PERSISTENT TRILLIUM

(*Trillium persistens*) Duncan

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Georgia Ecological Services Office
Athens, Georgia

October 2011

5-YEAR REVIEW

Species reviewed: Persistent trillium (*Trillium persistens*)

I. GENERAL INFORMATION

A. Methodology used to complete the review

A staff biologist, stationed at the Ecological Services Field Office in Athens, Georgia, completed this five-year review of *Trillium persistens*. The reviewer relied on published, scientific articles; consultation with botanical experts and horticulturalists; and unpublished data and reports provided by the Georgia Department of Natural Resources and the Georgia Power Company. No part of this review was contracted to an outside party. A complete digest of references utilized in this review can be found under the References section. The best available scientific information on this species was used in writing this review. The draft of this review was distributed for peer review (see Appendix A for peer review summary).

B. Reviewers

Lead Regional Office:	Southeast Region 4 Recovery Coordinator, Kelly Bibb, (404) 679-7132 Recovery Biologist, Nikki Lamp, (404) 679-7118
Lead Field Office:	Georgia Ecological Services, Athens Field Supervisor, Sandra Tucker, (706) 613-9493
Cooperating Field Office:	South Carolina Ecological Services, Charleston
Name of Reviewer:	Fish and Wildlife Biologist, Pete Pattavina, (706) 613-9493

C. Background

1. FR Notice citation announcing initiation of this review:

The U.S. Fish and Wildlife Service (Service) initiated a 5-year review of *T. persistens* on July 26, 2005 (Volume 70, No. 142: 43171-43173), *Endangered and Threatened Wildlife and Plants; 5-Year Review of 13 Southeastern Species*.

2. Species status

This is the first, formal status review of *T. persistens* since publication of the recovery plan (USFWS 1984). The species is considered stable throughout its range (Recovery Data Call 2011).

3. Recovery achieved

Based upon a review of the recovery outline and implementation activities, approximately 0-25% of the recovery objectives are completed or near completion.

4. Listing history

Original Listing
FR notice: Volume 43, Number 81:17910-17916
Date listed: April 26, 1978
Species: *Trillium persistens*
Classification: Endangered

Revised Listing, if applicable

N/A

5. Associated rulemakings

N/A

6. Review History

This is the first, formal status review of *T. persistens* since publication of the recovery plan (USFWS 1984).

7. Species' Recovery Priority Number at start of review

T. persistens is currently assigned a recovery priority number of 8, which means the species has a moderate degree of threat and high recovery potential.

8. Recovery Plan or Outline

Name of plan: Persistent Trillium (*Trillium persistens*) Recovery Plan
Date issued: March 27, 1984
Dates of previous revisions: N/A

II. REVIEW ANALYSIS

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

The DPS policy does not apply to plants.

B. Recovery Criteria

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

__X__ ***Yes***
_____ ***No***

2. Adequacy of recovery criteria.

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

_____ ***Yes***
__X__ ***No***

The recovery criteria perform fairly well in addressing up-to-date information on the biology of the species, but could use some minor adjustments to account for contemporary refinements in plant genetics and *T. persistens* life history information. For example: (1) recovery criteria recommend protection of essential habitat that would envelope 75% of flowering *T. persistens* individuals, but without genetic studies of all populations over the global range, important and unique genotypes that could be important to future recovery of the species could potentially be excluded from protection; (2) it appears that recovery criteria assume a one-way progression in size class that is assumed to reflect the relative age of individual *T. persistens* stems—however, multiple progressive and regressive transitions in size class are possible, irrespective of age; and (3) the development of a commercial source of plants may not be necessary and would prove difficult, as *T. persistens* is a poor horticultural performer, is difficult to transition from tissue culture into viable plants, and most importantly, the threat of over-collection does not appear to be a contemporary threat to the species' survival in the wild.

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

_____ ***Yes***
__X__ ***No***

There is new information to consider regarding existing and new threats.

3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information. For threats-related recovery criteria, please note which of the 5 listing factors are addressed by that criterion. If any of the 5-listing factors are not relevant to this species, please note that here.

The five listing factors addressed by threats-related recovery criteria are as follows:

A) Present or threatened destruction, modification or curtailment of its habitat or range;
B) Overutilization for commercial, recreational, scientific, or educational purposes;
C) Disease or predation;
D) Inadequacy of existing regulatory mechanisms;
E) Other natural or manmade factors affecting its continued existence

- 1.0 Protect the essential habitat of at least 75 percent of known individuals, populations or population segments.

  This threats-related recovery criterion addresses Listing Factor A and has been partially met. The Service has not completed an up-to-date analysis of how species abundance relates to parcel ownership or current land management, especially regarding the largest population, the Tallulah Gorge/Tallulah River population.

  Since the publication of the recovery plan (USFWS 1984), *T. persistens* is afforded a higher level of protection because a substantial portion of Georgia Power Company (GPC) lands were transferred to State and Federal ownership. Over 90% of the global abundance of *T. persistens* occurs on lands owned by the U.S. Forest Service (USFS), GPC, and Georgia Department of Natural Resources (GADNR): all parties afford certain types of land protection in some areas with *T. persistens* plants, but it is unknown what percentage of global abundance is protected by long-term management strategies, since land use and threats vary across the species' range.

  The entirety of the Panther Creek population was deeded to the USFS and is preserved through maintenance of the existing habitat (USDA 2004). In 1985 surveys (Candler 1985), the Panther Creek population accounted for approximately 10% (N=2,113) of global abundance estimates (N=20,028). Subsequent to 1985, researchers found additional *T. persistens* plants that were likely not accounted for in previous surveys (J. Sullivan, Professional Botanist, Forest Watch, pers. comm., 2006). In response to a potential under-estimate of *T. persistens* abundance at Panther Creek, U.S. Fish and Wildlife Service biologists and Jim Candler, GPC, embarked on a 2010 census of *T. persistens* at Panther Creek. Core occurrence areas were divided in sections using twine, to avoid double-counting plants. Fringe areas, known to contain only few plants (likely <100) were not surveyed due to steep terrain and difficulty of accessing the areas. Four researchers, each working four hours, tallied 3,822 *T. persistens* individuals, and recorded 1,102, 1,602, and 1,118 flowering plants, three-leaved sterile individuals, and one-leaved juveniles, respectively. New, 2010 census numbers (3,822 plants) for Panther Creek account

for approximately an 80% increase in abundance, above 1985 abundance estimates (2,113 plants). In 2010, the USFS and U.S. Fish and Wildlife Service treated 42 Eastern hemlock trees (*Tsuga canadensis*) at Panther Creek with imidacloprid soil treatments to stave off a moderate infection of hemlock wooly adelgid (*Adelges tsugae*). U.S. Fish and Wildlife Service biologists feared that losing dominant hemlock trees from the forest canopy from adelgid infestations could change light and moisture conditions for *T. persistens*.

The Tallulah Gorge/Tallulah River Population is a mixture of properties that are owned by the GADNR, GPC, and a few other small landowners. The percentage of *T. persistens* global abundance that corresponds to land ownership is unknown. Georgia Power Company retains fee-simple ownership of Moccasin Creek and Battle Branch, as well as some portions of the population within Tallulah Gorge, in areas that GPC retains as part of its Federal Energy Regulatory Commission (FERC) operation license (J. Candler, pers. comm., 2010). Georgia Department of Natural Resources retains fee-simple ownership of Moody Branch, Black Branch, and portions of the Tallulah Gorge populations.

Both GPC and GADNR have protection plans in place for areas that harbor *T. persistens*. Much of the area where *T. persistens* occurs is virtually inaccessible, due to steep terrain, limiting threats to the species, but also making it incredibly difficult to perform population censusing. However, large numbers of *T. persistens* occur near a popular point of access at Hurricane Falls Trail. To account for foot traffic impacts, GADNR implements a permit system, only allowing 100 persons per day to access the Hurricane Falls Area. Additionally, controlled burns are timed to avoid impact to *T. persistens*. At Battle Branch, GPC prohibits timber cutting, motorized vehicles, horseback riding, camping, construction, and hiking trails. In addition, for *T. persistens* areas within powerline rights-of-way, special measures such as hand-clearing are employed to avoid impacting the species.

Without genetic evidence to indicate otherwise, protection of 75% of the populations may be sufficient to capture most genetic diversity and maintain the species within its natural range. Generally, narrowly endemic species have lower levels of genetic diversity (Godt and Hamrick 2001, Kruckeberg and Rabinowitz 1985) than widespread species, and protection of 75% of the populations may preserve enough genetic variation to allow the species to maintain self-sustaining populations within its natural range of ecological conditions. However, only with genetic analyses can an informed decision be made regarding the best methods to protect the genetic integrity of the species.

1.1 Search for Additional Populations.

This recovery action has been completed. Numerous searches throughout the years have not extended the known and expected global range of the species, although new aggregations of plants have been

found within boundaries of the known range. Searches in the Sumter National Forest in South Carolina over the years have proven unsuccessful (R. Mackie, Botanist/Ecologist, Sumter National Forest, pers. comm., 2006). Similarly, repeated searches determined that *T. persistens* does not occur or is extremely rare north of Hurricane Falls, GA (Gaddy 1996). Additional searches within Tallulah Gorge (GA), Black Branch (GA), Moody Branch (GA), Moccasin Creek (GA), or Battle Creek (SC) are probably not warranted, since repeated surveys since 1983 have not significantly expanded the range of the species in the last two decades. An area within the Panther Creek drainage (Big Shoal Creek) was selected by James Sullivan (Professional botanist for the U.S. Forest Service and Forest Watch) as a potential within that drainage that could harbor the species, since it is an area of acidic soil. U.S. Fish and Wildlife Biologists (Ben Dickerson and Pete Pattavina) and James Sullivan surveyed Big Shoal Creek in 2009 but did not observe any *T. persistens*.

1.2 Determine Population Size and Age-class Distribution.

This recovery action has not been completed. Studies by Slay (1989) and Gaddy (1985) provided much needed information on population demographics, but it should be determined if their studies were adequate to determine temporal trends or need continuation or re-initiation. For a long-lived species such as *T. persistens*, a longer study may be required, especially since Slay's (1989) findings showed virtually no change in demographic structure over five seasons. There is most likely turnover in the population, and this rate of change should be determined.

Current global abundance estimates are based on censuses of portions of the species' global range spanning numerous field seasons (1983-1985). Although these investigations offer a very good indication of global abundance, trilliums can respond differently to changes in climatic conditions (e.g., lie dormant, regress or progress in size class, etc.). Interpopulation abundance estimates may not be comparable since each population was quantified once and populations were assessed in different years. Additional investigations and higher replication of global abundance may be necessary.

1.3 Determine Population Protection Priorities.

This recovery action has not been completed. The recovery plan (USFWS 1984) assigns protection priorities for populations and their segments based on: (1) the variability in ecological conditions within contiguous blocks of occupied habitat; and (2) assumptions of genetic divergence through isolation. Assumptions of genetic divergence may

not be valid and were made by assessing each population's placement within the occupied global range and assumed genetic divergences by: (1) a population's relative distance from other populations, assuming gene flow would be limited or non-existent between widely disjunct populations; and (2) by a population's placement beyond a logical genetic/pollinator barrier, such as Tallulah River/Yonah Lake. Preservation of occupied habitats that provide a wide array or continuum of ecological conditions is an important and valid factor for population protection prioritization.

1.4 Evaluate Protection Alternatives.

This recovery action has not been completed. Through changes in land ownership and management responsibilities for certain populations, (e.g., creation of Tallulah Gorge State Park, fee-simple sale of a privately-owned, roadside park (Tallulah Gorge Park) to the State of Georgia, and the land-swap between Georgia Power Company and the USFS at Panther Creek), more security and less potential for land use changes is currently afforded to much of the global habitat for *T. persistens*. However, as stated in the recovery plan (USFWS 1984), habitat *preservation* through the inaction of the controlling party may not correlate to habitat *protection*. The GADNR performs some monitoring of a *T. persistens* population on land that they own, and limitations on public recreation by GPC and the GADNR reduces disturbance to habitat. The Service does not have any formal agreements with landowners that specifically aim to protect or recover *T. persistens*.

1.5 Implement the most appropriate protection measures.

This recovery action has not been completed. Long-term protection strategies employed by GPC, the GADNR, and the USFS currently involve habitat preservation (e.g., no timber harvesting), but long-term monitoring to determine population trends are needed to determine if preservation without active management is an effective strategy for species conservation. Much remains unknown regarding *T. persistens*' population dynamics and its potential variability due to differing ecological conditions.

- 2.0 Determine and implement management guidelines necessary for long-term reproduction, establishment, maintenance and vigor.

  This criterion addresses Listing Factor E and has not been met. Studies by Gaddy (1985, 1988) and Slay (1989) provided useful information regarding the apparent stability of populations in different ecological conditions, but past studies may be inconclusive in determining long-term or subtle changes in population reproduction,

establishment, maintenance and vigor across sites. Without an understanding of potential variability in population dynamics between sites with differing ecological conditions, development and implementation of management guidelines is infeasible.

- 3.0 Develop a commercial source of plants and provide for long-term seed storage.

  This criterion addresses Listing Factor B and has not been met. In the nearly 30 years since the species' listing, over-collection of *T. persistens* has not proved a major factor affecting the species (see section II.C.2.b in this review). The species can be propagated successfully using tissue culture techniques (Pence and Soukup 1995), but much effort is required in achieving viability of new plants once removed from the culture agar (V. Pence, Cincinnati Zoo and Botanical Garden, pers. comm., 2006). Trillium enthusiasts and horticulturalists propagate the species from collected seed, and under horticultural conditions using supplemental fertilizers, flowering can be achieved in 4-6 years (J. Ceska, Conservation Coordinator, The State Botanical Garden of Georgia, pers. comm., 2006; A. Tedrow, Horticulturalist, The State Botanical Garden of Georgia, pers. comm., 2006; S. Yates, avocational horticulturalist and trillium expert, pers. comm., 2006).

- 4.0 Enforce laws protecting the species and/or its habitat.

  This criterion addresses Listing Factor D and has been met. *T. persistens* is currently protected from wild collection, sale, and transport under the Georgia Wildflower Preservation Act of 1973 (O.C.G.A. 12-6-170) where it occurs on state-owned or leased lands, and the species is similarly protected on USFS lands under the Endangered Species Act of 1973 (16 U.S.C. 1531 *et seq*.). Further protection of *T. persistens* occurred when GPC's license was re-issued by FERC under the Federal Power Act (16 U.S.C. 791a, *et seq*.). Since collection from the wild does not appear to be a contemporary threat to the species, and considering the current percentage of ownership of occupied habitat by State and Federal entities, further regulation or enforcement is not currently required.

- 5.0 Develop materials to inform the public about the status of the species and the recovery plan objectives.

  This recovery criterion has been partially met. The Service has not published any popular or scientific articles on this species in the last twenty years. Past publications included small articles in botanical garden newsletters and the Fish and Wildlife Service News (USFWS 1985), likely reaching a small, niche audience. General publications that use this species to highlight the importance, uniqueness, and diversity of Southeastern flora may help build public appreciation of botanical resources. Availability of this review, especially sections that highlight the poor horticultural performance of *T. persistens*, may discourage collection of the species.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Abundance, population trends

The recovery plan (USFWS 1984) defined four populations, as shown in Table 1.

Table 1. Known populations of *T. persistens*, as reported in the recovery plan (USFWS 1984).

Population	State	County
Tallulah Gorge/Tallulah River	GA	Rabun and Habersham
Moccasin Creek	GA	Habersham
Panther Creek	GA	Stephens
Battle Creek	SC	Oconee

The recovery plan (USFWS 1984) contained the caveat that global abundance estimates for the four populations could be somewhat inaccurate because:
(1) they were based on best available, quantitative data from only a single year of observation, 1983 surveys, and comprised the first, comprehensive effort to assess abundance of the species; (2) some 1983 surveys were "not complete," that more plants both inside and outside of the [Tallulah River] gorge were probable, and therefore, measured global abundance may be an underestimate; and (3) size-class distribution [and, similarly, juvenile abundance] could be skewed toward larger plants since larger size classes are the easiest to observe in the field.

Possible confounding factors for a study of abundance or demography for a long-lived, perennial, especially that of the *Trillium* genus, is the nature of individuals to remain dormant for a season, experience high seasonable variability in senescence (often dependent on size class), suffer unpredictable herbivory, or regress in size class due to physical damage (S. Bowling, self-employed botanist, pers. comm., 2006; Gaddy 1985; Knight 2003, 2004; Miller et. al. 1992; Slay 1989). Additionally, *T. persistens* habitat is often very steep and difficult to traverse, making complete canvassing of habitat problematic. These confounding factors necessitate higher levels of replication, standard sampling practices, and standardized survey areas to account for and explain variation in measurements and to gain certainty about *T. persistens* population dynamics.

Consistent with assumptions made in the recovery plan (USFWS 1984) regarding probable vs. measured global abundance, later studies proved that abundance reported in the recovery plan (10,338 stems) was an underestimate. Revisions to the known global abundance of *T. persistens* are as follows:

- Population censuses conducted through 1984, with incomplete counts of some population segments, documented 15,850 *T. persistens* stems among the four populations (Candler 1984). Despite searches in new areas, 1984 studies did not extend the global range of the species but did discover two, small aggregations of

T. persistens within the Tallulah Gorge/Tallulah River population, unknown at the time of the 1983 counts. Level of survey effort/person hours through 1984 was 94 person-hours.

- Population censuses through 1985 documented 20,028 *T. persistens* stems (Candler 1985). Level of survey effort/person hours through 1985 was 100-150 person-days of labor, and Candler (1985) reported that counts were "complete" for the four populations. This survey represents the most extensive, comprehensive, and reliable abundance estimates.
- Stem counts within the Tallulah Gorge/Tallulah River population showed some consistency in abundance counts/estimates from two separate surveys. Candler (1985) counted 2,930 plants through the 1985 season, and Gaddy (1988) counted 2,339 stems during the 1987 season. Gaddy (1988), however, estimated at least 3,000 plants and felt that his count of 2,339 was an underestimate due to limitations in survey effort/person hours.
- Gaddy (1996) revisited the Tallulah Gorge/Tallulah River population, and although abundance of stems was not documented, investigators found a few aggregations of *T. persistens* that were previously undocumented. Despite searches of areas outside the currently known range, no revision or extension of the global range was observed. Investigators developed maps depicting the distribution of *T. persistens* within the Tallulah Gorge/Tallulah River and classified areas of occurrence as "widely scattered," "scattered," or "clustered." Survey effort included two researchers, each expending seven days and an additional researcher expending 17 days of effort.

Surveys completed by GPC through 1985 offer the best global abundance estimate of the species (20,028 stems, minimum), as surveys were completed for all populations spanning just one or two growing seasons (Candler 1985). U.S. Fish and Wildlife Service surveys in 2010 at Panther Creek provide a good estimate of abundance at this population, but no comparative studies of other populations were completed to determine if higher abundance at Panther Creek, when compared to older data, represents a global trend.

New Information on Species Demography

Data collected from the 1983 field season and presented in the recovery plan (USFWS 1984) showed potential differences between populations with respect to population age [size] class structure, where: (1) a plant with a single leaf [bract] < 2 cm long was considered a "small juvenile", probably 2-3 years old; (2) a plant, with a single bract > 2 cm long was considered a "large juvenile", probably 4-5 years old; (3) a non-reproductive plant with three bracts was considered "sterile", probably 6-9 years old; and (4) a reproductive plant with three bracts was considered a "flowering" individual, probably 7-30 years old. At the time of publication, the recovery plan (USFWS 1984) assumed a one-way progression in size class. Later research showed that other transitions, including regression in size class, were possible (Gaddy 1985, Slay 1989), consistent with other members of the *Trillium* genus (Knight 2003, 2004), confounding

estimates of an individual plant or population's age structure. Hence, it may be ill-advised to differentiate *T. persistens* plants by age class, but more appropriately by size class.

Based on demography observations of 1983, the recovery plan (USFWS 1984) suggested that: (1) reproductive success was lower, compared to other populations, in the Tallulah Gorge/Tallulah River population, based on a lower proportion of juveniles and sterile individuals when compared to flowering plants (1.0/0.9, flowering/non-flowering); and (2) that populations at Battle Creek, Moccasin Creek, and Panther Creek were increasing, evidenced by the high proportion of sterile and juvenile plants at these locations (1.0/4.8, 1.0/3.4, 1.0/4.2, flowering/non-flowering, respectively). The recovery plan (USFWS 1984) states that these predictions could be refuted by long-term monitoring, expressing the need for additional data. In 1987, Gaddy (1988) observed a high ratio of flowering to non-flowering plants (1/3.1, flowering/non-flowering) in the Tallulah Gorge/Tallulah River population, but not to the degree reported in the recovery plan (USFWS 1984), possibly due to a winter/spring drought in 1986 and causative regression in size class. Slay's (1989) five-year monitoring of permanent plots in the Tallulah Gorge/Tallulah River population showed less of a skew toward flowering plants (1.0/2.8 flowering/non-flowering, plots 2, 3, 4, 5 pooled for all years) than reported in the recovery plan (USFWS 1984).

Anecdotal evidence supports information presented in the recovery plan (USFWS 1984) that the Panther Creek population in recent years (circa 2004) appears to have good reproduction and a high proportion of juveniles (J. Sullivan, pers. comm., 2006). Lower elevation, mesic coves may also have more recruitment (J. Candler, Environmental Affairs Supervisor, Georgia Power Company, pers. comm., 2006; Tom Patrick, Botanist, GADNR, pers. comm., 2006) than higher elevation, drier sites (under Virginia pine (*Pinus virginiana*) canopy), including aggregations of plants within portions of the Tallulah Gorge/Tallulah River population.

Slay's (1989) demography study of *T. persistens* from 1984-1988 found populations (except the Panther Creek population, which was not sampled) to be extraordinarily static in their composure, with extremely low sexual reproduction. Populations appeared stable, long-lived, and required few, new individuals to maintain themselves. This is corroborated by other casual observations that suggest that the populations generally look the same from year-to-year and appear stable (T. Patrick, pers. comm., 2006; J. Sullivan, pers. comm., 2006; C. Wentworth, USDA Forest Service Botanist, pers. comm., 2006). Although Slay (1989) noted sexual reproduction to be low overall, in a mesic area below the Wallenda trail (roughly the center of the Tallulah Gorge/Tallulah River population) recruitment of shrubs and subsequently *T. persistens* is occurring within previously bare access trails at an old campground (T. Patrick, pers. comm., 2006). As noted in 1983 observations (USFWS 1984), a high proportion of flowering to non-flowering plants in Tallulah Gorge was still evident during Slay's (1989) studies throughout 1984-1988, but not as high as reported in the recovery plan (USFWS 1984).

Horticultural observations corroborate Slay's (1989) findings regarding low sexual reproductive rates and subsequent low recruitment. The species is smaller-fruited than other trilliums (T. Patrick, pers. comm. 2006) and typically has only 2-6 seeds (S. Yates, pers. comm. 2006), with up to about 10 seeds (A. Tedrow, pers. comm., 2006), per fruit. *T. persistens* is not known to reproduce clonally.

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

No studies examined inter or intra-population genetic variation for *T. persistens*. Considering the species' limited geographic range, genetic polymorphism is probably lower than for more widespread congeners (Gonzales and Hamrick 2005, Karron 1987, Kruckeberg and Rabinowitz 1985). However, factors such as life history traits (outcrossing vs. selfing) and population size can affect genetic diversity (Hamrick and Godt 1996, Whitlock 2000). Although endemic species are typically depauperate genetically (Godt and Hamrick 2001), inferences can not be made with certainty regarding genetic composure of the species without specific genetic analyses across the global range. Considering the low reproduction rates, long-life of individual stems, coupled with the large size of populations, it is possible that *T. persistens* populations are quite ancient in origin. Garst (1990) postulates the Tugaloo/Tallulah River system could be the location of the speciation event that created *T. persistens* or functioned as species' refuge during the last glacial maximum. If *T. persistens* populations are ancient, they could exhibit higher levels of heterozygosity through the steady accumulation of chance mutations.

Morphologically, *T. persistens* resembles *T. catesbaei*, *T. nivale*, and *T. pusillum*, each having a prominent, common style (Duncan et al. 1971). Genetic analyses conducted in the 1980s by Dr. Eloise Carter found *T. persistens* most closely related to *T. pusillum* (J. Candler, pers. comm., 2006; T. Patrick, pers. comm., 2006). *T. pusillum* and *T. persistens* are distant enough that hybridization is probably not likely, and given that the two congeners do not overlap in their ranges, loss of *T. persistens* genetic identity through introgression with another *Trillium* species is not a threat (T. Patrick, pers. comm., 2006).

c. Taxonomic classification or changes in nomenclature:

The *Trillium* genus is complex and the subject of much phylogenetic research (Weakley 2011). When listed in 1978, the *Trillium* genus was part of the Liliaceae (sensu latu), but Weakley (2011) places the genus within the family Trilliaceae (sensu Dahlgren et al. 1985) in his draft *Flora of the Carolinas, Virginia, and Georgia, and Surrounding Areas*. Others place the genus within the family Melanthiaceae (sensu Angiosperm Phylogeny Group 1998). No former or future name changes at the specific level are known for *T. persistens*, and changes in taxonomy at the family level do not appreciably change our knowledge of the species, but rather, allows researchers to place *Trillium* within a broader plant evolutionary context.

d. Spatial distribution, trends in spatial distribution

Although new *T. persistens* aggregations/population segments were located subsequent to the species listing, these new areas of distribution were within the species' known, historic range. Small aggregations discovered subsequent (Gaddy 1996) to the publication of the recovery plan (USFWS 1984), between nodes of known occupancy at Moody Branch, Black Branch, and Tallulah Gorge may alter the recovery plan's (USFWS 1984) purported disunities between populations or population segments, perhaps indicating that gene flow between population segments of the Tallulah Gorge/Tallulah River population may be underestimated and our delimitation of populations and/or their segments somewhat artificial. Only in-depth genetic analyses would answer these questions, and until such time, the recovery plan (USFWS 1984) remains the best available information on purported genetic isolation between populations and/or their segments.

e. Habitat or ecosystem conditions

Although little is known about microhabitat requirements of *T. persistens*, it appears the species can tolerate harsh conditions (e.g., drought, temperature extremes) without marked reduction in mortality or seed set (Gaddy 1985, Slay 1989). However, drier areas, like the upper slopes of Tallulah Gorge, tend to have aggregations of plants skewed toward older individuals, either sterile or flowering individuals, with fewer juveniles (J. Candler, pers. comm., 2006; T. Patrick, pers. comm., 2006; Slay 1989; USFWS 1984), suggesting lower levels of recruitment under harsh conditions. *T. persistens* is one of the few Southeastern U.S. members of the genus, along with *T. erectum*, *T. undulatum*, and *T. catesbaei*[1] that prefers highly acidic soils and may require lowering of soil pH below 5.2 (S. Yates, pers. comm., 2006).

Despite the ability of mature *T. persistens* plants to tolerate drought (Gaddy 1985, Slay 1989), persist at a range of edaphic and moisture regimes within the species' natural range, and to remain hardy to Michigan winters (F. Case, author and trillium expert, pers. comm., 2006) and hotter summers (S. Yates, pers. comm., 2006), the species appears limited in its ability to reproduce naturally, via self-sowing of seed, and gradually wanes when transferred from the wild into garden settings. In this respect, *T. persistens* is a notoriously poor horticultural performer (F. Case, pers. comm., 2006; T. Patrick, pers. comm., 2006; S. Yates, pers. comm., 2006) and performs much like another difficult-to-grow species, painted trillium (*T. undulatum*), with the exception that *T. persistens* is smaller-fruited and sets less seed (T. Patrick, pers. comm., 2006). Only one instance is known where *T. persistens* has shown unaided recruitment in a garden setting, at The State Botanical Garden in Athens, Georgia (A. Tedrow, pers. comm., 2006). The State Botanical Garden records document that 15 *T. persistens* plants were established in a moist, shaded garden in 1983. Today, there are

[1] *T. catesbaei*, unlike other congeners, can tolerate a wide pH range, and is found on acidic and circumneutral soils.

approximately 20-30 plants (A. Tedrow, pers.comm., 2006), with new individuals located in a four-foot radius around the original planting site (J. Ceska, pers. comm., 2006).

In horticultural (and probably natural) settings, *T. persistens* inconsistently produces a viable fruit (Slay 1989), that typically produces only 2-6 seeds (S. Yates, pers. comm., 2006), with an observed maximum of 10 seeds (A. Tedrow, pers. comm., 2006). Low reproductive rates suggest that *T. persistens* may require an effectively large population size to maintain self-sustaining levels.

2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

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

Logging and Land Clearing Activities

The recovery plan stated that clearing of vegetation for logging or other land usage could increase erosion risks. In 1986, the U.S. 441 widening changed drainage patterns and excessive erosion destroyed approximately 50-100 plants, ruining a permanent study plot of Slay's (1989) (T. Patrick, pers. comm., 2006). The erosion problem has since been corrected, although the denuded area allowed for the establishment of kudzu (*Pueraria montana*) that threatens remaining *T. persistens* stems and habitat on the very fringe of the Tallulah Gorge population. Other than the highway project, some small-scale land clearing was completed circa 2002 when facilities for Tallulah Gorge State Park were constructed. Most land clearing occurred outside of areas occupied by *T. persistens*, with the exception of a wooden stairway that destroyed a few plants. However, the stairway does direct foot traffic away from other occupied areas and reduces trampling of plants.

The imminence of threats from timber harvest was largely eliminated, first by voluntary conservation efforts on the part of the primary landowner GPC, and then through a transfer of property from GPC to GADNR that created the Tallulah Gorge State Park in 1993. Additionally, GPC transferred ownership of the Panther Creek population to the USFS. The GADNR purchased a privately-owned roadside tourist park (Tallulah Gorge Park) referred to in the recovery plan (USFWS 1984), thus reducing threats of timber removal and development.

Recreational Use of Habitat

Threats to habitat degradation through visitation and usage of trails, roads, and rapids have lessened since the publication of the recovery plan (USFWS 1984). Now maintained as a State park, visitor usage and access to the bottom of Tallulah Gorge is restricted by permit, limiting gorge access to 100 persons per day. Although construction of a wooden stairway (circa 2002) displaced approximately 200 *T. persistens* stems (T. Patrick, pers. comm., 2006), the stairway alleviates foot traffic in

natural areas and probably lessened the degree of direct damage to *T. persistens* that would have occurred without the stairway (T. Patrick, pers. comm., 2006, J. Sullivan, pers. comm., 2006). Additionally, GPC made efforts to better control road access to cottages on Lake Yonah land leases within *T. persistens* habitat--no known impacts occurred in this area since 1986 (T. Patrick, pers. comm., 2006).

Much of *T. peristens* habitat is extremely steep and/or difficult to access. The Battle Creek population is accessible only by boat, limiting visitation pressure (J. Candler, pers. comm., 2006). A closed campground, below the Wallenda Trail, is recovering, and shrubs and *T. persistens* are moving into areas that were laid bare from foot traffic (T. Patrick, pers. comm., 2006).

Excessive visitor usage at the Panther Creek population does not seem to be a threat, as the species is in an area that experiences little foot traffic from trout fishermen or other day-users (J. Sullivan, pers. comm., 2006; C. Wentworth, pers. comm., 2006).

Other Factors for Consideration

In general, the large contiguous blocks of forest that comprise the habitat of *T. persistens* should remain somewhat insulated from large-scale infestations of invasive plant species. Georgia Power Company, the GADNR, and the USFS are aware of areas occupied by *T. persistens* on their respective properties and are committed to protecting *T. persistens*, by avoiding timber operations, and through the use of various management plans. Intensive forestry practices that may include clear-cutting, extensive soil disturbance, and broad-scale spraying of herbicides, all factors that could physically damage *T. persistens* stems and/or provide a niche for invasive plant species establishment, are highly unlikely.

Within the last decade the exotic hemlock wooly adelgid invaded Georgia forests. This small, aphid-like insect can heavily infest hemlock (*Tsuga spp*.) trees and cause die-offs of hemlock forest. Hemlock is a component of the canopy at *T. persistens* sites, and the die-off of hemlock from the canopy has the potential to affect the structure and composition of plants in the understory and potentially change the microenvironment and nutrient cycling (Orwig and Foster 1998). Large openings in the forest canopy can also promote the proliferation of weedy and other aggressive plant species that could displace *T. persistens*. Bio-control efforts are underway in Georgia, but are costly and small in scale. The effect that heavy infestations of hemlock wooly adelgid could have on *T. persistens* is unknown. It is possible that *T. persistens* could tolerate shifts in forest canopy density and species composition, since the species appears to be found under many different tree and shrub canopies, with differing light, moisture, and edaphic regimes.

In February 2010, USFS and U.S. Fish and Wildlife Service personnel treated 42 mature hemlock canopy trees with an imidacloprid insecticide to halt a moderate infection of the forest canopy from the hemlock wooly adelgid. Imidacloprid

treatments are highly effective on other parts of the National Forest and can typically prevent hemlock die-off for approximately five years (M. Brod, U.S. Forest Service, pers. comm., 2010).

b. Overutilization for commercial, recreational, scientific, or educational purposes:

Collection pressure of the species was identified in the recovery plan (USFWS 1984) as a potential threat. The magnitude of this threat is low, as there will probably always be a few trillium collectors that want all species of *Trillium*, including *T. persistens*, in their gardens, but these individuals are few. In the nearly 20 years since the publication of the recovery plan, collection has not been an issue. The species is less novel (species named in 1971 (Duncan et. al 1971)) now than when originally listed, potentially making it a lesser prize to trillium enthusiasts. Considering the steep terrain and access difficulties of most of the populations, much effort would be necessary to collect a large number of plants, particularly from population interiors. The inclusion of access points into the Georgia State Park system, places a higher degree of protection on plants under provisions enforceable under the Georgia Wildflower Preservation Act. Similarly, the U.S. Forest Service ownership of the Panther Creek population would now make collection of *T. persistens* from that area illegal under section 9 of the Endangered Species Act. This may offer enough deterrent for some collectors.

The recovery plan (USFWS 1984) recommended development of a commercially-available stock of *T. persistens* to preempt collection pressure. Whether efforts to effect this goal would kindle or curb wild collection of the species is questionable—complicating this goal is the fact that the species cannot be shipped across State lines without a section 10 recovery permit issued under the Endangered Species Act by the Service. Tissue culture is an effective method of propagation (Pence and Soukup 1995), and the species can be maintained for long periods in culture but presents difficulties in growing to a stable, viable size (V. Pence, Cincinnati Zoo and Botanical Garden pers. comm., 2006), further complicating development of a commercially-available stock. Dissemination, through public documents (such as this one and/or updates to the recovery plan), of information on the species' legitimate difficulty or inability to adapt to artificial, horticultural conditions outside of its natural range may be the most effective method of staving off collection pressure.

c. Disease or predation:

A well-known threat to many rare wildflower species, including trilliums, is herbivory, particularly from white-tailed deer (*Odocoileus virginianus*) (Augustine and deCalesta 2003, Knight 2003, 2004, Miller et al. 1992). Sporadic herbivory by deer is likely to disproportionately affect *T. persistens* growing in gently sloping coves and streambeds, rather than in steep ravines largely inaccessible to deer. Some signs of herbivory were observed at the Moccasin Creek population (J. Candler, pers. comm. 2006), but overall, herbivory does not seem to be a problem at most sites (J. Candler, pers. comm., 2006; J.

Sullivan, pers. comm., 2006; C. Wentworth, pers. comm., 2006). *T. persistens* habitat is within an area of Georgia with one of the lowest deer populations, approximately 20-30 deer/mi^2 (GADNR 2005).

There are no substantial, new threats to the species from disease or predation. Deer browse is presently not a serious threat to *T. persistens*, as many areas of occupied habitat are steep and generally not conducive to deer browse. However, as urban development of the Georgia mountains continues, and patchy habitats are formed that are conducive to higher production of deer, browse could become more of a concern, especially lower elevation sites on slight grades.

Granivory by rodents, especially on the edges of clear-cuts (Jules and Rathcke 1999, Tallmon et al. 2003) and possibly in upslope, xeric areas (Gaddy 1985), may impact the species to some degree, lowering successful seed set and recruitment. However, much of *T. persistens* habitat occurs in large, contiguous blocks of forest. Forest edges that may disproportionately experience increased levels of seed depredation likely account for a small percentage of *T. persistens* global abundance.

d. Inadequacy of existing regulatory mechanisms:

Inadequate regulatory mechanisms are not a primary factor affecting this species. Although not required under the Endangered Species Act, GPC employs voluntary conservation measures to protect *T. persistens*. The formation of Tallulah Gorge State Park in 1993 enveloped a majority of the species global range and now protects digging of *T. persistens* stems under auspices of the Georgia Wildflower Protection Act. Section 9 of the Endangered Species Act prohibits take of plants from Federal lands, therefore digging of the species from USFS property is prohibited. Both the Georgia Wildflower Preservation Act and the Endangered Species Act limit the practicability of selling *T. persistens* commercially.

e. Other natural or manmade factors affecting its continued existence:

The recovery plan (USFWS 1984) stated that the creation of Lake Yonah in 1925 historically impacted *T. persistens* and may function as an impediment to gene flow. Genetic studies would help provide a better understanding of the potential magnitude of this threat. Detailed genetic information could guide management decisions and justify whether or not to facilitate infusion of genetic variation into populations that may be experiencing an unnatural, anthropogenic barrier to gene flow.

Conservation efforts to propagate *T. persistens* by tissue culture were successful, but the difficulty in growing plants to a size large and adaptable enough for out-planting suggests that such techniques may be labor and/or cost-intensive. The seeming universal failure of creating self-sustaining populations *ex-situ*, without artificial pollination and managed seed germination techniques underscores *T. persistens* habitat specificity and the importance of habitat protection within the species' natural range.

Results from demographic and abundance studies (Gaddy 1985, Slay 1989) appear to eliminate the need for *in-situ* population augmentation or manipulation. All wild populations appear outwardly healthy and self-sustaining, or at least change so slowly as to appear the same from year-to-year. Maintenance of suitable habitat conditions for *T. persistens* as the forest ages and approaches climax condition remains critical. Although infestations of exotic plant and animal species are localized and may not constitute an imminent threat, efforts to remove and continually monitor such factors potentially affecting *T. persistens* habitat is paramount to recovery of the species.

Competition with other species

The recovery plan (USFWS 1984) suggested that aggressive weedy and/or exotic species, including *Rubus,* Japanese honeysuckle (*Lonicera japonica*), kudzu (*P. montana*), *Sambucus,* and *Hydrangea* potentially displaced *T. persistens* stems within powerline right-of-way clearings. Additionally, *T. persistens* stems in areas on the edges of cleared rights-of-way may experience higher levels of seed depredation by rodents and subsequently lower levels of recruitment (Gaddy 1985, Jules and Rathcke 1999, Tallmon et al. 2003).

The magnitude of the threat posed by aggressive, exotic plant species has likely increased, and a prompt effort should be made to look at edge habitats and set goals for controlling exotic species that could penetrate the interiors of *T. persistens* sites.

Currently, kudzu is creeping down the edge of the U.S. 441 road slope, very near some *T. persistens* stems. At Panther Creek, kudzu is established along the stream floodplain and the site has sporadic English ivy (*Hedera helix*), both of which could threaten *T. persistens* habitat higher upslope. U.S. Fish and Wildlife biologists Ben Dickerson and Pete Pattavina hand-pulled English ivy and grubbed out kudzu tubers in 2009 at Panther Creek, but follow-up treatment is necessary and planned for 2012. At the top of Tallulah Gorge, the area defined in the recovery plan as the privately-owned Tallulah Gorge Park (now defunct and owned by the GADNR since the early 1990s), has a stand of English ivy that, if allowed to spread, could slowly threaten *T. persistens* habitat (T. Patrick, pers. comm., 2006).

D. Synthesis

Although the global abundance estimate reported in the recovery plan (USFWS 1984) was lower than what subsequent studies observed, the global range of *T. persistens* remains virtually the same as defined in the recovery plan, indicating *T. persistens* is a rare and narrowly-endemic species. Despite information on the species' demographics and anecdotal evidence suggesting the species' stability, sound, scientific data is lacking on measured population stability or potential response of the species to changes in forest health and/or composition. Slay's (1989) five-year findings on the apparent stability of *T. persistens* size class structure indicate that any positive or negative trends

in population structure would be extremely slow to manifest themselves in an outwardly observable manner.

Nearly three decades after the species' listing, much remains unknown regarding the adaptability of *T. persistens* and its ecological relationship to its environment. Without continued monitoring of population dynamics, correlated to forest structure, there remains no reliable evidence of *T. persisten's* potential to remain viable within an ever-changing environment. Little consistent data exists that allows for measurement of recovery success.

Land usage uncertainties stated in the recovery plan (USFWS 1984), and their associated, potential threats to destruction of habitat, are presently much less of a concern. A high level of protection and responsibility is afforded to lands owned and/or managed by the USFS, GADNR, and the GPC. The development of strong private-public relationships, to the benefit of the species, was an extraordinary success in years past. Continued partnering efforts, combined with a clear goal toward species recovery (with updated recovery criteria) that incorporates monitoring of existing, new and unanticipated threats, and site-specific management plans, should be implemented prior to reclassification of listing status.

Implementation of recovery criteria occurred in various fashions over the three decades since *T. persistens* was listed as endangered.

<u>Recovery criterion—Protection of essential habitat</u>

- It is likely that 75% of the global abundance of the species is within areas that have some level of forest protection. However, the ownership of various land holdings, management needs, abundance of *T. persistens* within each landholding, and levels of species protection need to be reviewed and documented. Although the major partners in *T. persistens* conservation (Georgia Power, Georgia Department of Natural Resources, and the U.S. Forest Service) implemented procedures to keep occurrence areas from being timbered, additional invasive species management needs to be assessed and implemented throughout the species' range before essential habitat for *T. persistens* can be considered protected. This recovery criterion is partially complete.
    - Additional searches for new *T. persistens* sites is not warranted, as successive searches over the past decades have not appreciably changed the global range of the species. This recovery action has been completed.
    - Additional and regular censuses of population size and age-class are needed to determine population trends. Surveys should occur across the species' range and data should be collected during a number of successive years to determine variability. This recovery action has not been completed.

- Population protection priorities should focus on performing genetic analyses on inter and intrapopulation variation to determine how much land or abundance of *T. persistens* needs to be in permanent protection. This action has not been met.
- Implementation of the most appropriate protection measures for the species has been partially met. Additional invasive species control needs to be implemented at a few sites and long-term management plans that benefit the species need to be drafted and implemented. This action has been partially met.

Recovery criterion—Determine and implement management guidelines necessary for long-term conservation

- More studies are needed to determine population health and demography. Although *T. persistens* occurs in a wide range of conditions, no long-term studies have been implemented to determine population trends or if certain areas and/or management techniques are more conducive to conservation of the species. This criterion has not been met.

Recovery criterion—Develop a commercial source of plants

- This criterion is no longer relevant. Collection pressure is not a contemporary threat to *T. persistens*; therefore, a commercial source of plants is unnecessary.

Recovery criterion—Enforce laws protecting the species and/or its habitat.

- This criterion has been met. The appropriate level of enforcement is being applied for the protection of this species.

Recovery criterion—Develop materials to inform the public.

- This criterion is partially complete. More information could be produced to inform the public about this species and on-going recovery efforts.

Currently, one of the most significant threats to this species is likely competition with exotic plant species and potential changes in the forest structure due to infestations of hemlock wooly adelgid.

III. RESULTS

A. Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered

____ **Delist** (*Indicate reasons for delisting per 50 CFR 424.11):*
____ *Extinction*
____ *Recovery*
____ *Original data for classification in error*
_X_ **No change is needed**

B. New Recovery Priority Number: NA

IV. RECOMMENDATIONS FOR FUTURE ACTIONS (listed in order of priority)

a) Efforts should be employed to eradicate kudzu presently established at US 441 in the Tallulah Gorge/Tallulah River population and on the floodplain below the Panther Creek population. Threats from kudzu are currently localized, but could become a problem in the next ten years if not adequately controlled. Eradicating kudzu would require at least a few years, but could be done, at present, relatively inexpensively at US 441 and Panther Creek. Inattention to the problem of kudzu eradication now would only increase the financial and biological costs of controlling this aggressive invader in the future. A stand of English ivy at the former, private roadside park (Tallulah Gorge Park) should also be controlled, but probably does not pose as large of a threat to *T. persistens* habitat as kudzu, considering its slower rate of growth.

b) Annual monitoring of occupied *T. persistens* habitat should be employed at all populations to evaluate potential threats from the hemlock wooly adelgid and potential infestations by invasive plant species.

c) Genetic analyses should be funded to determine variation among and between populations and/or their segments. Detailed genetic analyses represent a primary data need and are imperative to objectively direct management decisions to populations most important for preserving the genetic integrity of the species.

d) The effectiveness of recovery criteria and the implementation schedule should be evaluated and the recovery plan updated, as deemed necessary.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Trillium persistens*

Current Classification __Endangered___
Recommendation resulting from the 5-Year Review

____ **Downlist to Threatened**
____ **Uplist to Endangered**
____ **Delist**
__v__ **No change is needed**

Appropriate Listing/Reclassification Priority Number, if applicable _____

Review Conducted By _Pete Pattavina, Fish and Wildlife Biologist, Georgia Ecological Services

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve Sandra S. Tucker Date 6/30/11

The lead Field Office must ensure that other offices within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. The lead field office should document this coordination in the agency record.

REGIONAL OFFICE APPROVAL:

The Regional Director or the Assistant Regional Director, if authority has been delegated to the Assistant Regional Director, must sign all 5-year reviews.

Lead Regional Director, Fish and Wildlife Service

Approve _____ Date 10/26/11

The Lead Region must ensure that other regions within the range of the species have been provided adequate opportunity to review and comment prior to the review's completion. If a change in classification is recommended, written concurrence from other regions is required.

APPENDIX A: Summary of peer review for the 5-year review of *Trillium persistens*

A. Peer Review Method: Copies of this five-year review were provided to: (1) Jim Candler, Georgia Power Company, who performed the most comprehensive surveys on this species in the 1980's and has since been an expert on persistent trillium and its habitat for over 25 years; (2) Tom Patrick, Georgia Department of Natural Resources, a trillium expert and State Botanist for over 20 years; and (3) Dr. Chick Gaddy, renowned botanist and expert on trillium, and who performed many persistent trillium surveys under contract for Georgia Power Company over the last 20 years.

B. Peer Review Charge: Reviewers were asked to provide written or oral comments to Pete Pattavina, USFWS.

C. Summary of Peer Review Comments/Report: (1) Mr. Candler provided comments to Pete Pattavina via telephone and clarified the number of person hours/labor required to perform surveys on the species from 1983-1985. Mr. Candler also clarified the nature of land ownership and land swaps/transfers between Georgia Power Company and Georgia Department of Natural Resources and the U.S. Forest Service. Mr. Candler's comments were incorporated into the final draft of this document. (2) Mr. Patrick offered few comments orally and clarified some of the information related to Hudson Slay's demography work. No significant changes to the document were required. (3) Dr. Chick Gaddy responded to Pete Pattavina via email. Dr. Gaddy comments reinforced what the five-year review proposed regarding the need to perform genetic studies on persistent trillium before any delisting action occurs. Mr. Gaddy stated that protection of 75% of the species abundance is likely an outdated or arbitrary goal, considering the relative ease of genetic studies and their ability to inform conservation decisions. No modification of the document was required from Dr. Gaddy's comments.

D. Response to Peer Review

Reviewer comments on the five-year review were positive or functioned to correct small discrepancies in the document. No information within the five-year review was refuted or challenged by reviewers and any small clarifications provided by reviewers were incorporated into the final document.