

Whorled Sunflower
(*Helianthus verticillatus*)

5-Year Review:
Summary and Evaluation



Photo by Dr. Jennifer Mandel, University of Memphis

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U.S. Fish and Wildlife Service
South Atlantic–Gulf and Mississippi Basin Regions
Mississippi Field Office
Jackson, Mississippi

5-YEAR REVIEW

Whorled Sunflower (*Helianthus verticillatus*)

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, disturbances, and potential threats to this species. We announced initiation of this review and requested information in a published *Federal Register* notice with a 60-day comment period (84 FR 28850). We did not receive any public comments during this comment period. In an effort to acquire the most current information available, various sources were solicited, including data housed at State natural heritage programs, internet searches, and knowledgeable individuals associated with academia, and Federal, State, and non-governmental conservation organizations. Specific sources included the final rule listing this species under the Endangered Species Act; the recovery outline; peer reviewed scientific publications; unpublished field observations by Federal, State, and other experienced biologists; unpublished studies and survey reports; and notes and communications from other qualified individuals. The completed draft review was sent to affected U.S. Fish and Wildlife Service field offices and four peer reviewers for review. Comments were evaluated and incorporated into this final document as appropriate (see Appendix A).

B. Reviewers

Lead Region: South Atlantic–Gulf and Mississippi Basin Regions, Aaron Valenta, (404) 679-4144

Lead Field Office: Mississippi Field Office, M.S. Wiggers, (601) 364-6910

Cooperating Field Offices: Alabama Ecological Services Field Office, Shannon Holbrook, (251) 441-5837; Georgia Ecological Services Field Office, Michele Elmore, (706) 544-6428; Tennessee Ecological Services Field Office, Geoff Call, (931) 525-4983

C. Background:

1. **Federal Register Notice citation announcing initiation of this review:** June 20, 2019. 84 FR 28850.

2. **Species status:** Stable.

3. **Recovery achieved:** 1 (0-25% of recovery objectives achieved)

4. Listing history

Original Listing

FR notice: 75 FR 44712

Date listed: August 1, 2014

Entity listed: Species

Classification: Endangered

5. **Associated rulemakings:** Critical habitat designation, 79 FR 51002, August 26, 2014.

6. Review History:

Recovery Outline

The recovery outline was approved on October 23, 2014, and represents a preliminary guide for the recovery of whorled sunflower while the recovery plan is being prepared. The outline provides an overview of the species, including its habitat, biology, ecology, status, threats, and conservation actions and needs. The outline also provides a preliminary recovery strategy, including recommended recovery actions, for whorled sunflower.

Recovery Plan

A final, approved recovery plan was not available during this 5-year review process. We have initiated the recovery planning process for the whorled sunflower, which includes drafts of the species status assessment, recovery plan, and recovery implementation strategy.

5-year Reviews

No previous 5-year reviews have been completed for this recently listed species. Because the final, approved recovery plan is not available, we used the existing recovery outline, described above, to guide this 5-year review. This 5-year review was also informed by the draft species status assessment and its associated references.

7. Species' Recovery Priority Number at start of review (48 FR 43098): 2

Degree of Threat: High

Recovery Potential: High

Taxonomy: Species

8. Recovery Plan: Final recovery plan has not been approved. Only a recovery outline is currently available.

Name of Outline: Recovery outline for *Helianthus verticillatus* (whorled sunflower)

Date Issued: October 23, 2014

II. REVIEW ANALYSIS

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

The Endangered Species Act (ESA) defines species as including any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate wildlife. This definition limits listing DPSs to only vertebrate species of fish and wildlife. Because the species under review is a plant, the DPS policy is not applicable.

B. Recovery Criteria

1. **Does the species have a final, approved recovery plan containing objective, measurable criteria?** No. The species does not have a final, approved recovery plan. We are in the process of writing the species' recovery plan and its associated documents, the species status assessment and recovery implementation strategy.

Currently, only the Recovery Outline is available to guide the recovery of whorled sunflower. This outline does not present recovery criteria, but does summarize

information pertinent to the conservation and recovery of whorled sunflower and identifies various conservation needs of the species.

C. Updated Information and Current Species Status

1. Biology and Habitat

a. New information on the species' biology and life history:

Little published information about the biology of whorled sunflower is available and the causes for its current rarity are not well understood. Whorled sunflower is a self-incompatible, clonal perennial and flowers from August into October (Matthews *et al.* 2002, Ellis and McCauley 2009). Self-incompatibility is a common strategy of flowering plants to promote outcrossing and prevent inbreeding (Silva and Goring 2001). Whorled sunflower propagates clonally via rhizomes (horizontal underground stems that produce roots and shoots) as well as by sexual reproduction (i.e., flowering and seed production); thus, many stems that appear to be individual plants are genetically identical to their neighbors, resulting in a clumped distribution (Ellis *et al.* 2006, Mandel 2010). Clumped distribution coupled with the species' self-incompatibility and short flight distances of potential pollinators (e.g., two-spotted long-horned bees [*Mellisodes bimaculatus*] and honeybees [*Apis mellifera*] have been observed visiting flowers of the species) increase the likelihood of geitonogamous self-pollination (transfer of pollen between flowers of this same genetic individual) that will result in unsuccessful pollination (Ellis 2008, Mandel 2010). Whorled sunflower likely requires pollinating invertebrates for successful reproduction; although, studies to determine effective pollinators of this species have not been conducted.

The species is readily cultivated and seed germination is generally high in the laboratory. Upon transplanting, this species has been shown to reproduce rapidly from rhizomes, creating dense colonies of stems that can reach over 4 meters (13 feet) in height (Matthews *et al.* 2002). However, Ellis and McCauley (2009) reported lower germination rates in seeds produced from crosses between plants from a Madison County, Tennessee, population compared to plants from a larger Alabama population. Lower rates of seed viability were also observed in second-generation crosses of the Tennessee versus Alabama plants. These results suggest a possible influence of population size on individual fitness in whorled sunflower populations.

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

Populations

Currently, there are five natural whorled sunflower populations known to be extant, most consisting of multiple tracked subpopulations (Table 1, Figure 1) (Brandon pers. comm. 2017a, Tennessee Natural Heritage Inventory Database [TNHID] 2020, Alabama Natural Heritage Program [ANHP] 2019, Georgia Department of Natural Resources [GDNR] 2019). When the species was listed in 2014, four populations were known to be extant in three states (Alabama, Georgia, and Tennessee), but an additional population was discovered in

Mississippi in 2017. In addition, one population in Tennessee, where the species was first collected, is considered historical because it has not been observed in over 100 years. See Table 1 and Figure 1 for the county distribution of these populations.

Estimating population size for whorled sunflower is difficult. Initial efforts to estimate population sizes of whorled sunflower relied on counting individual stems (Schotz 2001, Allison 2002); however, due to the species' clonal growth habit, stem counts alone are likely to overestimate the true number of genetically distinct individuals (genets). Ellis *et al.* (2006) found that the genetic population size is much smaller than the number of stems in a population and that a more accurate population census could be made at most whorled sunflower sites by counting obvious clusters of stems (i.e., groups of stems separated by at least 1 meter [3.3 feet]; Ellis *et al.* 2006) rather than individual stems. However, such a population assessment may not be possible at every site, as Mandel (2010) reported that individual clusters were much less distinct in a portion of the Alabama site she sampled.

Table 1. Distribution and status of whorled sunflower populations.

State	County
Pop. Count	Pop. Count
Alabama: 1	Cherokee: 1
Georgia 1	Floyd: 1
Mississippi: 1	Marshall: 1
Tennessee: 2 (1)	Chester: (1)
	Madison: 1
	McNairy: 1

Notes: Parentheses indicate populations that are either extirpated or historical, whereas numbers that are not in parentheses denote extant populations.

State Population Summaries

ALABAMA – Alabama is home to one known population of whorled sunflower (in Cherokee County), which consists of two subpopulations, near the state line with Georgia. The state once supported one of the largest known populations of whorled sunflower, with one subpopulation (at Kanady Creek Prairie) consisting of over 400 stems that represented 100 to 200 genets (Mandel 2010). However, Schotz (2011) found only 79 stems, distributed among 8 clusters, at this site in 2011 and only 15 stems in 3 clusters were observed in 2018 (Malcolm Hodges pers. comm. 2018). Alabama's second subpopulation (Locust Branch Prairie), had an estimated 175 to 200 stems in September 2008 (Al Schotz pers. comm. 2009), but there were only 42 stems found at this site in 2011 (Schotz 2011). Habitat management increased this subpopulation to 276 stems in 4 clusters by September 2018 (Patrick Thompson pers. comm. 2018a, 2018b). Together, these more recent observations by Schotz and others, indicate that Alabama's population is likely fewer than 100 individuals.

GEORGIA – Over 100 years after its initial discovery in Tennessee, whorled sunflower was rediscovered not in Tennessee, but in Georgia. This population,

which is currently owned by Weyerhaeuser Company, occurs in Floyd County near the state boundary with Alabama and most of the population is protected by a conservation easement (Coosa Valley Prairie) held by The Nature Conservancy (TNC). Habitat management at this site has promoted this population's growth.

Mandel (2010) sampled 15 clusters growing in the Wet Prairie at the Georgia site, which represents 1 of 4 subpopulations at this site, and determined that these clusters represented 18 genets. Similar information is not available for the remaining three subpopulations. The true number of genets at this site is likely much greater, as others have reported vigorous growth of whorled sunflower (with thousands of stems reported in 2012) in response to prescribed fires that are used to manage the Coosa Valley Prairie conservation easement area (Hodges pers. comm. 2012b; Tom Patrick pers. comm. 2012). Similar vigorous growth was also reported following a 2016 wildfire (Dr. Mincy Moffett pers. comm. citing M. Hodges 2017). Thousands of stems were again observed within the conservation easement area during September 2018 surveys by TNC and U.S. Fish and Wildlife Service (Service) staff (M.S. Wiggers, Botanist, Service, personal observation). This is now considered to be the largest known population of whorled sunflower.

MISSISSIPPI – Mississippi is home to one known population, which was discovered in 2017 growing near a stream in a highway right-of-way (Darrell W. Brandon, III pers. comm. 2017a). In 2018, more plants were discovered growing along the riparian corridor upstream of the original site (Brandon pers. comm. 2018b). With only three or four clusters of stems (Brandon pers. comm. 2018a, 2018b), this is the smallest known population of whorled sunflower.

TENNESSEE – Tennessee has two extant natural populations, with Madison and McNairy counties supporting one population each. The species also historically occurred in Chester County, which is where the first known specimen of whorled sunflower was collected, but no naturally occurring population is currently known to be extant in the county.

Ellis *et al.* (2006) counted 70 distinct clusters in a Madison County site, which genetic analyses revealed consisted of 70 distinct individuals; however, she did not sample all clusters at this site (Dr. Jennifer Mandel pers. comm. 2012) and, therefore, more individuals may have occurred at the site. No plants were found at the Madison County site during 2017 (Geoff Call, Fish and Wildlife Biologist, Service, personal observation). Surveys in 2019, however, found 155 stems in over 20 clumps within several of this population's subpopulations (Caitlin Elam pers. comm. 2019b, 2019c).

At the McNairy County, Tennessee, population, 36 clusters of plants were found growing along creek banks along the unplowed edges of cultivated crop fields and extended into a railroad right-of-way (Tennessee Division of Natural Areas [TDNA] 2008). Mandel (2010) sampled 19 clusters at the McNairy County population and determined these represented 24 genets; however, only 2 of the 4 subpopulations mapped at this population were sampled (Mandel pers. comm. 2012). During 2017, only 2 clusters were found at the McNairy County site, 1

consisting of 71 stems and the other of only 7 stems (Brandon pers. comm. 2017b). About 70 stems were counted at this population in 2019, with plants being found at only 1 of the 3 sites searched (Elam pers. comm. 2019b, 2019c).

VIRGINIA – A putative whorled sunflower population was discovered in Franklin County, Virginia, in 2019 (Dr. Chris Ulrey pers. comm. 2019), which is over 350 miles (over 560 km) northeast of the closest population (in Georgia). Plants are superficially similar to whorled sunflower and genetically distinct from known populations (potentially representing a hybrid or unknown population; Mandel pers. comm. 2020), but voucher specimens have not been collected to verify the identity of these plants (Ulrey pers. comm. 2020). Plants occur in two distinct clusters (with nearly 300 total stems) and are located at the margin of a mowed field on the Blue Ridge Parkway (owned and managed by the National Park Service) (Ulrey pers. comm. 2019). Because of the unusual location of these plants, their unconfirmed identity, and uncertainty of the population's origins (i.e., it may have been planted), this population is not considered to be a valid population contributing to recovery at this time. Additional information addressing these uncertainties is needed.

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

Ellis *et al.* (2006) investigated genetic diversity in the Alabama, Georgia, and Madison County, Tennessee, populations of whorled sunflower and found high levels of genetic diversity at the population and species levels despite its apparent rarity. They speculated that this is indicative of a species that was more widespread in the past and perhaps became rare relatively recently (Ellis *et al.* 2006). Whorled sunflower populations exhibited moderate levels of differentiation based on markers that are presumed to be selectively neutral. Because these populations are geographically distinct and ecological conditions vary somewhat among them, Ellis *et al.* (2006) concluded that they are likely similarly differentiated, if not more so, at adaptive loci (the specific location of a gene or DNA sequence on a chromosome). More recently, preliminary genetic analyses including Mississippi's population indicated that Mississippi's population (discovered in 2017) is genetically distinct from all other known populations (Moore *et al.* n.d.). Furthermore, Alabama's and Georgia's populations are genetically similar, indicating gene flow between these populations, while Tennessee's McNairy County and Madison County populations are most similar to each other.

Ellis and McCauley (2009) investigated whether there were differences among populations of whorled sunflower with respect to achene viability and germination rates and whether those differences might have a genetic basis. This experiment was conducted over two generations of plants, with the second generation produced from intra-population crosses of first generation plants. They also explored whether isolation of populations from one another could have fitness consequences by conducting inter-population crosses and evaluating whether they found (1) evidence of genetic rescue, expressed as higher fitness of hybrid individuals as compared to any or all of the parental populations, or (2) evidence of outbreeding depression. Their study included material from

populations in Alabama, Georgia, and Madison County, Tennessee. Flower heads from Georgia contained few viable achenes, which resulted in low germination rates, thereby preventing successful cultivation of plants from this population.

The number of crosses that produced no viable achenes was higher in the intra-population Tennessee crosses than in any other pair of crossings. Achenes produced by first generation Tennessee intra-population crosses exhibited lower germination rates than Alabama achenes, while second generation Tennessee achenes from intra-population crosses exhibited both lower viability and germination rates than the Alabama achenes. However, survival rates of germinated achenes did not differ among these populations in either generation (Ellis and McCauley 2009). Ellis and McCauley (2009, p. 1840) suggested three possible mechanisms that could explain these results, none of which are mutually exclusive: “(1) limited mate availability in the Tennessee population due to limited diversity of self-incompatibility alleles, (2) more extensive inbreeding within the Tennessee population, or (3) differential adaptation between the two populations.”

When Tennessee plants were crossed with pollen from Alabama plants, the second generation mean achene viability and germination rates were equal to or greater than those of Alabama intra-population crosses or Alabama plants crossed with pollen from Tennessee plants. Whereas, mean achene viability of Tennessee intra-population second-generation crosses was lower than all other groups and germination rates were lower than both Alabama intra-population crosses and Alabama plants crossed with pollen from Tennessee plants (Ellis and McCauley 2009).

Based on their results, Ellis and McCauley (2009) concluded that populations of whorled sunflower are not interchangeable with respect to phenotypic fitness-related characters (i.e., achene viability and germination rates) and suggested that the potential exists for genetic rescue of the Tennessee population by transplanting either seeds or seedlings produced from crosses between Tennessee and Alabama plants into the Tennessee population.

d. Taxonomic classification or changes in nomenclature:

Whorled sunflower was described by John Kunkel Small (1898) based on a collection by Samuel McCutchen Bain from Chester County, Tennessee, in 1892. Small distinguished it from the related *Helianthus giganteus* (tall sunflower) by its smooth and hairless stems, narrow, entire leaf blades, and its narrowly linear-lanceolate involucre bracts. No additional collections of this species had been made when Beatley (1963) speculated that the specimens from this single collection site perhaps represented a single aberrant individual formed from hybridization of an opposite- and alternate-leaved *Helianthus* species. With no new material to examine, Heiser *et al.* (1969) and Cronquist (1980) accepted Beatley's suggestion that whorled sunflower was a hybrid.

Rediscovery of the species in 1994 in Georgia provided ample material for reexamination of this species' taxonomic status. Plants throughout these new populations were found to conform to the morphology of the type collection of

whorled sunflower. Morphological studies and root-tip chromosome counts by Matthews *et al.* (2002) validated this taxon's status as a distinct, diploid species. The taxonomic validity of this species was also confirmed through genetic studies by Ellis *et al.* (2006). Their studies showed through comparative genetic studies with its putative parents, *H. grosseserratus* (sawtooth sunflower) and *H. angustifolius* (swamp sunflower), that whorled sunflower is a distinct taxonomic species of non-hybrid origin (Ellis *et al.* 2006). More recent genetic studies were either inconclusive (Timme *et al.* 2007) or have further supported the phylogenetic distinctiveness of *H. verticillatus*, but indicated that the species is more closely related to *H. grosseserratus* and *H. giganteus* than to *H. angustifolius* (Stephens *et al.* 2015).

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

Whorled sunflower is found in three Level IV Ecoregions (Figure 1): Loess Plains (in Mississippi), Northern Hilly Gulf Coastal Plain (in Tennessee), and Southern Shale Valleys (in Alabama and Georgia) (see U.S. Environmental Protection Agency [USEPA] 2013 for ecoregion descriptions). The known range of whorled sunflower spans less than 250 miles east to west and 100 miles north to south. Within its known range, populations are generally isolated, with most separated from their nearest neighbors by 20 miles or more. Alabama's and Georgia's populations are separated by about 1 mile, but are separated by 190 miles or more from populations in Tennessee and Mississippi. As such, population connectivity is typically low, which limits potential gene flow between populations and makes natural reestablishment of a given population unlikely should the population become extirpated.

Whorled sunflower was first collected in 1892 from an unknown location near Henderson, in Chester County, Tennessee, (Small 1898), but was not documented from the wild again until 1994, when it was found in Floyd County, Georgia (Matthews *et al.* 2002). Given that the species has not been relocated in Chester County since its first collection, this population is currently considered to be historical (TNHID 2020).

As noted above (Section II.C.1.b and Table 1; see also Figure 1), there are currently five known extant populations in four southeastern states (Alabama, Georgia, Mississippi, and Tennessee). In Floyd County, Georgia, there is one population composed of four subpopulations (GDNR 2019), while nearby in Alabama there is one population in Cherokee County, composed of two subpopulations (ANHP 2019). These Georgia and Alabama populations are less than 2 km (1.2 mi) apart. Given their proximity to one another, should additional subpopulations be located within areas between these two populations, they could be considered one large population. In Tennessee, there is one population composed of six subpopulations in McNairy County and one population composed of four subpopulations in Madison County. A small roadside population was found in Marshall County, Mississippi, in 2017 (Brandon pers. comm. 2017a). Follow-up searches in 2018 discovered more plants growing upstream of the original site within a forested riparian corridor between agricultural fields (Brandon pers. comm. 2018b). Given this recent discovery,

additional surveys may discover yet more whorled sunflower populations in northern Mississippi and/or southwestern Tennessee.

Dr. Jennifer Mandel (pers. comm. 2017) suggested that whorled sunflower might have been collected and misidentified during its nearly 100-year gap in collection records. For example, S.M. Bain’s 1892 collection of whorled sunflower was originally identified as *H. schweinitzii* (Schweinitz’s sunflower). As such, a review of sunflower herbarium specimens collected within the species’ range may reveal additional historical collections and locations of this species.

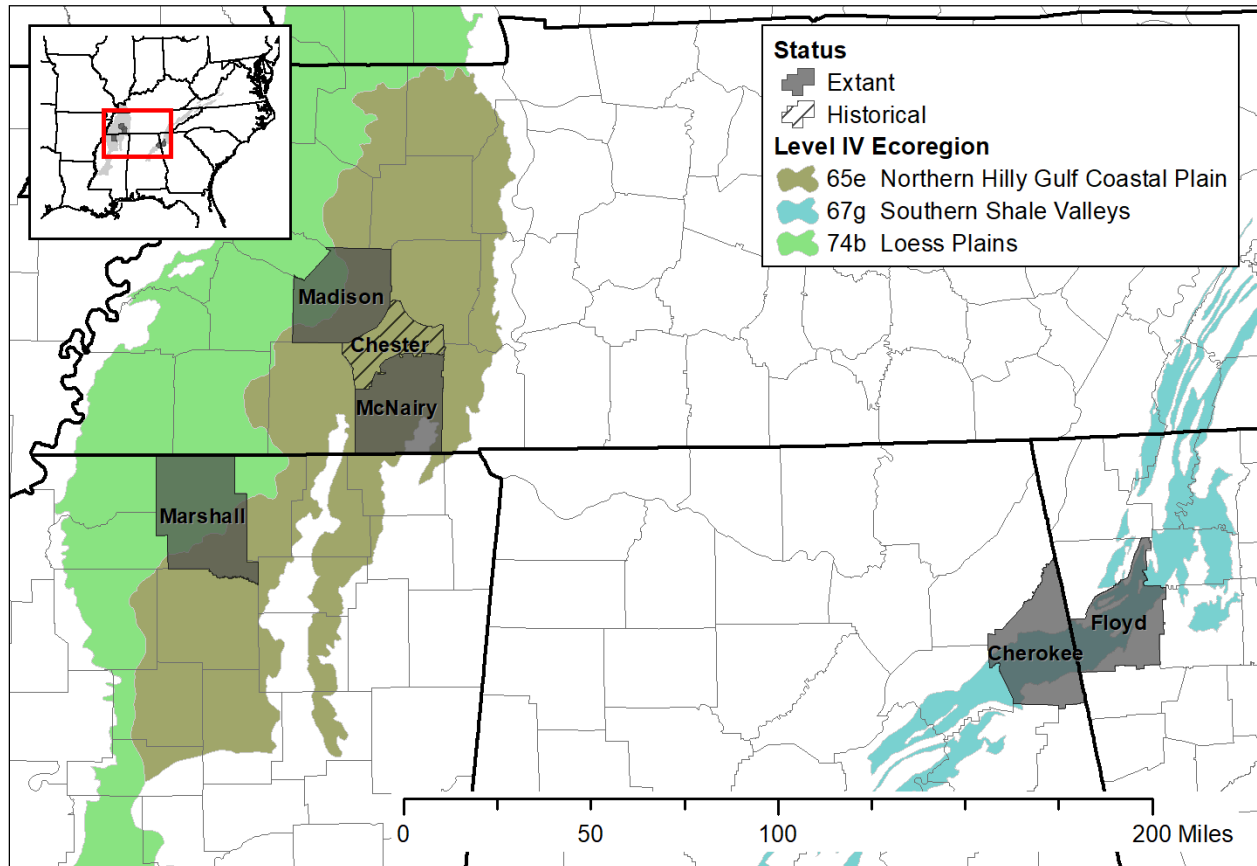


Figure 1. Whorled sunflower distribution.

f. Habitat or ecosystem conditions:

Habitat

Whorled sunflower is found in moist-soiled areas where little to no overstory canopy is present. Habitat quality ranges from remnant prairie or woodland sites to degraded sites along roadsides, railroad tracks, and agricultural fields. Today, the only known whorled sunflower site where the ecological integrity of the native plant community has been retained over a relatively large area is the Coosa Valley Prairie of northwest Georgia, where the species occurs in prairie openings and woodlands interspersed among lands managed for commercial forest products. At one of the Alabama subpopulations, whorled sunflower occurs in a narrow, open strip of vegetation between a roadside and adjacent forest. The

second Alabama subpopulation occurs along a small intermittent stream and adjacent floodplain, in a site where an immature hardwood forest was harvested in 1998. Whorled sunflower and associated prairie species responded favorably to the timber removal, but the site was soon converted into a loblolly pine plantation and the planted seedlings have grown into a young, dense stand into which little light penetrates. As of 2015, there were few whorled sunflower plants or prairie associates present at this site. Known populations of this species in Tennessee are relegated mostly to narrow bands of vegetation between cultivated fields and creeks that have been channelized for drainage and adjacent to roads and railroad rights-of-way. The largest concentration of plants in Tennessee was once found at the Madison County population, in a 1 hectare (ha) (2.5-acre [ac]) patch of remnant, wet prairie habitat wedged between a highway and railroad right-of-way. In recent years, this site has been degraded by encroachment of woody vegetation in the absence of mowing. A portion of the Madison County, Tennessee population is also found scattered along the edges of agricultural fields. Mississippi's only known population occurs near a stream in and upstream from a highway right-of-way in Marshall County (Brandon pers. comm. 2017a, 2018b).

Soils

Whorled sunflower typically occurs on well-drained, acidic soils with low fertility, but occasionally occurs on neutral and poorly drained soils. In Georgia, Conasauga, Lyerly, Townley, and Wolftever silt loams and Dowellton silty clay loam are the most common soil mapping units (U.S. Department of Agriculture [USDA] 1978a). Alabama plants are found on Gaylesville silty clay loam and Conasauga silt loam soil mapping units (USDA 1978b). The Marshall County, Mississippi, population is found on Vicksburg silt loam soil mapping unit (USDA 1972). In Madison County, Tennessee, the population is primarily found on Falaya silt loam soil mapping units (USDA 1978c). The McNairy County, Tennessee, population occurs on Iuka and Enville fine sandy loam soil mapping units (USDA 1997). Recent observations of whorled sunflower sites in Tennessee by Natural Resources Conservation Service's Regional Ecologist – Milan, Tennessee, Barry Hart, suggest that these soil mapping units may not be an entirely accurate reflections of actual soils the species is found on (Elam pers. comm. 2020 citing Hart pers. comm. 2020). Unlike naturally occurring populations, an introduced population in Chester County, Tennessee, (described in section 2.C.1.g – Conservation Efforts) is found on hydric soils (Elam pers. comm. 2020), which may indicate that this species' can tolerate a broader range of soil conditions than previously known. Further study into the species' soil requirements is needed to inform searches and conservation efforts for whorled sunflower. Planned mapping of soils associated with whorled sunflower in Tennessee during 2020/2021 (Elam pers. comm. 2020) is expected to reveal a more precise and detailed description of the species' soil requirements.

Associated Species

Whorled sunflower is commonly found with species having strong prairie and/or hydrophytic affinities. Dominant grasses of tall grass prairies are present, including *Schizachyrium scoparium* (little bluestem), *Sorghastrum nutans* (Indian

grass), *Andropogon gerardii* (big bluestem), and *Panicum virgatum* (switch grass). Other common herbaceous associates include *Bidens bipinnata* (Spanish needles), *Carex cherokeensis* (Cherokee sedge), *Hypericum sphaerocarpum* (roundseed St. Johnswort), *Helianthus angustifolius* (swamp sunflower), *Helenium autumnale* (common sneezeweed), *Lobelia cardinalis* (cardinal flower), *Pycnanthemum virginianum* (Virginia mountain mint), *Physostegia virginiana* (obedient plant), *Saccharum giganteum* (sugarcane plume-grass), *Silphium terebinthinaceum* (prairie rosinweed), *Sporobolus heterolepis* (prairie dropseed), and *Symphotrichum novae-angliae* (New England aster) (Schotz 2001, Matthews *et al.* 2002, TDNA 2008). Some of these areas also provide habitat for various other rare plant species, including the federally threatened *Marshallia mohrii* (Mohr's Barbara's buttons). Various aggressive native species, including several woody species and vines, have been noted at some degraded sites in Tennessee, including *Acer negundo* (box elder), *Bignonia capreolata* (crossvine), *Campsis radicans* (trumpet creeper), *Liquidambar styraciflua* (sweetgum), *Passiflora incarnata* (purple passionflower), *Platanus occidentalis* (sycamore), *Rubus pensylvanicus* (Pennsylvania blackberry), and *Vitis* spp. (grape species) (TDNA 2006, Elam pers. comm. 2020). Various exotic invasive species have also been found at whorled sunflower sites, including *Ligustrum sinense* (Chinese privet), *Lonicera japonica* (Japanese honeysuckle), *Microstegium vimenium* (Nepalese browntop, Japanese stiltgrass), and *Rosa multiflora* (multiflora rose) (Schotz 2011, Elam pers. comm. 2020, Hodges pers. comm. 2020).

g. Other:

Conservation Efforts

Temple-Inland Corporation donated a conservation easement for the Coosa Valley Prairie property in Floyd County, Georgia to TNC, thereby protecting most of the Georgia population of this species. This is the only whorled sunflower population protected by a permanent conservation mechanism and is now owned by Weyerhaeuser Company, a timber, lands, and forest products company. This easement area is cooperatively managed with TNC based on a conservation management plan developed with a previous landowner (Hodges pers. comm. 2012a). Prescribed fire is the primary management tool used to perpetuate and restore the native plant communities on this site and also serves silvicultural objectives. The conservation easement recognizes fire as being necessary to maintain prairies and oak woodlands on this property (Hodges pers. comm. 2020), but implementation of prescribed fire requires landowner cooperation. In addition to prescribed fire, selective harvests, and mechanical thinning and control of woody species and exotic plants have been used to manage the site (Hodges pers. comm. 2007, 2009).

Weyerhaeuser Company also owns the land where one of the two Alabama subpopulations is located and is willing to work with the Service, TNC, and others to improve habitat conditions for whorled sunflower (Chris Muckenfuss pers. comm. 2017). This subpopulation is located in a site where the prior owner harvested an immature hardwood forest in 1998 and subsequently established a loblolly pine plantation. Although whorled sunflower responded favorably within

a few years of harvest, there were very few whorled sunflower plants present in 2012, and those that were present were in a suppressed vegetative condition due to overshadowing.

State Plant Conservation Alliances (PCAs; non-governmental associations comprised of a variety of individuals, organizations, universities, state and federal agencies, and other stakeholders with interest and expertise in plant conservation) in Alabama, Georgia, and Tennessee have expressed interest in whorled sunflower conservation (Thompson *et al.* 2017). The Alabama PCA, in particular, has been actively involved in a variety of whorled sunflower conservation projects in Alabama, including landowner outreach and education, habitat management, and *ex situ* (off-site) conservation of the Cherokee County population (Gray and Thompson 2017, Thompson 2018). The Georgia PCA also provides management assistance in the form of volunteer workdays for rare plant species in the state, including site management of the TNC easement, where other federally protected species, such as the endangered *Clematis socialis* (Alabama leather flower), are found (Moffett pers. comm. 2017). More recently, the Tennessee PCA has begun assisting with population monitoring and *ex situ* conservation (Cooper A. Breeden pers. comm. 2018), including preparing a draft safeguarding strategy for the species.

Whorled sunflower has received some seed banking attention, *ex situ* safeguarding of cultivated plants, and population establishment. In 2003, prior to the species' listing, scientists affiliated with the USDA Agricultural Research Service (ARS) collected seeds from populations in Madison County, Tennessee, and Floyd County, Georgia (Seiler and Gulya 2004, Gulya *et al.* 2007). These seeds were deposited in USDA-ARS's germplasm seedbank in Ames, Iowa. Although the primary purpose of this seedbank is improvement of cultivated sunflowers rather than conservation of wild species, this effort may provide valuable data to inform conservation and assist with preservation of the species' genetic diversity (Seiler and Gulya 2004, Gulya *et al.* 2007). There has also been more recent interest in establishing a seed bank in Tennessee with limited seed collection initiated (Call pers. comm. 2017, Breeden pers. comm. 2019, Elam pers. comm. 2019a). Seeds have also been collected in Tennessee for live plant collections (Breeden pers. comm. 2018). Auburn University's Davis Arboretum (an affiliate of the Alabama PCA) has been growing whorled sunflower plants from seeds collected in Cherokee County, Alabama for at least 8 years (Gray and Thompson 2017, Thompson 2018). In Tennessee, 70-100 plants were outplanted into 5 plots within a wetland restoration site in 2007 on the campus of Freed-Hardeman University (Dr. Paul Fader pers. comm. 2012; David Lincicome pers. comm. 2017). As of 2019, 93 stems remained in two patches on the restoration site (Elam pers. comm. 2019b). This site, which is in Chester County, is now tracked by the Tennessee Natural Heritage Program (D. Lincicome pers. comm. 2017, TNHID 2020) and is presumably in the vicinity of the historical type collection in Henderson. In addition, Tennessee Department of Environment and Conservation (TDEC) is pursuing habitat restoration and potential outplanting whorled sunflower on Pinson Mounds Archaeological State Park in Madison

County, Tennessee, and on other private conservation lands in the state (Elam pers. comm. 2020).

Whorled sunflower is included in State Wildlife Action Plans (SWAPs) in Alabama (included as a Plant of Conservation Concern; Alabama Department of Conservation and Natural Resources 2016), Georgia (a High Priority Plant; GDNR 2015), and Tennessee (a Tier 4 species of Greatest Conservation Need; Tennessee State Wildlife Action Plan Team 2015). SWAPs do not compel specific conservation actions or guarantee funding of such actions for whorled sunflower, however, inclusion within these SWAPs serves to highlight and focus attention on the conservation needs of this species and its habitats.

The Service has funded several surveys (e.g., Nordman 1998, 1999, Lincicome 2003, TDNA 2008, Schotz 2001, 2011), monitoring activities (e.g., TDNA 2015), other conservation-related activities (e.g., habitat modeling: Bailey and Nordman 1999, Crabtree 2014; genetics: Ellis and McCauley 2009, Mandel 2010), and a draft safeguarding strategy (via Section 6 funds) for whorled sunflower since the 1990s. Cooperative agreements with the State of Tennessee pursuant to section 6 of the Endangered Species Act have been a primary component of supporting conservation activities in Tennessee. Conservation plans for populations in Madison and McNairy Counties, Tennessee have been prepared by TDNA (TDNA 2006, 2007), but these plans are not legally binding and do not ensure long-term protection of these populations. Additionally, USDA's Natural Resources Conservation Service has three programs to support prairie habitat restoration in Tennessee counties where whorled sunflower occurs: Environmental Quality Incentives Program (EQIP; <https://www.nrcs.usda.gov/wps/portal/nrcs/main/tn/programs/financial/eqip/>), Conservation Stewardship Program (CSP; <https://www.nrcs.usda.gov/wps/portal/nrcs/main/tn/programs/financial/csp/>), Wetland Reserve Enhancement Program (WREP; <https://www.nrcs.usda.gov/wps/portal/nrcs/main/tn/programs/easements/acep/>). These programs, which are funded through 2021/2022, could help to restore potential habitat for whorled sunflower in Tennessee (Elam pers. comm. 2020).

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

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

Whorled sunflower appears to be a narrow habitat specialist, occurring in natural wet meadows or prairies and calcareous barrens. Such habitats likely were more extensive in the eastern United States before European settlement, subsequent fire suppression, and conversion of habitat to cropland or residential areas (Allison 1995). Today, these prairie areas are not very extensive and are often degraded or have been destroyed for various reasons. Most remaining prairie vegetation in the geographic area where whorled sunflower occurs exist as remnants along roadside and utility rights-of-way (Allison 1995), where small prairie remnants are maintained through various management activities. Where whorled sunflower habitat remains, it faces threats due to indiscriminate use of mechanical or chemical vegetation management for industrial forestry, right-of-way

maintenance, or agricultural purposes that could adversely affect it. Because the species requires well-lit habitats for its growth and reproduction, shading and competition due to vegetation succession in the absence of natural or human-caused disturbance also threaten whorled sunflower habitat.

Incompatible Forestry Practices

Industrial forestry practices have altered much suitable whorled sunflower habitat in Georgia and Alabama and currently threaten one known subpopulation in Alabama. While surveying potential habitat for additional populations, Jim Allison (pers. comm. 1999) observed that much of this species' prairie habitat in Georgia had been converted to pine plantations. Nearly all of the Georgia subpopulations and one of the Alabama subpopulations of whorled sunflower are located on lands used for timber production that are currently owned by Weyerhaeuser Company. In Georgia, subpopulations on these lands receive some protections from habitat destruction by their inclusion in a conservation easement area, which was donated to TNC by a previous landowner. However, this area is subject to periodic disturbance from forestry activities (e.g., skid trails and logging decks). On land outside this conservation easement area, site preparation for planting pine seedlings has included subsoil plowing to improve drainage and conditions for tree root development, and mechanical or chemical methods to control competing vegetation. These site preparation activities may continue under the property's current ownership, depending on site conditions and needs, but buffers and alterations to specific site preparation practices are employed to limit impacts to rare species (Muckenfuss pers. comm. 2017), such as whorled sunflower. However, without adequate precautions, these practices could cause direct mortality of whorled sunflower plants at one of the Alabama subpopulations and contribute to habitat degradation due to shading and competition (see "Shading and Competition", below) from planted pines. During timber harvests, either to thin (i.e., reduce density of pine trees in order to improve growth conditions for remaining trees) or to clear-cut the stand, whorled sunflower plants at this subpopulation could be subjected to indirect adverse effects from soil disturbance or direct mortality due to movement of harvesting equipment.

Right-of-Way Maintenance

Incompatible maintenance activities in utility and transportation rights-of-way have adversely affected whorled sunflower in Alabama, Mississippi, and Tennessee and could affect one subpopulation in Georgia. At one of the Alabama subpopulations, whorled sunflower occurs in a narrow strip of vegetation between a roadside and adjacent pine forest, where it is vulnerable to mortality or reduced vigor and reproductive output due to indiscriminate use of herbicides or mowing for right-of-way maintenance. Poorly timed mowing of this right-of-way prevented flowering and seed production in some plants at this site in 2008; however, the Alabama Department of Conservation and Natural Resources (ADCNR), Alabama Department of Transportation, and Cherokee County Highway Department cooperated in placing signs at the site to mark the presence of whorled sunflower and attempt to prevent such deleterious actions in the future

(Dr. Wayne Barger pers. comm. 2009). Likewise, no plants were found at the original subpopulation located along railroad tracks in McNairy County, Tennessee, during 2019 surveys (Elam pers. comm. 2019b, 2019c), but plants were discovered elsewhere along the railroad tracks at a previously unknown location (Elam pers. comm. 2020). The original plants may have been deleteriously affected by shading from adjacent forested area and/or due to maintenance of the riprap bed underlying the railroad tracks (Elam pers. comm. 2020).

Indiscriminate herbicide application along rights-of-way threatens some whorled sunflower populations. For example, Mississippi's population occurs in a highway right-of-way and was apparently sprayed with herbicide shortly after its discovery in 2017, which stressed the plants, but did not kill them (Brandon pers. comm. 2017b, 2017c, 2018a). However, whorled sunflower plants extending onto a roadside within a powerline right-of-way at the Madison County, Tennessee population were sprayed with herbicide during roadside and powerline maintenance in 2004, which caused substantial mortality (Lincicome pers. comm. 2006; Andrea Bishop pers. comm. 2008). Similarly, plants extending into the railroad right-of-way at the McNairy County, Tennessee population are vulnerable to adverse effects from potential indiscriminate herbicide application used for railroad right-of-way maintenance, but installation of appropriate signage could alleviate this threat. A small cluster of plants in one of Georgia's subpopulations is located on the bank of a road adjacent to the Coosa Valley Prairie easement area and is not protected. Coordination with parties responsible for maintenance of these right-of-way locations is necessary to avoid future adverse effects to local whorled sunflower populations from indiscriminate mowing and herbicide application.

Agricultural Practices and Land Conversion

Whorled sunflower has not been rediscovered at the type locality in Tennessee despite intensive surveys of that area (Nordman 1998, 1999). Locality information for this record, from an 1892 collection, is vague (Matthews *et al.* 2002), so it is not possible to determine why this population was lost. In Tennessee, much of this species' suitable habitat has presumably been converted to agricultural use, as substantial portions of the counties in the state where the species has been found have been in row crop production since 1850 (Waisanen and Bliss 2002). Because this species was not seen following the initial 1892 collection until it was rediscovered in 1994, and was not seen again in Tennessee until 1998, it is impossible to know the historical distribution and abundance of its habitat. Land conversion to agricultural uses has a long and sustained history in the Tennessee counties where whorled sunflower has been found (cf. Waisanen and Bliss 2002) and has likely contributed to loss of the species' habitat and populations.

Agricultural practices including field preparation, herbicide use, and harvesting of crops are threats to both of the extant Tennessee populations due to the species' presence in habitats adjacent to actively farmed crop fields in both locations. In July 2009, TDNA biologists observed that one cluster consisting of two whorled sunflower stems had been destroyed by row crop cultivation in a previously

fallow field at the McNairy County, Tennessee, population. Unpaved access roads around the perimeter of this field have also been widened, encroaching on whorled sunflower plants (7 clusters, 140 stems) in an adjacent railroad right-of-way (Bishop pers. comm. 2010). With the exception of the approximately 1-ha (2.5 ac) patch of old field habitat discussed above, the Madison County, Tennessee, whorled sunflower population is distributed in narrow strips of vegetation along borders of row crop fields and is vulnerable to mechanized disturbance of these habitats or to effects from herbicide application. Based on this information we conclude that habitat at both whorled sunflower populations in Tennessee faces substantial threats associated with agricultural practices used in row crop production.

Shading and Competition

Absent natural or human-caused disturbance, habitats where whorled sunflower occurs are threatened by succession of vegetation to a shrub-dominated or forested condition, which degrades habitat quality. The largest concentration of plants at the Madison County, Tennessee, population is located in a successional old field approximately 1 ha (2.5 ac) in size, which has become almost entirely wooded (Lincicome pers. comm. 2017), degrading the largest patch of contiguous habitat where the majority of this population occurs. Woody species present at this site include box elder and sweetgum (TDNA 2006, Elam pers. comm. 2020), which can rapidly invade moist old-field habitats if left unmanaged. No conservation agreements or management plans are in place to ensure that this site receives periodic disturbance to maintain open conditions needed for the growth and sexual reproduction of whorled sunflower. Invasive plants—including, Japanese honeysuckle, Nepalese browntop (Japanese stiltgrass), and multiflora rose—have been noted at both natural populations in Tennessee (Elam pers. comm. 2019b, 2020). Likewise, the invasive Chinese privet is a persistent problem for Georgia's population (Hodges pers. comm. 2020).

The Alabama subpopulation on Weyerhaeuser Company lands is located in a site where the prior owner, Temple-Inland Corporation, harvested an immature hardwood forest in 1998. Initially, this timber harvest was thought to have adversely affected the whorled sunflower population, but these plants and associated prairie species responded favorably within a few years following the harvest. However, the site was subsequently converted into a loblolly pine plantation and the trees have attained sufficient size and density to threaten whorled sunflower plants due to increased shading and competition (Schotz 2011). As of 2012, there were few whorled sunflower plants present at this site, and those present were in a suppressed, vegetative condition due to considerable shading and competition from planted pines and vegetation growing in the understory. Encroachment by invasive, non-native plants following the timber harvest and establishment of the loblolly pine stand also is a threat at this site (Schotz 2011). The second Alabama subpopulation is relegated to a narrow strip of vegetation between a roadside and adjacent pine forest with a densely vegetated understory. The spatial extent of this subpopulation is limited by whorled sunflower's inability to grow in the shaded habitat of the adjacent forest.

Based on this information we conclude that habitat degradation due to shading and competition resulting from vegetation succession is currently a significant threat to two whorled sunflower populations. Both of the Alabama subpopulations and the largest contiguous patch of suitable occupied habitat for the species in Tennessee are at risk from this threat.

Climate Change

Since 1970, the average annual temperature across the Southeast has increased by about 2°F, with the greatest increases occurring during winter months. The geographic extent of areas in the Southeast region affected by moderate to severe spring and summer drought has increased over the past three decades by 12 and 14 percent, respectively (Karl *et al.* 2009). These trends are expected to increase. Rates of warming are predicted to more than double in comparison to what the Southeast has experienced since 1975, with the greatest increases projected for summer months. Depending on the emissions scenario used for modeling change, average temperatures are predicted to increase by 4.5°F to 9°F by the 2080s (Karl *et al.* 2009). While there is considerable variability in rainfall predictions throughout the region, increases in evaporation of moisture from soils and loss of water by plants in response to warmer temperatures are expected to contribute to increased frequency, intensity, and duration of drought events (Karl *et al.* 2009).

Climate change has the potential to affect distribution and abundance of plants by influencing seasonal weather patterns, frequency and timing of severe weather events, species interactions, and myriad plant physiological responses (Hawkins *et al.* 2008). The predicted increase in drought frequency, intensity, and duration could adversely affect the moist prairie habitats inhabited by whorled sunflower by reducing soil moisture and increasing sunflower mortality rates or reducing flowering and seed production rates. A positive effect of increased drought could result from increased mortality of woody vegetation and reduced rates of vegetation succession, which would otherwise diminish habitat abundance and quality for whorled sunflower. Climate change may also disrupt plant-pollinator interactions via phenological shifts in flowering and/or pollinator activity (Memmott *et al.* 2007, Hawkins *et al.* 2008), which may thereby reduce sexual reproduction of whorled sunflower. However, while climate has changed in recent decades in the region where whorled sunflower occurs and the rate of change is expected to continue increasing for the foreseeable future, uncertainty remains regarding the extent, severity, and precise impacts of how whorled sunflower's habitats and its interspecific interactions will be affected by these changes and how the species will respond to these changes. Given the variety and complexity of potential effects of climate change on plant species and communities (cf. Hawkins *et al.* 2008, Walther *et al.* 2010), more research is needed to assess its potential long-term impacts on whorled sunflower populations and habitats.

In light of such uncertainties, a climate change vulnerability assessment was recently prepared for the Tennessee Wildlife Resources Agency (Glick *et al.* 2015). The study ranked potential responses of numerous plants and animals, including whorled sunflower, to exposure to a variety of climate change variables to assign an overall vulnerability score for each species. Accordingly, whorled

sunflower was ranked as extremely vulnerable, suggesting that the species may experience substantial decreases in abundance in the state by 2050 (Glick *et al.* 2015). Similar assessments are not known for whorled sunflower elsewhere within its range.

- b. Overutilization for commercial, recreational, scientific, or educational purposes:** Whorled sunflower currently is of limited availability in the horticultural trade, although no negative impacts are known to have occurred due to collection of wild material for commercial sale. The conspicuous, attractive flowers of this species combined with easy access of some sites leaves the species vulnerable to collection or poaching. Poaching from the small populations of whorled sunflower could contribute to altered demographic or genetic structure of these populations, potentially diminishing their viability; however, we have no information to suggest this is currently an active threat or has adversely affected populations in the past.
- c. Disease or predation:** There have been limited observations of pathogens or predators associated with whorled sunflower, but none are known to threaten whorled sunflower populations. Fungal-caused leaf spot (Edwards *et al.* 2017) and powdery mildew (Trigiano *et al.* 2016) have been reported for the species, but only the leaf spot has been reported for wild populations. Powdery mildew is currently only known from cultivated whorled sunflower plants, but can readily spread locally among plants and reduce plant growth (Trigiano *et al.* 2016). Likewise, larvae of Curculionid weevils (“true” weevils), which consume seeds, have also been found in achenes (Elam pers. comm. 2019b, Allan Trently pers. comm. 2019a, 2019b). Only one known incidence of seed predators, such as weevils, has been reported.
- d. Inadequacy of existing regulatory mechanisms:**

Whorled sunflower is state-listed as endangered in Georgia and Tennessee, but has no official state status in Alabama or Mississippi. While the species does not receive specific protections in Mississippi, theft of the species is punishable as a misdemeanor in the state under Mississippi Code § 97-17-89 (2013).

In Georgia, whorled sunflower is protected by the State’s Wildflower Preservation Act of 1973 (O.C.G.A. 12-6-170). Under this law, no protected plant may be collected without written landowner permission. No protected plant may be transported within Georgia without a transport tag with a permit number affixed. Permits are also used to regulate a wide array of conservation activities, including plant rescues, sale of protected species, and propagation efforts for augmentation of natural populations and establishment of new ones. No protected plants may be collected from State-owned lands without the express permission of the GDNR. The Georgia Environmental Policy Act (GEPA) (O.C.G.A. 12-16-1), enacted in 1991, requires that impacts to protected species be addressed for all projects on state-owned lands and for all projects undertaken by a municipality or county if funded half or more by state funds or by a state grant of more than \$250,000. The provisions of GEPA do not apply to actions of non-governmental

entities. On private lands, the landowner has ultimate authority on what protection efforts, if any, occur with regard to protected plants (Patrick *et al.* 1995).

The Tennessee Rare Plant Protection and Conservation Act of 1985 (T.C.A. 11-26-201) forbids persons from knowingly uprooting, digging, taking, removing, damaging, destroying, possessing, or otherwise disturbing for any purpose, any endangered species from private or public lands without the written permission of the landowner. On private lands, regulations require written permission from the landowners or land managers before knowingly removing or destroying state listed species (T.C.A. §§70-8-301–314), while state-issued permits are required for knowingly removing such species from state-owned lands (TDEC Rule 0400-02-02-.23). Furthermore, state-issued licenses are required to sell state-listed species in Tennessee (TDEC Rule 0400-06-02-.06). Other state laws and regulations that protect riparian buffers and associated species (such as, aquatic/semi-aquatic and wetland species) may confer some additional legal protections for whorled sunflower and its habitats in the Tennessee (Elam pers. comm. 2020).

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

Whorled sunflower is vulnerable to local extirpation because of its extremely restricted distribution and small population sizes at most known sites, which reduces the resilience of these populations and their ability to recover from acute demographic effects of threats to its habitat discussed above under Factor A. Whorled sunflower is dependent upon the existence of prairie openings and woodlands or degraded remnant roadside prairie habitats for its survival. Alteration or elimination of disturbance processes that maintain these openings could result in further degradation or loss of populations of this species. Furthermore, the highly fragmented distribution of populations in Tennessee and Mississippi combined with their disjunct location with respect to those in Georgia and Alabama, likely precludes gene flow among populations and leaves little chance for natural recolonization of these populations in the event of local population losses.

Small population size may be affecting reproductive fitness of whorled sunflower. Ellis and McCauley's (2009) findings suggest that the Madison County, Tennessee, population is reproductively less fit than the Alabama population. The Tennessee population's reduced reproductive fitness may be attributed to limited mate availability due to limited diversity of self-incompatibility alleles or more extensive inbreeding, both of which may contribute to reduced seed production and viability rates. Ellis and McCauley (2009) could not assess the fitness of the Georgia population because seed heads collected for the study contained few viable seeds that produced poor germination rates. However, the lack of viable seeds collected for this study suggests that poor reproductive fitness could be a threat in this population, as well.

D. Synthesis

Despite the fact that a new population was discovered after whorled sunflower was listed, only five natural populations are known to be extant. Furthermore, most of these

populations are small, consisting of 100 or fewer stems, and isolated, occurring more than 20 miles from their nearest neighbor. Small populations are more susceptible to deleterious stochastic events (such as severe drought, which may be exacerbated by future climate change) and demographic processes (such as reduced fitness due to restricted mate availability). The species' fragmented distribution limits potential gene flow between populations and makes natural reestablishment of a given population unlikely should the population become extirpated. Land conversion has reduced available habitat for this species and continued land conversion could further restrict available habitat. Today, incompatible forestry and agricultural practices, incompatible right-of-way management (e.g., indiscriminate herbicide application), and habitat degradation due to inadequate management (e.g., activities that promote closed canopies and increased competition) are the primary threats to this species. Limited long-term protection (only one population is currently protected) and inconsistent habitat management increase susceptibility of whorled sunflower to these threats. Together, these factors make whorled sunflower extremely vulnerable to local extirpation and overall extinction in the foreseeable future. As such, the species continues to meet the definition of an endangered species.

III. RESULTS

A. Recommended Classification:

No change is needed

B. New Recovery Priority Number: 5

Whorled sunflower's taxonomy (species) and degree of threat (high) remain unchanged from the recovery outline, but its recovery potential is currently considered to be low (previously considered to be high). While the species' apparently responds well to beneficial habitat management actions (e.g., prescribed fire and hand clearing of competing woody vegetation), consistently implementing such actions at all known extant sites remains a persistent problem. Likewise, the lack of protections for most extant populations (only one population receiving any protections) coupled with the limited number of known extant populations, most of which are small and isolated from each other, limits the species' recoverability at this time.

IV. RECOMMENDATIONS FOR FUTURE ACTIONS

1. Finalize the recovery plan.
2. Continue and expand work with federal and state conservation agencies, non-governmental organizations, right-of-way owners and managers, and private individuals and organizations to protect and manage existing habitats and populations, including the development and implementation of management plans, as needed.
3. Safeguard representative genetic material from all known populations.
4. Search for new populations.
5. Investigate efficacy of habitat management techniques (e.g., fire). Update and improve monitoring and habitat management methods.
6. Conduct studies into the species' life history, biology, and ecology to improve management of the species and its habitat.

7. Conduct studies to determine the number and distribution of populations required to maintain the species' genetic diversity and long-term viability.
8. Investigate metapopulation structure and dynamics of the species.

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Whorled sunflower 5-year review

**U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Whorled Sunflower (*Helianthus verticillatus*)**

Current Classification: Endangered.

Recommendation resulting from the 5-Year Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: Not applicable.

Review Conducted By: M. Scott Wiggers, Mississippi Field Office.

FIELD OFFICE APPROVAL:

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

Approve: *Craig Wiggins* Date: 5/22/2020

REGIONAL OFFICE APPROVAL:

Lead Regional Director, U.S. Fish and Wildlife Service, Region 4

Approve: _____ Date: _____

Appendix A. Summary of peer review for the 5-year review of whorled sunflower (*Helianthus verticillatus*)

A. Peer Review Method: The Service conducted peer review coordinated by the Asheville Ecological Services Field Office in North Carolina. Four peer reviewers were identified by the Service for their knowledge of and expertise with whorled sunflower and invited to review the draft document. Individual responses were received from three of the peer reviewers.

Peer Reviewers: Caitlin Elam, Botanist, Division of Natural Areas, Tennessee Department of Environment and Conservation; Malcolm Hodges, Ecologist, The Nature Conservancy – Georgia; Dr. Jennifer Mandel, Assistant Professor, The University of Memphis, Tennessee.

B. Peer Review Charge: See attached guidance.

C. Summary of Peer Review Comments:

Caitlin Elam – Ms. Elam provided several comments, that are summarized below.

1. Noted that the introduced population of whorled sunflower in Chester County, Tennessee, is the only known population in the state found on hydric soils. Also suggested using “soil mapping units” rather than simply “soils” as being a more accurate descriptor, as soils have not been confirmed on the ground in Tennessee. Provided additional detail on soils associated with whorled sunflower in Tennessee.
2. Noted that many of the species included in the Associated Species discussion (section 2.C.1.f) are hydrophytic and may be more applicable to more “natural” sites outside of Tennessee. Detailed lists of associated plants were provided for Madison and McNairy counties populations.
3. Noted state efforts in Tennessee to restore whorled sunflower habitat on a state park and private conservation lands, which may serve as future outplanting sites. Also provided information on Natural Resources Conservation Service (NRCS) programs that may benefit whorled sunflower by restoring prairie habitat in Tennessee.
4. Based on Tennessee populations, suggested that whorled sunflower may not be the narrow habitat specialist noted in the review and may be helophytic (a marsh plant). Also suggested that it is high quality plant communities supporting whorled sunflower that are rare.
5. Noted that plants along a railroad in McNairy County, Tennessee, were not relocated at their original mapped location, but plants were found at a previously unmapped location elsewhere along the railroad tracks. Likewise, suggested that the previously known plants along the railroad were more likely negatively affected by shading or riprap from railroad maintenance.
6. Disagreed with observations of *Salix nigra* (by TDNA 2006), noting that the site may be too wet based on her 2019 observations. Further noted that *S. nigra* is more likely to be found on nearby Waverly soil mapping units rather than the Falaya series mapping unit where whorled sunflower occurs and suggested removing the species from the list of woody species until additional observations can be made to confirm or refute whether *S. nigra* is associated with this population. Also agreed with the Service’s assessment of shading threats to these sites.

Whorled sunflower 5-year review

7. Noted that the Virginia Natural Heritage Program thinks that the recently discovered whorled sunflower site in Virginia is planted.
8. Noted that Tennessee has laws conferring additional protections on riparian buffers and aquatic/semi-aquatic and wetland species in Tennessee.

Malcolm Hodges – Noted that Mandel’s (2010) collection came from “the Wet Prairie” in Georgia rather than “a ‘wet prairie’”. Noted that the conservation easement recognizes fire as a required process to maintain the prairies and woodlands within the easement area, contending that landowners precluding prescribed fire would violate the “spirit of the easement”. Finally, Mr. Hodges noted that invasive species, such as Chinese privet, are a problem at the Georgia population’s site.

Dr. Jennifer Mandel – Dr. Mandel agreed with the information and conclusions presented in the review and reiterated that the putative Virginia population is genetically distinct and that no voucher specimen has been collected to confirm this population.

D. Response to Peer Review: Each of the peer reviewers’ responses were incorporated as follows.

Caitlin Elam – Most of Elam’s comments and suggested edits were incorporated into the review. Specific responses are summarized below.

1. Updated the Soils discussion (section 2.C.1.f) to note that the introduced population in Chester County, Tennessee occurs on hydric soils, citing Elam accordingly. Per Ms. Elam’s suggestion, “soil mapping units” was used in place of “soils,” as appropriate in the soils discussion. Likewise, a brief note that soil mapping units likely need further evaluation was included in the soils description.
2. Updated the plant list (Associated Species in section 2.C.1.f) to note that species have prairie and/or hydrophytic affinities. Expanded associated species list to include select aggressive plant species (native and exotic; provided by Elam and others) associated with some whorled sunflower populations, especially degraded sites in Tennessee.
3. Information provided by Elam on habitat restoration efforts and NRCS programs promoting prairie restoration in the state was added to the “Conservation Efforts” discussion in section 2.C.1.g.
4. While the Service agrees with Elam in the sense that whorled sunflower may be tolerant of a broader range of habitat conditions; however, Elam does not present adequate evidence or rationale to support her suggestion that whorled sunflower habitat “could be very broad throughout its known range”. Elam noted that her suggestions are from observations in Tennessee. These Tennessee populations exist in a generally degraded condition and the fact that populations can persist under degraded habitat conditions does not in and of itself support the suggestion that whorled sunflower may have “very broad” habitat requirements. Rather, such observations alone only support whorled sunflower’s ability to tolerate degraded habitat conditions for some unknown length of time. The suggestion by Elam that whorled sunflower is helophytic is not supported by habitat observations across known sites in Mississippi, Alabama, or Georgia. Furthermore, the only known population found on hydric soils in Tennessee (Chester County), has declined since it was planted. For these reasons, the Service’s description of whorled sunflower as a narrow habitat specialist has not been modified.

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5. Updated the “Right-of-Way Maintenance” discussion in section II.C.2.a to incorporate Elam’s comments, removing incompatible mowing as the potential contributor to the apparent loss of plants at the railroad site.
6. Reviewed TDNA 2006 and found that it is not entirely clear if *S. nigra* is directly associated with the whorled sunflower or simply occurs nearby. The Service agrees with Elam’s rationale that this putative association needs confirmation. Removed *S. nigra* from appropriate species lists per Elam’s suggestion. No additional response is required.
7. Elam’s note aligns with the Service’s understanding of the Virginia site, which is described in the “Populations” discussion of section II.C.1.b. No further response required.
8. Cited Elam in section II.C.2.d, noting that other state laws protecting riparian areas and associated species confer some additional protection to whorled sunflower.

Malcolm Hodges – Changed “a ‘wet prairie’” to “the Wet Prairie”, as suggested. Revised the statement regarding implementation of prescribed fire on the conservation easement to reflect Mr. Hodges’s comment, citing Mr. Hodges accordingly. Included Chinese privet as a threat to the Georgia population, citing Mr. Hodges.

Dr. Jennifer Mandel – No response is required.

Peer Review Invitation Letter Text

On June 20, 2019, the U.S. Fish and Wildlife Service published a notice in the *Federal Register* (84 FR 28850) announcing a 5-year review of eight federally listed species, including whorled sunflower (*Helianthus verticillatus*). The purpose of 5-year reviews is to ensure that the classification of species as threatened or endangered is accurate and reflects the best available information.

Following current Service policy and guidelines on the process to conduct independent peer review, the Asheville Field Office is assisting the Mississippi Field Office to complete peer review of the science in the 5-year review for the whorled sunflower. You have provided data used to review the status of whorled sunflower and/or are knowledgeable about it. Therefore, in order to ensure that the best available information has been used to conduct this 5-year review, we now request your peer review of the attached draft document. Specifically, we ask for comments concerning:

- Have we assembled the best available scientific and commercial information?
- Is our analysis of this information correct and properly applied?
- Can you identify any additional new information on whorled sunflower that has not been considered in this review?

Please note that we are not seeking your opinion of the legal status of this species, but rather that the best available data and analyses were considered in reassessing its status.

As part of the peer review process, we must evaluate the potential for conflicts of interest with the subject species or the action. We therefore ask that you sign the enclosed Conflict of Interest Certificate and return it to this office with any notes, comments, or questions that you are willing to provide as your review.

We appreciate your interest in furthering the conservation of rare plants and animals by becoming directly involved in the review process of our Nation's threatened and endangered species. Your review and comments will become a part of the administrative record for this species, and you can be certain that your information, comments, and recommendations will receive serious consideration.

We hope that you view this peer review process as a worthwhile undertaking. Please give me a call (828-258-3939 x42238) or send me an e-mail (rebekah_reid@fws.gov) if you have any questions on this peer review. Please share your response by email or letter by May 1, 2020. Thank you in advance for your assistance.