Interim Core Map Documentation for Cooley's Meadowrue

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

Species Summary

The Cooley's meadowrue (*Thalictrum cooleyi*; Entity ID 852) is an endangered plant (dicot). The U.S. Fish and Wildlife Service (FWS) has not designated critical habitat for the Cooley's meadowrue. This species is typically found in wet pine savannas, grass-sedge bogs, and savanna-like areas with circumneutral soils. Additional information is provided in **Appendix 1**.

EPA Review Notes

The developers created this core map using 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. This documentation may include views that are not necessarily the view of EPA or its staff.

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 Cooley's meadowrue is based on biological information, which was used to refine an extent determined by known location information for the species (**Figure 1**). The extent of the core map is represented by occurrence data from NatureServe in North Carolina, occurrence data from the Georgia Department of Natural Resources (GDNR) in Georgia, and a conservation easement containing the only known population of the species in Florida. Other available known location information from the Global Biodiversity Information Facility (GBIF) database confirms that no other known locations are absent from the extent. Identification of core map areas based on biological information (habitat) was treated differently in Georgia and Florida versus how it was selected in North Carolina.

In Georgia and Florida, the core map identifies areas within an extent created as part of this analysis (and described in detail in **Appendices 1 and 2**) with land cover/habitat classes from the LANDFIRE Existing

Vegetation Type (EVT) that match habitat descriptions for the Cooley's meadowrue. Land cover categories within the core map extent were identified based on matches of these key words, from a subset of LANDFIRE classes occurring within the range of the species: "Pine," "Savannah," "Bog," and "Swamp forest." This resulted in the EVT classes listed in Table 1:

LANDFIRE: EVT_NAME
East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland
East Gulf Coastal Plain Near-Coast Pine Flatwoods
East Gulf Coastal Plain Near-Coast Pine Wet Flatwoods
East Gulf Coastal Plain Southern Loblolly Flatwoods
East Gulf Coastal Plain Wet Prairie
East Gulf Coastal Plain Wet Savanna
Florida Longleaf Pine Sandhill

Table 1. LANDFIRE EVT classes comprising the core map of the Cooley's meadowrue for range in Georgia and Florida.

In North Carolina, a state-level program from the North Carolina Department of Transportation (NCDOT) named ATLAS was found to have developed a high-quality habitat suitability model for the Cooley's meadowrue. Their continuous model (a raster with assigned habitat probability for the species) was converted by NCDOT into a categorical model of high, moderate, and low probability of habitat suitability; moderate and low probability areas were excluded from the core map.

The core map developed in this document for the Cooley's meadowrue spans 58,529 acres. A summary of acreage by National Landcover Database (NLCD) land use type is provided in **Table 2**.

Based on EPA's "best professional judgment classification" system, CSI has graded this core map as "average" because it comprises land cover areas from geospatial datasets matched to habitat descriptions of the species. More information about this classification system and its definitions can be found in the core map process document (EPA 2024).

When FWS reviews this interim core map, it may be possible to improve the confidence in this core map by revising population location information this analysis and may be further refined by including any other known areas that are observed from reliable and precise observational datasets. Additional considerations for refinement may include application a different land cover filter to remove areas and habitats that are inconsistent with the FWS habitat descriptions for this species.

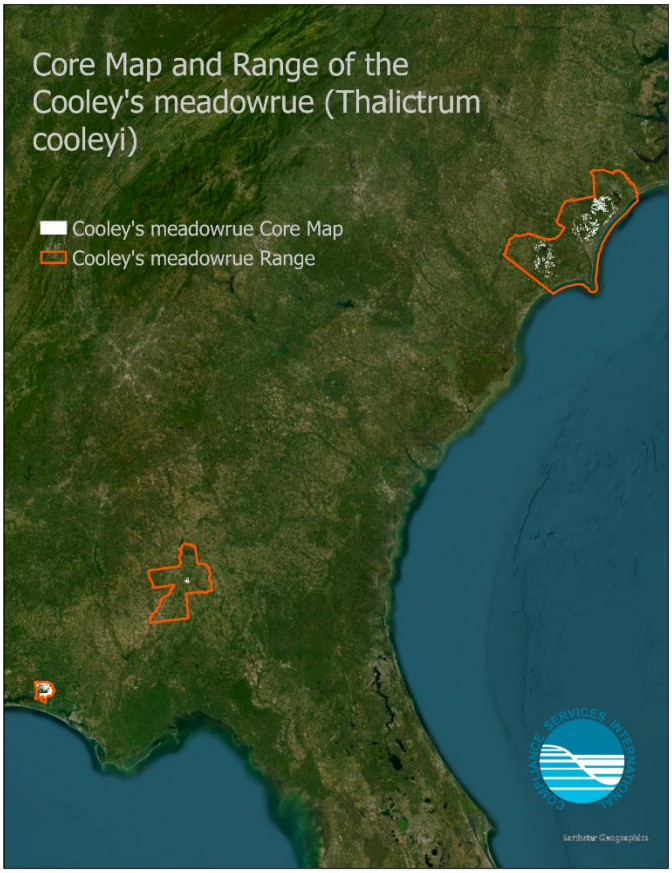

Figure 1. Interim core map for the Cooley's meadowrue.

NLCD_Land_Cover_Class	Acres
Evergreen Forest	22,613
Woody Wetlands	22,097
Shrub/Scrub	4,019
Herbaceous	2,248
Developed, Open Space	1,998
Cultivated Crops	1,840
Emergent Herbaceous Wetlands	1,020
Developed, Low Intensity	650
Mixed Forest	620
Hay/Pasture	200
Developed, Medium Intensity	75
Barren Land	63
Deciduous Forest	61
Open Water	23
Developed, High Intensity	6

Table 2. Acres by National Land cover Database (NLCD) class within the core map of the Cooley's meadowrue. Total core map area (based on NLCD pixel count): 58,333 acres[1].

[1] This acreage is slightly different from the core map acreage (58,529) due to the pixelation of NLCD land cover. The core map is not developed exclusively 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 (CSI) evaluated these four datasets before developing the core map. Overall, there were 37 research-grade observations found in iNaturalist.[2] These locations were generally consistent with the locations available through GBIF, NatureServe, and FWS.

Approach Used to Create Core Map

The core map was developed using the process EPA uses to develop core maps for draft Pesticide Use Limitation Areas for species listed by the FWS and their designated critical habitats[2] (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. Document the core map.

For step 1, CSI compiled available information for the Cooley's meadowrue from FWS, as well as observation information available from various publicly available sources including iNaturalist, GBIF, NatureServe, GDNR, and the Nokuse Plantation (Nokuse Plantation n.d.). The information compiled for the Cooley's meadowrue is included in **Appendix 1**. Influential information that impacted the development of the core map includes a description of the species habitat from the FWS Recovery Plan:

- "This rare herb is typically found in wet pine savannas, grass-sedge bogs, and savanna-like areas with circumneutral soils" (FWS 1994).

For step 2, CSI used the compiled information including the species range, known locations, and habitat location information to determine the core map type. CSI compared the known location data to the range and found that known locations were consistent with the range and fully contained within it and usable as an extent for the core map development process[3]. Review of the available data also suggested that the species is likely located in smaller areas within the extent (based on known observations) because the species has specific habitat requirements that are not located everywhere within this extent. When

[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-).

[3] One NatureServe public element occurrence is partially outside of the range and was not clipped to the range.

weighing that information together, for the Cooley's meadowrue CSI selected the biological information core map type, limited to an extent more refined than its range. CSI used a combination of range, known observation/occurrence location data, and habitat information 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 the 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 biological information. Designated critical habitat was quickly eliminated as a core map type because the Cooley's meadowrue does not have critical habitat. The range core map type was not used because the species range is not refined and encompasses a large contiguous area. However, CSI judged that there was known occurrence/location data that would better represent the current distribution of extant populations of the species and used these data to refine the extent of the core map to an area smaller than the species range. That extent was established using state-level datasets for two states (Georgia and Florida) and the species range in North Carolina. The LANDFIRE Existing Vegetation Type layer was queried for classes relevant to the Cooley's meadowrue in Georgia and Florida, while a species/state-specific layer for habitat was developed by the NCDOT and used for core map development for North Carolina. **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

Soil Survey Geographic Database (SSURGO)

The USGS Soil Survey Geographic Database (SSURGO) database could have been used to find areas with circumneutral soils, but the species habitat was better-defined by land cover descriptions that could be matched to habitat type. The SSURGO database could be used as a further refinement of the core map layer. The NCDOT layer references "Geology and Soils" as a thematic group contributing to its 70 considered environmental data layers; it was assumed that the species-specific model included soil type in the development of the model underlying the Cooley's meadowrue potential habitat.

SSURGO contributes to LANDFIRE's Existing Vegetation Type (EVT) classifications, but indirectly. It provides detailed soil characteristics, which influence vegetation patterns and ecosystem dynamics. While LANDFIRE EVT is primarily derived from remote sensing, field plot data, and ecological models, SSURGO data can be incorporated into predictive models to refine vegetation mapping, especially in areas where soil properties strongly determine vegetation types (e.g., wetlands, grasslands, and forested ecosystems). Additionally, SSURGO-derived variables like soil texture, drainage, and organic matter can support LANDFIRE's Biophysical Settings (BpS) and Environmental Site Potential (ESP) layers, which, in turn, inform EVT classifications. However, SSURGO is not a direct input to EVT mapping in LANDFIRE's core methodology.

LANDFIRE

In North Carolina, the LANDFIRE Landscape Fire and Resource Management Planning Tools was considered as an alternative dataset as a refinement of the core map area from its extent. Ultimately, it was not used in favor of the state- and species-specific habitat suitability model of the Cooley's meadowrue developed by the NCDOT for areas in North Carolina, as the LANDFIRE dataset is most suitable for national and/or cross-regional analysis and when equivalent and more accurate state- or region-level data are not available.

Appendix 1. Information compiled for Cooley's Meadowrue

1. **Recent U.S. Fish and Wildlife Service (USFWS) documents**
   - 5 Year Review (2020) https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/2957.pdf
   - Recovery Plan (1994) https://ecos.fws.gov/docs/recovery_plan/940421.pdf
   - Listing Document (1989) https://www.govinfo.gov/content/pkg/FR-1989-02-07/pdf/FR-1989-02-07.pdf#page=23

2. **Background information**

- Status: Federally listed as threatened in 1989.
- Resiliency, redundancy, and representation (the 3Rs)
  - The 3 Rs were not specifically described in the species recovery plan or most recent 5-year review for this species and there is no species status assessment.

- Habitat, Life History, and Ecology
  - Habitat: "This rare herb is typically found in wet pine savannas, grass-sedge bogs, and savannalike areas with circumneutral soils." (Recovery Plan, 1994).
  - Habitat requires fire or other disturbance (Recovery Plan, 1994).
  - Pollinators: "displays characteristics of wind pollination (smooth pollen, elaborate stigma. reduced perianth. terminal inflorescence in an open habitat) with some suggestion of insect pollination (conspicuous stamens with somewhat expanded filaments)" (Recovery Plan, 1994).

- Taxonomy
  - Wetland plant – *Thalictrum cooleyi* differs from other similar species in the *Leucocoma* section of this genus in having lavender rather than white filaments (although this character is not always consistent even within the same population), in having much narrower leaflets that are narrowly lanceolate instead of oblong to ovate, and in having fewer leaf divisions (Listing Document, 1989)
- Relevant Potential Pesticide Use Sites
  - "*Thalictrum cooleyi* sites located within utility rights-of-way are threatened by herbicide use or mowing during critical growth periods" (5 Year Review, 2020)

- Relevant Recovery Criteria and Actions
    - 5-Year Review (2021) – Downlisting Criteria (downlisting will be considered when the following have been met)
        1. Management plans have been prepared and are being implemented for all publicly owned population centers and those owned by The Nature Conservancy, and [Status: partially complete].
        2. Populations at these centers have been monitored for at least five years and are determined to be stable. [Status: partially complete].
    - Recovery Criteria (5 Year Review, 2020) - *Thalictrum cooleyi* shall be considered for removal from the Federal list when the following criteria are met:
        1. It has been documented that at least 16 self-sustaining populations exist and that necessary management actions have been undertaken by the landowners or cooperative agencies to ensure their continued survival.
        2. All the above populations and their habitat are protected from present and foreseeable human-related and natural threats that may interfere with the survival of any of the populations.

3. Range

Historical Range

From the most recent 5-year review (FWS 2020): "When the recovery plan was written in 1994, *Thalictrum cooleyi* was known from 12 sites (these sites are now considered subpopulations) in the coastal plain of North Carolina and one population in the Florida panhandle. Since that time, additional occurrences have been found in North Carolina, and several sites of uncertain taxonomy (described above) have been found in Georgia. Our records currently indicate a total of nine extant populations including 24 extant subpopulations in NC. Of the 25 subpopulations once known from North Carolina, one is believed to be extinct and no *Thalictrum cooleyi* plants were observed at four other subpopulations during the last visit to those sites (by a competent botanist during the appropriate season); however, those four sites have not been labeled extirpated yet by the NCNHP. Two populations (consisting of seven subpopulations) are known in Georgia. The one population consisting of one subpopulation is still extant in Florida."

Current Range (**Figure 2**)

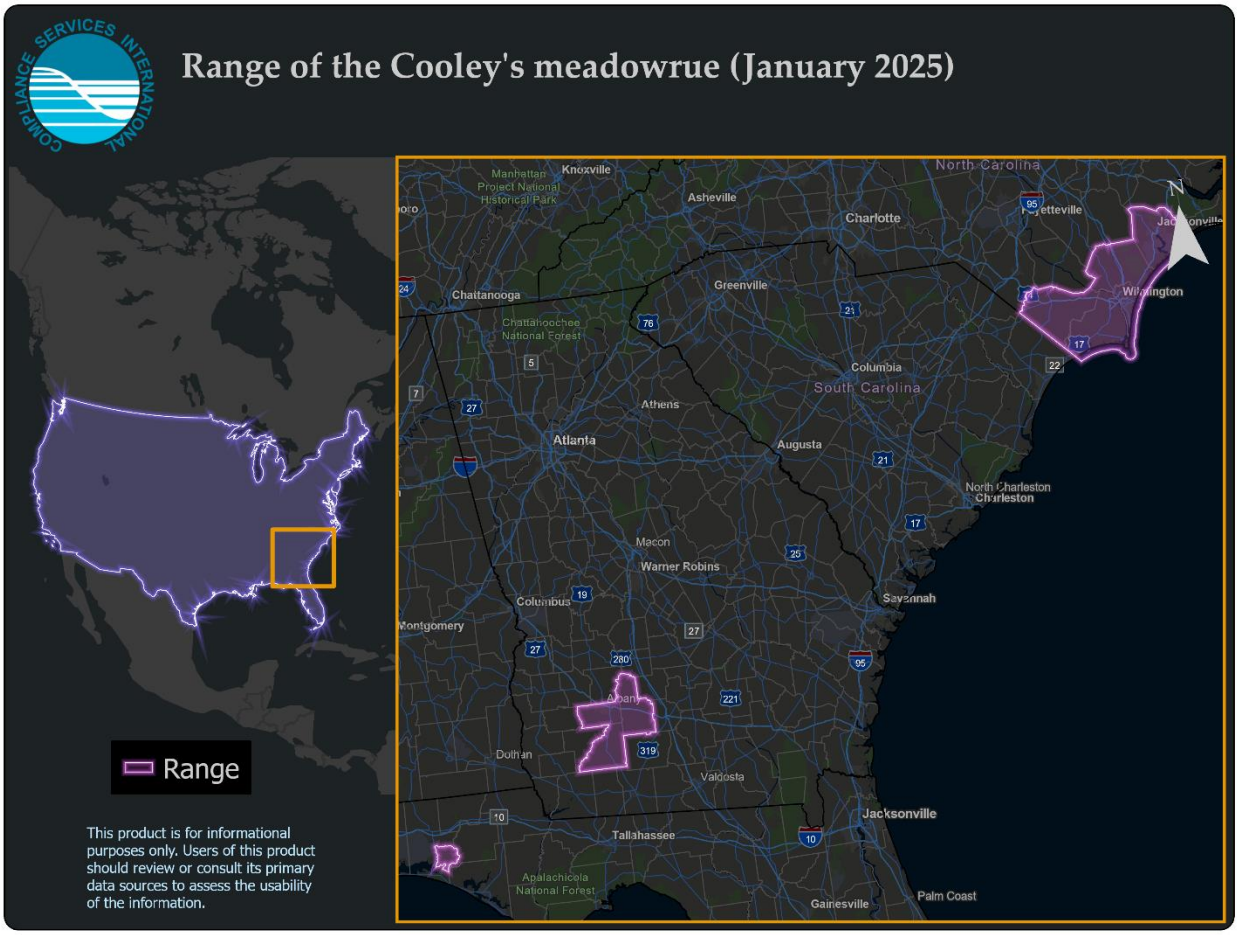

Figure 2. Current range of the Cooley's meadowrue (FWS 2025).

4. Description of Critical Habitat

This species does not have designated critical habitat.

5. Known Locations

"In summary, several new EOs have been found in NC, including one entirely new population and four EOs that expand the size of a known population. One new discovery is a county record for New Hanover County, NC; however, it is located within a few hundred feet of the boundary with Pender County, where this species has been known since listing. One new population was discovered in Worth County, GA. Currently, state natural heritage programs recognize 19 extant populations (10 in NC, 8 in GA and 1 in FL). Of these, 10 populations (6 in NC, 3 in GA and 1 in FL) have some level of protection, and are either owned and/or managed for conservation by state agencies or private conservation organizations" (5-Year Review, 2020).

Table 3 notes the number of populations and EOs at various times. The following is information for populations and/or EOs that are protected or partially protected.

- Florida: The one known population in Florida occurs on the Nokuse Plantation and is in a protected area (Protected by a Conservation Agreement).

- Georgia: One population is protected by The Nature Conservancy and Managed as the Dry Creek Swamp Preserve.
- North Carolina: "A total of five subpopulations comprising four populations are protected in North Carolina. In 2006, the N.C. Division of Parks and Recreation (NCDPR) was granted permission to create the Sandy Run Savannas State Natural Area and began acquiring land from The Nature Conservancy (TNC) and other local landowners soon thereafter. When complete, the Sandy Run Savannas State Natural Area will protect a variety of fire dependent plant communities including areas that are important for the recovery of *Thalictrum cooleyi*. Currently, the NCDPR protects the Neck Savanna, Watkins Savanna and the Sandy Run Savannas (including the Cooley's Meadowrue Powerline Site and the Pine Plantation Survey Site). One site, the Haws Run Mitigation Site, is owned by the N.C. Department of Transportation and is managed by the N.C. Ecosystem Enhancement Program (NCEEP). The Southwest Ridge Savanna site is owned by the State of North Carolina and managed by the Wildlife Resources Commission as Holly Shelter Game Land. Another site, Shaken Creek Savanna, is owned by TNC."

	NC	GA*	FL	Total
No. extant populations at listing (1989)	unknown	0	1	unknown
No. extant EOs/subpopulations at listing (1989)	12	0	1	13
No. extant populations in 2008	9	2	1	12
No. extant EOs/subpopulations in 2008	24	7	1	32
No. extant populations in 2019	10	8	1	19
No. extant EOs/subpopulations in 2019	28	8	1	37

Table 3. Number of extant populations and subpopulations (or Element Occurrences, EOs) of Thalictrum cooleyi *at the time of listing (February 7, 1989), in 2008 and 2019 (Florida Natural Areas Inventory 2019, GDNR 2019, NCNHP 2019). Reproduced from Table 1 of the FWS 5-Year Review (FWS 2020).*

The following figures (**Figure 3** and **Figure 4**) were taken from FWS documents that illustrate occurrence data described in those documents.

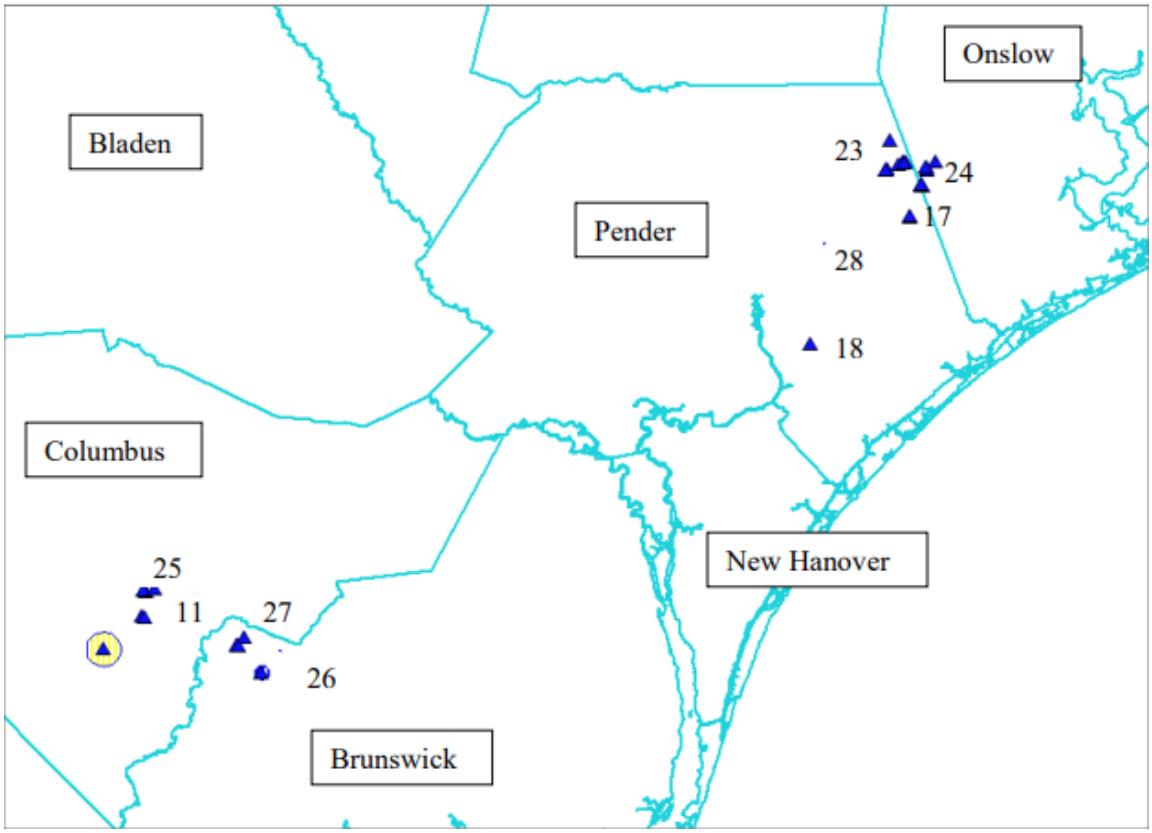

Figure 3. Thalictrum cooleyi *populations in North Carolina. Numbers indicate the Natural Heritage Program Element Occurrence (EO) Numbers Map provided by the N.C. Natural Heritage Program. Reproduced from Figure A1-1 in the 5-Year Review of the Cooley's meadowrue (FWS 2020).*

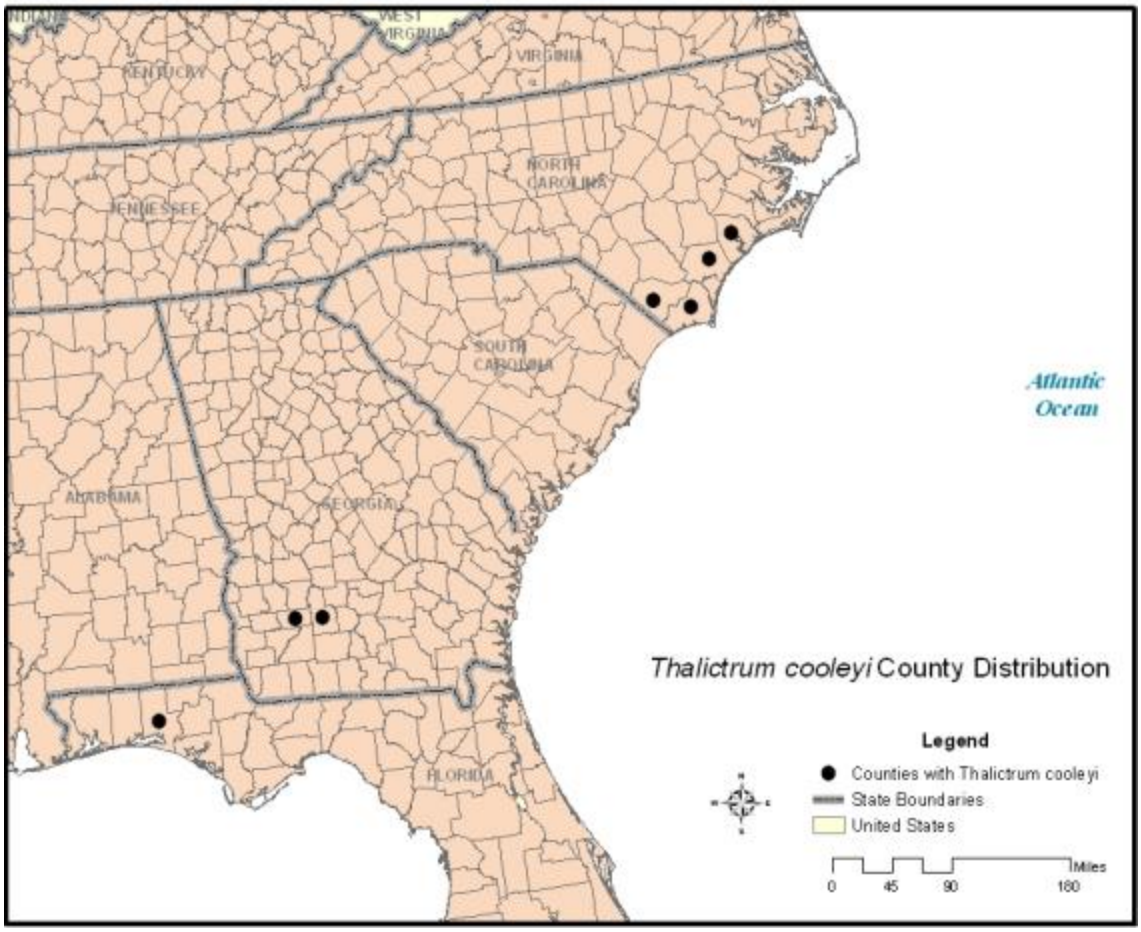

Figure 4. Distribution and state conservation status of Thalictrum cooleyi *(FWS 2008 map). Reproduced from Figure A1-2 in the 5-Year Review of the Cooley's meadowrue (FWS 2020).*

- iNaturalist: https://https://www.inaturalist.org/observations?verifiable=true&taxon_id=169655
  - 37 research grade observations with coordinates, all dated since June 2016 (**Figure 5**).
  - These locations align with the FWS documentation of known populations in North Carolina.
  - There are no occurrences for the Cooley's meadowrue outside of North Carolina, despite range in Georgia and Florida.

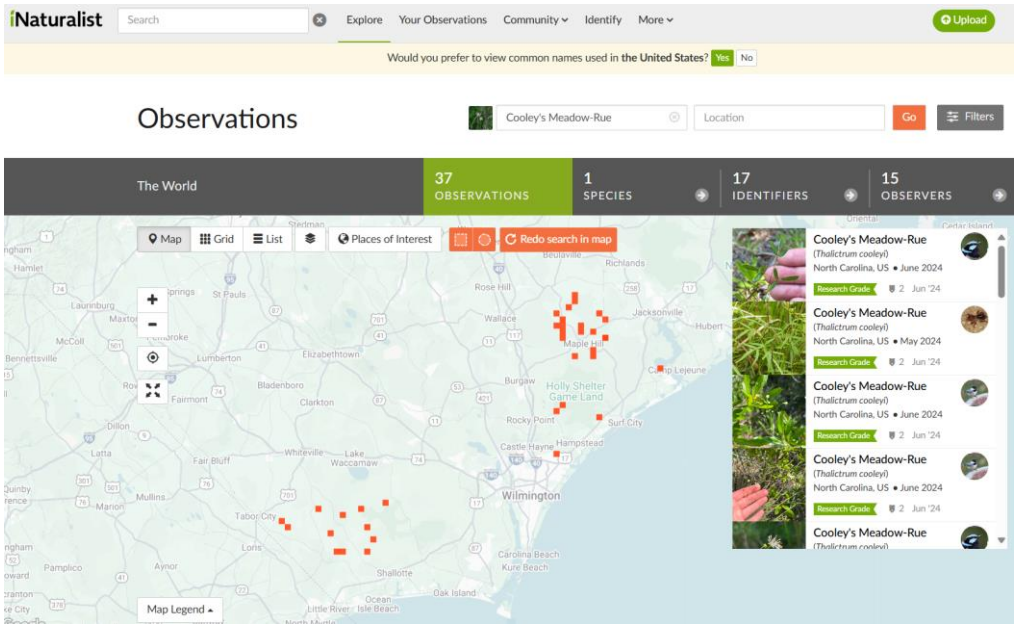

Figure 5. iNaturalist occurrences for the Cooley's meadowrue (iNaturalist 2025).

- GBIF: https://https://www.gbif.org/species/3033165
    - GBIF includes 128 records, 16 of which had usable coordinate data based on latitude/longitude precision (3+ decimal places) and relative recency (2010-present).

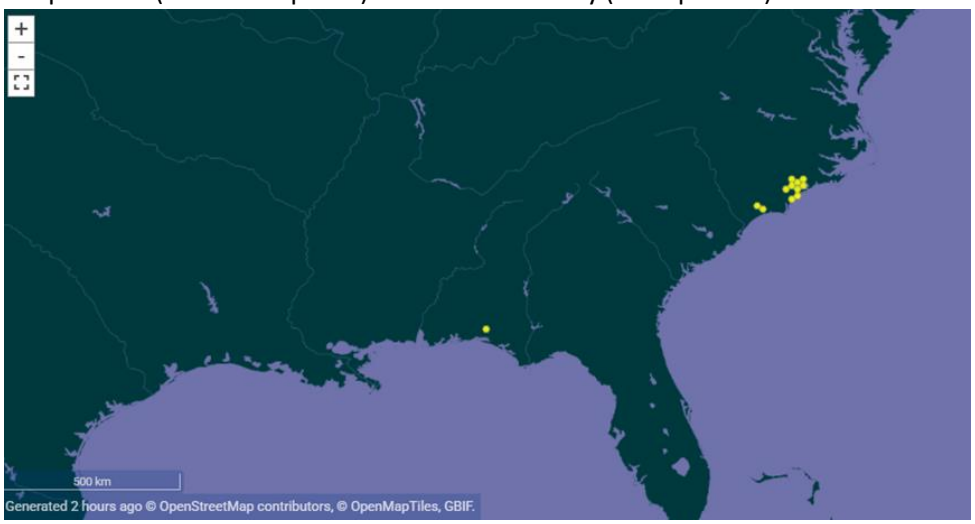

Figure 6. GBIF occurrences for the Cooley's meadowrue.

- NatureServe Explorer: https://explorer.natureserve.org/
    - Available public occurrence information from NatureServe Explorer aligns with the information from iNaturalist in North Carolina and additionally includes observations within the species range in other states (Georgia and Florida, **Figure 7**).

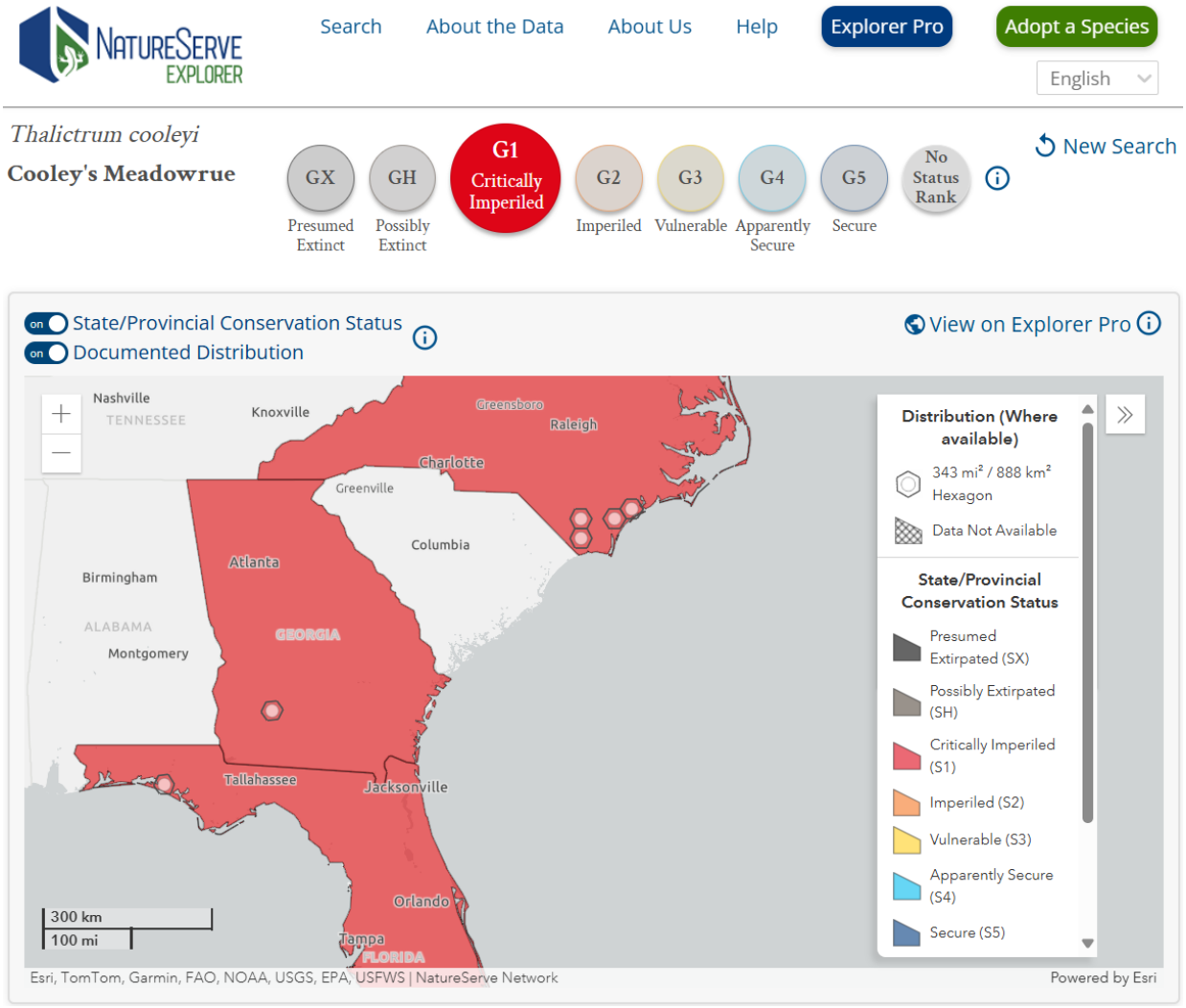

Figure 7. NatureServe Explorer occurrences for the Cooley's meadowrue (NatureServe 2025).

- CSI requested and received from NatureServe a feature layer that included 343 mi^2 hexagons viewable in the public version of the Explorer mapper (NatureServe, 2025b). NatureServe notes that "If ground-disturbing activities are proposed on a site, the appropriate NatureServe Network Program should be contacted for a site-specific review of the project area. For contact information, go to the NatureServe Network Directory at: https://www.natureserve.org/ns-network-directory."

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

The core map for this species is based on biological information, which includes the habitat used by this species found within an extent based on known observations. The core map identifies all areas within the extent (described below) matching its habitat description of "wet pine savannas, grass-sedge bogs, and savanna-like areas with circumneutral soils," using professional judgment to match classes in the LANDFIRE Existing Vegetation Type dataset (FWS 1994, LANDFIRE 2022). The LANDFIRE dataset is regarded as a high quality national-level dataset that is appropriate to identify habitat for plant species (LANDFIRE 2022).

1. **References and Software**
   - Georgia Department of Natural Resources. 2025. "Range Maps: Cooley's Meadowrue." *Georgia Biodiversity Portal*. Accessed March 1, 2025. https://georgiabiodiversity.org/portal/rangemaps?es_id=18704.
   - LANDFIRE. 2022. "Existing Vegetation Type (EVT)." U.S. Department of Agriculture and U.S. Department of the Interior. Accessed March 1, 2025. https://landfire.gov/data/FullExtentDownloads.
   - NatureServe Network Biodiversity Location Data accessed through NatureServe Explorer [web application]. NatureServe, Arlington, Virginia. Available https://explorer.natureserve.org/. (Accessed: March 2, 2025).
     - Data for Cooley's Meadowrue available at: https://explorer.natureserve.org/pro/Map?taxonUniqueId=ELEMENT_GLOBAL.2.137457.
   - Nokuse Plantation. n.d. "Maps." Accessed March 1, 2025: https://nokuse.org/maps/
   - North Carolina Department of Transportation. 2020. "Cooley's Meadowrue - Potential Habitat." ATLAS Project. Accessed March 1, 2025. https://xfer.services.ncdot.gov/gisdot/AtlasData/AtlasSpeciesModels/ATLASPlantMachineLearningModels/.
   - Software used: ArcGIS Pro version 3.2.
   - U.S. Fish and Wildlife Service. 2024. "Cooley's Meadowrue (Thalictrum cooleyi)." Environmental Conservation Online System (ECOS). Accessed March 1, 2025: https://www.fws.gov/species/cooleys-meadowrue-thalictrum-cooleyi.

2. **Datasets Used in Core Map Development**

   2.1. Range

The range for this species was last updated by FWS on April 15, 2002. A shapefile including species range for all listed species was downloaded from the FWS ECOS website on January 24, 2025. The shapefile was converted to a feature class stored in a file geodatabase and reprojected to WKID #4269 ("North America Albers Equal Area Conic").

1. Using an ArcGIS Web Map the species was queried based on the ECOS listed "Entity ID" of 852 and exported as a feature class to a temporary file geodatabase as a standalone Entity ID-specific layer.
2. The area of the range was calculated automatically by loading it into the software (ArcGIS Pro version 3.2) and reading its area from the attribute table ("Shape_Area"), then converting its units (square meters) into acres with a conversion rate of 0.000247105.
3. This shapefile was added to an ArcGIS Pro map and compared against the available known locations described in the FWS 5-year review (5YR), and the available occurrence information from the GBIF database. The current range and NatureServe public Element Occurrences (EOs) capture the

locations identified in the 5-year review and include the occurrence information from iNaturalist to within the published uncertainty of each observation.

2.2. Nokuse Plantation

According to FWS documents, the Cooley's meadowrue has only a single known population in Florida, located within the Nokuse Plantation. This land is protected by a conservation easement. Spatial data for the plantation boundary and the conservation easement were not found. However, a detailed map of the plantation boundary was obtained from the Nokuse Plantation website and georeferenced according to the procedure detailed in Section 3 ("Creating the Core Map") below (https://nokuse.org/maps/). The resulting shape was later merged with others to form the extent of the core map.

2.3. GDNR Biodiversity Portal

The Georgia Department of Natural Resources (GDNR) Biodiversity Portal includes a mapping tool that was used to query and download known location information for the Cooley's meadowrue (**Figure 8**). A shapefile of the most detailed dataset available, "Quarter Quads," was exported to a file geodatabase and queried for recent observations according to the procedure detailed in Section 3. The resulting shape was later merged with others to form the extent of the core map.

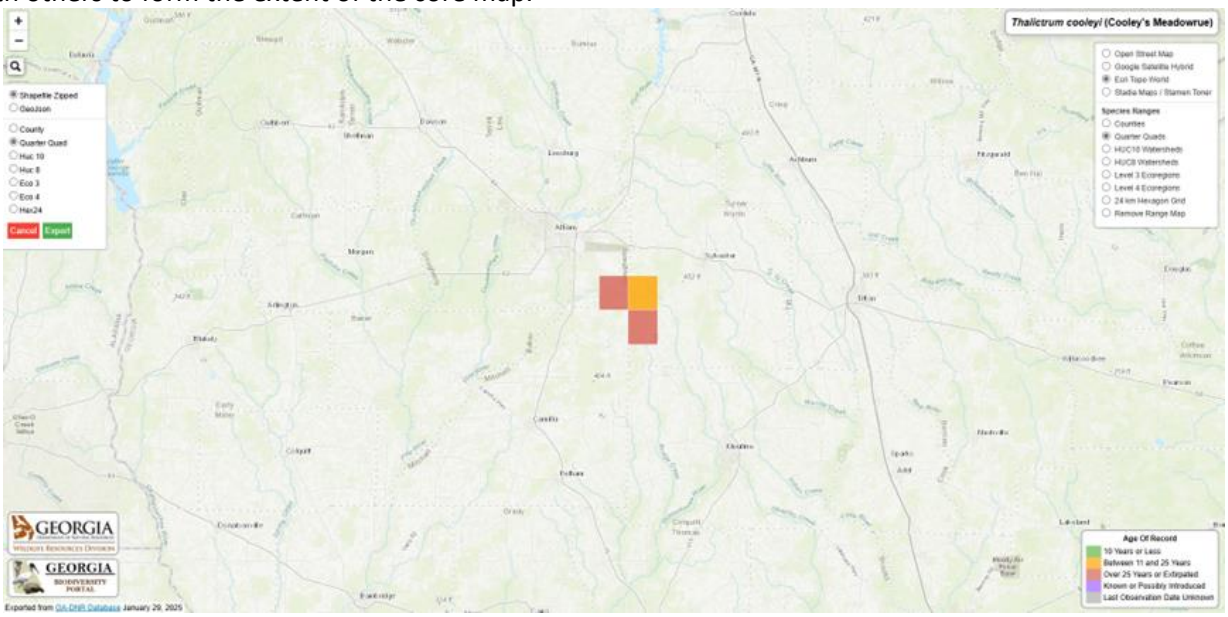

Figure 8. Quarter Quads of the Cooley's meadowrue. Coral-colored quads represent areas where the observation is over 25 years old or extirpated; orange-colored quad represents areas where the observation(s) are between 11 and 25 years old (GDNR 2025).

2.4. NatureServe Explorer

NatureServe Explorer was used to identify public EOs with respect to the FWS range for the Cooley's meadowrue. These were compared with other known occurrence data from GBIF and iNaturalist, and the known populations in North Carolina identified by FWS in the 5-Year Review document. GBIF coordinates were buffered to their largest uncertainty distance of 28,874 m2 for this species (all coordinates had uncertainties greater than 28 km). It was observed that EO data were more precise (smaller area) and still captured all known populations published by FWS, so EOs were adopted as the extent in North Carolina. FWS did not provide maps or spatial data for populations in other states, so only the North Carolina portion of species range was analyzed this way. The public NatureServe EOs were georeferenced and made into usable spatial data according to the procedure detailed in Section 3 and shown in **Figure 12**.
In Georgia, there is one EO representing the Cooley's meadowrue. It overlaps with the lone recent "quarter quad" from the GDNR.

In Florida, there is one EO within the range of the Cooley's meadowrue. However, the detailed shape of the Nokuse Plantation was determined to be a more precise and accurate representation of extent, so this EO was not used (see Section 2.5 for more details on the creation of spatial data for the Nokuse Plantation).

2.5. Nokuse Plantation

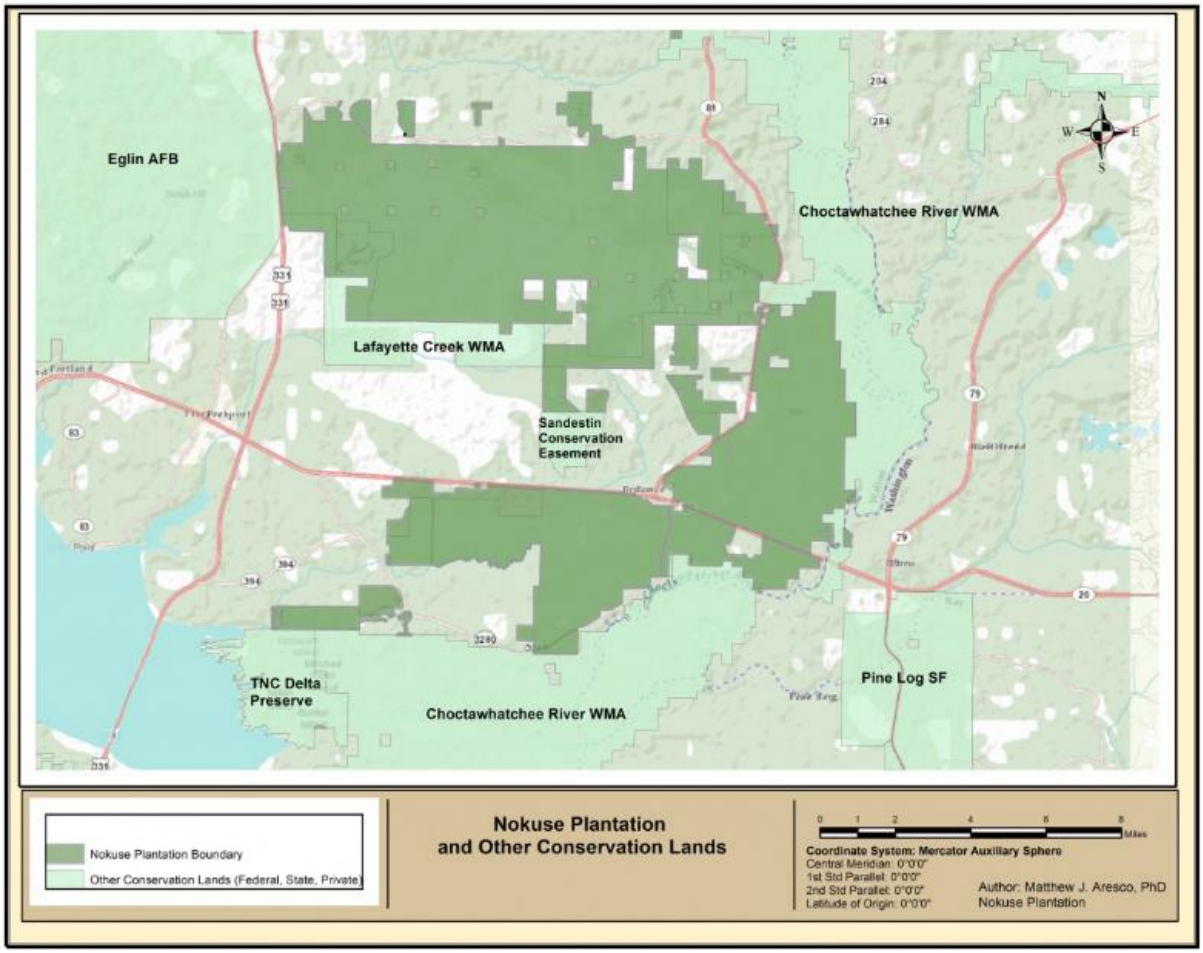

Figure 9. Map displaying the Nokuse Plantation boundary that was used to georeference and delineate the core map extent of the Cooley's meadowrue in Florida (Nokuse.org 2025).

A map of the Nokuse Plantation (**Figure 9**) was georeferenced and converted to a usable polygon for core map development according to the process outlined in Section 3. The resulting shape is shown in **Figure 10**.

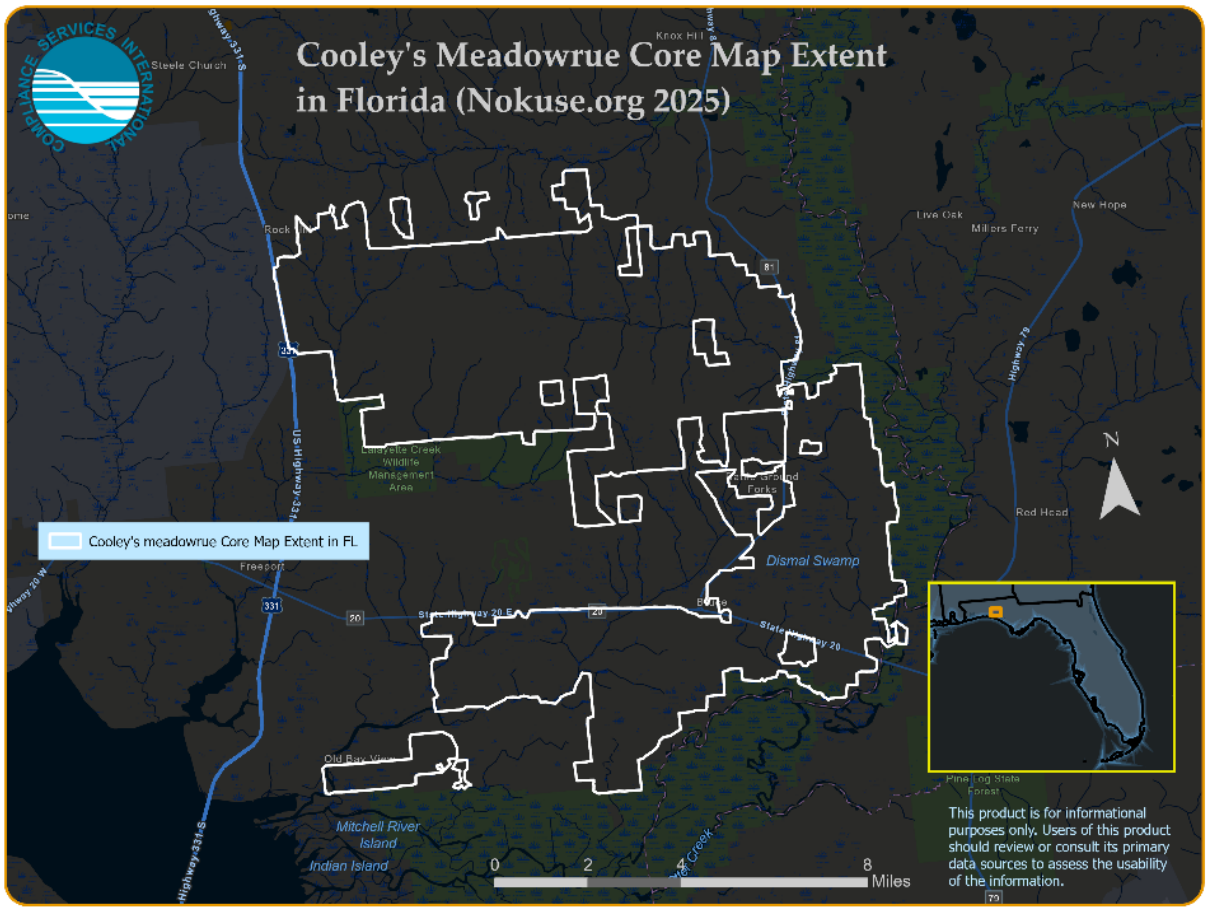

Figure 10. Core map extent of the Cooley's meadowrue in Florida (Nokuse.org 2025).

2.6. NCDOT ATLAS

Regions of suitable habitat were used to refine the core map based on biological information. The North Carolina Department of Transportation (NCDOT) completed a project named "ATLAS" in 2021 that categorized land within the range as low, moderate, or high suitability for species habitat for the Cooley's meadowrue. Ultimately, regions of "Low" and "Moderate" suitability were excluded from the core map, while "High" suitability were included. Categories of "Low" and "High" for this species are defined as follows ("Moderate" was not defined; NCDOT 2021):

- Low: regions and sites where biologists would be very surprised to find this species and its habitat (occurrence here should be extremely rare).
- High: biologists expect to frequently encounter areas that look like potential habitat based on visible environmental and vegetation community characteristics.

The thresholds for this species in the underlying continuous variable model are: Low-Moderate (0.28) and Moderate-High (0.35) (**Figure 11**).

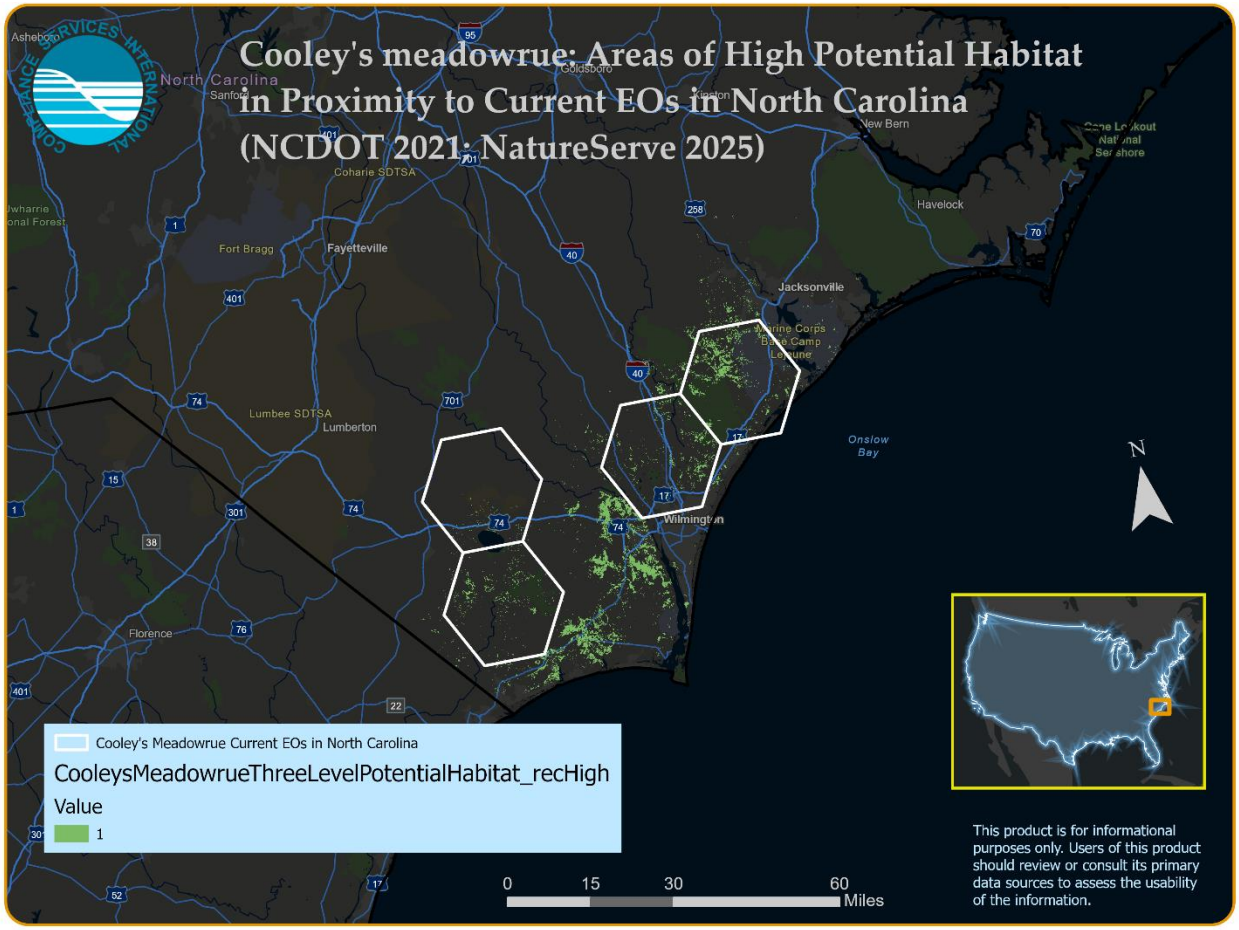

Figure 11. Areas of high habitat suitability (green) for the Cooley's meadowrue within and near NatureServe EOs (white) (NCDOT 2021; NatureServe 2025).

2.7. LANDFIRE

In Georgia and Florida, biological information was spatially rendered using the LANDFIRE CONUS EVT dataset. LANDFIRE provides datasets that cover the entire United States, including vegetation types, disturbance events, and fuel distributions. These datasets are mapped at a 30-meter pixel resolution, which allows for refinement of the Cooley's meadowrue extent. As described below, the core map extent relies on spatial data that are more generalized than local sites where the species has been observed; therefore, CSI determined it is appropriate to use select LANDFIRE classes matching habitat descriptions to identify areas within the extent that are suitable to represent the species' core map. Details on the key words used for class identification are provided in the "Description of Core Map" section above.

3. Creating the Core Map

Defining Extent

The extent for the Cooley's meadowrue was created in three distinct processes, one for each state the species range overlaps.

North Carolina

In North Carolina, the core map for the Cooley's meadowrue was developed using NatureServe public EOs as the extent within which habitat refinements were considered. CSI received from NatureServe a feature class ("NatureServe_PublicEOs_343sqmi_forCSI_20250502") containing usable EO boundaries for a few select species, including the Cooley's meadowrue. These EOs were queried and processed as follows:

1. Use the Select by Attributes tool to select EOs corresponding to just the Cooley's meadowrue (SQL query: BLD_EO_SPECIES_GCOMNAME = 'Cooley's Meadowrue'). Export selected features to a new feature class named "CM_NS".
2. Use the Select by Attributes tool to select historical EOs from "NS" (SQL query: BLD_EO_SPECIES_EORANK_CD IN ('H', 'X') Or BLD_EO_SPECIES_LASTOBS_D IN ('1928-06-30', '1958-06', '1988-06-26', '1989-07', '1996-05-25', '1996-06-07', '1996-07-19', '1996-08-02', '1998-06-21')).
3. Use the Switch tool to switch the selection of EOs in the previous step. This identifies EOs that are considered "current" and thus appropriate for core map development. Export selected features from "NS" to a new feature class named "CM_NS_current".
4. Use the Select by Location tool to select features from the previous layer ("CM_NS_current") that intersect with the state of North Carolina and export selected features as a new layer named "CM_NS_current_NC".
5. Use the Pairwise Dissolve tool to dissolve the previous layer ("CM_NS_current_NC") into a single feature and save as a new layer named "CM_NS_current_NC_pd".

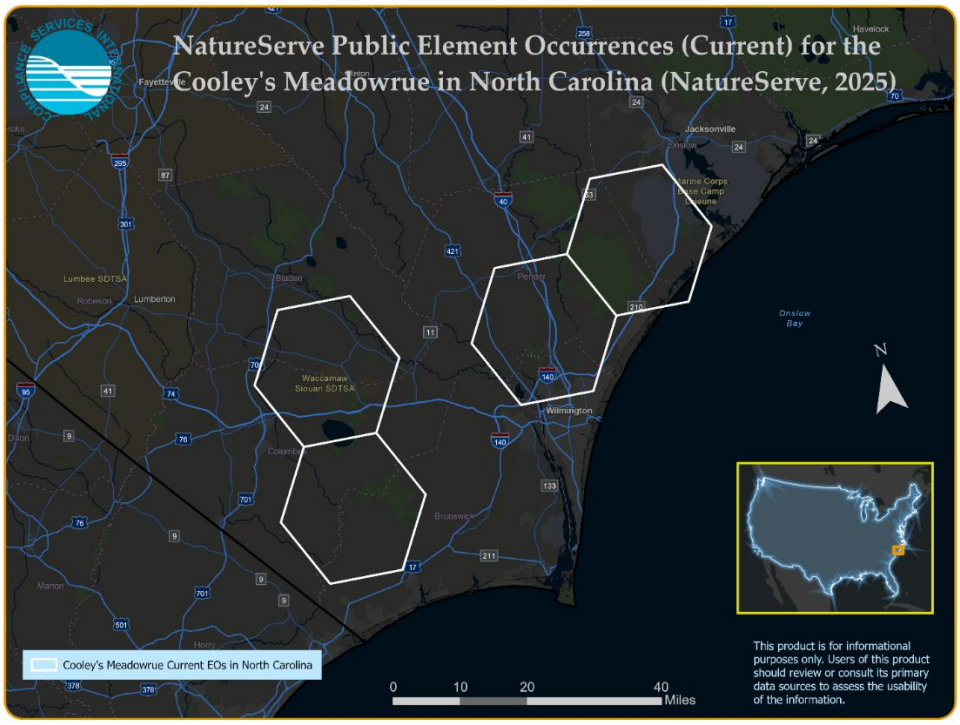

Figure 12. Core map extent for NatureServe public occurrences in North Carolina (NatureServe 2025).

Georgia

1. Download the quarter quads as a shapefile and export as a feature class in a file geodatabase ("GDNR_quarter_quads").
2. Use a SQL query to select only recent quads: age_text2 IN ('10 Years or Less', 'Between 11 and 25 Years'). Export selected quads as a new feature class ("GDNR_quarter_quads_recent").

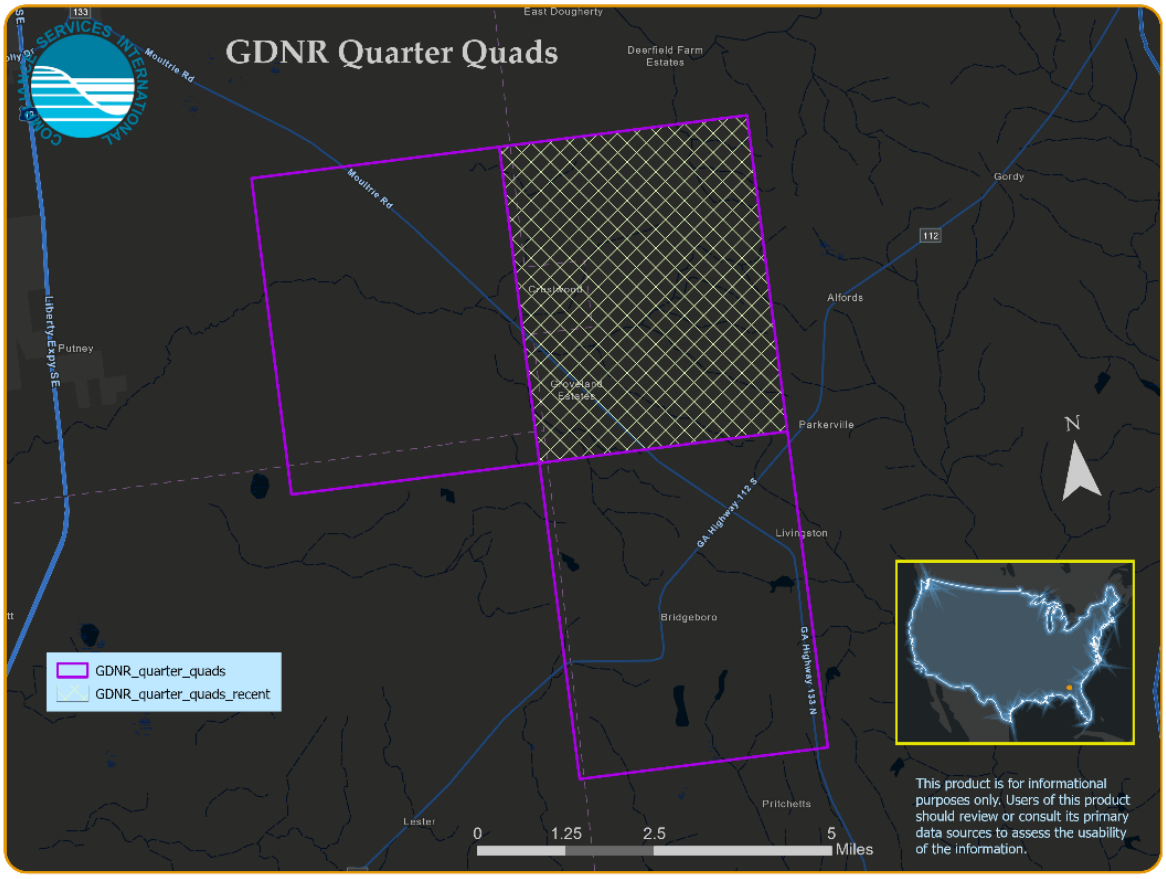

Figure 13. Core map extent of GDNR quarter quad (recent, green cross-hatching), in comparison to all quarter quads for the Cooley's meadowrue (purple) (GDNR 2025).

Florida (**Figure 14**)

2.1. Save an image of the Nokuse Plantation map as an image file. Add the image to the GIS and save it to the working file geodatabase ("Nokuse"). Fit the image to a window zoomed into the vicinity of the species range, render it partially transparent (70% transparency was used) and use control points to reorient the image to be aligned with identifiable features in the background.
2.2. Reclassify the image to isolate the color associated with subpopulations on the original map, dark green in this case ("Nokuse_rec").
2.3. Use the Raster to Polygon tool to convert the reclassified layer to a vector layer. This is done to facilitate future steps, including final delivery of a feature class representing the core map ("Nokuse_rec_r2p").
2.4. Use the Pairwise Clip tool to clip the polygon shape from the previous step by the species range ("Nokuse_rec_r2p_pc").
2.5. Use the Feature to Polygon tool to fill any holes in the polygon layer ("Nokuse_rec_r2p_pc_f2p").

2.6. Use the Pairwise Dissolve tool to dissolve the polygons from the last step into a single polygon ("Nokuse_rec_r2p_pc_f2p _pd").

Figure 14. Core map extent for the Nokuse plantation (Nokuse.org 2025). A georeferenced image (top-left) was reclassified (top-middle), converted to a polygon (top-right), clipped to exclude irrelevant areas (bottom-left), had its holes filled in (bottom-middle), and dissolved into a single shape (bottom-right).

Refinement based on Biological Information

The total extent of the Cooley's meadowrue core map—which comprises EOs in North Carolina, one quarter quad in Georgia, and the Nokuse Plantation in Florida—includes a significant area and number of different land cover types that do not align with descriptions of the Cooley's meadowrue habitat. This is especially true of the area spanned by NatureServe EOs in North Carolina, with an extent of 878,079 acres. To improve confidence in the core map, a refinement based on biological information was applied to extent in each state.

The best available dataset for suitable species habitat was found to be a model developed by the North Carolina Department of Transportation, which developed an artificial intelligence-based model with the explicit purpose of identifying habitat for the Cooley's meadowrue. Since this dataset is bounded by the state of North Carolina, it was used only for North Carolina core map extent. In Florida and Georgia, the best available dataset was determined to be the LANDFIRE Existing Vegetation Type layer, which was used to refine the core map as described below.

North Carolina

Areas within the Cooley's meadowrue range are classified into 3 categories: Low, Moderate, and High potential for species habitat. Low and Moderate probability areas were excluded using the Reclassify tool in ArcGIS Pro. Then the Clip Raster tool was used to clip medium/high probability areas to the core map extent in North Carolina, as described above. The resulting habitat-based layer in North Carolina is saved in a file geodatabase as "CooleysMeadowrueThreeLevelPotentialHabitat_recHigh".

Georgia and Florida

In Georgia and Florida, the core map identifies areas within a core map extent created as part of this analysis with land cover classes from the LANDFIRE Existing Vegetation Type (EVT) that match habitat descriptions for the Cooley's meadowrue. Land cover categories within the core map area were identified based on matches of these key words, from a subset of LANDFIRE classes occurring within the range of the species: "Pine," "Savannah," "Bog," and "Swamp forest." This resulted in the EVT classes listed in Table 1 and reproduced below (**Figure 15**):

LANDFIRE: EVT_NAME
Atlantic Coastal Plain Fall-line Sandhills Longleaf Pine Woodland
Atlantic Coastal Plain Upland Longleaf Pine Woodland
East Gulf Coastal Plain Interior Upland Longleaf Pine Woodland
Florida Longleaf Pine Sandhill
Central Atlantic Coastal Plain Wet Longleaf Pine Savanna and Flatwoods
Southern Atlantic Coastal Plain Wet Pine Savanna and Flatwoods
East Gulf Coastal Plain Near-Coast Pine Flatwoods
East Gulf Coastal Plain Southern Loblolly Flatwoods
East Gulf Coastal Plain Wet Prairie
Southern Coastal Plain Herbaceous Seep and Bog
East Gulf Coastal Plain Near-Coast Pine Wet Flatwoods
East Gulf Coastal Plain Wet Savanna

Figure 15. LANDFIRE classes within the extent of the Cooley's meadowrue in Georgia and Florida (left), reclassified to habitat-suitable areas (right) (LANDFIRE 2022).

Combining Habitat-Suitable Datasets Across All States

The following procedure was used to combine reclassified datasets into a finalized (interim) core map:

1. The Mosaic to New Raster tool was used to combine reclassified raster datasets from North Carolina ("NCDOT_ATLAS_High_crCMextent") and Georgia/Florida ("LF_crGAFLAextent_rec") into a single layer ("CM_Habitat_mosaic").
2. The Raster To Polygon tool was used to convert the raster layer from the previous step

("CM_Habitat_mosaic") to a usable polygon layer ("CM_Habitat_mosaic_r2p").
3. The Pairwise Dissolve tool was used to export the previous layer ("CM_Habitat_mosaic_r2p") as a finalized (interim) core map ("Cooleys_meadowrue_CoreMap").

4. Datasets Considered but Not Used in Core Map Development

4.1. SSURGO

The USGS SSURGO database could have been used to find areas circumneutral soils, but the species habitat was better-defined by land cover descriptions that could be matched to habitat type. The SSURGO database could be used as a further refinement of the core map layer. The NCDOT layer references "Geology and Soils" as a thematic group contributing to its 70 considered environmental data layers; it was assumed that the species-specific model included soil type in the development of the model underlying the Cooley's meadowrue potential habitat.

SSURGO (Soil Survey Geographic Database) contributes to LANDFIRE's Existing Vegetation Type (EVT) classifications, but indirectly. It provides detailed soil characteristics, which influence vegetation patterns and ecosystem dynamics. While LANDFIRE EVT is primarily derived from remote sensing, field plot data, and ecological models, SSURGO data can be incorporated into predictive models to refine vegetation mapping, especially in areas where soil properties strongly determine vegetation types (e.g., wetlands, grasslands, and forested ecosystems). Additionally, SSURGO-derived variables like soil texture, drainage, and organic matter can support LANDFIRE's Biophysical Settings (BpS) and Environmental Site Potential (ESP) layers, which, in turn, inform EVT classifications. However, SSURGO is not a direct input to EVT mapping in LANDFIRE's core methodology.

4.2. LANDFIRE

In North Carolina, the LANDFIRE Landscape Fire and Resource Management Planning Tools was considered as an alternative dataset as a refinement of the core map area from its extent. Ultimately, it was eschewed in favor of the state- and species-specific habitat suitability model of the Cooley's meadowrue developed by the NCDOT for areas in North Carolina, as the LANDFIRE dataset is most suitable for national and/or cross-regional analysis and when equivalent and more accurate state- or region-level data are not available.

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