

Interim Core Map Documentation for the Michigan Monkey-Flower

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Species Summary

The Michigan monkey-flower (*Mimulus michiganensis*; Entity ID 969) is a dicotyledonous endangered plant found in Michigan. The U.S. Fish and Wildlife Service (FWS) has not assigned designated critical habitat for the Michigan monkey-flower. This species inhabits seepages and streams, usually in association with northern white cedar swamps. Additional habitat information is provided in **Appendix 1**.

EPA Review Notes

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, and EPA may have edited this documentation for clarity or other purposes. Some views in this documentation may not necessarily be the views 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 the U.S. Fish and Wildlife Service (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 Michigan monkey-flower is biological information type based on known location information of the species and its range. The most recent 5-Year Review (FWS 2018) includes a map of areas where the species is known to occur. Additional known location information from the iNaturalist, Global Biodiversity Information Facility (GBIF), and NatureServe databases provided supporting confirmatory information of these general locations but were not otherwise used in core map development.

The core map developed in this document for the Michigan monkey-flower spans 6,134 acres (**Figure 1**). A summary of acreage by National Landcover Database (NLCD 2021) land use type is provided in **Table 1**.

Based on EPA’s “best professional judgment classification” system, CSI has graded this core map as “moderate” (4) because assumptions were made when connecting species life history and/or biological needs (habitat preferences) to a Geographical Information System (GIS) dataset, in this case the National Wetlands Inventory dataset (NWI 2023). The species inhabits seepages and streams, usually in association with norther white cedar swamps; the NWI dataset was queried for all classes consistent with this habitat description. Additionally, areas of occupancy were represented using a partly manual approach, identifying point locations before applying geoprocessing techniques. More information about this classification system and its definitions can be found in the core map process document (EPA 2024).

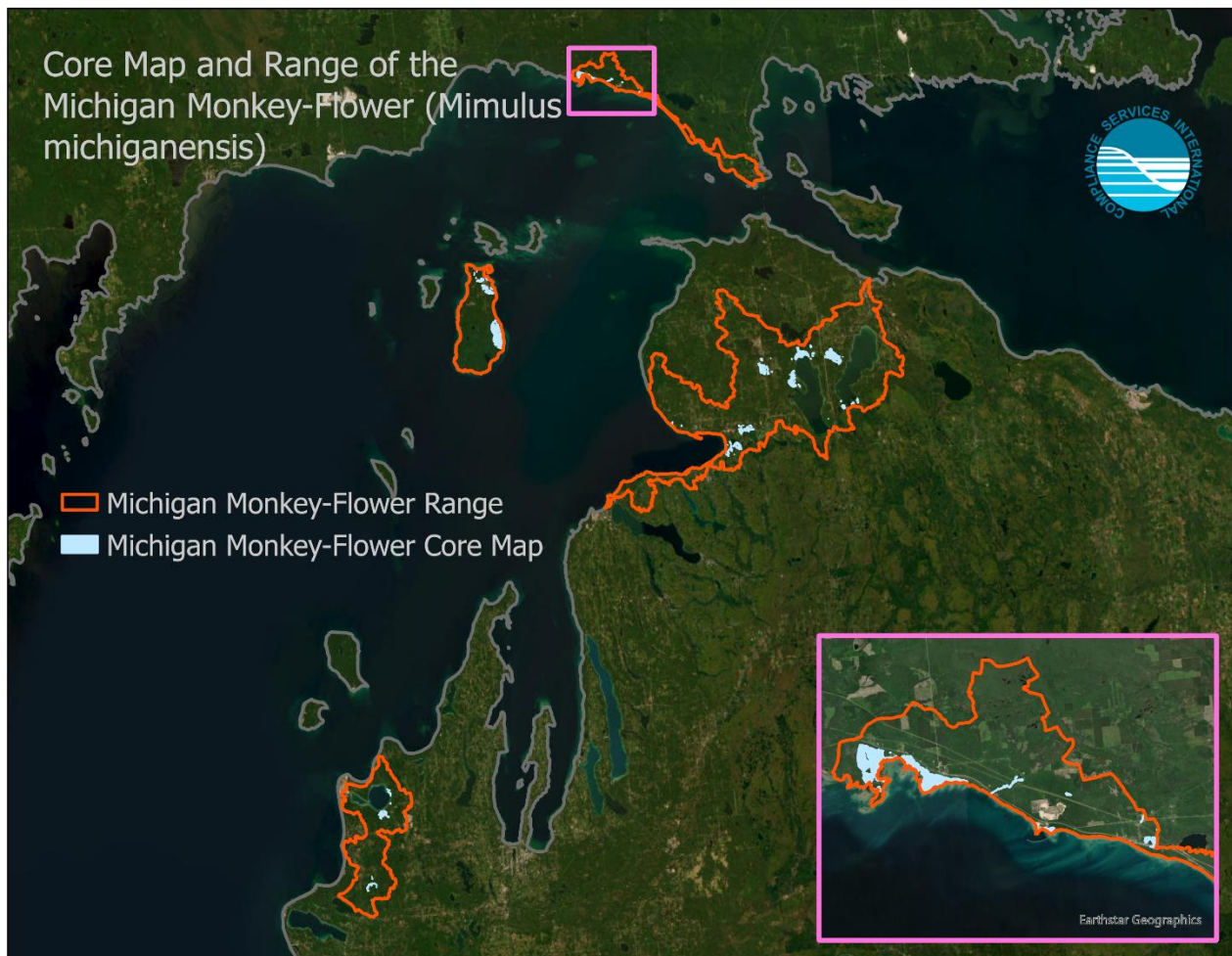


Figure 1. Interim core map for the Michigan monkey-flower (*Mimulus michiganensis*; Entity ID 969). The core map spans 6,134 acres, while the range is 358,495 acres.

Table 1. Acres by National Land cover Database (NLCD 2021) class within the core map of the Michigan monkey-flower. Total core map area (based on NLCD pixel count): 6,136 acres¹.

NLCD_Land_Cover_Class	Acres
Woody Wetlands	5,414
Emergent Herbaceous Wetlands	197
Developed, Open Space	115
Open Water	103
Developed, Low Intensity	93
Mixed Forest	50
Deciduous Forest	45
Barren Land	33
Evergreen Forest	28
Developed, Medium Intensity	24
Hay/Pasture	21
Herbaceous	11
Developed, High Intensity	1
Shrub/Scrub	1
Cultivated Crops	-

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 GBIF; and
- Occurrence locations in NatureServe

Compliance Services International evaluated these four datasets before developing the core map. Overall, there were eight usable research-grade observations found in iNaturalist². The GBIF dataset comprised 17 georeferenced observations, six of which were considered usable based on the criteria described below. Both datasets were useful to identify extant population sites for the Michigan monkey-flower but did not represent significant improvements in capturing or supplementing areas missing from FWS. The iNaturalist and GBIF datasets were redundant because the iNaturalist observations comprised all the GBIF observations.

FWS location information provided significant refinement. These areas were converted into usable spatial data to form the extent of the core map. Further refinements to this extent were made based on species

¹ This acreage is slightly different from the core map acreage (6,134) due to the pixelation of NLCD land cover. The core map is not developed exclusively from raster data.

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->).

range and the biological information/habitat needs of the species.

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 habitat (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: critical habitat, range, and biological information. From EPA, summaries of each core map type are provided below (EPA 2024).
 - Critical Habitat: Habitat core maps are appropriate in cases where the critical habitat includes all or nearly all the species' current habitat or areas that are targeted by FWS for conservation of a species.
 - Range: Range core maps are most appropriate for narrow (small) range endemic species (a species that is native and restricted to a certain place) with maps that FWS has refined. A refined range map from FWS will typically follow landscape features rather than political boundaries (such as county or state boundaries) and will generally have a more limited total area; ranges with an area of 10,000 acres or less are likely refined. Ranges with larger areas may still be refined using species locations or landscape features such as habitats or watersheds. The larger refined ranges, often include many (more than 10) disconnected polygons with boundaries that do not have straight lines or right angles.
 - Biological Information: Core maps based on biological information should reflect the spatial/mappable data that best represent the biological requirements of a species, and this may include one or more datasets. These biological requirements will vary by species, but examples include habitat type, soil requirements, foraging range, migratory area, or bloom periods. This type of core map should reflect the best available information but may have greater uncertainty in representing areas that are most important to species conservation.
3. Develop the core map for the species; and
4. Document the core map.

For step 1, CSI compiled available information for the Michigan monkey-flower (*Mimulus michiganensis*) from FWS, as well as observation information available from various publicly available sources including iNaturalist, GBIF, and NatureServe. The information compiled for the Michigan monkey-flower (*Mimulus michiganensis*) is included in **Appendix 1**. Influential information that impacted the development of the core map includes a description of the species habitat from the Recovery Plan:

- '*Mimulus glabratus* var. *michiganensis* is restricted to cold, alkaline spring seepages and streams, usually in association with northern white cedar (*Thuja occidentalis*) swamps occurring along current or post-glacial Great Lakes shorelines. It frequently occurs in northern white cedar swamps formed in drainages found at the base of relatively steep. morainic slopes and bluffs. In these sites, *M. glabratus* var. *michiganensis* generally flourishes best in tree canopy openings along forest edges, or along streams adjacent to open, meadow-like areas. It flowers most abundantly when growing in full sunlight, although it appears to persist as mostly sterile colonies when growing under heavy tree canopy cover' (FWS 1997).

For step 2, CSI used the compiled information including the species range, known locations, and habitat location information to determine the core map type. Compliance Services International compared the known location data to the range and found that known locations from FWS (occurrences from the most recent 5-Year Review) were usable as a refinement of range in determining the core map extent. Other known location data from GBIF, iNaturalist, and NatureServe were not used to develop the core map.

Review of the available data also suggested that the core map should exclude landcover types inconsistent with the Michigan monkey-flower habitat. To represent the species' habitat, the NWI dataset was used to identify habitat classes associated with the species' habitat description above. Using the "ATTRIBUTE" field, several unique water body types were selected from the subset of classes falling within the core map extent, as catalogued in **Appendix 2** Section 2.3. These water body types represent the potential habitat of the Michigan monkey-flower. NWI water bodies were clipped to the species extent prior to subsequent geoprocessing steps.

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 biological information. Designated critical habitat was eliminated as a core map type because the Michigan monkey-flower does not have designated critical habitat. The range core map type was not selected because the species range is not refined.

Geographical areas known to be inhabited by the Michigan monkey-flower were identified in FWS documentation; these areas represent the outer boundary ("extent") considered for core map development. The NWI database was clipped to this extent and its features dissolved to create a layer representing potential habitat for the Michigan monkey-flower. **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

LANDFIRE

CSI selected the National Wetlands Inventory (NWI) over the LANDFIRE dataset to represent habitat areas for a species living in seepages, streams, and shorelines which was not an obvious choice for a species reliant on a combination of aquatic and terrestrial environments. This is because LANDFIRE classes associated with other elements of species habitat description ("northern white cedar swamps... flourishes best in tree canopy openings along forest edges, or along streams adjacent to open, meadow-like areas") pull in more forested areas without the necessary aquatic components and cannot explicitly differentiate the northern cedar forests from other hardwood forest layers. Therefore, NWI riverine, palustrine and littoral lacustrine layers aligned more closely with the aquatic dependency of this species compared to the broader terrestrial classes in the LANDFIRE dataset than the NWI dataset.

Appendix 1. Information compiled for the Michigan monkey-flower

1. Recent FWS documents

- 5-Year Review (2011): https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/1719.pdf
- 5-Year Review (2018): https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/2606.pdf
- 5-Year Review (2023) https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/10275.pdf
- Recovery Plan (1997) https://ecos.fws.gov/docs/recovery_plan/970917a.pdf

2. Background information

- Status: Federally listed as endangered in 1990.
- Resiliency, redundancy, and representation (the 3Rs) were not evaluated for this species.
- Habitat, Life History, and Ecology
 - ‘*Mimulus glabratus* var. *michiganensis* is restricted to cold, alkaline spring seepages and streams, usually in association with northern white cedar (*Thuja occidentalis*) swamps occurring along current or post-glacial Great Lakes shorelines. It frequently occurs in northern white cedar swamps formed in drainages found at the base of relatively steep morainic slopes and bluffs. In these sites, *M. glabratus* var. *michiganensis* generally flourishes best in tree canopy openings along forest edges, or along streams adjacent to open, meadow-like areas. It flowers most abundantly when growing in full sunlight, although it appears to persist as mostly sterile colonies when growing under heavy tree canopy cover’ (FWS 1997).
 - ‘Northern white cedar is an important and usually dominant overstory tree, commonly occurring with *Abies balsamea* (balsam fir), *Betula papyrifera* (paper birch), and occasionally *Larix laricina* (larch or tamarack). In some sites, such as along the Mackinac County shoreline, *M. glabratus* var. *michiganensis* occurs in seeps and ravines bordered by upland hardwood forest, dominated by species such as paper birch, *Acer rubrum* (red maple), *Acer saccharum* (sugar maple), and *Fagus grandifolia* (beech). *Caltha palustris* (marsh-marigold), *Impatiens capensis* (jewelweed), and *Nasturtium officinale* (watercress) are nearly constant herbaceous associates. *Myosotis scorpioides* (forget-me-not), although non-native, is often present’ (FWS 1997).
 - ‘While it has not been documented in reports or literature, Michigan monkey-flower vegetation persists year-round (pers. comm. L. Voran, J. Marquis, and L. May, July 2023). It appears that individuals can live even under snow or water during the winter. This indicates that hydrology needs are not seasonal, but rather during the full year’ (FWS 2023).
 - ‘Individuals from the Maple River population were capable of self-pollination, regularly set selfed-fruits in the greenhouse, and had 27–52% pollen viability (mean of 41%) (Posto and Prather 2000; Posto 2001). During the greenhouse experiments, Posto and Prather (2000) also noted the amount of self-pollination in the controlled setting was higher than that in the field and proposed that limited fruit set in nature may be limited by resource competition. When Posto (2001) conducted interpopulational crosses between pollen-sterile individuals from other sites and Maple River individuals (the pollen donors), all the flowers survived to fruiting and all set fruit. In this crosspollination experiment, fruit set was indicated by observations of a swollen ovary and calyx, which was suggestive of viable

ovules and that seed will set. However, Roberts (1964) found during studies of synthesized F1 hybrids of other *Mimulus* species that self-pollinated, semi-sterile plants exhibited enlargement of the capsule and calyx, but did not set seed. This was also observed in backcross experiments with a greater degree of enlargement. Roberts (1964) suggested that hormone action following pollination may be responsible for this effect. Therefore, Posto (2001) concluded that it is unclear whether fruit set in the interpopulational crosses between Maple River and pollen-sterile plants is due to seed development or hormone action' (FWS 2011).

- 'Beadle found that colonies nearly always occurred in muck-covered sand (Tawas soil series) in cold, flowing water that ranged in temperature from 8.7° to 16.6° C (47.6° - 61.9° F). Beadle also found that *M. glabratus* var. *michiganensis* occurs in an exceptionally narrow pH range, which over numerous study sites ranged only from 7.66 to 8.21. This range is very comparable to that indicated for *M. glabratus* var. *michiganensis* habitat on Glen Lake, where pH has been reported as ranging from 7.8 to 8.4 (Jones 1991). Conductivity readings, indicative of nutrient content, were predictably high, ranging from 190 µmhos at Brevort to well over 300 µmhos at most other sites. Selected water sample tests indicated high concentrations of ammonium (NH₃), nitrate (NO₃), and phosphorus (P)' (FWS 1997).

- Taxonomy

- '*Mimulus*, a large, highly variable (i.e., polymorphic) genus of as many as 150 species (Pennell 1951), was placed in the section *Simiolus* (within the tribe Gratioleae) by Grant (1924), who considered *Mimulus glabratus* and its varieties to be the most widely distributed group in the genus. *Mimulus glabratus* is found from Quebec to Saskatchewan, ranging south through Mexico and southern Chile, and seven varieties of the species have been named (Grant 1924; Pennell 1935; Fassett 1939; Skottsberg 1953). The varieties represent diploid as well as several polyploid races, which are strongly correlated with well documented geographical, morphological, and other differences, such as allozyme patterns and cytogenetic characteristics (Vickery 1990).

Pennell (1935) recognized *M. glabratus* var. *michiganensis* as a subspecies of *M. glabratus* based on its larger, "unspotted corollas", the more conspicuously toothed, sinuate-dentate leaves, and a more erect growth habit. The type specimen was collected from the banks of Niger Creek "near Topinabee," Cheboygan County, in July 1925 (J. H. Ehlers 3240, MICH). Specimens correctly identified as *M. glabratus* var. *michiganensis* were also previously collected near Harbor Springs, Emmet County (C. F. Wheeler July 12, 1890, MSC; M. Irwin, July 1892, MSC)' (FWS 1997).

- Relevant Potential Pesticide Use Sites

- Pesticides are only mentioned in relation to future climate change where climate change is likely to result in increasing deposition of pesticides as the result of increased precipitation (FWS 2018).

- Relevant Recovery Criteria and Actions

- Criteria for Downlisting (FWS 2023)
- 'The criterion for Michigan monkey-flower is securing long-term protection for all occurrences and when eight occurrences are ranked at or higher than good than the species will be considered for downlisting. Most of the known occurrences are not secured in long-term protection and only 6 of the known populations are considered to have good, estimated viability. There are eight occurrences that have long-term protection as they are

located partially or fully on lands owned by the State of Michigan, federal government, land conservancies, or biological stations. The one AB ranked population is on biological station property, 3 ranked as B occur on land conservancy and state lands, 1 ranked as B? is located on Federal land, 2 ranked BC occur on land conservancy and state land, and 1 ranked C occurs on land conservancy lands. The two populations that are privately owned and estimated to be in good viability are recorded as last being surveyed in 2012' (Table 2).

Table 2. Number of populations by Element Occurrence viability ranking and land ownership. Copied from Table 1 of the most recent 5-Year Review (FWS 2023).

Element Occurrence Estimated Viability Rank	Partially or fully protected	Privately owned	Total
AB (excellent or good)	1		1
B (Good)	3	2	5
B? (Possibly Good)	1		1
BC (Good or Fair)	2	1	3
C (Fair)	1	2	3
C? (Possibly Fair)		1	1
CD (Fair or Poor)		2	2
D (Poor)		2	2
Total	8	10	18

- Recommendations for Future Actions (FWS 2023)
 1. Develop a plan for conducting regular surveys, assessments, and monitoring at all known extant and historical Michigan monkey-flower locations. It is especially important to prioritize populations that have not been surveyed in the last decade. An updated population status is crucial for these areas. Continue exploration for new occurrences in the Lower Peninsula and eastern Upper Peninsula and provide detail mapping of all occurrences. Document habitat and status conditions and population trends during these assessments. Recovery plan action numbers: 2-21, 2-22, 2-23, 4-45.
 2. Monitor non-native and aggressive native species and control as appropriate.
 3. Genetic research to understand the diversity among and between populations. Recovery plan action number: 2-44.
 4. Acquire land containing occupied or suitable Michigan monkey-flower habitat. Create outreach materials for public and private landowners, site managers, and general stakeholders to inform and protect the species and its habitat. Recovery plan action numbers: 1-121, 1-122, 1-123, 1-15.

3. Range

- Species ranges from Benzie and Leelanau Counties in northwestern Michigan to Mackinac County in the eastern Upper Peninsula. Most occurrences are known from the Mackinac Straights region (FWS 1997).
- See **Figure 2** for a map of the current range.

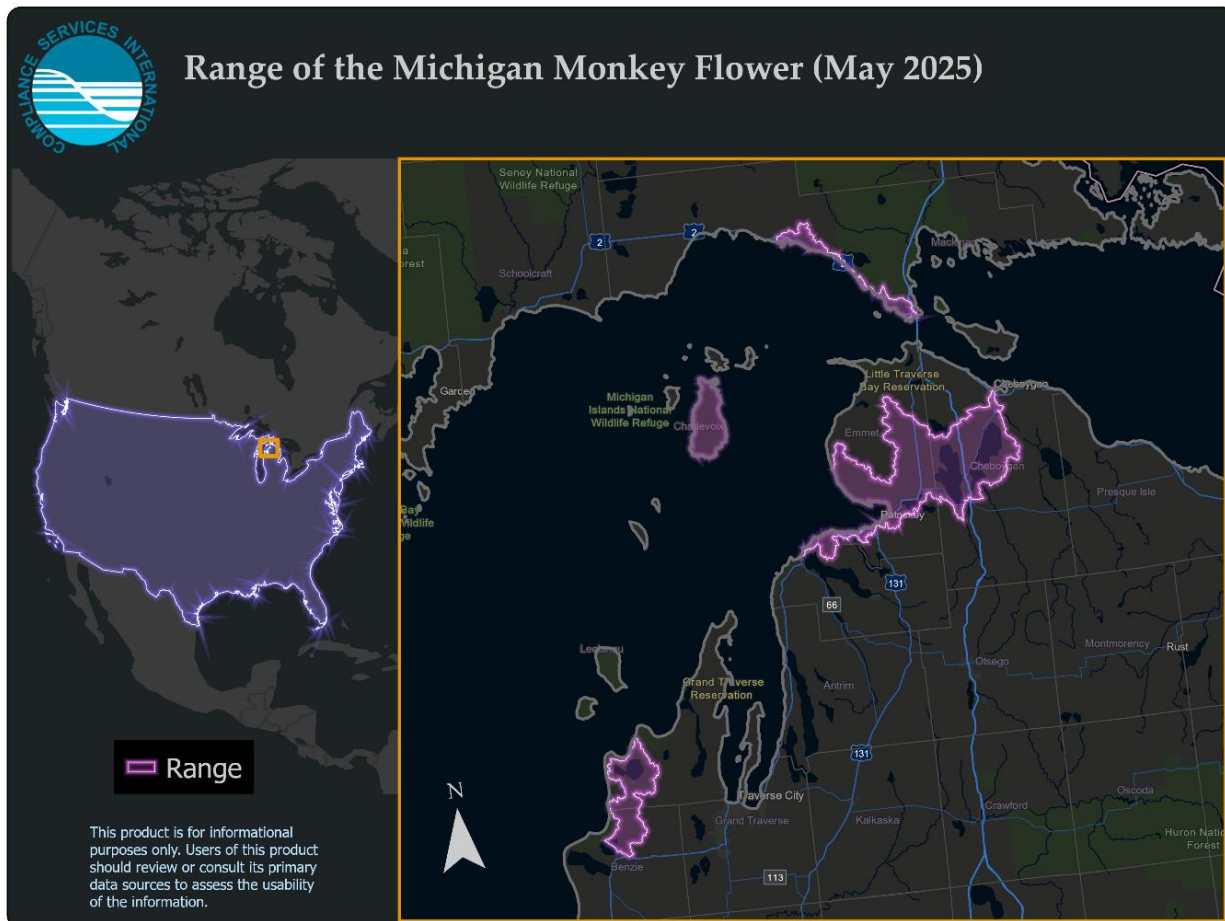


Figure 2. Range of the Michigan monkey-flower (FWS 2025).

4. Description of Critical Habitat

- Critical habitat has not been designated for this species.

5. Known Locations

- 'Currently Michigan monkey-flower has 18 extant element occurrences. Recent surveys have indicated that at two areas, populations had extended beyond the area previously thought to be occupied and therefore, some adjacent element occurrences have been combined. The previous status review (2018) for Michigan monkey-flower listed 23 element occurrences. The species still occurs in the same six Michigan counties – Benzie, Leelanau, Charlevoix, Emmet, Cheboygan, and Mackinac' (FWS 2023).
- FWS 2023 explicitly states that "the overall distribution remains unchanged from the prior five-year review (FWS 2018) as they are all previously known occurrences." This was used to justify the rationale for basing the core map extent on these published element occurrences.
- **Figure 3** shows the known and verified Michigan monkey-flower occurrences as of the recent 5-Year Review (2023). The figure is copied from the 2018 5-Year Review document; however, the population locations were confirmed to be unchanged as of 2023.

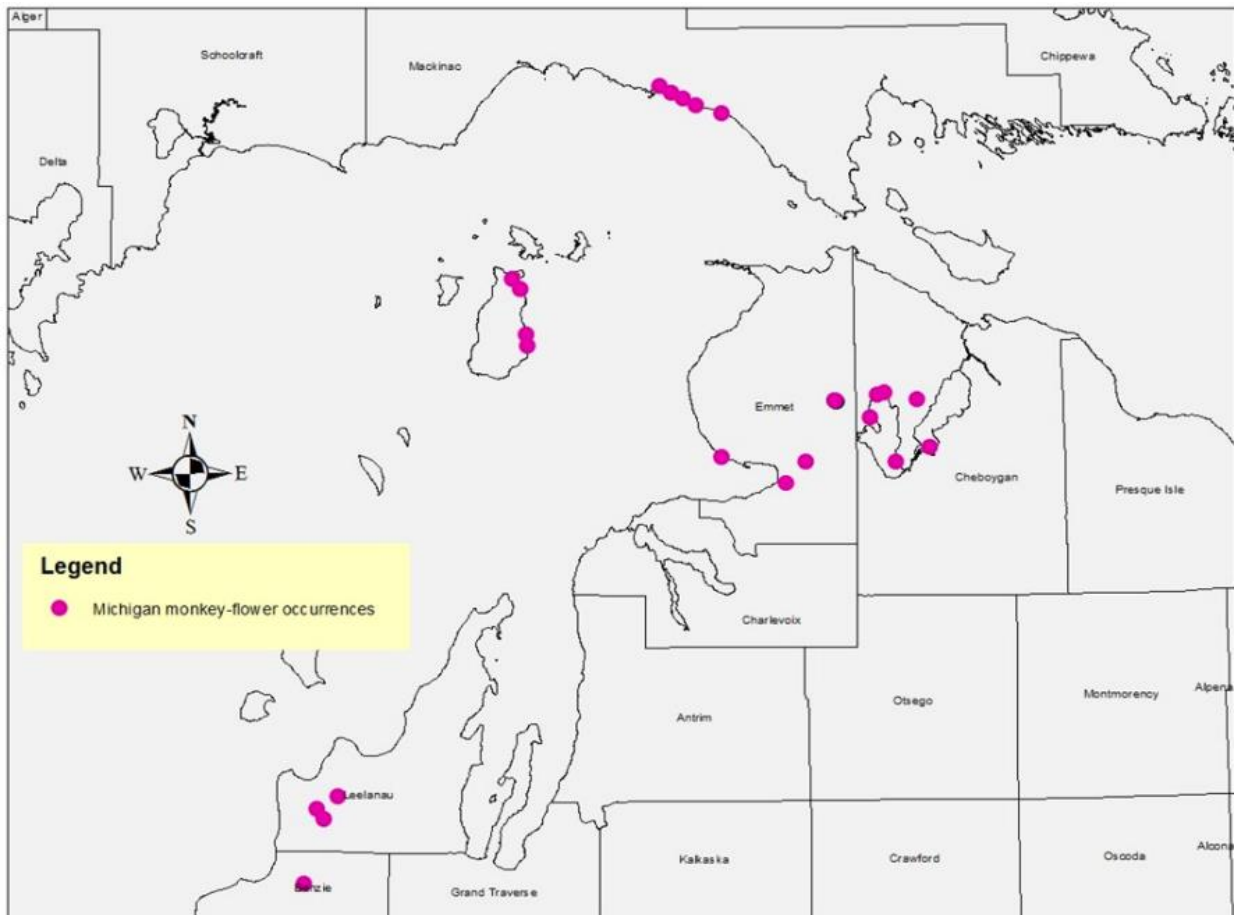


Figure 3. Known and verified Michigan monkey-flower occurrences. Copied from Figure 1 of the FWS 2018 (FWS 2018).

- GBIF: <https://www.gbif.org/species/7569866>
 - GBIF includes 193 occurrence records; 70 of which are georeferenced (**Figure 4**). 66 of these had usable coordinate data based on these criteria:
 - U.S. only (excludes Mexico)
 - Latitude and longitude precision were both 3+ decimal places.
 - Coordinate uncertainty values no greater than 30 km ³.
 - Relative recency (2010-present)
 - Must include date information.
 - No “preserved specimen” observations; only “human observation.”
 - The 66 usable coordinates were mapped against the species range to evaluate their utility in representing species extent (**Figure 5**). It was observed that all the usable GBIF coordinates are originally sourced from iNaturalist, which also had more records. Therefore, the GBIF dataset was not used for core map development.

³ For “obscured” observations, public positional accuracy (PPA) represents the diagonal of a 0.2 x 0.2 arc cell. See the iNaturalist geoprivacy page for more details on this and related terms [What is geoprivacy? What does it mean for an observation to be obscured? : iNaturalist Help](#).

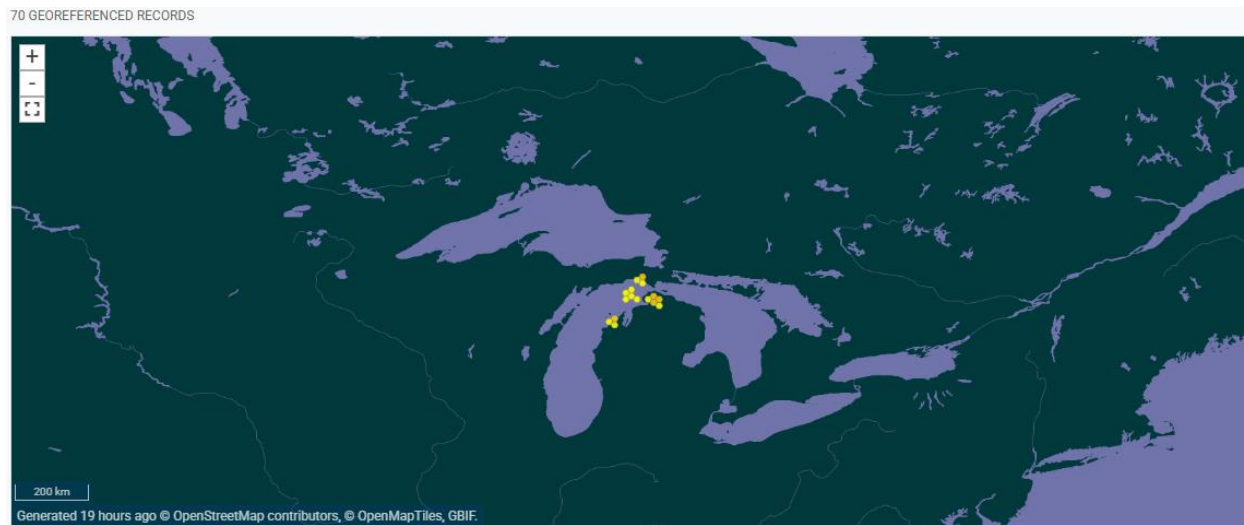


Figure 4. GBIF occurrences for the Michigan monkey-flower (GBIF 2025).

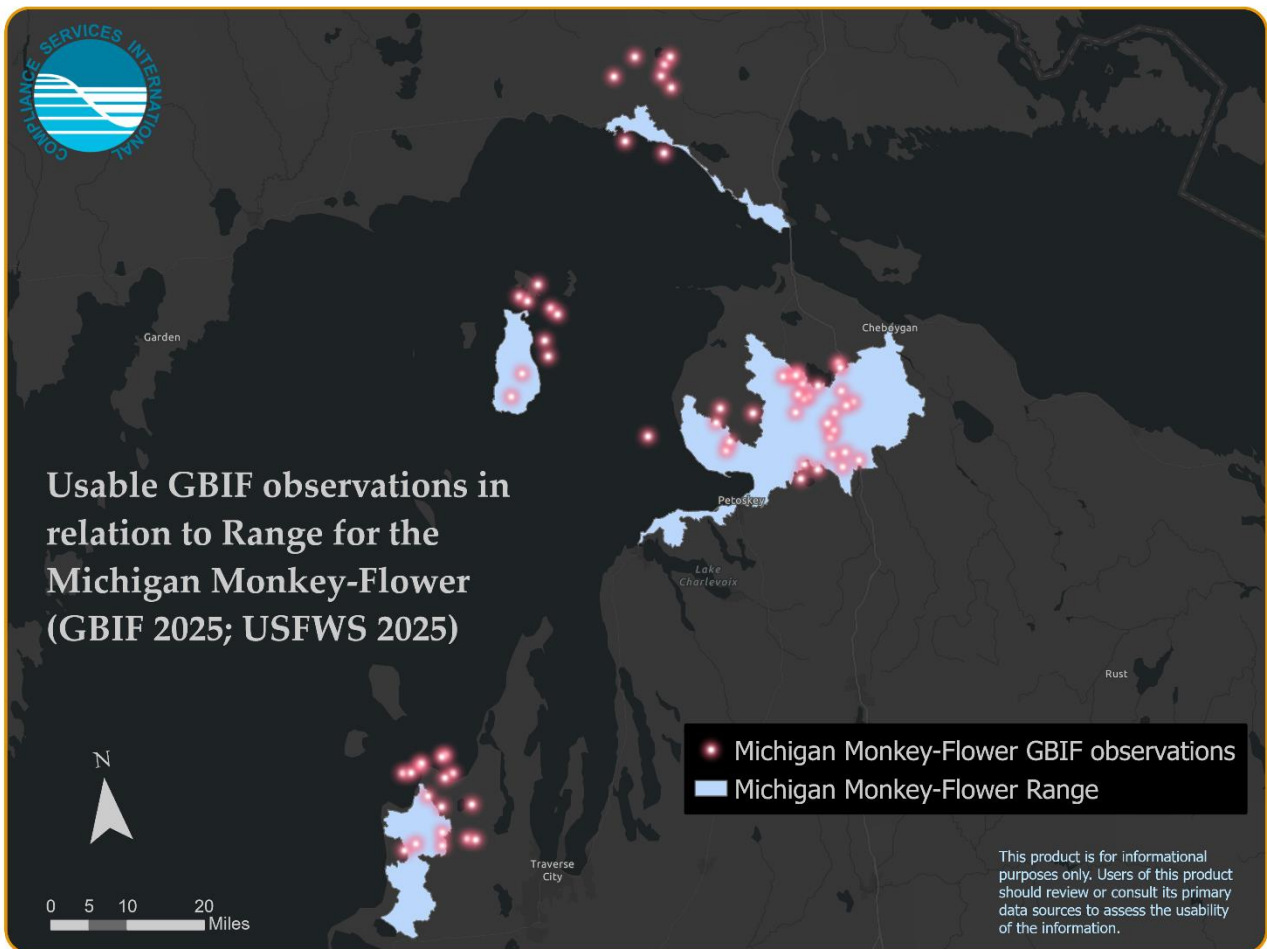


Figure 5. Usable GBIF occurrences (pink) in relation to the range of the Michigan monkey-flower (GBIF 2025; FWS 2025).

- iNaturalist:

https://www.inaturalist.org/observations?quality_grade=research&subview=map&taxon_id=509684

- iNaturalist includes 161 total observations (**Figure 6**), 96 of which are research-grade with usable coordinate data based on these criteria:
 - U.S. only (excludes Canada)
 - Latitude and longitude precision were both 3+ decimal places.
 - Relative recency (2010-present)
 - Observation description did not include the text “intentionally incorrect.”
 - Public positional accuracy (PPA) value no greater than 30 km
 - This resulted in the exclusion of one record.
- Locations are consistent with GBIF, which is expected because all the GBIF observations are imported from iNaturalist.
- Some iNaturalist locations are just outside of the range of the Michigan monkey-flower; however, all the observations intersect the range when accounting for the PPA uncertainty value (**Figure 7**).
- The iNaturalist data align well with the range and support its use as the core map extent.

Observations

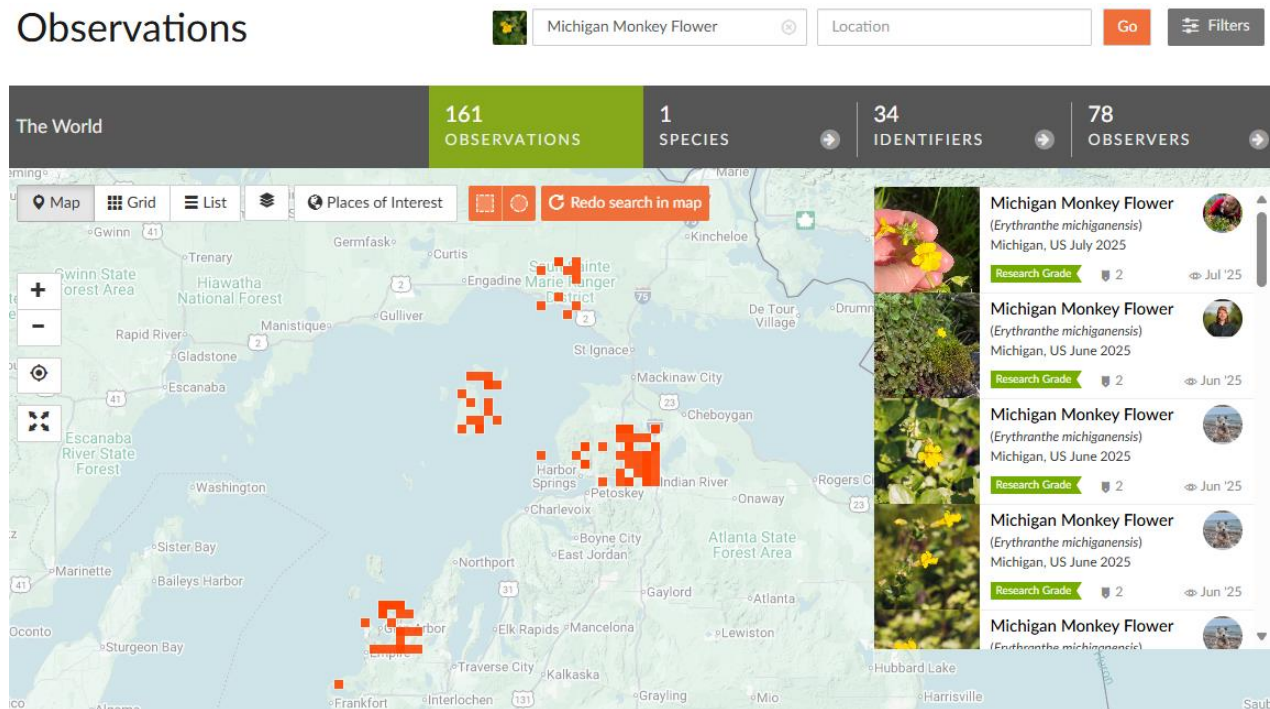


Figure 6. iNaturalist occurrences for the Michigan monkey-flower (iNaturalist 2025).

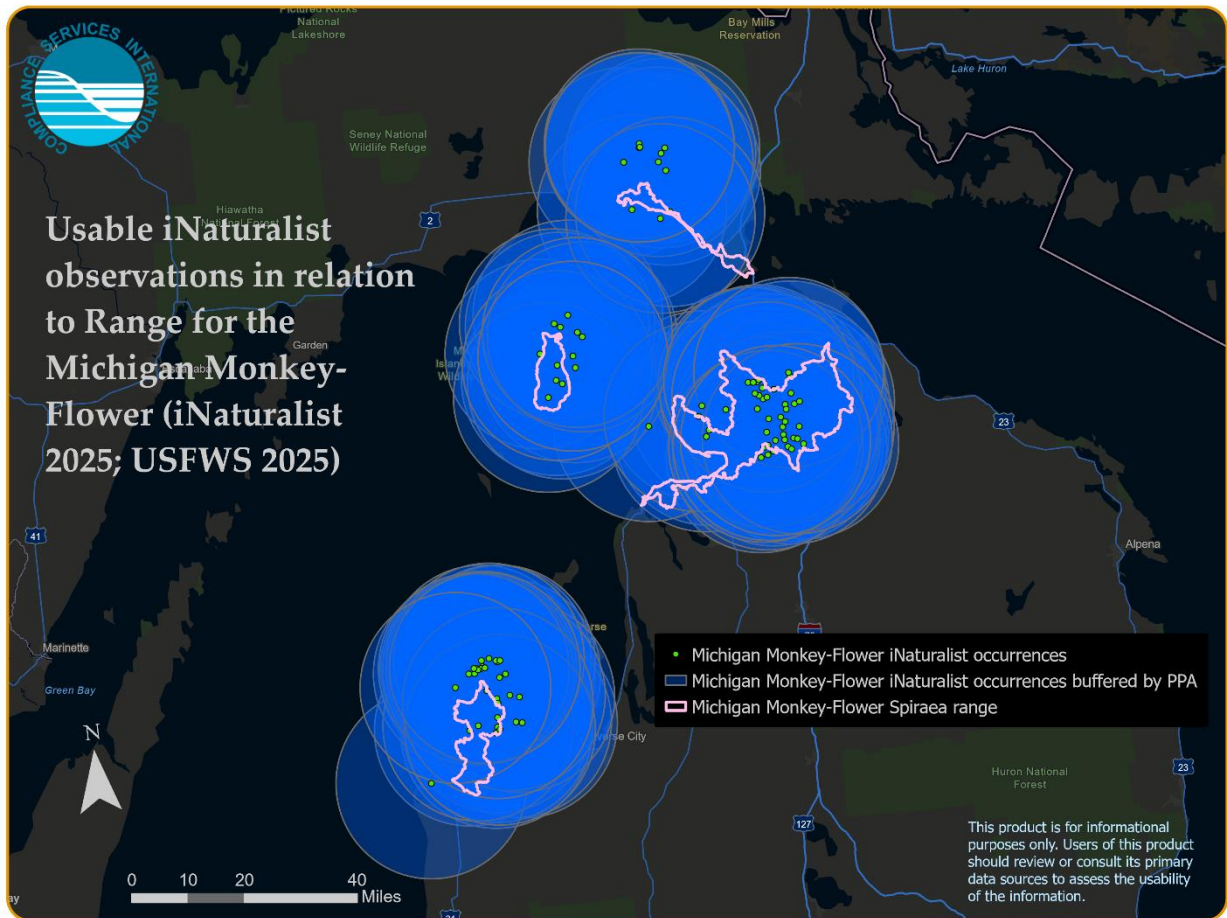


Figure 7. Usable iNaturalist observations, buffered by public positional accuracy (PPA), for the Michigan monkey-flower in relation to species range (iNaturalist 2025; FWS 2025).

- NatureServe Explorer: <https://explorer.natureserve.org/>
 - Available public occurrence information from NatureServe Explorer aligns with the information from iNaturalist and GBIF.
 - EOs were consistent with the range and did not support expanding the core map outside of the outer extent of the species range.

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 a spatial extent based on the known location information for extant populations of the Michigan monkey-flower. The core map identifies all areas within the extent (described below) matching the species habitat description from **Appendix 1**. Professional judgment was used to select water body types from the NWI dataset as described below (NWI 2023). NWI is regarded as a high quality national-level dataset that is appropriate to identify vegetation types and ecosystems that are suitable habitat for plant species such as the Michigan monkey-flower.

1. References and Software

- Software used: ArcGIS Pro version 3.5.2.
- FWS Species Range: <https://ecos.fws.gov/ecp/species/5295>.
- National Wetlands Inventory (FWS 2023): <https://www.fws.gov/program/national-wetlands-inventory>.

2. Datasets Used in Core Map Development

2.1. Range

The range for this species was last updated by FWS on April 3, 2023. A shapefile including species range for all listed species was downloaded from the FWS ECOS website on May 5, 2025. The shapefile was converted to a feature class stored in a file geodatabase and reprojected to WKID #102008 (“North America Albers Equal Area Conic”).

1. Using an ArcGIS Web Map the species was queried based on the ECOS listed “Entity ID” of 969 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 factor of 0.000247105.

This shapefile was added to an ArcGIS Pro map and compared against the known location information areas from FWS in its 2018 5-Year Review (FWS 2018; while 2023 was the most recent 5-Year Review, it indicated that occurrences have not changed since the 2018 5-Year Review). The range was used to establish the outer boundary (“extent”) of the core map by clipping known location information (a buffered points layer) by this range. More details on the geoprocessing steps used are provided in **Appendix 2.3**.

2.2. FWS 5-Year Reviews (2018 and 2023)

The most recent 5-Year Review includes the most up-to-date information about extant population locations of the Michigan monkey-flower (FWS 2023). However, this information only reinforced that the locations presented in the previous (2018) 5-Year Review were unchanged. These sites are catalogued in the 2018 document’s Figure 1 (**Figure 3** of this document). A spatial layer of these locations was created by CSI and incorporated into the development of the core map extent using the procedure detailed in **Appendix 2** Section 3.

All the occurrences presented in Figure 3 were presumed to be extant at the time of core map development.

2.3. National Wetlands Inventory (NWI) Dataset

The NWI dataset was preliminarily vetted to determine its appropriateness in representing aquatic areas matching descriptions of the Michigan monkey-flower habitat. The Michigan monkey-flower inhabits seepages and streams, frequently in association with and proximity to norther white cedar swamps (FWS

1997). CSI reviewed NWI attribute classes in relation to this description and determined that the species' potential habitat is best represented by a combination of riverine, lacustrine, and palustrine wetlands:

- Riverine (NWI code = R)
 - Subsystems: Lower Perennial (2), Upper Perennial (3)
 - Classes: Unconsolidated Shore (US)
- Lacustrine (L)
 - Subsystems: Littoral (2)
 - Classes: Rocky Shore (RS), Unconsolidated Shore (US)
- Palustrine
 - Classes: Unconsolidated Bottom (UB), Unconsolidated Shore (US), Emergent (EM), Scrub-Shrub (SS), Forested (FO).

Although palustrine waters would ideally include only alkaline pH levels, this information was not available in the waters within the extent of the Michigan monkey-flower. The possible site location types listed above were selected in the NWI dataset using a SQL query:

- `ATTRIBUTE LIKE '%R2US%' OR ATTRIBUTE LIKE '%R3US%' OR ATTRIBUTE LIKE '%L2RS%' OR ATTRIBUTE LIKE '%L2US%' OR ATTRIBUTE LIKE '%PUB%' OR ATTRIBUTE LIKE '%PUS%' OR ATTRIBUTE LIKE '%PEM%' OR ATTRIBUTE LIKE '%PSS%' OR ATTRIBUTE LIKE '%PFO%'`

The selected water body features within the core map extent were dissolved together to form the core map shape.

3. Creating the Core Map

3.1. Defining Extent

The core map extent for the Michigan monkey-flower was developed using known location information from FWS, using georeferencing and other techniques. During spatial data development, it was observed that the occurrence data shown in Figure 3 can be well-approximated by estimating their center and applying a radius of 1,600 m to create a circle overlapping the underlying feature. CSI additionally thought it appropriate to implement an additional 200 m to this distance (so, 1,800 m in total) to account for uncertainty associated with manual steps taken, and display resolution. The resulting distance conservatively captures the areas represented by these circular shapes.

1. Save an image of Figure 1 of the most recent 5-Year Review (FWS 2023; Figure 3 of this document) to a workspace ("Fig1.png").
2. Use the Raster To Geodatabase tool to import the saved image ("Fig1.png") into a file geodatabase, saved as "Fig1". Choose to output this layer and all subsequent layers in the preferred projection, WKID #102008.
3. In a georeferencing session, fit the previous image ("Fig1") 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. Save edits.
4. Create an empty points feature class ("MMF_EOs") and navigate to Edit/Create to create new points features. Use the Point tool to manually create points centered as precisely as possible on the centers of the circles identifying extant populations in the georeferenced layer. Save edits.
5. Use the Pairwise Buffer tool to buffer the points from the previous layer ("MMF_EOs") by 1,800 m and save as a new feature class, "MMF_EOs_pb1800m".
6. Use the Pairwise Dissolve tool to dissolve features from the previous layer ("MMF_EOs_pb1800m") into a layer with a single feature, saved as "MMF_EOs_pb1800m_pd".
7. Use the Pairwise Clip tool to clip the feature from the previous layer ("MMF_EOs_pb1800m_pd") by the species range ("MMF_range") and save as a new layer, "MMF_EOs_pb1800m_pd_pcRange".
8. (Optional) Export the feature from the previous layer ("MMF_EOs_pb1800m_pd_pcRange") and

save as a new layer recognizable as the spatial extent of the core map, “MMF_extent”.

3.2. Refinement based on Biological Information

The total extent of the Michigan monkey-flower core map, which comprises known locations, includes a significant area and number of different land cover types that do not align with descriptions of Michigan monkey-flower habitat. To improve confidence in the core map, a refinement based on biological information was applied to the core map extent.

The best-available dataset for suitable species habitat was found to be the NWI dataset. This spatial layer was used as a refinement of the core map area as follows:

1. Load the NWI state-level layer for Michigan wetlands into a GIS.
2. Use the Pairwise Clip tool to clip the NWI Michigan wetlands layer by the species extent (“MMF_extent”) and save as a new layer, “NWI_MI_pcExtent”.
3. Use the Select by Attributes tool to select only wetlands within the core map extent that match the habitat description for the Michigan monkey-flower. The selected riverine, lacustrine, and palustrine water bodies were queried for using the SQL query below. Save output to a new layer, “NWI_MI_pcExtent_sel”.
 - `ATTRIBUTE LIKE '%R2US%' OR ATTRIBUTE LIKE '%R3US%' OR ATTRIBUTE LIKE '%L2RS%' OR
ATTRIBUTE LIKE '%L2US%' OR ATTRIBUTE LIKE '%PUB%' OR ATTRIBUTE LIKE '%PUS%' OR
ATTRIBUTE LIKE '%PEM%' OR ATTRIBUTE LIKE '%PSS%' OR ATTRIBUTE LIKE '%PFO%`
4. Use the Pairwise Dissolve tool to dissolve the previous layer (“NWI_MI_pcExtent_sel”) into a feature class with a single shape, saved as “NWI_MI_pcExtent_sel_pd”.
5. (Optional) Export features from the previous layer (“NWI_MI_pcExtent_sel_pd”) into a new layer recognizable as the Michigan monkey-flower core map, “Michigan_Monkey_Flower_CoreMap”.

3.3. Cultivated Lands-based Refinement

The Michigan monkey-flower is not expected to be found in agricultural areas, so a refinement to exclude areas of agriculture would have been appropriate. However, it was observed that the output from the last geoprocessing step above (“NWI_MI_pcExtent_sel_pd”) contained less than one acre of cultivated land according to NLCD 2021 (Table 1). Therefore, the step of removing cultivated areas > 25 acres was considered unnecessary and thus was not performed.

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