Torreya taxifolia
Florida torreya

5-Year Review:
Summary and Evaluation

Liberty County, Florida. Photo by Vivian Negron-Ortiz

U.S. Fish and Wildlife Service
South Atlantic-Gulf Basin
Panama City Field Office
Panama City, Florida

5-YEAR REVIEW
***Torreya taxifolia* (Florida Torreya)**

I. GENERAL INFORMATION

A. Methodology used to complete the review: In conducting this 5-year review, we relied on the best available information pertaining to historical and contemporary distributions, life histories, genetics, habitats, and threats of this species. We announced initiation of this review and requested information in a published *Federal Register* notice with a 60-day comment period (83 FR 38322). A Working Recovery Group meeting was held on April 3, 2019 to discuss past, current, and planned activities and their relationship to the recovery actions stipulated in the Recovery plan and 5-yr review. Information from that meeting was incorporated into this 5-year status review. We received no public comments during the 60-day open comment period. We used a variety of information resources, including the Recovery Plan of September 1986, unpublished field survey results, reports of current research projects, peer-reviewed scientific publications, unpublished field observations by Service, State and other experienced biologists, and personal communications. The completed draft review was sent to five reviewers, and four provided comments. Comments were evaluated and incorporated as appropriate (see Appendix A).

B. Reviewers

Lead Region: South Atlantic-Gulf

Lead Field Office: Panama City Field Office, Dr. Vivian Negrón-Ortiz, 850-769-0552

C. Background:

1. **Federal Register Notice citation announcing initiation of this review:** August 6, 2018. 83 FR 38322

2. **Species status:** Declining. See section II.C.1.a. for current information.

3. **Recovery achieved:** 2 [2 = 26-50%; many recovery actions are ongoing], see sections II.B.3 and IV for details on recovery criterion and actions, and how each action has or has not been met.

4. **Listing history**

   Original Listing
   FR notice: 49 FR 2783
   Date listed: February 22, 1984
   Entity listed: species
   Classification: endangered

5. **Associated rulemakings:** None.

6. **Review History:**

Previous 5-year Review: July 30, 2010 (decreasing)
Each year, the Service reviews and updates listed species information for inclusion in the required Recovery Report to Congress. Through 2013, we did a recovery data call that included status recommendations such as "Decreasing" for this plant. We continue to show that species status recommendation as part of our 5-year reviews. The most recent evaluation for this plant was completed in 2019.

A previous 5-year review for this species was noticed on November 6, l991 (56 FR 56882). In this review, the status of many species was simultaneously evaluated with no in-depth assessment of the five factors, threats, etc. as they pertained to the individual species. The notices summarily listed these species and stated that no changes in the designation of these species were warranted at that time. No changes were proposed for the status of the species in this review.

Final Recovery Plan - 1986
No formal 5-year reviews were conducted on *T. taxifolia* prior to the Recovery Plan.

7. Species' Recovery Priority Number at start of review (48 FR 43098): 5C

Degree of Threat: High
Recovery Potential: Low
Taxonomy: Species
C: conflict with development and growth

8. Recovery Plan

Name of Plan: Florida Torreya Recovery Plan
Date Issued: September 9, 1986

II. REVIEW ANALYSIS

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

Torreya taxifolia is a plant; therefore, it is not covered by the DPS policy and it will not be addressed further in this review.

B. Recovery Criteria

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

Yes. The recovery plan included two recovery objectives: 1) production of a collection of sexually mature, healthy trees in cultivation representing the gene pool of the plants from the field; these plants will serve as stock for possible reintroduction into the native habitat; and 2) maintain the integrity of the torreya's native habitat. The Recovery Plan projected that downlisting could potentially be done when 5 populations with sexually mature offspring (viable or reproducing individuals) are established in secure portions of its native range. Delisting could be considered if 15

self-sustaining populations are established in separate ravine systems. The minimum population size and minimum land area for each population must be determined.

2. Adequacy of recovery criteria.

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

No. The recovery criteria were based on the available data at the time the plan was published 34 years ago.

b. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria?

No. The recovery plan only addressed factors A and C. See sections II.B.3 and II.C.2 for description of current information and 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:

The recovery criteria address factors A and C. Factor B is not addressed. Factor D, although relevant to this species, was not addressed by the Recovery Plan.

Evaluation of Criteria:

1. Ensure the preservation and appropriate management of Torreya's native habitat to allow for reintroduction.

Management is an ongoing action at The Nature Conservancy's Apalachicola Ravines and Bluffs Preserve (TNC), the Torreya State Park (TSP), and the Army Corps of Engineers' (Corps) Lake Seminole, GA, and by a few private landowners.

2. Produce cultivated plants of Torreya and conduct empirical investigations of methods to control the decline in cultivated plants.

Propagation of the species has been conducted by several botanical gardens (see Recovery action (RA) 3 for details), but specifically by the Atlanta Botanical Garden.

Several investigations have been undertaken, provided some understandings about pathogens, but controlling this species' decline is still ongoing. Investigations are ongoing. See RA 2.

3. Investigate the decline to determine its cause and, if possible, to find a cure.

Research into the cause of the decline is ongoing, see RA 2 for details.

4. Introduce cultivated plants into secure habitat within its former range

Ongoing, see RA 7 for details

We summarize our progress under existing recovery actions below.

Recovery Action 1: Protect the existing habitat

This is an ongoing action. The Atlanta Botanical Garden (ABG) and collaborators received a Recovery Challenge grant (Award #F20AC00357) to achieve objectives under Recovery Priority Action 1 of the Recovery Plan. The study will complete the following activities: post-hurricane survey to assess the biological damage to the existing preserves in Florida and Georgia; use of drones to record aerial imagery of 43 marked plants to assess damage, vegetative response and changes following Hurricane Michael (HM); outreach to property owners within the range of *T. taxifolia*; deliver a Citizen Science Kit to landowners, volunteers and staff interested in participating in Torreya conservation efforts; propagate cuttings from landowners and protected land; and safeguarding nursery expansion.

Protect the existing habitat

Management of existing biological preserves

Management is an ongoing action conducted by TNC, TSP, the Corps, and several private landowners including the Torreya Keepers.

2019-2020: The Torreya Keepers (TK) is a project of the Florida Native Plant Society (FNPS) which began as an assemblage of landowners and volunteers in 2018 to address recovery plan tasks associated with private lands. TK landowners and volunteers had been conducting surveys on private lands within the known range *T. taxifolia* distribution. Hurricane Michael (HM) delayed their 2018 and 2019 survey goals, because of the damage caused to the hardwood forest ecosystem that encompasses the distribution of the *Torreya* trees (B. Boothe, 11/18/2019, pers. comm.). Mr. B. Boothe has GPS data on about 35 trees found on his property; most Torreya are less than three feet tall and some have been "studied" for work performed by ABG (Boothe, 11/18/2019, pers. comm.). The TK visited other properties in the Crooked Creek watershed and documented some additional 40-50 trees that ranged from 91-609 cm (3-20 feet) tall.

The FNPS received permission from 40 private landowners to survey their properties for *T. taxifolia* (J. Rynear, FNPS, 6/03/2020, pers. comm). At least three landowners acknowledged to have *T. taxifolia* on their properties. Unfortunately, landowners have not been able to inspect the plants after HM because of the hazardous conditions, and worried about the plants' survival given their detrimental health conditions prior to HM (J. Rynear, FNPS, 5/11/2020, pers. comm.).

2011-2012: subset of 25 caged trees (5 treatments x 5 replicates) were used in ecological experiments to establish the best management conditions for remaining trees and provide minimum condition guidelines for successfully reintroducing trees into the park. The experimental treatments were set up during February-April 2011. The treatments included 1) Control (caged tree), 2) application of mulch and cage, 3) application of lime and cage, 4)

experimental opening of canopy over the *Torreya* to allow increased morning sunlight and caging, and 5) a combination of all treatments. These treatments were monitored in 2012 to measure the effect of ecological manipulation. An additional 100 trees were located and caged to protect from herbivory during 2012. Currently, we don't have an update of this effort.

2010: Ms. Pamela Anderson (volunteer at TSP) monitored 400+ trees, and collected data related to stem length and width. According to her results, she noticed an apparent decline since 2000. HM damaged most trees in 2018, but we don't have current information.

Management plans have been developed and implemented by TSP. Management includes constructing enclosures to prevent damage from deer, restoring adjacent uplands, preventing erosion in the sandhill and slope forests, and exotic species control. The Corps has no written management plan and we do not have information for the TNC population.

Determine protection strategies for *Torreya* habitat outside of preserves

2019-2020. The TK received funding in 2019 and 2020 from Section 6 and FEMA, respectively, to 1) seek out property owners within the predicted range of the species; 2) survey for Florida torreya trees once landowner permission has been obtained; 3) collect genetic material for analysis and propagation; 4) set up and monitor seed trials on private lands; 5) utilize and advise on best management practices, and 6) work with conservation partners to monitor trees and provide educational opportunities for students and volunteers. The TK intend to use some areas on their private lands as experimental plots to study different environmental perimeters on growth and survival. They have fenced several trees to prevent deer rubbing and damage from falling limbs and trunks of other tree species.

A species distribution model conducted by Ramirez-Reyes et al. (2020) will be used to guide survey on predictive range in private lands. TK will determine the present natural distribution range for the species.

2010. Ms. Anderson on her property planted a few seedlings and used oak leaves as compost and found that the seedlings have grown faster. Mr. Bill Boothe has property with naturally occurring *Torreya* trees and helped identify GPS locations on other nearby properties. Some of these were 40-50 trees of about 6-15 feet tall. He would like to see the use of private lands as experimental plots – opening the canopy, using smoke for pest control to limit die off.

The *Torreya* guardians, a religious group based out of northern Georgia that was created in 2004, translocated seedlings of *T. taxifolia* outside of the species native habitat (two sites in North Carolina mountains). One of the identified goals of their intentional assisted migration was to save *T. taxifolia* from extinction (http://www.torreyaguardians.org/save.html). Recent surveys of *T. taxifolia* outplantings in northern Georgia and North Carolina natural areas in 2020 by staff at ABG have found cankers formed by fungal infections on the *T.*

taxifolia trees, and on other species of trees surrounding *T. taxifolia*, including *Tsuga caroliniana* (E. Coffey, ABG, 6/10/2020, review). The identity of these fungal infections remains to be confirmed, but these observations indicate there is some risk of *Fusarium torreyae* being transported with transplanted *T. taxifolia* to the southern Appalachian Mountains, and the fungus moving onto other threatened species of trees.

Recovery Action 2: Control the Torreya decline

This is an ongoing action.

Identify pathogen(s) responsible for the decline

2020: An ongoing project at ABG is focused on determining whether the fungal pathogen (see 2011, 2013 Smith & collaborators findings) has infected outplanted material at Vogel State Park and Smithgall Woods State Park, GA and if it has moved into surrounding trees. A preliminary inspection of trees at Vogel State Park revealed fungal cankers on outplanted *T. taxifolia* material, and fungal infections on surrounding *Tsuga caroliniana* and *Carya* sp. Fungal material from these trees has yet to be sequenced to determine if the species infecting these trees is *Fusarium torreyae*.

2019: Kumarihamy et al. (2019) investigated endophytic fungi isolated from a diseased leaf of cultivated *T. taxifolia*; compounds isolated showed potent in vitro activity against *P. falciparum* D6 and W2 strains (protozoan parasite that causes malaria).

2013: A systematic survey (soil-borne pathogen survey of roots, soil and plant litter associated with *T. taxifolia*) was conducted from three sites at TSP, Florida, and one site in Decatur, Georgia. About 102 fungi were isolated: 27 isolates (26%) were from TSP and 75 (74%) from Georgia. All *T. taxifolia* trees sampled showed moderate to severe levels of decline; 48 % had root necrosis and stem cankers. Composition of fungal community included plant pathogens, lignin and cellulose decomposers, endophytes and saprophytes.

2011, 2013: Smith et al. (2011) conducted an above-ground plant pathogen study. They isolated numerous fungi from cankers and consistently found *Fusarium torreyae* (Aoki et al. 2013), as possible etiological agent. According to the studies, when *Torreya* plants were inoculated with *F. torreyae*, it leads to canker development, lesions, and mortality.

Dr. Smith's lab identified *F. circinatum* in a canker on one of the lower branches of a permanently planted individual at the Bok Tower Garden (Bok Garden; P. Lynch, Bok Garden, 6/03/2020, pers. comm.).

1997: Herman and Schwartz (1997) studied the pathogenicity of *Scytalidum* sp. They inoculated both needles and stems causing needle spots and necrosis, but couldn't provide evidence that it was the cause of the original decline of *T. taxifolia*.

1967: This ongoing action goes back to 1967 (Alfieri et al. 1967). The authors observed that the stem and needle blight disease of *T. taxifolia* appears to be incited by a fungus causal agent implicating *Physalospora* and *Macrophoma*. Alfieri et al. (1987) isolated six other fungi from leaves and stems of *T. taxifolia*. Lee et al. (1995) isolated more than 30 different endophytic fungi, but consistently, *Pestalotiopsis microspora* (a fungus that resides in the inner bark of symptomless *T. taxifolia* trees) was found on diseased trees. They concluded that the pathological activity of this fungus could be triggered by physiological and/or environmental stress.

Conduct empirical experiments into disease management in mature cultivated specimens

Conduct integrated scientific tests of the effectiveness of various culture regimes

J. Smith and collaborators (2011, 2013) conducted independent fungicides tests for stem canker. In addition, the ABG has an ongoing study to determine whether the pathogen has infected outplanted material, Vogel State Park and Smithgall Woods State Park, and if it has moved into surrounding trees (see above).

J. Smith proposes to assess the potential use of mycoviruses to reduce virulence of *Fusarium torreyae* (J. Smith, UF, 06/26/2019 comm. to Torreya Tree Conservation project) and its applicability to Torreya trees.

Investigate mycorrhizal relations of *Torreya* (completed)

2012: Dr. Melissa McCormick (2012, upubl. report) examined the mycorrhizal associations of *T. taxifolia* within its native range along the Apalachicola River in northern Florida and extreme southern Georgia and in several explants from northern Georgia into North Carolina. It was determined that *Torreya* forms associations with arbuscular mycorrhizal (AM) fungi, mostly belonging to *Glomus,* a genus with a role in protecting host trees against root pathogens. The study suggested that *Torreya* is strongly dependent on mycorrhizal fungi, and native populations have sufficient diversity of mycorrhizal fungi available to support healthy tree growth. Torreya in native populations were heavily shaded and diseased, as well as less extensively colonized by AM than in other locations. Thus, to help increase colonization by AM and improve pathogen resistance, management activities could increase light available to native populations.

Develop a protocol for experiments on seedlings and cuttings

See action 3, sections *establish seedling production programs* and *propagate from cuttings.*

Recovery Action 3: Produce seedlings and cuttings

This is an ongoing action

Locate seed-bearing trees

Most of the wild population persists as stump sprouts, so seed-bearing trees are rare.

2010 to present: about 15 plants were observed coning in the wild: three female cone bearing plants at TSP; one female cone bearing tree at Corps' property; and three male plants on private lands; locations of the other 8 plants are unknown.

Several botanical gardens have seed-bearing trees (Atlanta Botanical Garden (ABG), GA; Callaway Garden, GA; Biltmore Gardens, NC). In cultivation, a large proportion (>60) of the *Torreya* trees in the conservation collection at ABG began producing reproductive cones. Seedlings from these mature plants also became reproductive within 10 years. The Callaway Garden has a partial duplicate set of ABG cutting inventory trees that had produced seeds, however, they are in decline.

Protect seed from frugivores

This action has not been initiated, but concerns were raised related to seed predation by squirrels. Most trees do not produce cones in the wild population. In *ex situ* collections, cones on female seed-bearing trees are caged at the ABG and at one of the safeguarding locations at Georgia Department of Natural Resources Smithgall Woods/Dukes Creek Conservation Area (Smithgall Woods) to protect seeds and facilitate collection for propagation.

Disseminate and propagate seeds

2019: Seed trials are being conducted by ABG to determine if different maternal lines show variation in germination and survival. Thus far, there is no statistical difference among the seven maternal lines tested. The study is ongoing.

2016: The ABG provided seeds to Bok Garden and successfully germinated ca. 60 plants.

2010: ABG has 500-600 seeds in some years that they propagate and grow in the conservation collection at the garden, and in some cases disseminate to other botanical gardens, to universities for study, use for outreach (display), and long-term storage. The Biltmore Gardens harvested 300 seeds in 2009 and were distributed to interested parties (http://www.torreyaguardians.org/2009-seeds.html).

Establish seedling production programs

The ABG has the largest collection of seed-bearing plants. Seeds have been collected from 15-20 trees and been propagated and shared with conservation or research partners, and ABG holds approximately 70 female trees in conservation collections.

Ma et al. (2011) developed a somatic embryogenesis tissue culture system that can be used for cryogenic storage of *T. taxifolia* cultures and subsequent plant regeneration. Induction of embryogenic tissue from this species averaged 76% over 2 yrs. with six seed sources. With inability to store *T. taxifolia* whole seed and

natural populations of continuing to decline, this is critical tool to safeguard existing germplasm and for producing disease-free trees. The material can be stored in liquid nitrogen as a library/bank for future use. As of October 2011, about 25 embryogenic cultures from five mother trees were placed into liquid nitrogen for long-term storage and confirmed to survive after retrieval from liquid nitrogen (ABG 2011).

Propagate from cuttings

The ABG is currently safeguarding 584 individual's ex-situ (ABG 2019); of the total trees, 189 cuttings were collected post HM representing individuals not currently housed in ex-situ; unfortunately, 20 did not survive the first 6 months.

As part of the Center for Plant Conservation program, 2,622 stem cuttings were collected from 166 trees at 14 sites in the late 1980s to the early 90s. Rooted cuttings were sent to 10 institutions (including the Bok Garden, Lake Wales, Florida) for safeguarding but this material posed several challenges: could carry unknown pathogens responsible for the decline of this species; and the cuttings were mainly collected from lateral branches and in cultivation they often display plageotropic architecture (they have dominant lateral growth and end up looking like shrubs). The ABG has switched to propagating cuttings made from 'leaders'- the rapidly growing apex (top) of a tree. This process forms upright plants of about two-feet tall in about two years.

Of the 15 permanent plantings reported by the Bok Garden in 2009 (USFWS 2010), 9 plants remain; but it is unknown when or why the missing individuals were removed (P. Lynch, Bok Garden, 6/03/2020, pers. comm.). Currently, the Bok Garden has 80 plants located on the Garden grounds, ten of which are permanent plantings in addition to another 70 seedlings in their nursery (P. Lynch, Bok Garden, 6/03/2020, pers. comm.). In 1991, Bok Garden received 97 plants from the Arnold Arboretum, and staff actively propagated clones and annually reported growth and mortality data to Mercer Arboretum, Arnold Arboretum and to the Center for Population Biology.

The ABG has been propagating *T. taxifolia* in its conservation collection for more than 20 years and has increased the number of trees in its collection to more than 1200 stems. This is the largest *ex-situ* collection of Florida Torreya outside the natural range of the species (and potentially as large as the remaining wild population). After more than 20 years since the *ex situ* collections were established at ABG, they have the first reproductive offspring. The seedlings have the correct vertical architecture and are good candidates for reestablishment in the wild populations.

Conduct grafting experiments

The recovery plan suggests grafting [asexual propagation where the tissues (vascular cambium) of one plant are fused with those of another] with *T. californica*. However, *T. californica* is exhibiting some issues with cankers caused by pathogens with a different *Fusarium* species which is killing the cambium.

Recovery Action 4: Investigate the ecological requirements, population dynamics, and life history of Florida torreya

This is an ongoing action.

Study the ecological physiology of torreya

2014: Mola et al. (2014) compared leaf litter flammability of nine species including *T. taxifolia* from TSP. The authors measured maximum flame height, flame duration, smoldering duration, mass loss, absorptive capacity, and drying rate. Fuel consumption segregated species into two distinct groups, most species had means ranging from 73 to 89% consumption, whereas rare *T. taxifolia* and *Taxus floridana* had only 44% and 41% mass loss, respectively. However, these two species had the longest duration flaming and the brief smoldering. Results suggest that extant *T. taxifolia* contributes little to the litter fuels because it has declined in both abundance and stature; average tree height near only 1 m. Thus, increased fire in the ravines may further imperil these two species and other rare ravine taxa.

1999: Koehn and Doudrick (1999) investigated diurnal patterns of chlorophyll fluorescence and CO_2 fixation. The study indicated that plants recovered from daily periods of high light and temperatures, suggesting that they may tolerate higher light conditions in their native habitat. Tree rings studies somewhat indicated that growth in *T. taxifolia* is light limited (Schwartz and Herman 1999).

Herman and Schwartz (1997) conducted shade and open canopy treatments on TNC Apalachicola Bluffs, TSP, and the Corps property. Mortality was high, and no patterns associated with light were detected when data was pooled across sites.

Evaluate the native habitat

Since 2008, the ABG in collaboration with TSP and University of Florida and landowners (including TK) have conducted an updated survey of habitat conditions and population status with the natural range if *T. taxifolia*. In-situ conditions for *T. taxifolia* and its habitat were dramatically altered by HM in late 2018, thus the ABG efforts shifted from tree monitoring to search and rescue. They were able to uncover 292 trees from fallen debris. As of 2019 more than 650 trees have been georeferenced and baseline data on the individuals recorded across the range.

2010: Collaborators have georeferenced and collected information on approximately 150 trees from locations throughout the natural range of *T. taxifolia*. According to the surveys and studies, the population range has not contracted and in some cases habitat management has improved and restored habitat especially at TSP and in the Nature Conservancy's Apalachicola Bluffs and Ravines reserve, but the demographic health of the population has declined. Future efforts should evaluate the success of habitat management experiments in improving the health of *in situ* trees.

Study population dynamics and life history

Current status surveys conducted between 2008 – 2010 in collaboration between the ABG, TSP, and the University of Florida have documented the health and size of several trees (see section C1 for details). All of the plants were stem sprouts and none of the plants had reached reproductive maturity. No seeds or seedlings were found. Funding should be made available to continue the status surveys and update the information regularly. No demographic studies have been done.

Recovery Action 5: Establish experimental collections of Torreya outside its native habitat

This is an ongoing action.

Georgia: The ABG and the Georgia Department of Natural Resources outplanted 19 individuals of *T. taxifolia* at the Smithgall Woods in White County in north Georgia. The purpose of the Smithgall Woods collection and two additional off-site plantings (Blairesville, GA and Vogel State Park) were to establish safeguarding populations of *Torreya* to conserve material that had been propagated at the ABG in backup collections at more than one location (Cruse-Sanders 2010, pers. comm.). The material planted at Smithgall Woods was propagated from all Georgia source population material (Army Corps. Of Engineers, site at Woodruff Dam, Lake Seminole, in Georgia). The trees have grown quite large and are now reproductively mature producing male and female cones annually. Most of the plants were placed in full sun and they are quite healthy. Major threats to the trees at this location are lawn management (weed wackers) and fire ants. The trees at Vogel State park are smaller than those at Smithgall Woods and have not yet reached reproductive maturity. Trees that are planted outside of the range of *T. taxifolia* need documentation of lineage.

2020. A preliminary inspection of trees at Vogel State Park revealed fungal cankers on outplanted *T. taxifolia* material, and fungal infections on surrounding *Tsuga caroliniana* and *Carya* sp. The ABG will be determining whether the fungal pathogen *Fusarium torreyae* has infected outplanted material at Vogel State Park and Smithgall Woods State Park, and if it has moved into surrounding trees.

North Carolina: In 1939 nearly a dozen specimens of *T. taxifolia* were planted at the Biltmore Gardens; 31 seedlings were planted in 2008 at two locations near Waynesville; this site summarizes the outplantings conducted in NC http://www.torreyaguardians.org/north-carolina.html).

Recovery Action 6: Place seed in long-term storage

See action 3 section *disseminate and propagate from seeds.*

Recovery Action 7: Reestablish Torreya in its native habitat

This is an ongoing action.

In 2002, the ABG in collaboration with Florida State Park Service reintroduced seedlings propagated from seed produced from the cuttings collected by the Arnold Arboretum of Harvard University in 1989 (ABG 2007). The cuttings were obtained from the wild population at TSP. The plants were reintroduced into ravines where *T. taxifolia* were lost due to the fungal blight. Sixty seedlings were

subjected to four different treatments (fungicide, fertilizer only, fertilizer and lime, and control) for determining the optimum reintroduction techniques for this species. Only 34.5 % survived after one-year post planting. No current information is available.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. Abundance, population trends, demographic features, or demographic trends:

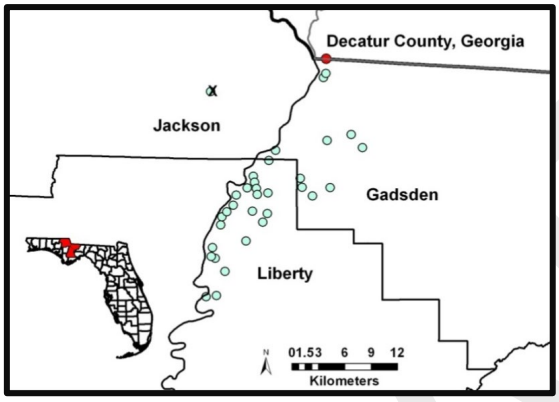

Fig. 1. Map of Florida (inset) showing the counties and locations of *T. taxifolia.* Dots show the historical EOs of *T. taxifolia* in Florida and Georgia.

This species, which belongs to the yew family (Taxaceae), is an endemic tree of ravine slopes on the eastern bank of the Apalachicola River in northern Florida and in Georgia (Fig. 1). Based on GIS coverage, the range of *T. taxifolia* is about 55,239 ha (Schwartz et al. 2000a). The authors suggested that the ravines probably occupy 36.8% of the total area, resulting in an estimate of 20,370 ha of ravine habitat potentially available for *T. taxifolia*.

Prior to 1950's, *T. taxifolia* was estimated to be the seventh most abundant tree species within Apalachicola Bluff regions; over 600,000 individuals were estimated (Schwartz 1993). The tree may had had heights of up to 18m (59ft) and 80cm (31in) diameter trunk, but nowadays trees show stems die-back that often re-sprout to less than 3m (9.8 ft) tall. Surveys conducted in areas with known high tree densities suggested that *T. taxifolia* has **lost at least 98.5% of its total population size**; it was estimated less than 1500 trees in the wild (Schwartz et al. 1995, 2000a). The west side of the Apalachicola River in Jackson County was surveyed about 20 years ago; no live trees were found, although logs were located (Fig. 1).

2018 to present: The Florida panhandle and southwest Georgia took a direct hit from Hurricane Michael (a Category 5 hurricane with wind bursts up to 200 mph) in 2018, and the entire native range of *T. taxifolia* was impacted with an estimated 80-90% canopy loss (Liberty and Gadsden Counties, Florida, and Decatur County, Georgia). Thus, the 750 number of plants estimated prior to HM has decreased because of the hurricane and its aftermath (ABG 2019). To date, surveys at TSP located 292 trees: 29% were found dead/missing (54 trees) or dead (32 trees), and 4% (12 trees) were new recorded trees (ABG 2019).

The Corps surveyed for Torreya trees on June and December 2019 (Griffin, Corps, 05/18/2020, pers. comm.) but all the debris from HM hindered the effort. They were able to find and evaluate 5 trees (4 alive, one dead). Future surveys to locate remaining known individuals are planned with the help of the ABG and collaborators.

2007-2017: **Florida**: Prior to HM, surveys between 2012 to 2014 revealed 645 wild *T. taxifolia* from six sites and < 25% fenced against deer rub (AGB 2012-2014). Surveys indicated that long-term and population trends are not different from those published by Schwartz et al. (2000b): the naturally occurring population of *T. taxifolia* is decreasing; little to no reproduction with no recruitment in the wild was observed, and remaining trees are impacted by disease, herbivory, deer rub, along with other confounding factors.

In 2012, a total of 380 Torreya trees were surveyed representing 60% of the total known documented wild population. The survey work was primarily done at Torreya State Park: 211 trees were found and assessed for the first time, 124 were reassessments, and 30 were included as part of an ecological experiment.

- Average height of trees visited: 121.8 cm with a basal diameter of 1.87 cm.
- Of the trees re-visited: 32.4% showed stem dieback and loss of stem length averaging 52.67 cm.
- 67.6% remaining trees:
  - did not lose stems
  - showed growth averaging 12.51 cm/year
  - 61.9% showed signs of stem canker
  - 59.8% showed signs of deer rub.

Between 2007-2009 the TSP and collaborators measured stem length and diameter of 223 *Torreya* trees in its native habitat. The trees show an average height of 115 cm (3.7 feet) and a basal diameter of about 1 cm. About 80% of the trees were with stem cankers, affecting all diameter classes. On June 2009, 12 plants were measured (Rivera 2009) and showed root necrosis and stem cankers in 45.8 % of trees examined.

Georgia:

- Four surveys conducted in Decatur County, between 1980 and 2014 indicated the presence of 27 trees (Allison 1988; Griffin, Corps, 2010, pers. comm.; AGB 2012-2014; Table 1). Overall, the surveys indicated a 15 % decline in the number of trees. Presently, a comprehensive survey post-HM is essential (Table 1).
- Twelve plants were measured on June 2009 by Rivera (2009) and PCFO botanist. Heights of main stems varied from 80 - 400 cm (2.6-13 feet) with a mean of 176.4 cm (5.8 feet). Stem circumference varied from 4 - 14 cm with a mean of 10.9 cm. Five of the 12 plants had stem cankers; one of the five plants had both stem canker and root rot (necrosis); and one plant shows signs of declining (branches were dying).

Table 1. Number of trees reported on three censuses conducted on *T. taxifolia* in Decatur County, GA population. '-' represents no data.

SURVEY	# OF TREES	MEAN HEIGHT (CM)	NOTES
1980-1981	27	100 (25-200)	Stem canker on one tree
1988	26	139 (28-272)	Sprouts observed with stem canker, stem lesions, necrotic spots on leaves
2010	21	-	one plant has deer damage (rub) and one is in decline
2011			8 trees were surveyed, stem canker on one tree
2012-2014	23	-	All caged and protected against deer rub
2019	5		4 trees alive, one dead; status of other trees: unknown

In general, the current populations, which are declining in numbers, are characterized by small individuals that are failing to achieve reproductive maturity. Trees appeared to be smaller at Florida sites compared to trees in Georgia's site, but currently it is unknown. Given the lack of seed production in the wild and potentially a decline due to a disease, **all population viability models predict extinction** (Schwartz et al. 2000b).

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

2019: ABG is currently expanding their population genetic studies using modern techniques. They are working with colleagues at the University of Georgia and the Royal Botanic Gardens Edinburgh to use a target gene capture approach to characterize thousands of single-nucleotide polymorphisms across the entire genome of the tree. Data from such an assessment will inform if they are properly safeguarding genetic diversity of the wild population and identify locations that may have unique genetic diversity that could be used in future breeding programs to create a fungal pathogen resistant line.

2012: Through section 6 funding (ABG 2012), the ABG and collaborators estimated the level of genetic diversity in *ex-situ* populations of Florida Torreya. Among 13 allozymes examined, seven of 26 loci identified were monomorphic. The genetic diversity detected in ex-situ was closed to average for other gymnosperms, with % of polymorphic loci (P) =69.23%, and expected heterozygosity (H_e) =0.178. These data suggest that the ABG ex-situ collection may not show a bottleneck effect and decline in genetic variation based on comparisons to average values for other conifers (Hamrick and Golt 1990) and when compared to a genetic study of natural populations of *T. taxifolia* using a non-overlapping set of molecular markers (Schwartz 1993).

ABG and collaborators also examined individuals collected from wild trees in the early 1990s and characterized the possibility of shared genotype with the current ex-situ collection. A total of 370 multilocus genotypes were identified: 356 trees had unique genotypes, and only 14 pairs of individuals shared same genotypes.

1993. Allelic variation was examined for 189 *T. taxifolia* in 17 populations distributed throughout the range. Results revealed that low levels of genetic

variation characterize the species (Schwartz 1993). Of the 20 loci sampled, seven exhibited allelic variation (contained two alleles), and three of these were variable in only one population. The author concluded that the genetic pattern observed is consistent with a species subjected to several population bottlenecks, and these bottlenecks probably occurred prior to the 1950's decline.

d. Taxonomic classification or changes in nomenclature:

Kingdom:	Plantae
Division:	Conifers
Order:	Taxales
Family:	Taxaceae
Genus:	*Torreya*
Species:	*taxifolia* Arn.
Common name:	Florida torreya, Florida nutmeg, stinking cedar

Comparisons of *rbc*l chloroplast DNA sequences involving *T. californica*, *T. grandis*, *T. jackii*, *T. nucifera,* and *T. taxifolia* indicated that Florida torreya is very distinct from other species, and is most closely related to *T. californica* and *T. grandis* (Price 1999). In addition, the DNA sequences suggested that the closest generic relative is the Asian *Amentotaxus.*

Interspecific relationships of *Torreya* were examined using nuclear ribosomal DNA ITS region (Li et al. 2001). The study shows that the New World species, *T. californica* and *T. taxifolia,* form a monophyletic clade separated from the Old World *Torreya* species. This suggests that the present distribution is a result of a single vicariance event separating the New World from the Old World.

Other taxonomic studies have not been conducted.

e. Spatial distribution, trends in spatial distribution, or historical range:

Fossil records of *Torreya* are limited to seeds, leaves, and secondary wood of the Upper Cretaceous (Boeshore and Gray 1936, Chaney 1950). The records indicated that the distribution of the genus in past geological times was much wider than the present distribution. A fossil named *T. antigua,* which has some characteristics in common with *T. taxifolia* and *T. californica*, was described from the Mid-Cretaceous of North Carolina and was also collected from the near MacBride's Ford, Georgia (Boeshore and Gray 1936).

Currently, Florida torreya grows naturally in two counties in Florida: Gadsden and Liberty. It is also found in southern Decatur County, GA, just north of Chattahoochee, FL. Based on fossil records, we can speculate that the geographical range of *T. taxifolia* included North Carolina and perhaps, it was forced south by glaciers, and when they retreated, it became isolated in small areas of the southeastern United States.

Historically, the distribution of *T. taxifolia* included the ravine slopes along the eastern side of the Apalachicola River from Bristol (Liberty County), FL to just across the Florida-Georgia state line, north of Chattahoochee, FL (Schwartz et al. 2000a). According to G. Nelson (2010, pers. comm.), no live trees were found in a survey conducted for the Jackson County's EO, therefore the current range has declined to just two counties in Florida and one in Georgia (Fig. 1).

f. Habitat:

The Florida torreya is a dioecious coniferous tree found in the slope forest (FNAI 2010) that cover hammocks, steep, deeply shaded limestone slopes and wooded ravines along the east side of the Apalachicola River in Florida (Fig. 1), and adjacent Lake Seminole in Georgia. Soils in these areas are within the orders Alfisols and Mollisols. Although scientists speculated that construction of Lake Seminole and logging contributed to the destruction of Florida torreya's habitat (e.g., alteration of water seepage patterns), the growth of *Torreya* plants was not suppressed during or immediately following the construction of the dam, and likely was not a major factor (Atchley 2004).

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

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

Habitat loss was not a factor in the decline of this species. Two factors have been speculated as potential threats: changes in soil chemistry associated with disruption of hydrology when upload topsoils were plowed in the 1950's, and perhaps fire suppression (Schwartz et al. 1995). In addition, a Woodruff dam construction at Lake Seminole in Chattahoochee, Georgia coincided with the decline and may have been responsible for warming ravine microclimates (Schwartz et al. 1995). But based on dendronological evidence, Atchley (2004) concluded that the construction of the dam was not a major factor contributing to the decline of *T. taxifolia* because growth of *Torreya* plants was not suppressed during or immediately following the construction of the dam. It was mentioned that "large-scale changes in the landscape coincided with unfavorable climate conditions during the mid-1950s decreasing photosynthesis rates and weakening *T. taxifolia."*

Previous Department of Environmental Protection (DEP) biologists stated that the habitat of *T. taxifolia* were altered as a result of past logging practices, reducing suitable habitat. However, M. Ludlow (DEP biologist, 6/18/2020, pers. comm.) specified that there is almost no evidence of past logging in the TSP Sweetwater slope forest. According to Ludlow (M. Ludlow, DEP, 6/18/2020, pers. comm.), "The Sandhill habitat adjacent to Torreya's Sweetwater slope forests were converted to industrial pine plantation when in private ownership. Under Florida

DEP ownership for the last 20 years, over 90% of the park Sandhill habitat has now been restored."

Previous DEP biologists also suggested that the non-native earthworms in leaf litter are affecting the forest health. As to fire, it has been stated that many of the lower slopes do have longleaf pine and wiregrass down in the ravines and may have a long fire interval. But the areas where *T. taxifolia* occurs are unlikely to have had fire in the past given the type of topography and the presence of a river on one side (Harper 1914). In addition, Mola et al. (2014) study of leaf litter flammability suggested that extant *T. taxifolia* contributes little to the litter fuels because it has declined in both abundance and height, and increased fire in the ravines may further imperil this species and other rare ravine taxa.

Since the habitat continues to be restored due to past logging and the plants in outplanted areas grow but eventually die, then habitat alteration is a present threat.

b. **Overutilization for commercial, recreational, scientific, or educational purposes:**
Many of the largest Florida torreya trees were harvested and used for fenceposts, shingles, and as fuels for riverboats (Schwartz et al. 2000a). Also, the species has been cut for Christmas trees, but in 1980 and 1981 there were only a few Florida torreya tall enough to be used for this purpose. Therefore, at present there is no evidence to suggest that harvest is a threat.

c. **Disease or predation:**
Disease: The Recovery Plan identified a fungal disease as one of the primary threats responsible for the species' decline. Presently, *Fusarium torreyae* is causing canker development on *T. taxifolia* and likely the cause of stem dieback (Smith *et al.* 2011). Since there is no identified treatment to control this pathogen, *T. taxifolia* will most likely continue its decline. Research is ongoing to determine or arrest the fungal infestation (see *Research Recovery Action 2*). Therefore, this factor is a threat.

Deer damage: Deer rubs cause significant cambial bark tissue damage to young shoots from each branch, further stressing trees. Deer browsing affects small trees accounting for 46.5 % of the damage. Deer rub was present on more than 50% of the 223 *Torreya* trees surveyed in 2008-2010 (Spector, Cruse-Sanders, Smith, and Determann 2010, pers. comm.). Some of these rubs were extremely severe to the cambium as to break stems or kill trees. Deer rub the main stem and could introduce disease into the vascular cambium. It is a major problem at the TSP; only one plant was reported with deer rub damage at the Georgia population (Table 1). Therefore, stem damage caused by deer rubbing represents a threat to the *T. taxifolia* populations. To minimize this threat, trunk protectors or cages are being implanted to prevent deer rubs and damage due to herbivory.

d. **Inadequacy of existing regulatory mechanisms:**

The Endangered Species Act (Act) of 1973, as amended prohibits the removal of federally listed threatened and endangered plants or the malicious damage of such plants on areas under federal jurisdiction, or the destruction of endangered plants on non-federal areas in knowing violation of state law or regulations or in the course of any violation of a state criminal trespass law. However, the Act does not provide protection for plants on private lands or unless it is in violation of state law. Several populations of *T. taxifolia* occur on private land.

The State requires permission of private landowners for collecting of state-listed plants from their property. *Torreya taxifolia* is protected under Florida State Law, chapter 85-426, which includes preventions of taking, transport, and the sale of the plants listed under the State Law. The rule Chap. 5B-40, Florida Administrative Code, contains the "Regulated Plant Index" (5B-40.0055) and lists endangered, threatened, and commercially exploited plant species for Florida; defines the categories; lists instances where permits may be issued; and describes penalties for violations (http://www.virtualherbarium.org/EPAC).

The existing regulatory mechanisms are inadequate for plants.

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

Catastrophic events: The effects of climate change are worsening the impacts of natural disasters, including hurricanes, algal outbreaks, fire, droughts, and floods (Carter et. al 2014). Over the past 50 years, several U.S. regions have seen increases in extended periods of high temperatures, heavy downpours, and severe floods and droughts. Hurricanes, a primary disaster type for Florida, have impacted the Florida's East Coast, Gulf Coast, Panhandle, and Keys. As the warming of the ocean surface temperature continue to increase in the future, hurricane intensity and rainfall are projected to rise, increasing threats to rare plants and wildlife.

As previously mentioned, the Florida Panhandle and portions of GA were impacted by Hurricane Michael in 2018. The distribution and abundance of *T. taxifolia* were already been affected, and Hurricane Michael impacted the entire range of this species by increasing plant loss, decreasing the number of occupied sites, and thus, exacerbating fragmentation, and increasing the possibility of extinction. To date, the ABG and collaborators received a Recovery Challenge grant (Award #F20AC00357) to achieve objectives under Recovery Priority Action 1 of the Recovery Plan. One activity is to carry out post-hurricane survey to assess the biological damage to the existing preserves.

Invasive species. The invasive herb, *Tradescantia fluminensis* (Small-leaf Spiderwort) is spreading from the Apalachicola River floodplain to the slopes on the east side of the River (Gorchov 2019). Prior to HM the patches of *T. fluminensis* near Torreya trees consisted of only small ramets, but with the canopy loss, there is the potential for these patches to become denser. In Florida, this invader spreads only vegetatively (no seed production), but at a rate of 1.2 m/year

(Gorchov 2019). Management, i.e., raking and subsequent removal of *T. fluminensis* fragments, near Torreya trees should be considered, because dense patches have the potential to negatively impact at least small trees, based on findings from New Zealand, where plots invaded by *T. fluminensis* had lower species richness and abundance of native tree seedlings than uninvaded patches of the same forests. Due to the linear growth rate of *T. fluminensis* on these slopes, Gorchov (3/27/2019, pers. comm.) recommended to remove this species any time it is seen within 2 meters of a Florida Torreya.

D. Synthesis

Torreya taxifolia is a conifer tree presently located in two Florida panhandle counties and one county in Georgia (Fig. 1). It is extremely vulnerable because of its limited range, its low population number, rarity of habitat, and threats. The main threat for this species decline is still not well understood, even though considerable research and management activities have been and are presently conducted on this species. The loss of *T. taxifolia* is thought to have primarily been a result of fungal pathogens during the 1950s and 1960s, and/ or a combination of environmental stress and native pathogens, but studies have yet to provide an explanation for this species' decline. The pathogen *F. torreyae* is a key contributor to the continued decline of this species. The magnitude of stem damage caused by deer rubbing represents a current threat; the vascular cambium is rubbed off causing an aperture for fungal infection. Overcollection was a threat of high importance in the past, but at present is not of concern.

Current survey information indicates a decline in the number of plants and the present historical distribution. Only 45 observations locations grouped into 18 EOs distributed throughout this species range in Florida were documented, based on a strict 1km separation distance (P. Frank, FNAI, 6/18/2020, pers. comm.). Based on current survey information, we have less than 750 plants due to the devastating damage caused by HM. A comprehensive population survey is needed (and ongoing) in order to update the actual counts of plants. The Georgia population had declined overtime (Table 1), and current conditions are unknown.

The current status of *T. taxifolia* remains unchanged from previous surveys by Schwartz and Hermann (1993). Schwartz found that 32% of trees showed stem dieback during his 1988-1992 surveys. The primary health issues affecting stems are canker and deer rub. Canker caused by *Fusarium* sp. (Smith et al. 2011) has been demonstrated to cause stem death but no treatment is known to date. On the other hand, deer rub may be preventable to some extent by using exclosure devices. Despite the conservation actions to protect and determine the cause of this species' decline, the degree of threat to its persistence remains high; therefore, the threat of extinction that faces *T. taxifolia* is imminent.

At this time, *Torreya taxifolia* continues to meet the definition of an endangered species under the Act.

III. RESULTS

A. Recommended Classification:

_X_ No change needed

B. New Recovery Priority Number: 5
As the species is no longer in conflict with development and growth, the conflict category 'c' should be removed.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

- **Immediate actions**
  - **Management**
    - Complete a comprehensive assessment of HM damage to *Torreya* trees and habitat in Florida and Georgia (ongoing study)
    - Continue to build and maintain enclosures at TSP and GA (and other places if necessary) to protect the plants from deer herbivory and rubbing, and to better assess the impact of browsing on *T. taxifolia.* This is an ongoing action.
    - Survey private lands and collect plant material for ex-situ programs. This is ongoing. The FNPS will help census/survey for all the current ravines in private lands containing Torreya.
      - The species distribution model conducted by Ramirez-Reyes et al. (2020) can be used to guide surveys on predictive range in private lands.
    - Safeguarding of *ex-situ* collection should continue. Expansion of *ex-situ* collection is important to ensure continued genetic preservation of a wide range of *Torreya* individuals including long term storage of embryos.
    - Complete a comprehensive census/survey for all the current ravines containing *Torreya.* The TSP, ABG, FNPS, and Dr. Jason Smith have been collaborating on a survey of current ravines containing *Torreya* and have developed a standardized protocol that is followed during surveys. Copy of the protocol should be provided to all interested parties.
    - Conduct surveys and related activities within a practical timeframe to inform accurate population trends (one or twice every 5 years). A standardized method to ensure consistency in collecting data is in place; it was developed by the ABG and FNPS.
      - Georgia population: Since plants are tagged, for each plant record height, circumference, # of branches, stems and leaf disease (e.g., stem canker, leaf yellowing) and reproduction (male vs. female cones).
      - Florida population: mark a subset of the population and follow for each plant the above recommendations.
        - ABG currently has 40 trees marked for detailed long-term tracking and evaluation of ecological factors that lead to greater longevity of individuals.
        - Ms. Anderson's had monitored about 400+ trees, but current information about this effort is not available.
    - Identify and acquire parcels with high density of *Torreya* trees and good quality slope forest.

- Avoid the use fire practices within *Torreya* habitat.

Research

- Conduct surveys for new populations (and potentially for sites for reintroduction) where similar habitat exists. The species distribution model developed by Ramirez-Reyes et al. (2020) may support this action to initially determine potential sites, with subsequent validation or inspection of the sites for plants. This action needs to consider the below effort carried out by previous botanists.
    - Allison (1988) searched areas near the Flint River within a few miles of the known populations as well as of floristic composition like known population located north near the Chattahoochee River. The searches didn't find additional populations.
    - Robert F. Thorne conducted botanical explorations in southwestern Georgia between 1946 and 1949 without finding new sites (Allison 1988).
    - Roland Harper walked along the Flint River from Chattahoochee to Bainbridge, without finding additional *T. taxifolia* sites (Allison 1988).
- Pathogen mitigation. Continue and expand studies related to the identification of pathogens. Research should include determining treatments and recommendations applicable for managing *Torreya* in its historic range.
    - Evaluate (or develop) resistant Torreya trees (if applicable)
        - J. Smith will be assessing the potential use of mycoviruses to reduce virulence of *Fusarium torreyae* (J. Smith, UF, 06/26/2019, comm. to Torreya Tree Conservation project). He will test for reduced virulence by scanning isolates genomically for viruses and trying transmission. According to Smith, 'hypovirulent isolates could be used to "inoculate" trees in restoration efforts that would then be protected against the ubiquitous virulent strains.'
            - If successful: the steps required for resistant tree programs should be identified as well as key risks in the use of resistant trees in the wild
- Complete genetics studies and provide *in-* and *ex- situ* recommendations; ongoing study by the ABG, Univ. of Georgia, and the Royal Botanic Gardens Edinburgh.
- Expand ongoing *in-situ* seed germination and seedling survival throughout the species range; ongoing study by ABG and collaborators.
- Management practices: Further investigations should be considered:
    - Mycorrhizae. Studies on the natural mycorrhizal communities associated with *T. taxifolia* ecosystems was conducted by McCormick (2012). There is no evidence that native Torreya habitats were deficient in mycorrhizal species. The study recommended that management activities that increase light available to Torreya in native populations might help to increase colonization by mycorrhizal fungi and so increase pathogen resistance.
- <u>Grafting experiments</u>
  This recovery action should be considered no longer appropriate and removed from the recovery plan because *T. californica* is exhibiting some issues with cankers caused by pathogens. See page 7 for details.

- Establish experimental reintroductions, and populations outside the range. This is an ongoing action and should be expanded. A plan prior to establish populations outside the range must be developed, including lessons from previous experimental populations.
- The recovery plan should be updated to define with present data the objective measurable criteria and better address the five factors.

Preventing extinction emergency plan

Actions	Purpose
Maintain an *ex-situ* collection in perpetuity	Use the collection as an insurance against extinction in the wild as well as a recovery strategy until the plants in the wild improve, overcoming factors limiting recovery
Ensure funding is continually allocated	To implement actions from the recovery plan, 5-yr review, and catastrophic events such as hurricanes.
Ensure pathogen mitigation studies are completed	To best manage *Torreya* and habitat within the historic range
Develop approved guidelines for reintroduction, augmentation, and translocation (and/or managed relocation)	For planning, implementing and monitoring (of growth, threats, and habitat). ▪ Use disease-free *T. taxifolia* material in environments in which the pathogens are not recognized and/or the habitat has been managed and cleared from the threat that brought the species to endangerment. ▪ Accurately map the proposed outplanting sites and use the GIS database as a permanent record of the source of a population and to track the propagules. ▪ Address present threats
Reintroduction within the historical site	Habitat characteristics of the source population must be matched as close as possible with the outplanting site (using aerial photographs and species distribution modeling methods), and there should be no remnant population to prevent disease spread. ▪ Allison (1988) provided recommendations of potential sites. These sites should be revisited and evaluated.

Augmentation of an existing wild population	The source stock for augmentation should be chosen from the same or a geographically adjacent population (within a 1,000-meter radius). If the goal is to increase the genetic variability in a population to reduce the risk of extirpation, then a careful genetic analysis of the source stock should be conducted prior to its implementation.
Managed relocation efforts, if necessary	Foster a working partnership with interested parties to help direct translocation efforts (introduction of a species to a site outside the known historical range). This effort could only be taken if: 1) reintroduction and augmentation *in-situ* strategies are not effective, 2) the site(s) provide(s) the only place safe from the threats that brought the species to endangerment; and it can be shown that there is a net gain for the species conservation, i.e., recovery unit. This management option should be carefully evaluated, and planning should be done with the best biological science. If a population has been already translocated, it could potentially be evaluated as an experimental population.
Outreach and Awareness Campaign	To change public behavior towards species loss and mobilize action for a sustainable *T. taxifolia* future

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Acknowledgements

Thanks to the participants of the Recovery Working group; they provided their time, knowledge, and updates of current conservation activities. This meeting was held on April 3, 2019.

Participant	Information
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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of
***Torreya taxifolia* (Florida torreya)**

Current Classification:

Recommendation resulting from the 5-Year Review:

__X__ No change needed

Appropriate Listing/Reclassification Priority Number: 5

Review Conducted By: Dr. Vivian Negrón-Ortiz, Panama City Field Office, Ecological Services Field Office.

FIELD OFFICE APPROVAL:

Acting Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve: RAFAEL GONZALEZ GONZALEZ Digitally signed by RAFAEL GONZALEZ GONZALEZ Date: 2020.07.07 13:45:36 -04'00' Date: _____

Appendix A
Summary of peer review for the 5-year review of
***Torreya taxifolia* (Florida torreya)**

A. Peer Review Method
The document was peer-reviewed by four outside reviewers that were chosen based on their qualifications and knowledge of the species. It was also internally reviewed by Dr. Sean Blomquist of the Panama City Field Office.

B. Peer Review guidance:
We indicated our interest in all comments the reviewers may have about the document, including validity of the data used, and identification of any additional new information on the *T. taxifolia* that has not been considered in this review.

C. Summary of Peer Review Comments
Reviewers commented that annual censuses are unlikely to conduct given the field conditions post HM and the lack of manpower to complete the task; updated the number of private landowners supporting surveys on their property and the number of trees found post-hurricane Michael; clarified the TK role; informed the status of *T. taxifolia* outplantings in northern Georgia and North Carolina plots; clarified facts about past logging at TSP; and provided a few editorial comments.

D. Response to Peer Review: All peer reviewer comments were evaluated and incorporated to the document.