

U.S. Fish & Wildlife Service

Post-Delisting Monitoring Plan
for
Cumberland sandwort
(*Mononeuria (=Arenaria) cumberlandensis*)



Plan Prepared by:

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March 2021

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Acknowledgements: The Post-delisting Monitoring Plan for the Cumberland sandwort was prepared by biologists of the U.S. Fish and Wildlife Service (Geoff Call, Tennessee Ecological Services Field Office; Kelly Bibb, Southeast Regional Office). We wish to acknowledge valuable assistance that we received in preparing this plan from Roger McCoy of the Tennessee Department of Environment and Conservation.

Recommended Citation

U.S. Fish and Wildlife Service. 2021. Post-delisting monitoring plan for the Cumberland sandwort (*Mononeuria cumberlandensis*). Southeast Region, Atlanta, Georgia. 24 pp.

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I. Summary of Cooperators' Roles in the Post-Delisting Monitoring Planning Effort

Post-delisting monitoring is a requirement of the Endangered Species Act of 1973, as amended (Act; 16 U.S.C. 1531 *et seq.*). Section 4(g)(1) requires the Service to:

implement a system in cooperation with the States to monitor effectively, for not less than five years, the status of all species which have recovered to the point at which the measures provided pursuant to this Act are no longer necessary.

The purpose of this post-delisting monitoring (PDM) plan (Plan) is to verify that *Mononeuria cumberlandensis* (Cumberland sandwort) remains secure from the risk of extinction after its removal from the protections of the Act. The U.S. Fish and Wildlife Service (Service) prepared this PDM Plan, in coordination with the Tennessee Department of Environment and Conservation (TDEC), Office of Kentucky Nature Preserves, and National Park Service, based largely on the monitoring methods developed by TDEC (2007, p. 4). This Plan is designed to detect substantial declines in Cumberland sandwort populations with reasonable certainty. It meets the minimum requirement set forth by the Act by effectively monitoring the status of Cumberland sandwort using a minimum of five annual sampling events.

The majority (95%) of Cumberland sandwort occurrences are located on lands owned and managed by the National Park Service, Tennessee Division of Forestry, TDEC's Division of Natural Areas, or Tennessee State Parks. These agencies have cooperated with the Service to conserve Cumberland sandwort, undertaking actions to reduce or eliminate threats to the species and monitoring occurrences of the species to document that recovery has occurred. Three projects have been funded to support searches for new Cumberland sandwort occurrences (KSNPC 1991, entire; TDEC 2000, entire; TDEC 2008, entire). In 2010, TDEC conducted a status survey for Cumberland sandwort, documenting the species' range-wide distribution, determining the length of time that each occurrence had persisted, recording imminent and potential threats, and assessing protection and management efforts that had been completed or were still needed at the time (TDEC 2011b). Additionally, TDEC (2000, 2007, 2011a, 2012, 2014) has periodically monitored Cumberland sandwort occurrences since 2000 and recently assessed the stability of occurrences over time based on those data (R. McCoy 2018, TDEC, pers. comm.).

II. Summary of Species Status at Time of Delisting

A. Habitat and Species Description

Cumberland sandwort inhabits fine-grained, sandy floors in the interior of "rockhouses" (cave-like recesses produced by differential weathering of sandstone) behind the overlying cliffs, ledges, and solution pockets on cliffs, where these features occur in sandstone of the Pottsville Formation (Wofford and Smith 1980, p. 7; Walck et al. 1996, p. 339). The species occupies sites that generally share characteristics of high levels of shade, moisture,

and humidity, and relatively constant, cool temperatures (Wofford and Smith 1980, p.7); though, some smaller occurrences occupy drier and warmer sites.

Cumberland sandwort is a delicate perennial that has been reported to flower May through August, with some flowers persisting as late as November (Wofford and Kral 1979, p. 259; Winder 2004, p. 5). Plants occur in small cushion-like clumps, with upright stems 10 to 15 centimeters (cm) (4 to 6 inches (in)) tall that are slender and triangular in shape. Leaves are opposite, 2 to 3 cm (0.8 to 1.2 in) long and 1 to 3 millimeters (mm) (0.04 to 0.12 in) wide, and are thin and bright green in color, with glassy margins. Basal leaves are longer and wider than those at the top of the stems. The flowers are symmetrical, five-parted, and usually solitary at the end of the stems. The sepals (a part of the flower that provides protection for the flower in bud and sometimes provides support for petals when in bloom) are green and inconspicuously three-veined, and the white petals usually have five green veins. The fruit is a 3- to 3.5-mm-long (0.12 to 0.14 in) ovoid capsule containing numerous reddish-brown reticulated (having the form or appearance of a net) seeds that are 0.5 to 0.7 mm (0.02 to 0.03 inches) long (Wofford and Kral 1979, pp. 257-259, Kral 1983, pp. 363-364).

B. Discussion of Occurrences

When Cumberland sandwort was listed as endangered, there were 11 known occurrences (Wofford and Smith 1980, pp. 9-18), treated as 5 populations (53 FR 23745). The species recovery plan referred to occurrences, rather than populations, in setting criteria for considering whether to reclassify Cumberland sandwort to threatened from endangered or to delist the species (Service 1996, p. 10), but provided no guidance for how to delineate discrete occurrences. In the course of conducting a status survey for Cumberland sandwort in Tennessee, TDEC (2011b) developed the following specifications for delineating occurrences, which were used in determining the number of occurrences reported below, and aggregating them into populations:

1. At a minimum, an occurrence is defined as a noncontiguous cluster or patch of plants that naturally occurs in suitable habitat.
2. An occurrence may consist of several noncontiguous patches that occur in one or more rockhouses or cliff-faces which are located in a linear or vertical pattern with no barriers present. Discontinuity and barriers to dispersal have been identified based on slope aspect, stream connectivity, geologic connectivity (i.e., rockfalls), and elevation differences. These patches can be monitored separately and mapped as individual source points in order to repeat data collection.
3. Each occurrence is assigned to a population based on the Hydrologic Unit Code (HUC)-12 watershed in which it is located.

As of 2018, there were 71 extant occurrences of Cumberland sandwort (compared to 64 at the time of the recovery plan), distributed among the 5 counties where the species was reported extant when the recovery plan was published, as follows: 1 in McCreary County, Kentucky (Kentucky Natural Heritage Program (KNHP) 2018); 1 in Morgan, 26 in Fentress, 38 in Pickett, and 5 in Scott County, Tennessee (TNHID 2018). Twelve of the

71 extant occurrences lie within the Obey River drainage in Tennessee; of those, 11 occurrences have been discovered since 2005 on recently acquired State conservation lands, and one was discovered on privately owned lands in 2016. The remaining 59 occurrences lie within the South Fork Cumberland River drainage, all but one in Tennessee. These occurrences are distributed among 10 watersheds, delineated by 12-digit hydrologic units (HUC) (Table 1, Figure 1). In addition to these 71 natural occurrences of Cumberland sandwort, one introduced occurrence has been established in McCreary County, Kentucky, at Daniel Boone National Forest (Pence *et al.* 2011, entire).

The recovery plan states that Cumberland sandwort will be considered for delisting when 40 geographically distinct, self-sustaining occurrences are protected and have maintained statistically stable or increasing numbers for 5 consecutive years. At least 12 of the occurrences must be outside of Pickett County, Tennessee. To provide a framework for evaluating available data for Cumberland sandwort in the context of these recovery criteria, we assessed the species' viability using three conservation biology principles of resiliency, representation, and redundancy (Shaffer and Stein 2000, entire). The framework for this analysis is described in detail in the proposed delisting rule for the species (Service 2019, 85 FR 23302) and is summarized here. First, we characterized the resiliency of each occurrence using available data on three factors: occurrence size expressed as estimated abundance or areal coverage, recorded observations of threats causing disturbance to plants or substrates in which they were rooted, and assessment of general forest conditions from recorded observations or evaluation of aerial photography. Next, we considered the distribution of resilient occurrences among the counties and major (i.e., 8-digit HUC) watersheds from which the species is known in order to evaluate representation. Finally, we judged redundancy for the species based on the overall number of resilient occurrences distributed throughout its range.

Table 1. Distribution of Cumberland sandwort occurrences among 8- and 12-digit HUC watersheds, with counts of occurrences meeting recovery criteria of being self-sustaining and protected. Occurrence numbers in bold meet recovery criteria.

| 8-digit huc Watershed | 12-digit huc Watershed | Occurrence Numbers | Recovery Status | |
|-----------------------------|------------------------|-------------------------------------------------------------------------------------------|-----------------|----|
| | | | Yes | No |
| South Fork Cumberland River | Blair Creek | KY 1 | 1 | 0 |
| | Williams Creek | 59 | 1 | 0 |
| | No Business Creek | 1, 41 | 1 | 1 |
| | Rock Creek | 4, 5, 6, 8, 10, 11-13, 14, 15-16, 24, 26, 33, 34, 35-39, 66, 69-71, 77, 78, 80, 87 | 20 | 8 |
| | Station Camp Creek | 17-18, 19, 20, 21, 22, 27, 29, 31, 42-45, 47, 61, 64, 74, 79 | 14 | 4 |
| | Laurel Fork | 25, 60, 65, 84 | 2 | 2 |
| | North White Oak Creek | 7 | 0 | 1 |
| | Clear Fork Middle | 2, 3, 48, 54, 73 | 1 | 4 |
| Obey River | Rotten Fork Wolf River | 81-82, 83 | 2 | 1 |
| | Delk Creek | 58, 62-63, 72, 76, 85-86, 88 | 0 | 8 |

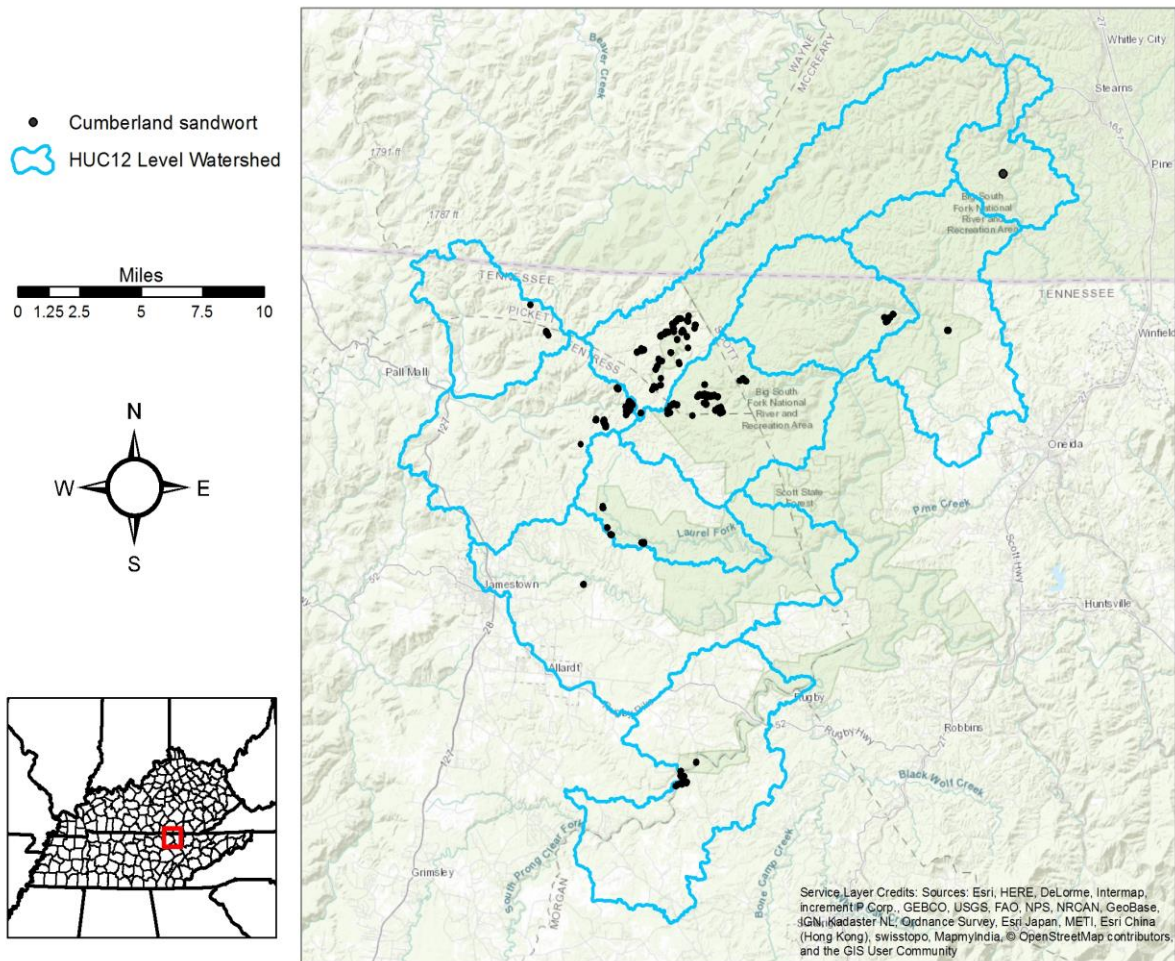


Figure 1. Cumberland sandwort occurrence map with 12-digit HUC watershed boundaries.

Resiliency factors were evaluated as follows, using available data on abundance/areal coverage, potential exposure to substrate disturbance, and evidence of logging activities in nearby forests. We used estimates of abundance, where available, combined with estimates of areal coverage to provide a basis for categorizing occurrences into groups of low, medium, or high abundance. Occurrences with less than 100 individuals (Heschel and Paige 1995, pp. 128-131; Münzbergová 2006, p. 148) or with areal coverage less than 1 m² were ranked “low”; occurrences with 100-1,000 individuals or with areal coverage ranging from 1 to 5 m² were ranked “medium”; and occurrences with more than 1,000 individuals or areal coverage greater than 5 m² were ranked “high”. We ranked substrate conditions at each occurrence based on recorded observations of threats (TDEC 2011b, pp. 37-44). Substrate conditions were ranked “high” for sites with no record of disturbance; “medium” for sites with limited historical evidence of digging for archeological artifacts (i.e., relic digging) or trampling by humans or wildlife in limited areas within available habitat; and “low” for sites with recent evidence of relic digging or trampling throughout available habitat. We used aerial imagery available through Google Earth Pro™ to determine whether forests in the general vicinity of Cumberland sandwort occurrences exhibited signs of timber harvest, as indicated by substantially reduced tree densities, presence of logging equipment trails, or conversion to non-native, evergreen forest types. Forest conditions were ranked “high” in locations where late seral (stage of secondary succession) forest was present upslope and downslope of occupied sites and in adjacent areas; “medium” in locations where evidence of logging within the prior 15 years was present within the vicinity, but not immediately upslope, downslope, or adjacent to occurrences; and “low” in sites where evidence of logging within the prior 15 years was present in the forest immediately surrounding the occupied habitat.

Using the ranks for the three resiliency factors (abundance, substrate condition, and forest condition), we calculated a resiliency index for 68 of the 70 Tennessee occurrences (Table 2) and the lone Kentucky occurrence. We assigned numerical scores of one for factor ranks of “low”, two for “medium” ranks, and three for “high” ranks. Using these scores for factor ranks, we calculated a weighted average, wherein factor ranks for abundance were given twice the weight of factor ranks for substrate and forest condition, due to the importance of population size in maintaining genetic variation and determining resiliency to demographic and environmental stochasticity (Sgrò *et al.* 2011, p. 329). The resulting resiliency index for an occurrence ranges from one to three and is categorized as follows:

- Low rank for scores of 1.5 or less
- Low-medium rank for scores greater than 1.5 and less than 2.0
- Medium rank for scores ranging from 2.0 to 2.5
- Medium-high rank for scores greater than 2.5 and less than 3.0
- High rank for scores of 3.0

Available data for the Kentucky occurrence indicate that the species abundance rank is medium at that location and that the occurrence is not exposed to threats from trampling or relic digging. This location is protected from timber harvesting and available data indicate that surrounding forests are undisturbed. These factors produced a resiliency index of

medium for this occurrence. In Tennessee, 56 occurrences had resiliency indices of medium or higher (Table 2).

Table 2. Resiliency index ranks for Cumberland sandwort occurrences in Tennessee. Cells shaded in grey represent counts of occurrences considered self-sustaining, as required by recovery criteria. Numbers in parentheses represent occurrences on private lands, which are accounted for in the main count given in each cell. Private lands under conservation easement held by Tennessee Parks and Greenways Foundation are indicated by an *.

| Monitoring Tier | Trend | Low | Low-Medium | Medium | Medium-High | High |
|-----------------|----------|-----------|------------|-----------|-------------|-----------|
| One | Decline | 2 | -- | -- | -- | -- |
| | Stable | 1 | 1 | 7 | 4 | -- |
| | Increase | -- | -- | -- | 2 | 1 |
| Two | Decline | 3 | -- | 2 (1*) | -- | -- |
| | Stable | 2 | -- | 10 (1*) | 3 | 3 |
| | Increase | -- | -- | -- | 1 | -- |
| Three | Decline | 1 | -- | 1 | -- | -- |
| | Stable | -- | -- | 4 | 3 | 3 |
| | Increase | | | 1 | | |
| Other | n/a | 1 | 1 | 7 (1) | -- | 4 |
| Total | | 10 | 2 | 32 | 13 | 11 |

For the purpose of evaluating Cumberland sandwort’s status with respect to recovery criteria, we defined self-sustaining to include those populations with a resiliency index rank of medium or higher that TDEC determined were stable or increasing based on available monitoring data. For the Kentucky occurrence, available data indicate that the occurrence is stable. We consider 66 occurrences on Federal or State conservation lands (Table 3) to be protected, as well as 2 occurrences located on private lands where land use is restricted by conservation easements. There are 57 occurrences with resiliency indices of medium or higher, 42 of which are protected occurrences that are self-sustaining (including 1 in Kentucky) (Table 2 presents data for Tennessee, note gray cells), exceeding the criteria for removing Cumberland sandwort from the List of Threatened and Endangered Plants. In this document, we refer to these as “recovery occurrences”.

Table 3. Land ownership for 66 Cumberland sandwort occurrences on Federal and State conservation lands. (note: number of occurrences in table sums to 70, but 4 occurrences occupy habitats spanning adjacent lands owned by Tennessee Division of Forestry and Tennessee State Parks and are counted only once for total as noted in table).

| Agency | Land Unit | Number of Occurrences |
|--------------------------------------------|----------------------------------------------------------------|-------------------------------|
| National Park Service (NPS) | Big South Fork National Scenic River and Recreation Area (BSF) | 27 |
| Tennessee Division of Forestry (TDF) | Pickett State Forest (PSF) | 29 (4 partially on TSP lands) |
| Tennessee Division of Natural Areas (TDNA) | Pogue Creek State Natural Area (PCNA) | 7 |
| Tennessee State Parks (TSP) | Pickett State Park (PSP) | 7 (4 partially on TDF lands) |

The recovery criteria also require that at least 12 of the protected, self-sustaining occurrences be located outside of Pickett County, Tennessee, presumably for the purpose of distributing the species representation and redundancy more evenly within its geographic range. Of the 42 occurrences meeting the criteria of being protected and self-sustaining, 9 are located in Fentress County, 28 in Pickett County, 4 in Scott County (Tennessee occurrences), and 1 is located in McCreary County, Kentucky. Another measure of representation for the species is its distribution among major watersheds. The species recovery plan reported that the species was known only from the South Fork Cumberland watershed, but there are now 12 occurrences in the Obey River watershed in Tennessee, 2 of which are recovery occurrences. The low number of occurrences meeting recovery criteria in this watershed primarily results from their recent discovery and thus lack of repeat observations. Not counted among the 42 recovery occurrences are 11 additional occurrences with resiliency indices of medium or higher, 9 in the Obey River watershed and 2 in the South Fork Cumberland watershed, that are located on protected lands. We lack repeat monitoring observations for these occurrences, which were discovered between 1999 and 2017, needed to determine whether they are stable or increasing and should be counted towards recovery at this time. Given their resiliency rankings and locations on protected lands, we expect these occurrences are self-sustaining and will contribute to the species representation of resilient occurrences into the foreseeable future.

C. Residual Threats

Site protection and habitat management efforts by TDEC (including both TDNA and TSP) and NPS, working cooperatively with the Service, have reduced habitat loss and disturbance from recreational activities and trampling so that it is no longer a high magnitude threat. We expect this trend to continue as the lands containing the 42 recovery occurrences and 10 other resilient, but more recently discovered, occurrences will remain permanently protected in state or federal ownership and will be managed to maintain current habitat conditions. Recreational impacts may continue at some occurrences, but the magnitude of these threats across the species' range has decreased with the placement of signs and/or construction of protective fencing at key sites located along well-used trails.

Timber management does not occur at BSF, PSP, or PCNA, but does occur at PSF. During the course of evaluating forest conditions in the vicinity of Cumberland sandwort occurrences, we observed that timber harvests had been conducted in the general vicinity of 10 known locations at PSF, during the period between approximately 2008 and 2017. Timber harvests occurred upslope or downslope of seven of these occurrences, where forest condition was ranked low for the purpose of calculating a resiliency index, and in the general vicinity of three occurrences, where forest conditions were ranked medium. Despite nearby timber harvests, four of these occurrences are considered self-sustaining, because they are stable (R. McCoy 2018, TDEC, pers. comm.), ranked medium to high in abundance, and ranked medium or high in substrate condition. These 4 occurrences (EO numbers 11, 36, 69, and 78) are included in the 42 recovery occurrences. Site visits by the Service to three of these four occurrences in February 2019 confirmed that the sites are undisturbed from logging activities and that the Cumberland sandwort occurrences at

these locations remain stable. Monitoring data collected by TDEC at EO 36 in 2016 verified the lack of disturbance at the fourth occurrence, which also is stable. These observations indicate that logging activities in the vicinity of Cumberland sandwort occurrences, that do not directly impact the species or its habitat, may pose little threat in terms of indirect effects. Sites where timber harvesting has occurred that are not considered self-sustaining received low resiliency ranks due to low abundance or poor substrate condition, or a combination of the two, in addition to diminished forest conditions.

While it is evident that Cumberland sandwort habitats are, in some cases, exposed to stressors that could adversely affect the species, available monitoring data indicate that the species is more resilient to these threats than was assumed at the time of listing. Nonetheless, some occurrences with low abundance are threatened by substrate disturbance and nearby timber harvesting, leaving them less resilient to environmental and demographic stochasticity, and are not counted among those contributing to achieving recovery criteria. Despite the presence of these potential stressors in or near habitats occupied by some Cumberland sandwort occurrences, there are 42 recovery occurrences on conservation lands with resiliency indices of medium or higher that have remained stable or increasing in abundance. These occurrences have been known to exist for an average of 21 years, with a range of 7 to 44 years spanning the first and most recent observations recorded for the species in these sites. There are an additional 10 protected occurrences in Tennessee, 9 in the Obey River watershed and 1 in the South Fork Cumberland watershed, that have resiliency indices of medium or higher, but currently lack sufficient monitoring data to evaluate trends in abundance. Seven of these have no evidence of substrate or forest disturbance and are located in PCNA, where TDEC surveys potential trail routes to prevent new trail construction that would expose occurrences to threats from recreational uses (TDEC no date, pp. 10-11). No other potential threats to the habitats at PCNA have been documented.

D. Legal and/or Management Commitments for Post-delisting Conservation

Only 5 of the 71 extant Cumberland sandwort occurrences are located on private lands. Two of these are located on parcels where conservation easements protect forests from development or timber removal in the Clear Fork gorge, where Cumberland sandwort is present, but would allow for limited residential development or selective timber harvest above the gorge on the plateau top (C. Henderson 2018, Tennessee Parks and Greenways Foundation, pers. comm.). No development has occurred on either tract.

The remaining 66 occurrences are located on Federal and State conservation lands, owned and managed by NPS, TDF, or TDEC (including TDNA and TSP) (Table 3). The NPS manages the 125,000-acre (ac) BSF according to prescriptions established for eight management zones in Alternative D of the Final General Management Plan/Environmental Impact Statement for Big South Fork National River and Recreation Area, Kentucky and Tennessee (NPS 2005, entire). Under this management framework, habitats occupied by Cumberland sandwort and those that are potentially suitable for the species fall within the Sensitive Resource Protection Zone, which is managed to reflect natural processes and be carefully protected from unnatural degradation (NPS 2005, pp.

31-40). The draft management plan for PCNA identifies Cumberland sandwort and habitat types suitable for the species among targets for conservation in the natural area (TDEC no date, pp. 8-11).

The species recovery plan identified the need for protecting Cumberland sandwort occurrences from recreational overuse of habitat and timber management activities. The 5-year review completed in 2013 (Service 2013, pp. 13-14) summarized site protection measures taken to reduce recreation-related impacts at eight occurrences. In addition to the protective measures discussed in the 5-year review, TDEC (2016, p. 3) also added a fence and stairways at EO 4 in PSP to further restrict foot traffic through this heavily used site. The seven occurrences at PCNA are protected from recreational activities by surveying proposed alignments for new trails and avoiding sites with Cumberland sandwort. It is likely that additional occurrences will be found as additional recreational access into the natural area is developed.

III. Monitoring Methods and Locations

Historical Monitoring Methods: TDEC began monitoring Cumberland sandwort in Tennessee during 2000, estimating abundance in 34 sites as part of a project to conduct surveys for new locations and update records for previously known occurrences of the species (TDEC 2000, entire). In addition to estimating abundance, observers prepared hand-drawn maps of each site depicting areas occupied by Cumberland sandwort (TDEC 2000, p. 7). Based on experiences from this first monitoring effort for the species, TDEC determined that attempting to census individuals would adversely affect Cumberland sandwort in most sites, due to trampling of the plants and disturbance or compaction of the sandy substrates they occupy. Beginning in 2006, TDEC expanded the monitoring program and modified it to include estimating area occupied by plants at each occurrence, still counting or estimating total numbers of plants in some sites where this could be done without adverse effects, and updating hand-drawn site maps to aid future observers in ensuring that all known occupied areas would be tracked in future monitoring events. In planning future monitoring, TDEC categorized sites into three tiers of differing priority (TDEC 2007, pp. 4-5):

- Tier 1 sites are located in Pickett State Park (PSP), Pickett State Forest (PSF), and Big South Fork National River and Recreation Area (BSF), primarily in areas with frequently used trails, and in many cases with a history of site disturbance related to recreational use or illicit digging of Native American artifacts.
- Tier 2 sites, with two exceptions on private lands, are also located on the public lands listed for Tier 1 sites in addition to Pogue Creek State Natural Area (PCNA), but face fewer immediate threats in the less frequently visited sites they occupy within these protected areas.
- Tier 3 sites are fairly evenly distributed among private lands and remote locations of PSF and BSF, where no imminent threats were known when TDEC categorized sites for monitoring purposes.

Designating monitoring tiers provided a mechanism for TDEC to more frequently monitor Cumberland sandwort sites with greater exposure to threats that could warrant management intervention. Tier 1 sites were scheduled to be monitored every 1 to 3 years, Tier 2 sites every 3 to 6 years, and Tier 3 sites every 6 to 10 years (TDEC 2007, p. 5). The Service receives monitoring data from TDEC in the form of written reports and as occurrence-level summary data provided in the TNHID (2018). Years during which monitoring has generally been accomplished for each tier are listed in Table 4.

Table 4. Primary years during which three tiers of Cumberland sandwort occurrences have been monitored.

| Tier | Years Monitored |
|------|-----------------------------------|
| 1 | 2000, 2006-7, 2010-11, 2014, 2017 |
| 2 | 2000, 2006-7, 2011-12 |
| 3 | 2000, 2006-7, 2016-2017 |

We used the summary data from TNHID (2018) to determine which sites in each tier had been monitored in two or more years, making it possible to assess whether Cumberland sandwort had declined, remained stable, or increased in estimated abundance or area occupied. Based on data provided in the TNHID, there are 18 occurrences in Tier 1, 23 in Tier 2, and 13 in Tier 3 for which data from two or more monitoring events were available for evaluating trends. Tier 1 occurrences have been monitored an average of 4.7 times, with time between initial and most recent monitoring events averaging 15.8 years. Tier 2 occurrences have been monitored an average of 2.4 times over an average timespan of 8.4 years. Tier 3 occurrences have been monitored an average of 2.4 times over an average timespan of 12.1 years. There are 16 occurrences in Tennessee where monitoring has occurred only once or that have not, as yet, been assigned to a monitoring tier.

PDM Monitoring Methods: For this PDM Plan, we selected the 42 recovery occurrences determined to be self-sustaining plus 8 additional occurrences on conservation lands, for which sufficient data are not yet available to evaluate whether they are self-sustaining. All but two of the 42 recovery occurrences are in the South Fork Cumberland watershed; the remainder are in the Obey River watershed. Six of the eight additional occurrences selected for PDM are in the Obey River watershed, ensuring that monitored occurrences encompass the full geographic range of the species' representation. Because they consist of recovery occurrences and others on conservation lands, most of the occurrences included in this PDM Plan rank medium to high in abundance (Table 5). Similarly, most occurrences selected for PDM rank medium to high in both substrate and forest condition reflecting the low to moderate threat levels they exhibit. Nonetheless, there are occurrences included in this PDM Plan that rank low on one of the three factors used to rank resiliency, ensuring that the status of recovery occurrences with exposure to residual threats is considered when evaluating the species condition in the context of management response triggers discussed in the following section.

Table 5. Distribution of Cumberland sandwort occurrences selected for PDM among abundance, substrate, and forest condition classes used to rank resiliency, as described in II.B. Description of Populations, above.

| Tier (# sites) | Abundance | | | Substrate Condition | | | Forest Condition | | |
|-------------------|-----------|-----------|-----------|---------------------|-----------|-----------|------------------|----------|-----------|
| | Low | Medium | High | Low | Medium | High | Low | Medium | High |
| 1 (14) | | 3 | 11 | 4 | 9 | 1 | 1 | | 13 |
| 2 (19) | 1 | 9 | 9 | | 7 | 12 | 1 | 1 | 17 |
| 3 (11) | 1 | 4 | 6 | | 4 | 7 | 1 | | 10 |
| n/a (6) | 1 | 4 | 1 | 1 | | 5 | 1 | | 5 |
| Totals | 3 | 20 | 27 | 5 | 20 | 25 | 4 | 1 | 45 |

The PDM for Cumberland sandwort will be conducted annually during May through June, for a minimum of five years, to allow for observation of flowering plants and presence of recently emerged seedlings. Data collection methods will be similar to those used by TDEC (2007, p. 4), in which hand-drawn maps showing locations of Cumberland sandwort patches were prepared for each site and area (square meters (m²)) covered by each patch was recorded. Abundance in each patch will be estimated or, in circumstances where it is possible to do so without harming Cumberland sandwort individuals, determined by counting. The proportion of flower/fruit bearing plants will be estimated, and the presence or absence of multiple size-classes will be recorded. Observations about potential threats causing substrate disturbance in Cumberland sandwort sites will be recorded, including the degree to which the habitat patches occupied by the species are exposed to the disturbance. The following practices will be followed to minimize variability by ensuring consistent sampling practices:

- TDEC will be the primary entity conducting the PDM and employs multiple staff that have conducted recovery monitoring for Cumberland sandwort. Service and NPS personnel will assist with sampling, in coordination with TDEC.
- A field data sheet will be prepared prior to initiation of PDM sampling and will be completed at each occurrence, ensuring that necessary data are recorded for each occurrence during each sampling event.
- Data collection will occur annually for five years during May through June.

The PDM period will be initiated during the first growing season following the publication of a final rule to delist Cumberland sandwort, extending through at least the fifth growing season following delisting. See VII. PDM Implementation Schedule, below, for a description of sites to be sampled in each of the five years following delisting.

IV. Definition of Response Triggers for Potential Monitoring Outcomes

Effective PDM requires timely evaluation of data and responsiveness to observed trends. In order to assure timely response to observed trends, it is necessary to identify possible outcomes from monitoring that could be anticipated and general approaches for responding to these scenarios. In order to identify thresholds that would trigger alternative responses in the case of Cumberland sandwort, it will be necessary to analyze data from the recovery monitoring period to identify the range of variability that has been observed with respect to each of the variables

that will be monitored during the PDM period. From this analysis, it will be possible to categorize observations into one of the following three possible PDM outcomes.

A. Category I

Cumberland sandwort remains secure without ESA protections. This would be true if:

- (1) at no more than 20 percent of PDM occurrences (10 occurrences) do abundance ranks decrease from baseline values determined when the species was delisted, and
- (2) at no more than 20 percent of PDM occurrences (10 occurrences) does the resiliency index decline to a lower rank (e.g., from medium to low ranking) than the baseline value determined when the species was delisted, and
- (3) no new or increasing threats to the species are observed.

In this case, PDM would be concluded at the end of the timeframe specified in this Plan.

B. Category II

Cumberland sandwort may be less demographically stable than anticipated at the time of delisting, but information does not indicate that the species meets the definition of threatened or endangered. This would be true if:

- (1) abundance ranks for more than 20 percent and less than 50 percent of occurrences (10 occurrences and 25 occurrences) decrease from baseline values determined when the species was delisted, or
- (2) resiliency indices for more than 20 percent but less than 50 percent of occurrences (10 occurrences and 25 occurrences) decline to a lower rank than the baseline value determined when the species was delisted, and
- (3) there are no new or increasing threats that are considered to be of a magnitude and imminence that may threaten the continued existence of Cumberland sandwort within the foreseeable future.

In this case, the PDM period should be extended for an additional five years from the year such decreases are observed, and if necessary, sampling intensity could be increased to provide greater precision in detecting trends at existing monitoring sites. Also, stage-specific counts or sampling would be conducted at a representative sample of sites in which declines are observed. Existing data will be analyzed to determine if any management interventions are available that would be expected to reverse declines and stabilize or improve trends.

C. Category III

PDM yields substantial information indicating that threats are causing a decline in the status of Cumberland sandwort since the time of delisting, such that listing the species as threatened or endangered may be warranted. This would be true if:

- (1) abundance ranks for more than 50 percent of occurrences (25 occurrences) decrease from baseline values determined when the species was delisted, or
- (2) resiliency indices for more than 50 percent of occurrences (25 occurrences) decline to a lower rank than the baseline value determined when the species was delisted, and
- (3) there are new or increasing threats that are considered to be of a magnitude and imminence that they could threaten the continued existence of Cumberland sandwort within the foreseeable future.

If only the first two of these conditions are true or the third condition is true by itself, then the Service should initiate a status review to assess changes in threats to the species, its abundance, population structure, and distribution to determine whether a proposal for relisting is appropriate. If all of these conditions are true, then the Service should promptly propose that Cumberland sandwort be relisted under the Act in accordance with procedures in section 4 of the Act.

V. Data Compilation and Reporting Procedures

Microsoft Excel spreadsheets containing all data collected and copies of all completed field data sheets will be submitted to the Tennessee Ecological Services Field Office of the Service, in a format collaboratively designed with TDEC biologists. These spreadsheets will be submitted by the end of each calendar year to ensure that adequate data are being collected and analyzed, to allow evaluation of the efficacy of the monitoring program, and to provide a periodic assessment of the status of Cumberland sandwort. The Service will review these data annually within the context of the response triggers outlined above to determine whether additional action is necessary. After five years of data are available, the field collection data will be reviewed to determine overall population change and status with respect to threats. The Service will prepare a final monitoring report that will be made available to the public, which will include a description of the geographic areas surveyed, the survey protocol, and updated population metrics for each colony surveyed.

If the response triggers described in Section IV above are met or exceeded, then the Service will consult with TDEC and other partners to determine whether to conclude the PDM process or to pursue alternative actions as described in Section IV. Our determination will also include, if necessary, an evaluation of the threats to Cumberland sandwort using the five factors required under the Act to list a species on the Federal List of Threatened and Endangered Species.

VI. Estimated Funding Requirements and Sources

The primary entity conducting the PDM and preparing reports will be TDEC with cooperation from the Service. Based on TDEC costs associated with recovery monitoring efforts, annual PDM expenditures should not exceed \$10,000. The Service will work with partners to help secure funding to implement this PDM plan.

Anti-Deficiency Act disclaimer. Post-delisting monitoring is a cooperative effort among the Service; state, tribal, and foreign governments; other Federal agencies; and other non-

governmental partners under the Act. Although the Act authorizes expenditures of both recovery funds and section 6 grants to the states to plan and implement PDM, Congress has not allocated nor earmarked any special funds for this purpose. To the extent feasible, the Service intends to provide funding for PDM efforts from annual Endangered Species general appropriations. Nonetheless, nothing in this Plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in contravention of the Anti-Deficiency Act (31 U.S.C. 1341) or any other law or regulation.

VII. PDM Implementation Schedule

As described in III. Monitoring Methods and Locations, above, TDEC designated three tiers for Cumberland sandwort occurrences, with exposure to potential stressors decreasing with increasing tier number. We retain those tier designations for occurrences selected for this PDM Plan, where already established by TDEC, and have assigned tier designations to occurrences for which tiers had not been previously assigned (Table 6). For this PDM Plan, monitoring frequency will be increased to provide a more robust dataset for evaluating the species status in the context of response triggers defined in the previous section. Tier 1 occurrences will be monitored in all years, Tier 2 occurrences during years one and three, and Tier 3 occurrences during years two and four. During year five, the Service and TDEC will cooperatively determine which sites from Tiers 2 and 3 should be monitored in order to provide a greater dataset for evaluating changes in their status.

Table 6. List of Cumberland sandwort element occurrences (EOs) selected for PDM monitoring, including baseline data on trends, resiliency factor rankings, and resiliency index rankings. All sites other than KY1 are located in Tennessee and represented by EO numbers from TNHID (2018).

| EO Number | Recovery Criteria (Y/N) | # Times Monitored Prior to PDM | Tier | Trend | First Observed | Abundance Data | Abundance Rank | Substrate Condition Rank | Forest Condition Rank | Overall Resiliency Rank |
|-----------|-------------------------|--------------------------------|------|----------|----------------|--------------------------------------------------------|----------------|--------------------------|-----------------------|-------------------------|
| KY 1 | Y | 2 | 2* | Stable | 1991 | ~1000 | Medium | High | High | High |
| 1 | Y | 5 | 1 | Stable | 1980 | 10 m2; ~3600 | High | Medium | High | Medium-High |
| 4 | Y | 5 | 1 | Stable | 1979 | >35 m2; | High | Medium | High | Medium-High |
| 6 | Y | 3 | 2 | Stable | 1978 | 10 m2; >1500 | High | High | High | High |
| 11 | Y | 4 | 1 | Stable | 1984 | 28 m2; 1000-3000 | High | Medium | Low | Medium |
| 12 | Y | 3 | 2 | Stable | 1980 | 0.25 m2; 35 | Low | High | High | Medium |
| 13 | Y | 5 | 1 | Increase | 1980 | 55 m2; >4150 | High | Medium | High | Medium-High |
| 15 | Y | 2 | 3 | Stable | 1980 | ~5 m2; ~500 | Medium | High | High | Medium |
| 16 | Y | 2 | 3 | Stable | 1993 | 25 m2; >2000 | High | Medium | High | Medium-High |
| 17 | Y | 5 | 1 | Stable | 1992 | 13 m2; >3000 | High | Low | High | Medium |
| 18 | Y | 2 | 3 | Stable | 1992 | >5000 | High | High | High | High |
| 20 | Y | 2 | 3 | Increase | 1992 | 0.5 m2; 122 | Low | High | High | Medium |
| 22 | Y | 2 | 3 | Stable | 1992 | 9.5 m2; 750-1000 | Medium | Medium | High | Medium |
| 24 | Y | 5 | 1 | Increase | 1973 | 9 m2; ~1000 | High | Medium | High | Medium-High |
| 29 | Y | 5 | 1 | Stable | 2000 | ~8 m2; >1325 | High | Low | High | Medium |
| 31 | Y | 5 | 1 | Increase | 2000 | ~7 m2; >2000 | High | High | High | High |
| 33 | Y | 3 | 2 | Stable | 2000 | 15 m2; ~2000 | High | Medium | High | Medium-High |
| 35 | Y | 4 | 3 | Stable | 2000 | 50 m2; >5000 | High | High | High | High |
| 36 | Y | 3 | 3 | Stable | 2000 | 3 m2; hundreds | Medium | High | Low | Medium |
| 37 | Y | 2 | 3 | Stable | 2000 | ~500 | Medium | High | High | Medium |
| 38 | Y | 3 | 3 | Stable | 2000 | > 30 m2 (dispersed in patches among ledges); 3000-3500 | High | Medium | High | Medium-High |

| EO Number | Recovery Criteria (Y/N) | # Times Monitored Prior to PDM | Tier | Trend | First Observed | Abundance Data | Abundance Rank | Substrate Condition Rank | Forest Condition Rank | Overall Resiliency Rank |
|-----------|-------------------------|--------------------------------|------|----------|----------------|---------------------------------------------------|----------------|--------------------------|-----------------------|-------------------------|
| 39 | Y | 3 | 2 | Stable | 2000 | 5-9 m2; >1500 | High | Medium | High | Medium-High |
| 42 | Y | 5 | 1 | Stable | 2000 | 5 m2; 500-1000 | Medium | Low | High | Medium |
| 43 | Y | 3 | 2 | Stable | 2000 | 37 m2; >1750 | High | High | High | High |
| 44 | Y | 3 | 2 | Stable | 2000 | >30 m2; >3,325 | High | Medium | High | Medium-High |
| 45 | Y | 5 | 1 | Stable | 2000 | 2-4 m2; ~290 | Medium | Medium | High | Medium |
| 47 | Y | 4 | 1 | Stable | 2000 | 2-4 m2; ~790 | Medium | Medium | High | Medium |
| 48 | Y | 2 | 2 | Stable | 1996 | 7.5 m2; ~700 | Medium | High | High | Medium |
| 58 | N | 2 | 2 | Stable | 2005 | 25-30 m2; 1000s | High | High | High | High |
| 59 | Y | 2 | 2 | Stable | 1990s | 2 m2; 138 | Medium | High | High | Medium |
| 60 | Y | 4 | 1 | Stable | 2004 | ~30 m2; ~5000 (2006) | High | Low | High | Medium |
| 61 | Y | 5 | 1 | Stable | 2000 | 9 m2 | High | Medium | High | Medium-high |
| 63 | N | 1 | 2 | n/a | 2007 | 10.7 m2 | High | High | High | High |
| 64 | Y | 3 | 2 | Stable | 2006 | 3.25 m2; 610 | Medium | High | High | Medium |
| 65 | Y | 5 | 1 | Stable | 2006 | ~30 m2; ~1760 in 2006 but not counted since | High | Medium | High | Medium-high |
| 66 | Y | 2 | 2 | Stable | 2007 | 2-3 m2: ~500 | Medium | High | High | Medium |
| 69 | Y | 2 | 2 | Stable | 2007 | 12.5 m2; >1800 | High | Medium | Medium | Medium |
| 70 | Y | 2 | 2 | Increase | 2007 | >60 m2; >5000 | High | Medium | High | Medium-high |
| 71 | Y | 2 | 2 | Stable | 2007 | 5 m2; 300 | Medium | Medium | High | Medium |
| 74 | Y | 2 | 3 | Stable | 1992 | 500 m2; >8400 | High | High | High | High |
| 76 | N | 1 | 2 | n/a | 2007 | 1.5 m2; 100s | Medium | High | High | Medium |
| 78 | Y | 2 | 2 | Stable | 1979 | 2-3 m2; ~300 | Medium | High | Low | Medium |
| 79 | Y | 2 | 2 | Stable | 2000 | 3.25 m2; ~300 | Medium | Medium | High | Medium |
| 81 | Y | 2 | 3 | Stable | 2010 | ~2500 | High | Medium | High | Medium-high |
| 82 | Y | 2 | 2 | Stable | 2010 | 2 m2; ~200 | Medium | High | High | Medium |
| 83 | N | n/a | 3* | n/a | 2012 | 10 clumps in 2 rockhouses | Low | High | High | Medium |

| EO Number | Recovery Criteria (Y/N) | # Times Monitored Prior to PDM | Tier | Trend | First Observed | Abundance Data | Abundance Rank | Substrate Condition Rank | Forest Condition Rank | Overall Resiliency Rank |
|-----------|-------------------------|--------------------------------|------|-------|----------------|-----------------------------|----------------|--------------------------|-----------------------|-------------------------|
| 84 | N | 1 | 3* | n/a | 2012 | ~3.5 m2; several hundred | Medium | High | High | Medium |
| 85 | N | 1 | 3* | n/a | 2015 | >9 m2; >1300 | High | High | High | High |
| 86 | N | n/a | 3* | n/a | 2015 | ~1 m2 | Medium | High | High | Medium |
| 87 | N | 2 | 2* | n/a | 2014 | 10 m2; 645 | Medium | Low | Low | Low |

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