

Interim Core Map Documentation for the South Llano Springs moss

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Draft Interim Core Map Developer: Compliance Services International (CSI)

Species Summary

The South Llano Springs moss (*Donrichardsia macroneuron*; Entity ID 11016) is an endangered aquatic moss found in south-central Texas. The U.S. Fish and Wildlife Service (FWS) has not assigned designated critical habitat for the South Llano Springs moss. This species inhabits limestone banks along the South Llano River. Additional habitat information is provided in **Appendix 1**.

EPA Review Note

The developers created this core map using the U.S. Environmental Protection Agency's (EPA) process available at: <https://www.epa.gov/endangered-species/process-epa-uses-develop-core-maps-pesticide-use-limitation-areas>. EPA reviewed the draft interim map and documentation and evaluated if: (1) the map and documentation are consistent with the agency's process; (2) areas included or excluded from the interim core map are consistent with the biology, habitat, and/or recovery needs of the species; (3) data sources are documented and appropriate; and (4) the GIS data and mapping process are consistent with the stated intention of the developer. EPA agrees that this map is a reasonable depiction of core areas for this species and was consistent with the agency's mapping process. This documentation was not prepared by EPA, but EPA may have edited this documentation for clarity or other purposes.

The core map developed for this species is considered interim and can be used to develop pesticide use limitation areas (PULAs). This core map incorporates information developed by FWS and made available to the public; however, the core map has not been formally reviewed by FWS. This interim core map may be revised in the future to incorporate expert feedback from FWS.

This core map does not replace or revise any range or designated critical habitat developed by FWS.

Description of Core Map

The core map for the South Llano Springs moss is a biological information core map based on known observation information as documented by the latest Species Status Assessment for the species (FWS 2023). The core map comprises the portion of the South Llano River adjacent to the only known extant population, buffered by 50 meters (m) to capture the riverbanks inhabited by the species. The core map spans 190 acres (**Figure 1**). A summary of acreage by National Landcover Database (NLCD) land use type is provided in **Table**

1.

Based on EPA’s “best professional judgment classification” system, CSI has graded this core map as “limited” (2) because the extant population was easily identified and a core map shape created that is both protective and narrow in extent. More information about this classification system and its definitions can be found in the core map process document (EPA 2024).



Figure 1. Interim core map for the South Llano Springs moss.

NLCD_Land_Cover_Class	Acres
Shrub/Scrub	125
Open Water	39
Evergreen Forest	9
Deciduous Forest	5
Woody Wetlands	4
Developed, Open Space	3
Developed, Low Intensity	2
Developed, Medium Intensity	1
Herbaceous	-
Emergent Herbaceous Wetlands	-

Table 1. Acres by National Land Cover Database (NLCD) class within the core map of the South Llano Springs moss. Total core map area (based on NLCD pixel count): 188 acres¹.

¹ This acreage is slightly different from the core map acreage (190) due to the pixelation of NLCD land cover. The core map is not developed from raster data.

Evaluation of Known Location Information

There were four evaluated datasets with known location information:

- Descriptions of locations provided by FWS;
- Occurrence locations in iNaturalist;
- Occurrence locations in Global Biodiversity Information Facility (GBIF); and
- Occurrence locations in NatureServe.

Compliance Services International evaluated these four datasets before developing the core map. Overall, there were no research-grade observations found in iNaturalist². The GBIF dataset comprised seven georeferenced observations, none of which were usable. Neither dataset was used for either core map development or validation of other datasets used.

FWS location information includes extant population information that identifies two areas of relevant occupancy historically, but only one is still considered extant. This information was used to develop the core map.

NatureServe public element occurrence (EO) data were also evaluated. These data comprised a single fuzzed location (hexagon) with a 343 mi² area. This extent was considered for core map development but ultimately ruled out in favor of more precise site identification.

Approach Used to Create Core Map

The core map was developed using EPA's process for developing core maps for species listed by the FWS and their designated critical habitat² (referred to as "the process"). This core map was developed by CSI using the four steps described in the process document:

1. Compile available information for a species;
2. Identify core map type from among the following defined types: designated critical habitat, range, and biological information. From EPA, summaries of each core map type are provided below (EPA 2024).
3. Develop the core map for the species; and
4. Document the core map.

For step 1, CSI compiled available information for the South Llano Springs moss from FWS, as well as observation information available from various publicly available sources including iNaturalist, GBIF, and NatureServe. The information compiled for the South Llano Springs moss is included in **Appendix 1**. Influential information that impacted the development of the core map includes a description of the

² According to iNaturalist, an observation is designated as "research grade" if it 1) is verifiable with date, coordinates, photos/sounds, and not captive; 2) achieves community agreement defined as "more than 2/3 of identifiers needs to agree on the species level ID or lower;" and 3) "must pass a data quality assessment, which includes checks for accurate date and location, evidence of a wild organism, and clear evidence of the organism itself" (<https://help.inaturalist.org/en/support/solutions/articles/151000169936-what-is-the-data-quality-assessment-and-how-do-observations-qualify-to-become-research-grade->).

locations described by the U.S. Forest Service (USFS) as well as a description of species habitat from the FWS Species Status Assessment:

- “*D. macroneuron* has an extremely endemic range: it has only been documented from Seven Hundred Springs (**Figure 3**), on the South Llano River in Edwards County, Texas, and from one additional site about 5 kilometers (km) (3.1 mi) downstream in Kimble County, Texas, both within the Edwards Plateau” (FWS 2023).

For step 2, CSI used the compiled information including known location information, and habitat descriptions to determine the core map type. The known location information from FWS were found to be much more appropriate for core map development than data from larger databases (iNaturalist and GBIF). Although the South Llano Springs moss would not be expected to be found on agricultural land (i.e., it is an “off-field” species), there is no agriculture in the area; therefore, no refinement was necessary to exclude cultivated land. When weighing this information together, CSI selected a known location core map type. A combination of known locations and habitat descriptions (for validation) were used to derive this core map.

For step 3, CSI used the best-available data sources to generate the core map. Data sources are discussed in EPA’s core map process document. For this interim core map, CSI followed EPA’s decision framework to arrive at a core map type of known location information. Both designated critical habitat and species range were quickly eliminated as core map types because the South Llano Springs moss does not have critical habitat or a spatially delineated range. **Appendix 2** provides more details on the GIS analysis and data used to generate the core map.

Discussion of Approaches and Data that were Considered but Not Included in Core Map

Other Known Observation Datasets

Datasets such as iNaturalist, GBIF, and NatureServe were considered but not used. NatureServe public EOs are viewable in their mapper as hexagons corresponding to locations where the species may have been observed. The lone EO for the South Llano Springs moss was much greater in extent than the core map shape that was developed from FWS location information while the GBIF and iNaturalist observations were not seriously considered for use in developing this core map, due to low confidence/precision of the data for this species.

Appendix 1. Information compiled for the South Llano Springs moss

1. Recent FWS documents

- Species Status Assessment (2023): <https://iris.fws.gov/APPS/ServCat/DownloadFile/227754>.
- ECOS Profile Page (2025): <https://ecos.fws.gov/ecp/species/10113>.

2. Background information

- Status: Federally listed as endangered in 2023.
- Resiliency, redundancy, and representation (the 3Rs) (USFWS 2023)
 - Resiliency: “As recently as 1979, *D. macroneuron* was abundant within an area of about 10 by 100 m (33 by 328 ft) at Seven Hundred Springs (Wyatt and Stoneburner 1980, p. 516). Any population limited to such a finite area is inherently vulnerable to stochastic demographic and environmental variation and to catastrophic events, such as flash floods or sedimentation. Furthermore, since only male individuals have been observed, the entire population may consist of clones of a single individual (an effective population size of 1). Thus, the population size is very small and is vulnerable to stochastic demographic variation.”
 - Redundancy: “Based on the best available data, our interpretation is that the Seven Hundred Springs population is extant and the Redfearn population is extirpated. Wyatt and Stoneburner (1980) did not observe *D. macroneuron* at 10 other springs in the upper Llano River watershed. Consequently, this species has no redundancy.”
 - Representation: “Since only one population of *D. macroneuron* is extant, its sexual reproduction has not been observed, and only male individuals are known, the remaining population may have little or no genetic diversity.”
- Habitat, Life History, and Ecology (USFWS 2023)
 - Habitat: “*D. macroneuron* requires continual immersion in spring water with a high mineral content. Spring water discharge is dependent on the supply of water from the Edwards-Trinity Aquifer.”
 - “*D. macroneuron* has an extremely endemic range: it has only been documented from Seven Hundred Springs (Figure 3), on the South Llano River in Edwards County, Texas, and from one additional site about 5 kilometers (km) (3.1 mi) downstream in Kimble County, Texas, both within the Edwards Plateau; we refer to the downstream location as the Redfearn site.”
 - “Mosses closely related to *D. macroneuron* reproduce both sexually and asexually. However, there is no evidence that sexual reproduction is occurring in the single remaining known site of occurrence as no plants with reproductive structures have been observed. Plants cultivated in captivity produced only male sexual structures.”
- Taxonomy
 - Wetland plant – “Eula Whitehouse, a Texas bryologist, first collected *D. macroneuron* in 1932. Grout (1933, pp. 1–2) described this moss as a new species in the family Amblystegiaceae. *D. macroneuron* resembles *Hygroamblystegium noterophilum*, another relatively large aquatic moss with broad costa, but its linear-flexuose upper median leaf cells, short apical cells, and serrulate leaf margins distinguish it from the latter species (Crum 1969, p. 243). The morphology of sporophytes provides important clues for the taxonomic classification of mosses. Since neither archegonia nor

sporophytes of this moss have been observed (see Figure 1 and Appendix A), its classification remained uncertain, and has been revised several times” (FWS 2023).

- Relevant Recovery Criteria and Actions
 - The species does not have a Recovery Plan.

3. Description of Species Range (FWS 2023)

- The entire known geographic range of *D. macroneuron* is limited to two sites, Seven Hundred Springs and Redfearn, located about 5 km (3.1 mi) apart, on the South Llano River, in Edwards and Kimble counties, Texas).
- Currently, based on the best available science, Seven Hundred Springs is the only remaining population, as the Redfearn Site is thought to be extirpated.
- There is no spatially delineated range for the South Llano Springs moss.

4. Critical Habitat

The South Llano Springs moss does not have designated critical habitat. Critical habitat was proposed for the species, but FWS declined to designate it, citing the benefits of failing to do so outweighing the benefits of inclusion.

5. Known Locations

- FWS Species Status Assessment (2023)
 - “*D. macroneuron* has only been documented at two sites in close proximity along the South Llano River in Edwards and Kimble counties, Texas. The most recent documentation of an extant population of *D. macroneuron* was in 1979 at Seven Hundred Springs in Kimble County immediately adjacent to the South Llano River. We have been unable to acquire permission to access this site on private land to determine with certainty the species’ current status there. The other known site, hereafter referred to as the “Redfearn Site”, was surveyed in 2017, but the species was not observed. We have concluded that the Redfearn population has likely been extirpated. Given that the species has been reduced to a single site that was last documented in 1979, we are uncertain whether the species is still extant. However, we base our assumption that *D. macroneuron* is extant on the 1979 report, since this is the best available scientific and commercial data.”

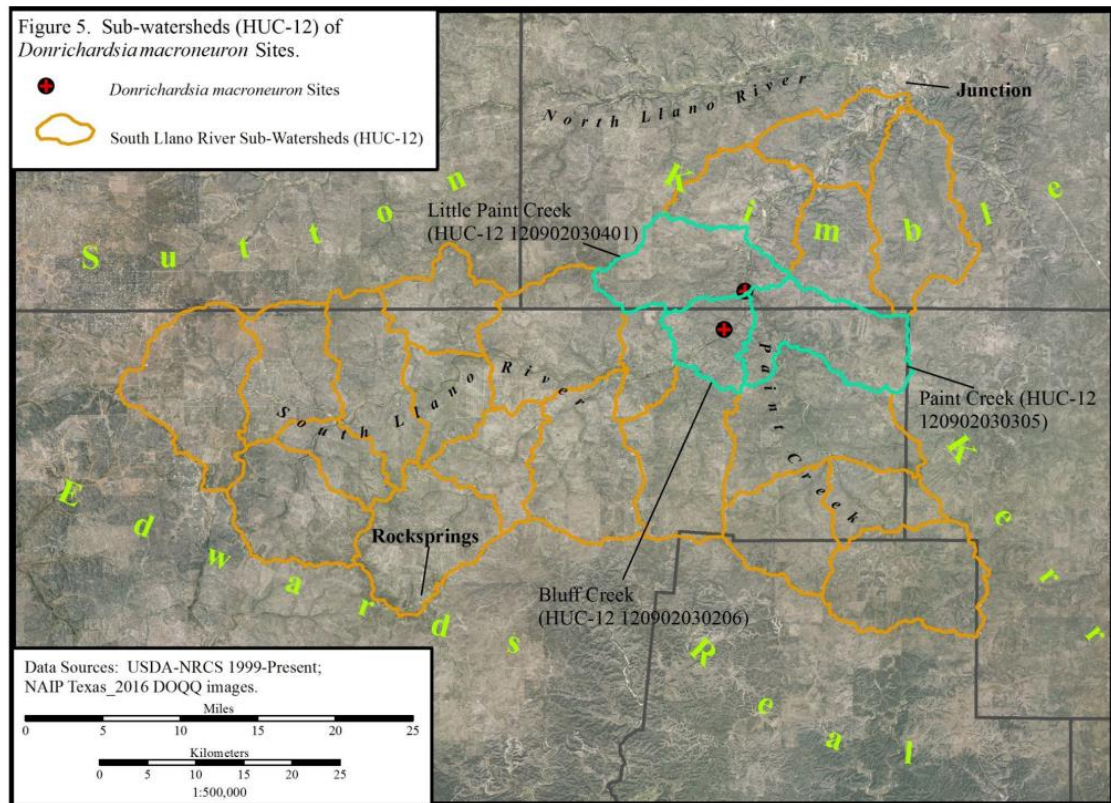


Figure 2. Sub-watersheds (HUC-12) of *Donrichardsia macroneuron* Sites. Copied from Figure 5 of the Species Status Assessment (FWS 2023).

- iNaturalist: https://www.inaturalist.org/observations?taxon_id=161983
 - One verifiable observation, which was not research-grade.
- GBIF: <https://www.gbif.org/species/2681589>
 - GBIF includes 59 occurrence records; seven of these are georeferenced, but none of these are the result of human observation (as opposed to preserved specimen).
- NatureServe Explorer: <https://explorer.natureserve.org/>
 - Available public EO information from NatureServe Explorer is generally consistent with the other sources given the precision of the data.

Appendix 2. GIS Data Review and Method to Develop Core Map

The core map for this species is based on known location information, which comprises a single site in south-central Texas. The site was located by georeferencing a map from the most recent Species Status Assessment (FWS 2023). Once the site was established, the core map was developed by identifying the corresponding water body from the National Wetlands Inventory (NWI) dataset and then buffering by 50 m to account for the limestone banks the species inhabits along the river. Although the species is considered to be “off-field,” the core map extent does not include agricultural area; therefore, the removal of cultivated areas > 25 acres was not necessary.

1. References and Software

- National Hydrography Dataset (NHD Plus v. 2): <https://www.usgs.gov/national-hydrography/access-national-hydrography-products>.
- National Wetlands Inventory: <https://www.fws.gov/program/national-wetlands-inventory>.
- Software used: ArcGIS Pro version 3.2.
- Species Status Assessment: <https://iris.fws.gov/APPS/ServCat/DownloadFile/227754>.

2. Datasets Used in Core Map Development

2.1. National Hydrography Dataset

The National Hydrography Dataset v. 2 was used for its HUC-12 boundary layer. An image from FWS (**Figure 2**) was georeferenced using HUC-12 boundaries to identify the extant site occupying HUC-12 #120902030206.

2.2. National Wetlands Inventory

Once the South Llano Springs moss extant population site was identified, the NWI dataset used to isolate spatial data—a polygon—for the South Llano River along which the species resides. This polygon was exported and buffered to a conservative distance, 50 m, to capture the limestone river banks the species is known to occupy.

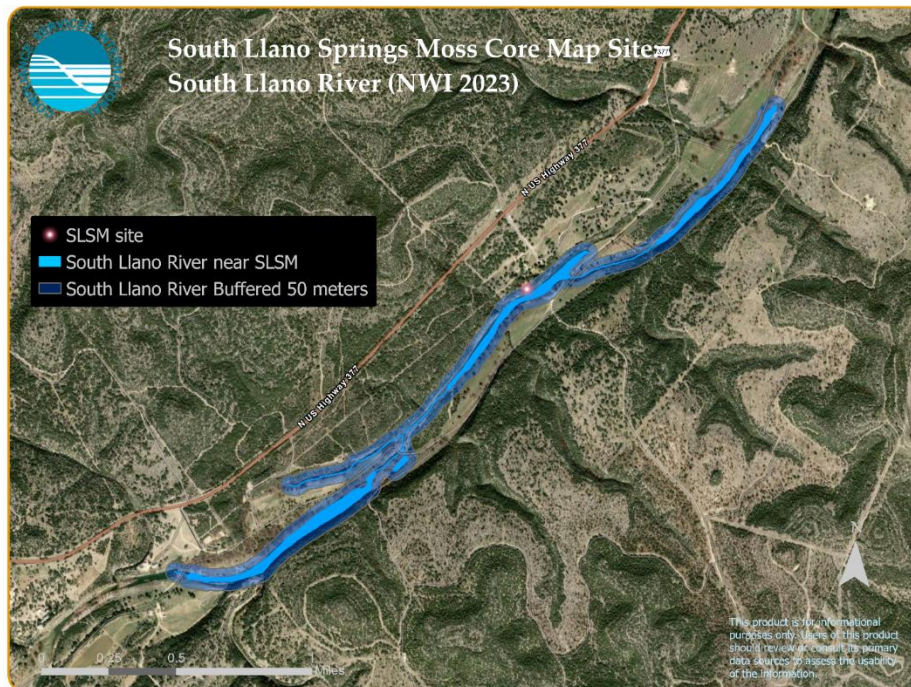


Figure 3. South Llano Springs Moss Core Map Site: South Llano River (NWI 2023).

3. Creating the Core Map

The South Llano Springs moss core map is developed from known observation data. The core map for the species was developed as follows:

1. Add the NHD Plus v. 2 HUC-12 boundaries into ArcGIS Pro. Use the Select by Attributes tool to select HUC-12 #120902030206. Zoom to selected feature and adjust the window to approximate the extent shown in **Figure 2**.
2. Add the saved image of **Figure 2** to the map. Use the Raster to Geodatabase tool to export this image to the working geodatabase, saved with a new file name "SLSM_site_png". Render the image 60% transparent to facilitate the georeferencing step that follows.
3. In a Georeference session, add control points to the image using HUC-12 intersections as guides. Verify that HUC-12 boundaries in the image and spatial data are aligned.
4. Create a new empty points layer, "SLSM_pts".
5. In an Edit session, create new features (points) for the newly created SLSM_pts layer by zooming to the identified sites in the georeferenced image and clicking on their centers. Save edits and exit Edit session.
6. Load the NWI layer for Texas. Use the Select tool to select the water body adjacent to the more southern point created in the preceding step; this is the extant population. Export the selected feature to a new layer, "SLSM_South_Llano_River".
7. Use the Pairwise Buffer tool to buffer the previous layer ("SLSM_South_Llano_River") by 50 m and save as a new feature class ("SLSM_South_Llano_River_pb50m").
8. (Optional) Export previous layer as a new layer identifiable as the species core map

("SLSM_CoreMap").

References

Documents

- U.S. Environmental Protection Agency. 2024. Process EPA Uses to Develop Core Maps for Pesticide Use Limitation Areas. Accessed May 9, 2025. <https://www.epa.gov/endangered-species/process-epa-uses-develop-core-maps-pesticide-use-limitation-areas>.
- U.S. Fish and Wildlife Service. 2023. Species Status Assessment Report for *South Llano Springs moss* (*Donrichardsia macroneuron* (Grout)). Accessed May 9, 2025. <https://iris.fws.gov/APPS/ServCat/DownloadFile/227754>.
- U.S. Fish and Wildlife Service. 2025. *South Llano Springs moss* (*Donrichardsia macroneuron*). Accessed May 9, 2025. <https://ecos.fws.gov/ecp/species/10113>.

Spatial Data & Software

- GBIF Secretariat. "*Donrichardsia macroneuron*." *GBIF Backbone Taxonomy*. Accessed May 9, 2025. <https://www.gbif.org/species/2681589>.
- NatureServe. 2025. NatureServe Network Biodiversity Location Data accessed through NatureServe Explorer [web application]. NatureServe, Arlington, Virginia. Available <https://explorer.natureserve.org/>. Accessed May 9, 2025.
- U.S. Fish and Wildlife Service. *National Wetlands Inventory*. 2023. Accessed April 25, 2025. <https://www.fws.gov/program/national-wetlands-inventory>.
- U.S. Geological Survey. 2023. National Hydrography Dataset (High Resolution). Accessed May 6, 2025. <https://www.usgs.gov/national-hydrography/access-national-hydrography-products>.
- iNaturalist. "*Donrichardsia macroneuron*". Accessed May 9, 2025. https://www.inaturalist.org/observations?taxon_id=161983.
- Software used: ArcGIS Pro version 3.2.