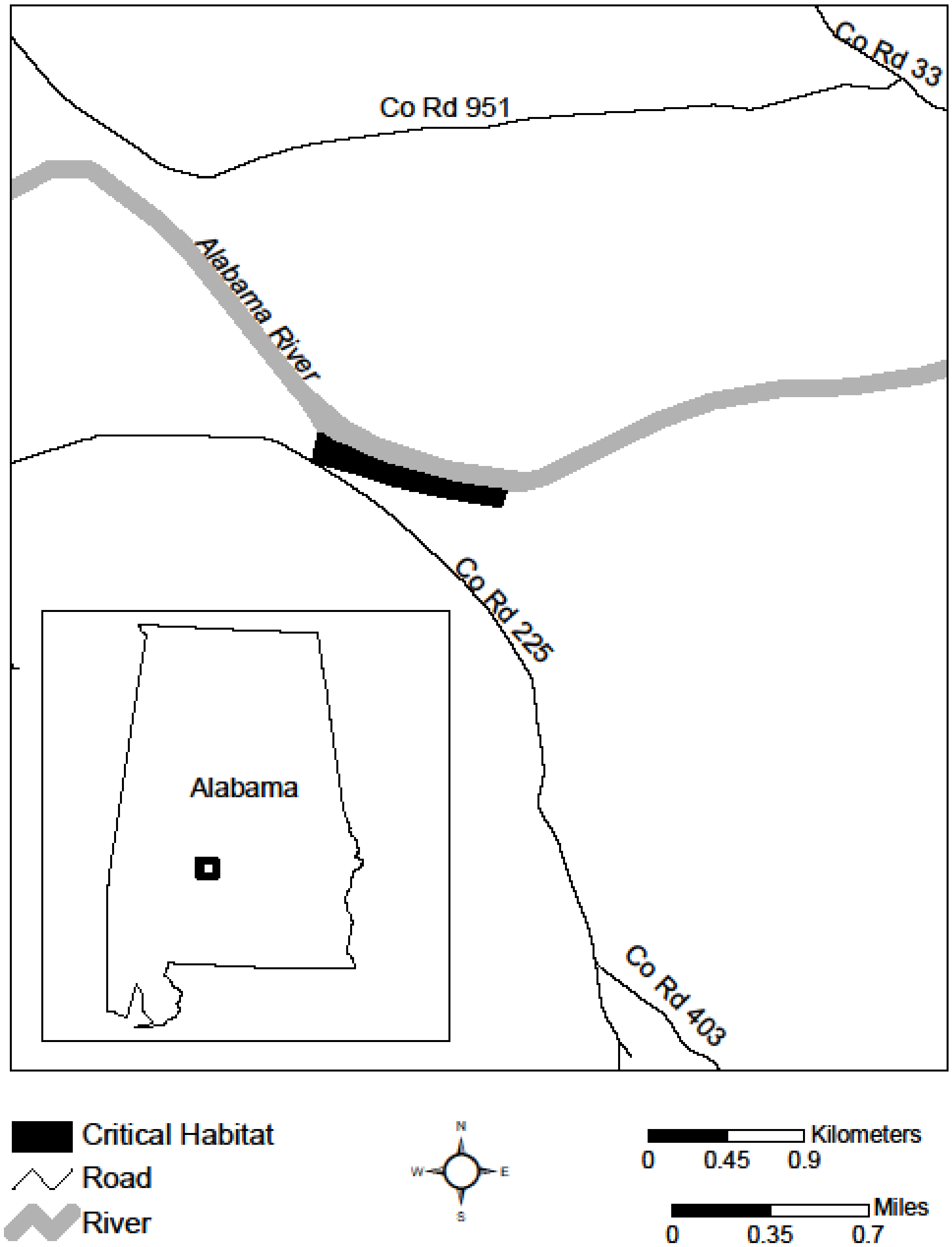
Unit 2: Marshalls Bluff
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Monroe County, AL



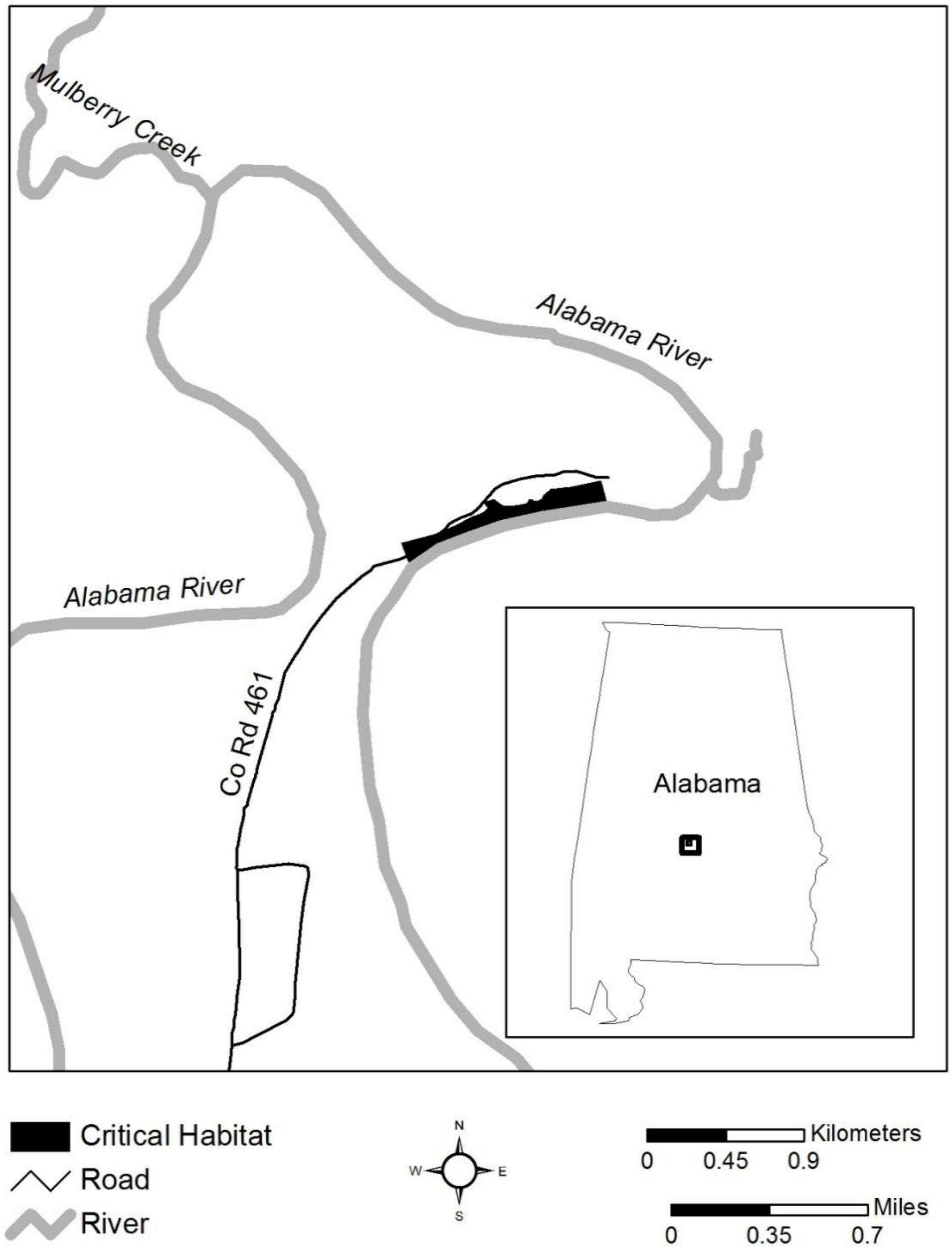
Unit 3: Prairie Bluff
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Wilcox County, AL



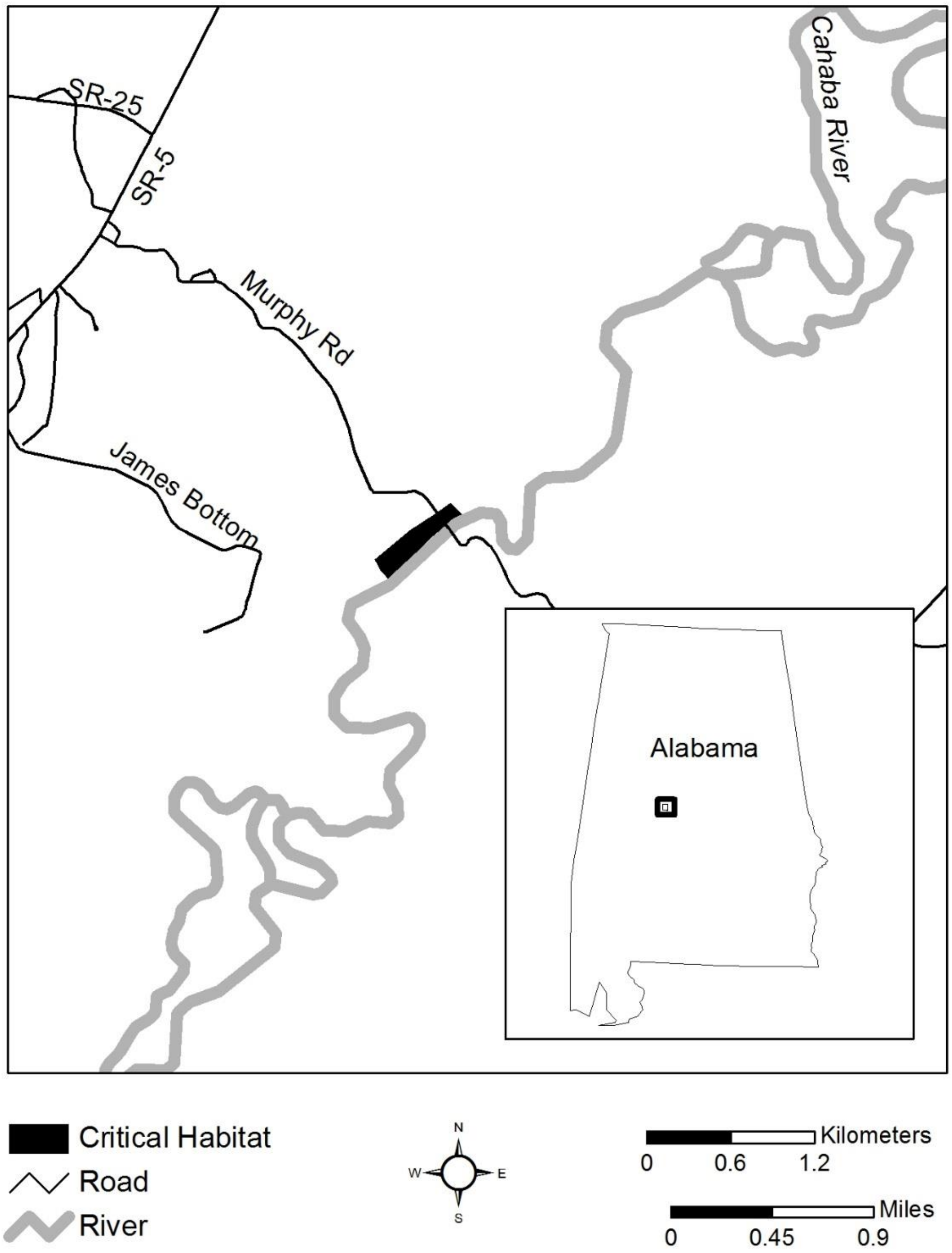
Unit 4: Portland Landing River Slopes
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Dallas County, AL



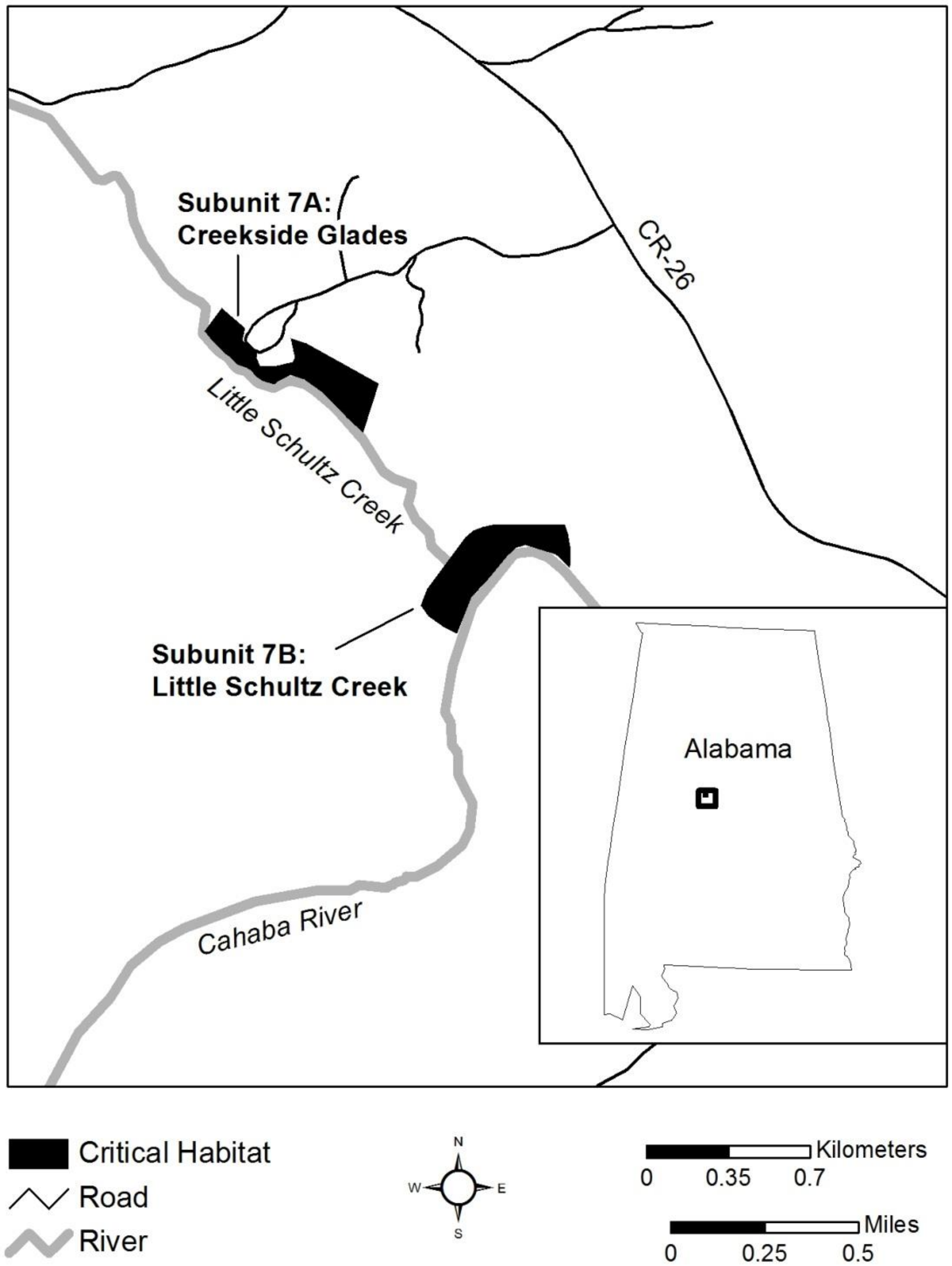
Unit 5: Durant Bend
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Dallas County, AL



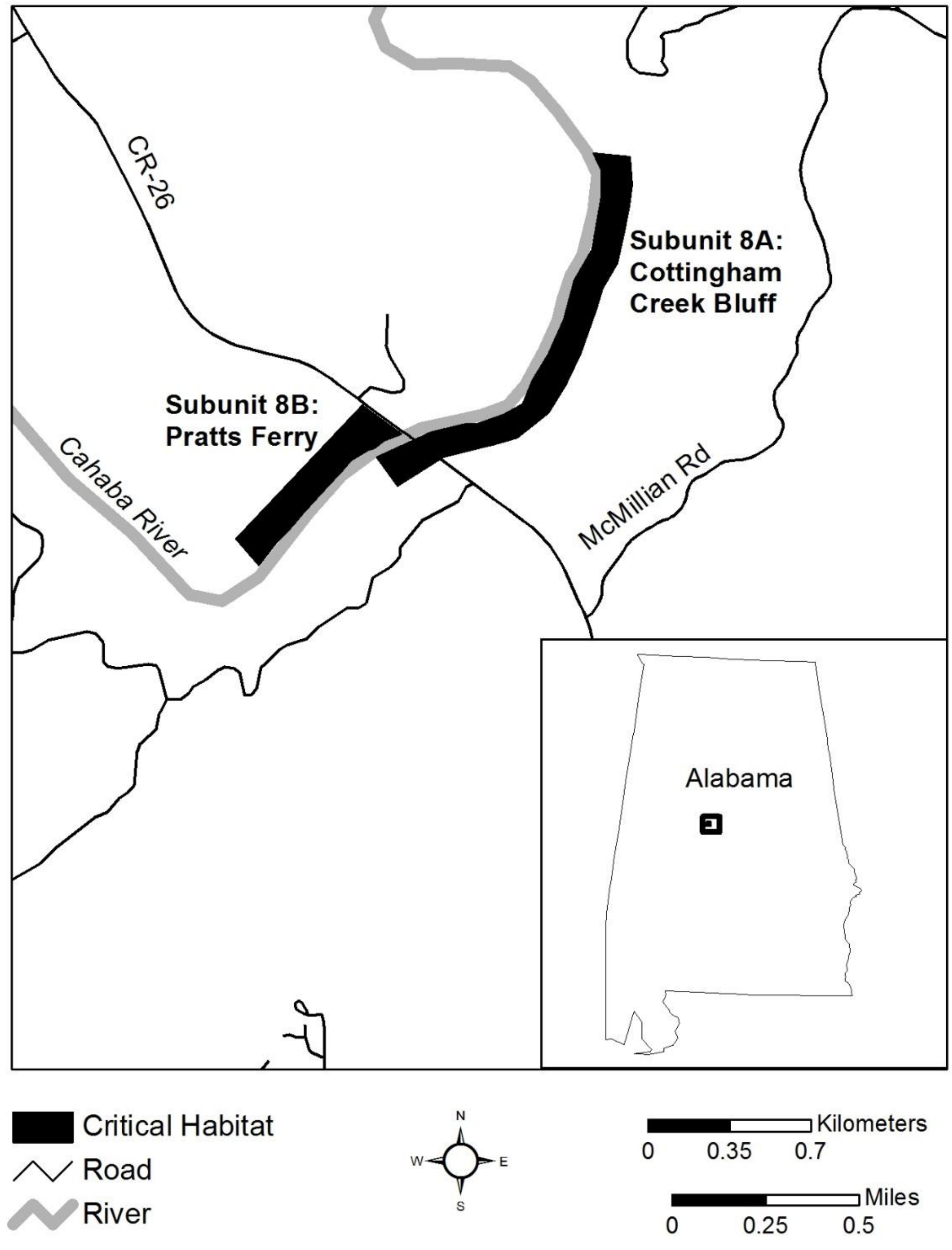
Unit 6: Murphys Bluff Bridge Cahaba River
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Bibb County, AL



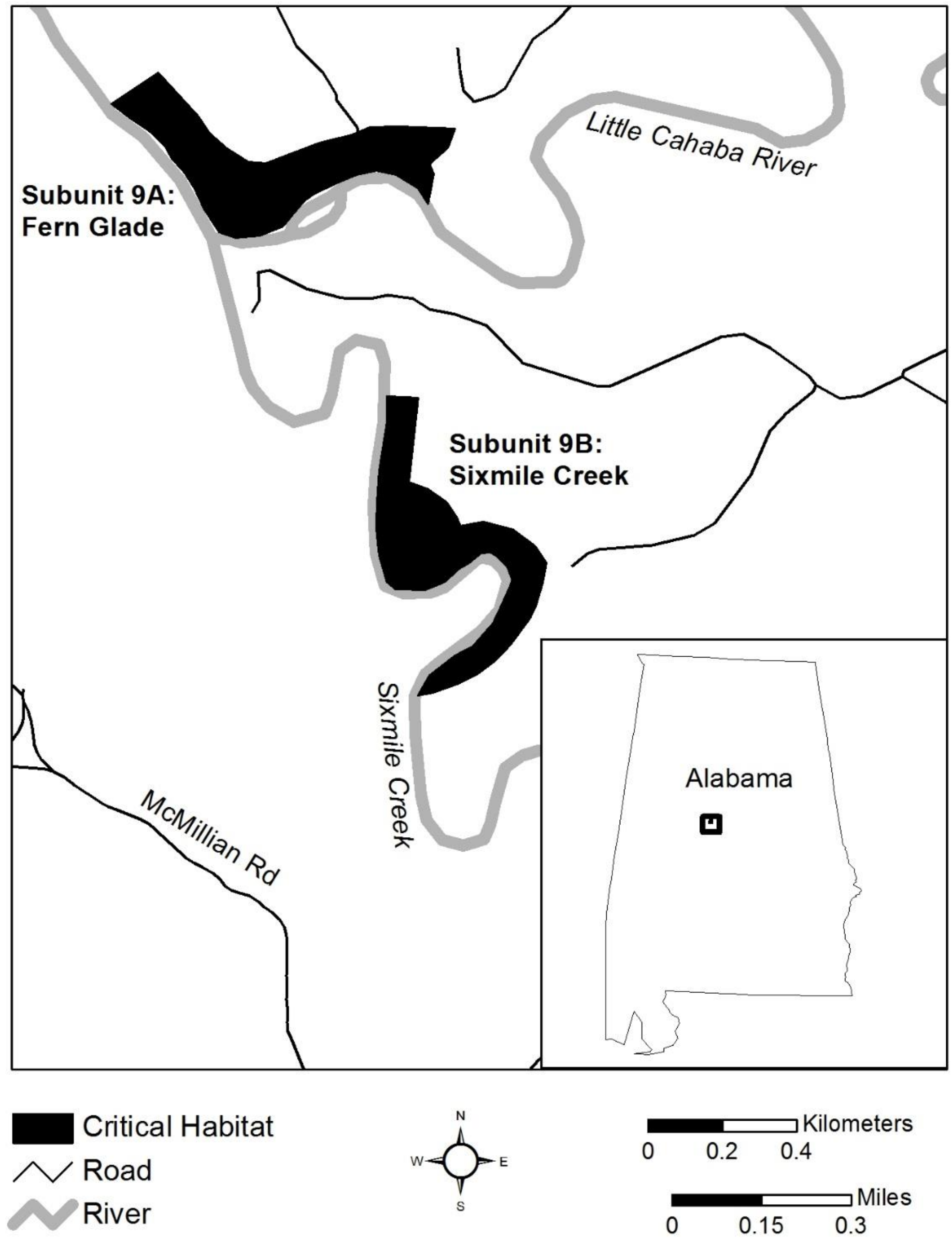
Subunits 7A and 7B: Creekside Glades and Little Schultz Creek
Critical Habitat for *Arabis georgiana* (Georgia Rockcress)
Bibb County, AL



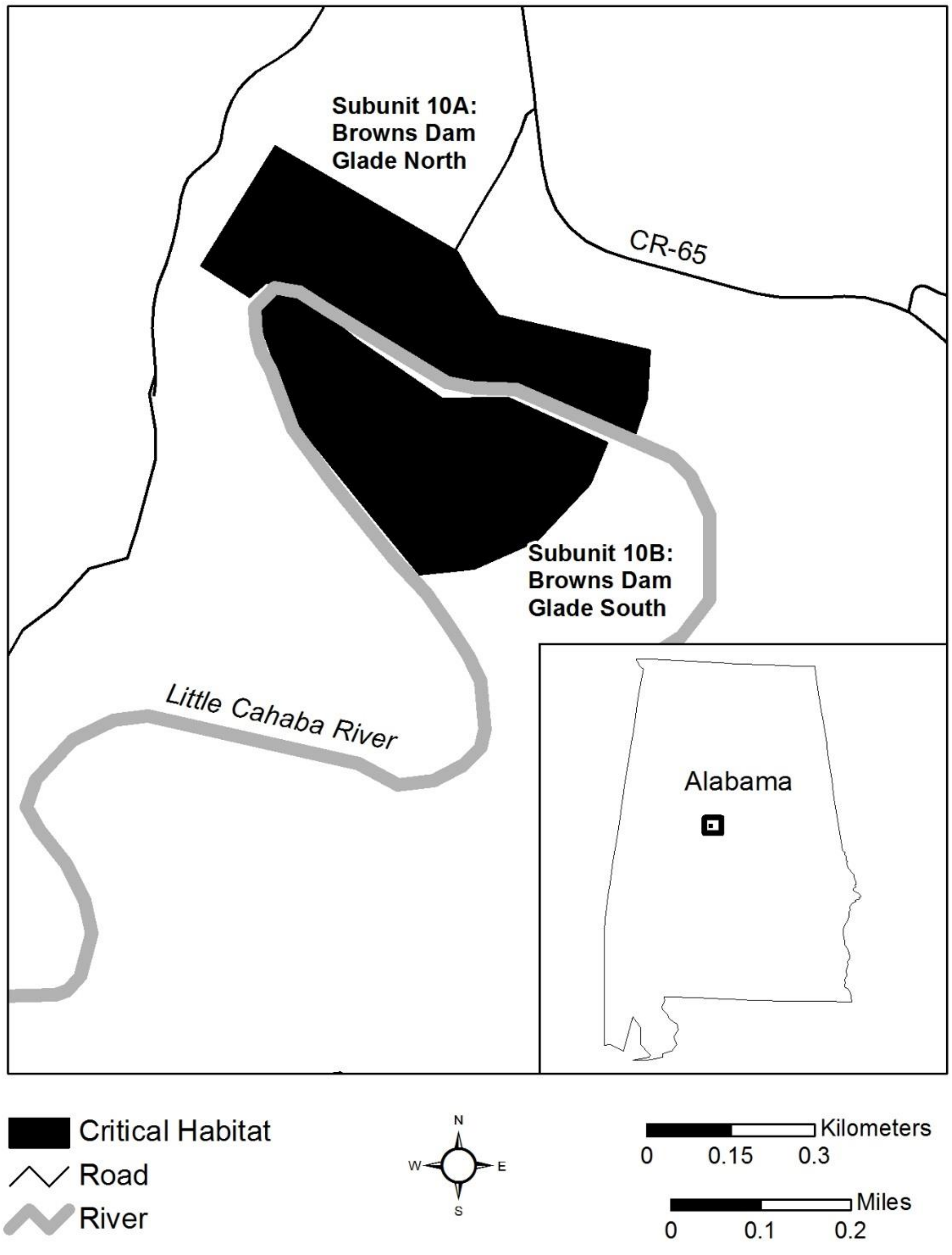
Subunits 8A and 8B: Cottingham Creek Bluff and Pratts Ferry
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Bibb County, AL



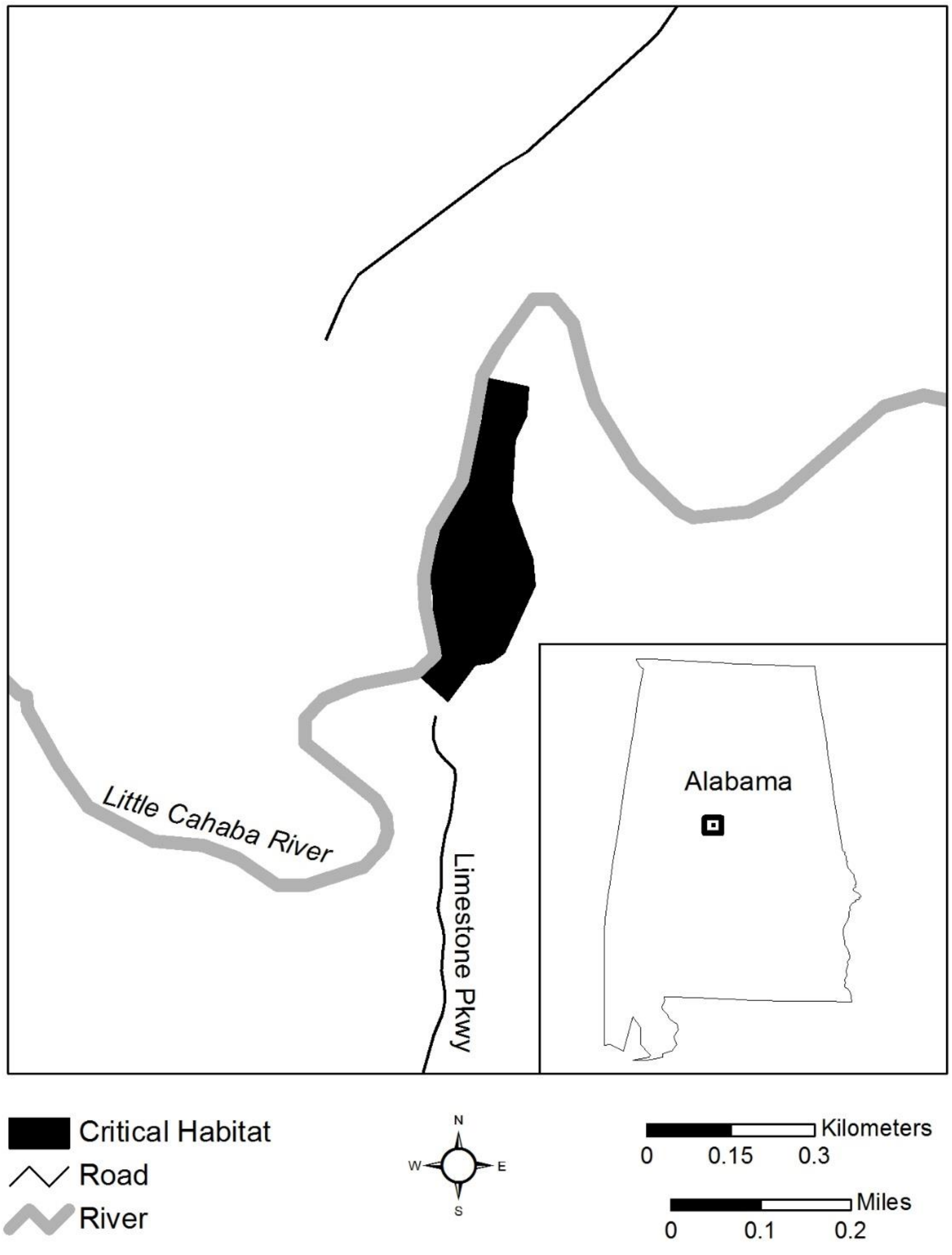
Subunits 9A and 9B: Fern Glade and Sixmile Creek
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Bibb County, AL



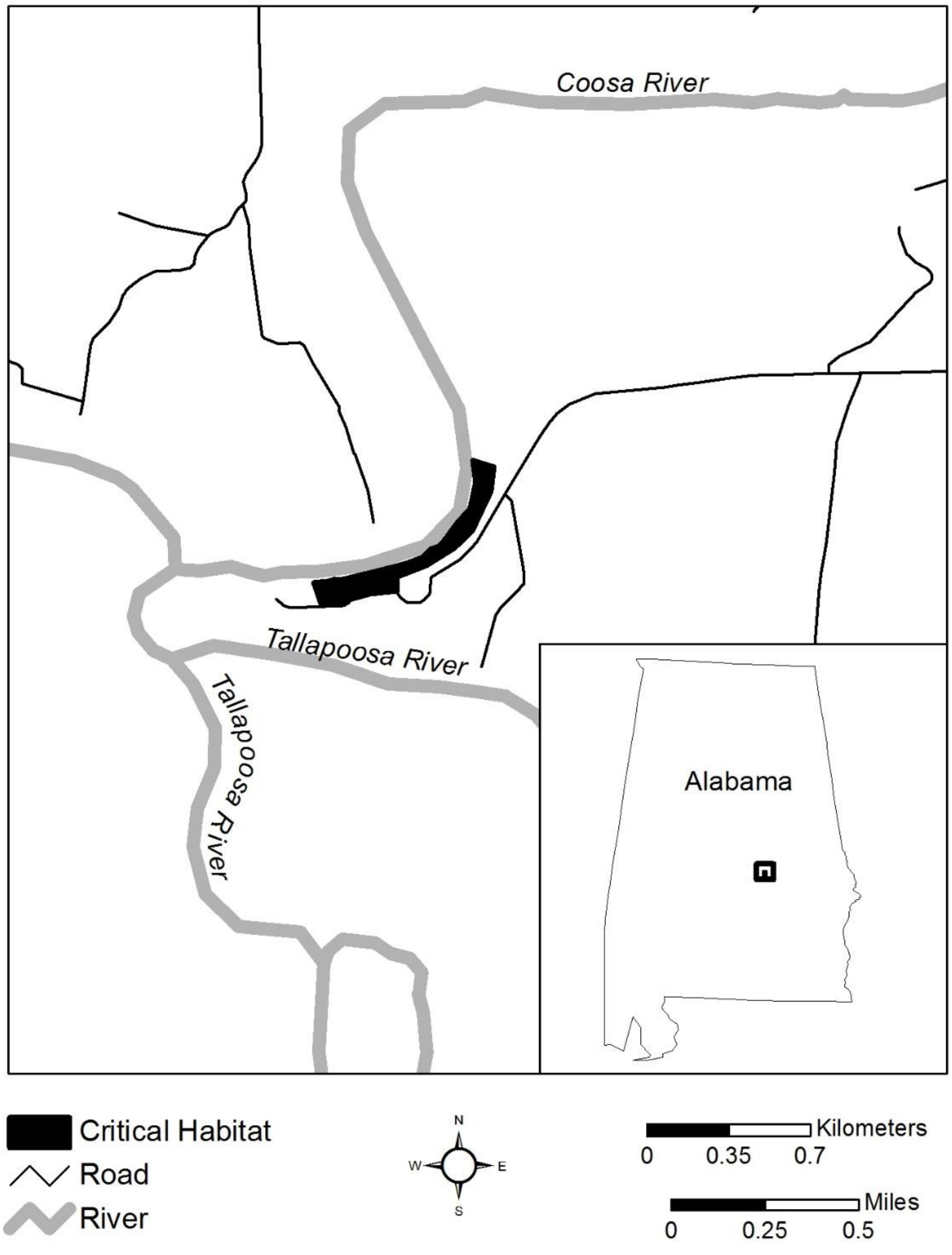
Subunits 10A and 10B: Browns Dam Glade North and Browns Dam Glade South
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Bibb County, AL



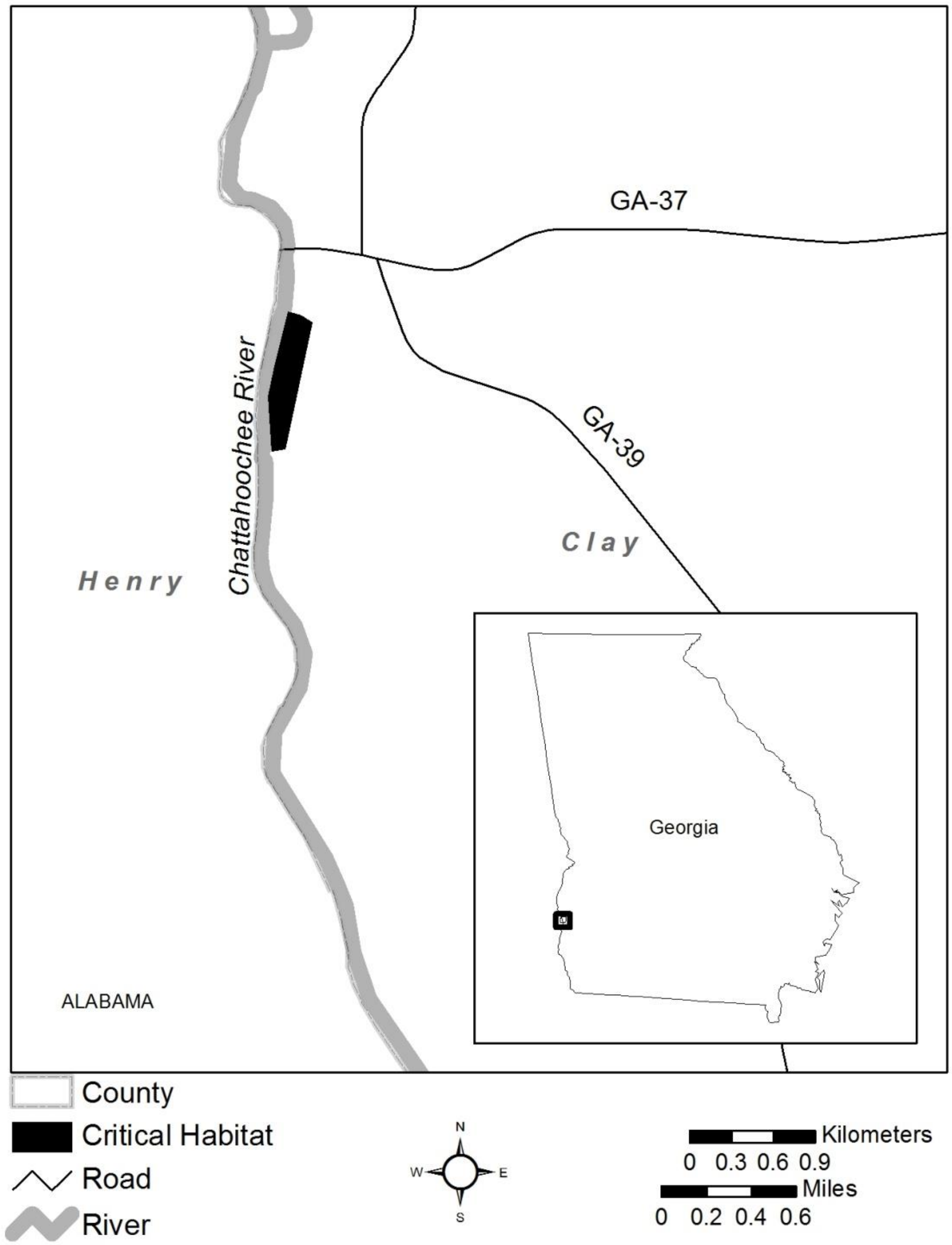
Unit 11: McGuire Ford/Limestone Park
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Bibb County, AL



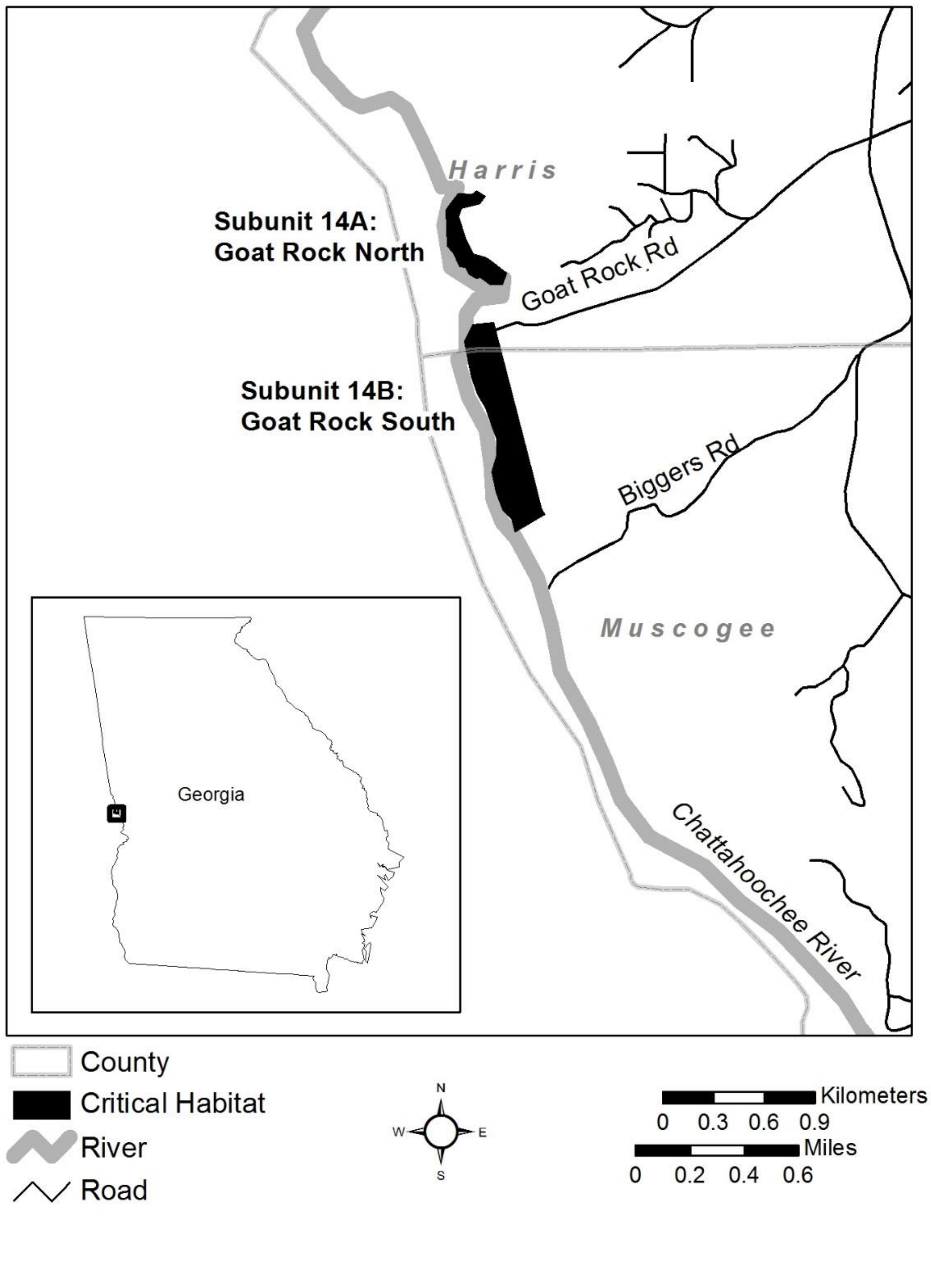
Unit 12: Fort Toulouse State Park
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Elmore County, AL



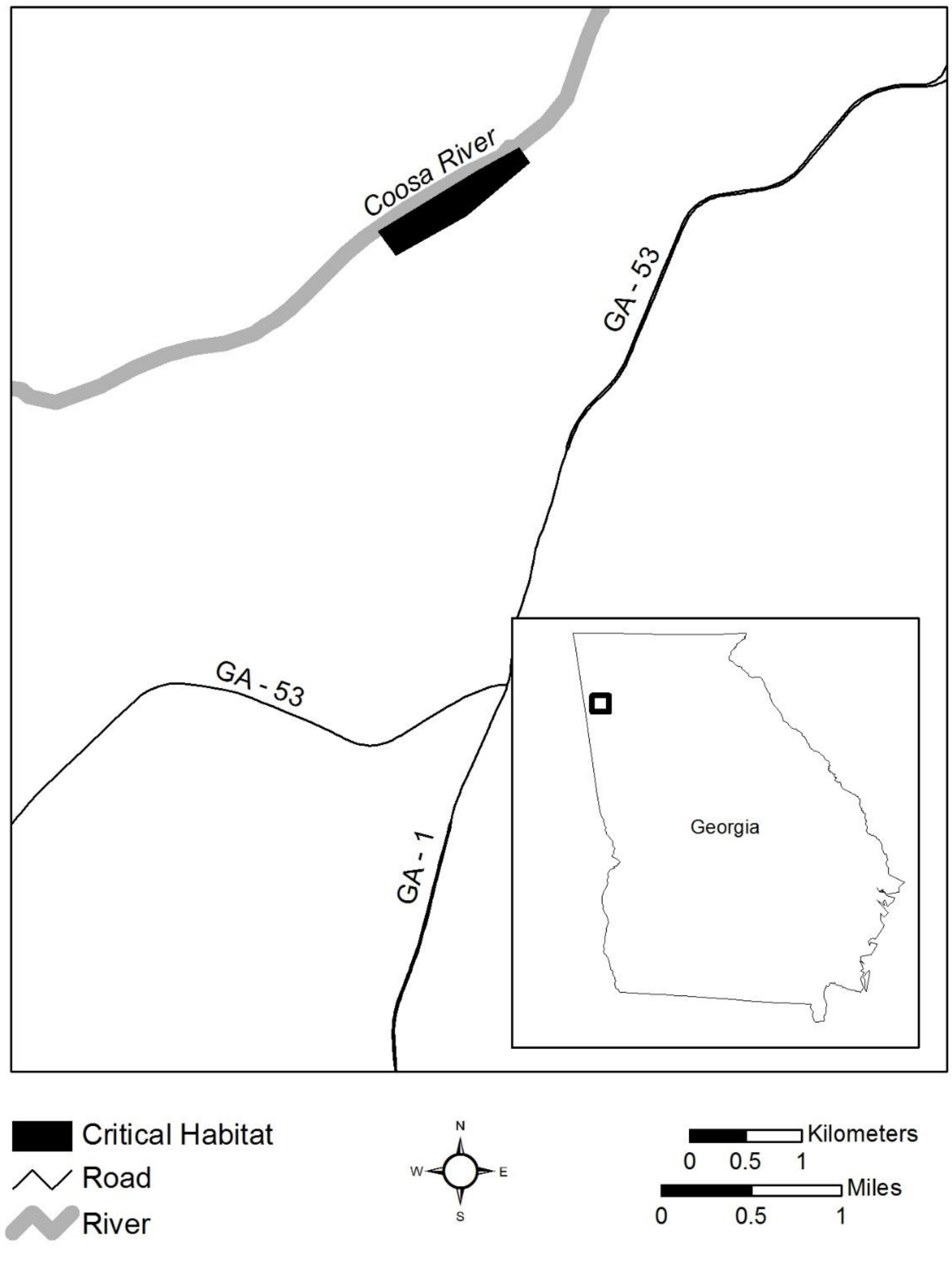
Unit 13: Fort Gaines Bluff
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Clay County, GA



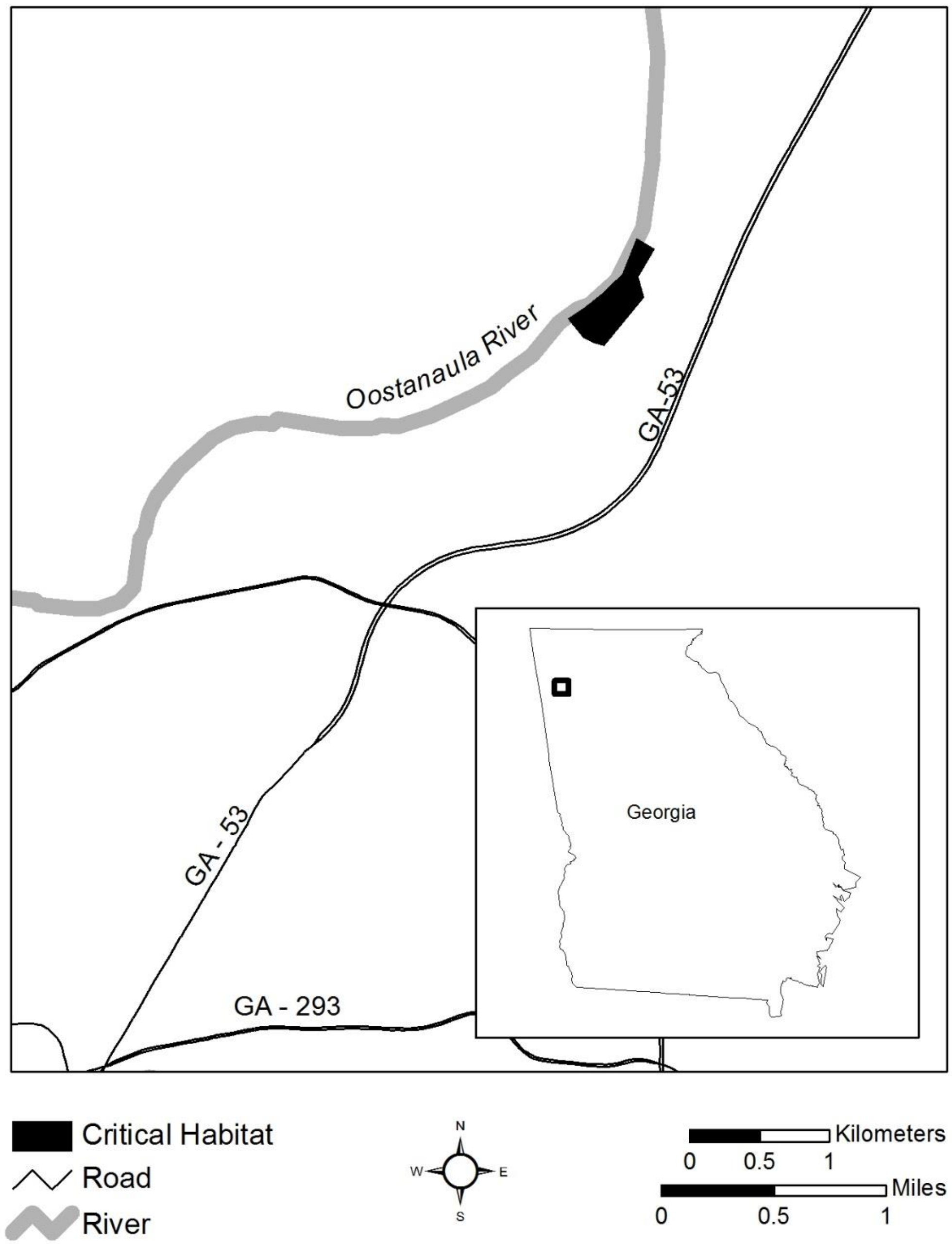
Subunits 14A and 14B: Goat Rock North and Goat Rock South
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Harris and Muscogee Counties, GA



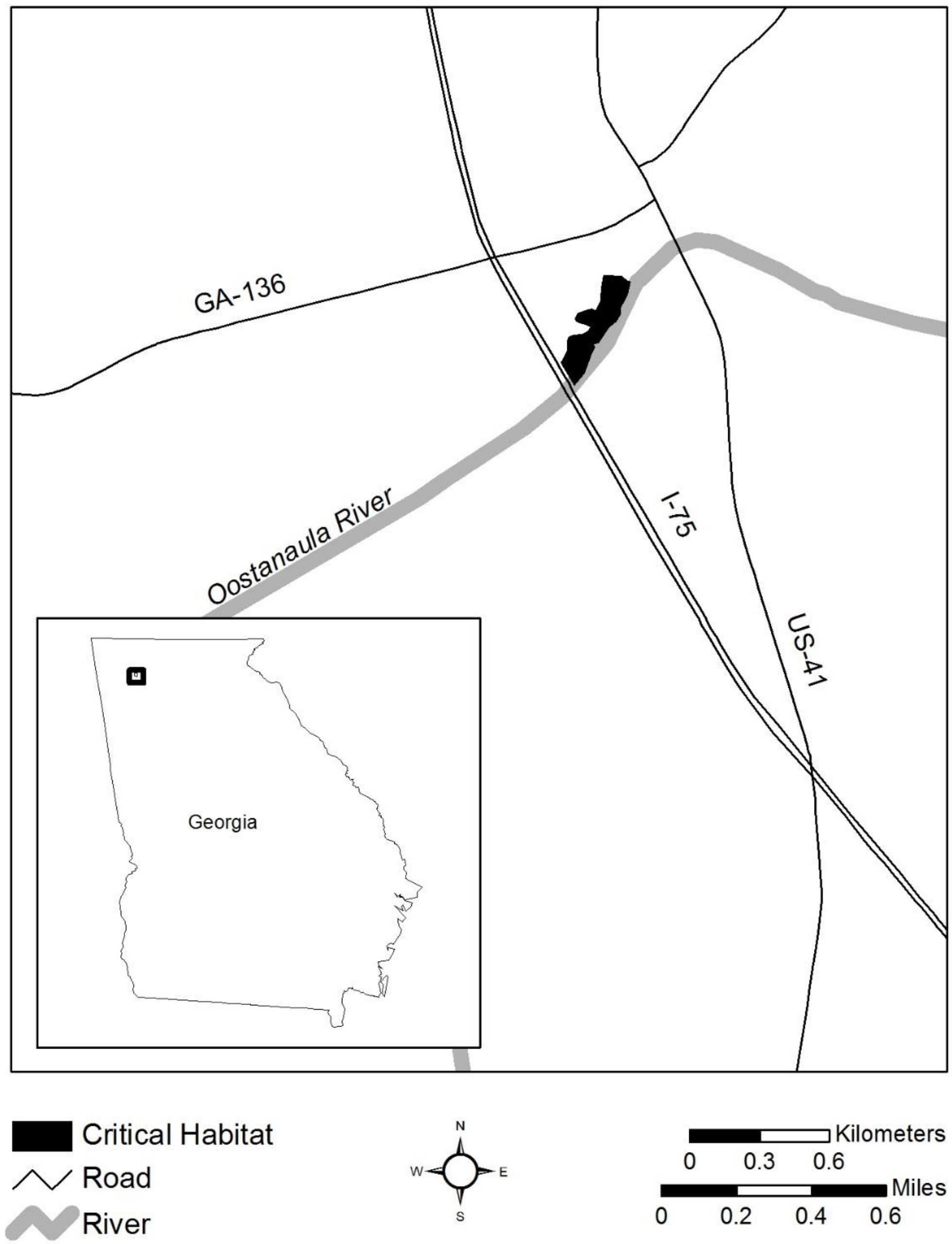
Unit 15: Blacks Bluff Preserve
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Floyd County, GA



Unit 16: Whitmore Bluff
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Floyd County, GA



Unit 17: Resaca Bluffs
Critical Habitat for *Arabis georgiana* (Georgia rockcress)
Gordon County, GA



APPENDIX B – Element Occurrence Population Delineation

Habitat-based Plant Element Occurrence Delimitation Guidance, NatureServe, 1 October 2004