Interim Core Map Documentation for the Knieskern's Beaked-Rush

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Species Summary

Knieskern's beaked-rush (*Rhynchospora knieskernii*; Entity ID 1228) is a monocotyledonous threatened plant found in New Jersey. The U.S. Fish and Wildlife Service (FWS) has not assigned designated critical habitat for the Knieskern's beaked-rush. This species inhabits wet bog-iron substrates near streams, and on disturbance sites such as drainage ditches, roads, and firebreaks. 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 EPA's mapping process. This documentation was not prepared by EPA, but 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 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 Knieskern's beaked-rush is biological information type, based on the species range and municipality boundaries in New Jersey refined by the species' preferred habitat. The species' Recovery Plan (FWS 1993) includes a list of municipalities in New Jersey where extant occurrences have been documented and textual descriptions of habitats where the species is known to occur. Known location information from the iNaturalist and Global Biodiversity Information Facility (GBIF) databases, and NatureServe, provided support for using the range as the outer boundary of core map extent, but were not otherwise used in core map development.

The core map for the Knieskern's beaked-rush is based on biological information, which was used to refine an extent based on state municipalities with known extant occurrences and species range. Municipalities with known extant occurrences were represented using a state-level dataset for New Jersey. Habitat areas were represented using the National Wetlands Inventory (NWI) water bodies with attributes matching descriptions of species habitat.

The core map developed in this document for the Knieskern's beaked-rush spans 4,850 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 (*i.e.* habitat preferences) to a Geographical Information System (GIS) dataset, in this case the NWI dataset (FWS 2023). These assumptions involved associating the species' primary habitat—emergent wetlands near streams—with corresponding NWI classifications, in this case, select palustrine and riverine wetlands listed in **Appendix 2** Section 2.4. More information about the best professional judgment classification system and its definitions can be found in the core map process document (EPA 2024).

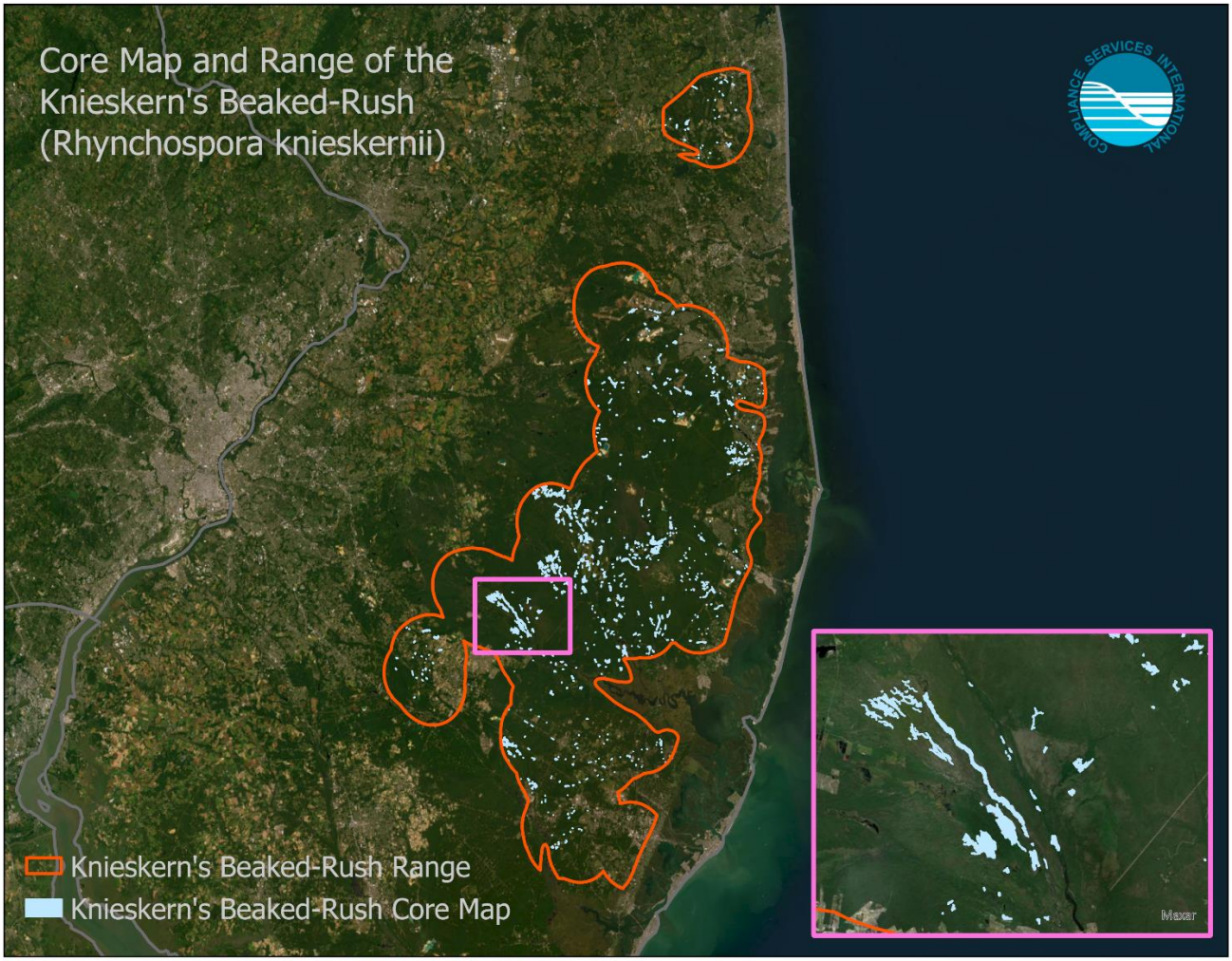

Figure 1. Interim core map for the Knieskern's beaked-rush (Rhynchospora knieskernii; Entity ID 1228). The core map spans 4,850 acres, while the range is 606,925 acres.

Table 1. Acres by National Land cover Database (NLCD 2021) class within the core map of the Knieskern's beaked-rush. Total core map area (based on NLCD pixel count): 4,847 acres[1].

NLCD_Land_Cover_Class	Acres
Woody Wetlands	3,843
Emergent Herbaceous Wetlands	559
Open Water	164
Cultivated Crops	52
Developed, Low Intensity	49
Herbaceous	42
Developed, Open Space	36
Evergreen Forest	35
Shrub/Scrub	16
Developed, Medium Intensity	14
Barren Land	13
Mixed Forest	13
Deciduous Forest	8
Developed, High Intensity	2
Hay/Pasture	1

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 seven usable research-grade observations found in iNaturalist[2]. The GBIF dataset comprised seventeen 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 Knieskern's beaked-rush, but not comprehensive enough to be used in core map development. These datasets were largely redundant because the iNaturalist observations comprised all the GBIF observations.

FWS location information comprised of municipalities in New Jersey where the species is known to occur; this provided a modest refinement of species range, removing 27.8% of potential core map area.

[1] This acreage is slightly different from the core map acreage (4,850) due to the pixelation of NLCD land cover. The core map is not developed 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-).

NatureServe public element occurrence (EO) data were also evaluated but did not contribute to the development of the core map.

Approach Used to Create Core Map

The core map was developed using EPA's process for developing core maps for species listed by 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).
3. Develop the core map for the species; and
4. Document the core map.

For step 1, CSI compiled available information for the Knieskern's beaked-rush (*Rhynchospora knieskernii*) from FWS, as well as observation information available from various publicly available sources including iNaturalist, GBIF, and NatureServe. The information compiled for the Knieskern's beaked-rush (*Rhynchospora knieskernii*) 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:

> - *'R. knieskernii* is found on wet bog-iron substrates that remain in early successional stages due to erosional forces from nearby streams. The species is also found on human-disturbed wet sites that exhibit similar early successional stages due to water fluctuation or periodic disturbance from vehicles, fire, or mowing… Knieskern's beaked-rush on WGR (Warren Grove Range) typically occurred in open, narrow patches along drainage ditches, roads, and firebreaks' (FWS 1993).

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 (municipalities in New Jersey with extant populations) 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.

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. The resulting shapes were dissolved together, clipped to the core map extent, and then had contiguous cultivated areas > 25 acres (EPA 2024) removed to develop the 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 biological information within an extent refined from species range. Designated critical habitat was quickly eliminated as a core map type because the Knieskern's beaked-rush does not have critical habitat. The range core map type was not selected because the species range is not particularly refined. **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

Known Observation Datasets

Datasets such as iNaturalist, GBIF, and NatureServe were considered but not used due to data resolution compared with other data sources.

Appendix 1. Information compiled for the Knieskern's beaked-rush

1. **Recent FWS documents**
   - 5-Year Review (2012): https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/3591.pdf
   - 5-Year Review (2019): https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/3855.pdf
   - 5-Year Review (2024): https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/21033.pdf
   - Recovery Plan (1993): https://ecos.fws.gov/docs/recovery_plan/930929b.pdf

2. **Background information**

- Status: Federally listed as threatened in 1991. Recommended for delisting in 2024
- Resiliency, redundancy, and representation (the 3Rs) (FWS 2024)
  - Resiliency: 'This large potential achene production increases the species' resiliency, or its ability to withstand stochastic disturbance events (Sobel pers. comm. 2023). Small plants can produce a few dozen achenes, while large plants can produce several hundred. Hence, a population of 10 plants can produce over 1,000 achenes. The 2022 rangewide survey indicated each EO contained up to 6,000 fruiting tufts.'
  - Redundancy: 'The number of known EOs for KBR has increased from 50 at the time the recovery plan was issued in 1993 to 105 currently. As shown in table 1, the number of known occurrences of KBR increased from 50 in 1993, to 73 in 2007, to 80 in 2012, to 96 in 2019, and to 105 in 2024. As noted, the EO numbers do not entirely reflect the overall increase for the species given that it is unclear how many EOs are at WGR due to the lack of information on the degree of interactions between the occurrences (it is approximated to be at least five but was considered one EO for the purposes of this review). These numbers (105 EOs) represent a significant increase in redundancy compared to the time of listing. While some occurrences of KBR are declining, other populations are persisting, and this may be part of the "boom and bust" cycle described in condition 4 of the recovery plan. Natural succession and resulting competition with woody and herbaceous species continue to threaten KBR habitat. While habitat destruction or degradation caused by ORVs is detrimental at some sites, KBR demonstrated resilience to ORV impacts at other sites. In some instances, the plant may benefit from the disturbance caused by ORVs.'
  - Representation: Representation has increased from 50 EOs at the time of listing to 105 EOs in 2024.

- Habitat, Life History, and Ecology
  - *'R. knieskernii* is found on wet bog-iron substrates that remain in early successional stages due to erosional forces from nearby streams. The species is also found on human-disturbed wet sites that exhibit similar early successional stages due to water fluctuation or periodic disturbance from vehicles, fire, or mowing.' (FWS 1993)
  - 'Knieskern's beaked-rush on WGR (Warren Grove Range) typically occurred in open, narrow patches along drainage ditches, roads, and firebreaks. Graminoid species were the dominant associate plants. When the litter layer was present, it was composed of slow decaying, low-nutrient pine needles. The soil moisture content averaged approximately 13 percent (N=345) among monitored study sites. Experimental data determined that soil

moisture between 10 and 12.5 percent was optimal for growth (Sobel 2015), and populations where the soil moisture remained either above or below 10 to 12.5 percent had lower densities (Bien and Sobel 2015). Because there is a direct relationship between plant water balance and soil moisture percent, plant seasonal growth and population size will be impacted during sustained flooding or water-limited conditions (Bien and Sobel 2015; Sobel 2015). Although light availability was variable among sites (28 to 90 percent), increased light availability had only a minimal positive influence on plant height and population density under either open or closed canopy cover.' (FWS 2024)

  - KBR populations tend to be small and clumped, so there may be limited genetic diversity within each locality. However, there is expected genetic diversity across the populations in the New Jersey Pine Barrens (Sobel pers. comm. 2023). Additionally, some research suggests inbreeding depression may not affect plants as much as it affects animals. As a result, genetic diversity may not be as critical to maintaining healthy and persistent populations. There have never been reported signs of disease in KBR, and an insect infestation was recorded only once. (FWS 2024)
  - Pollination: 'Buddenhagen (2016) used a sequencing methodology to examine beaksedge (tribe Rhynchosporeae) diversification. The nuclear and plastid DNA regions classify KBR in the same clade as *R*. *alba*, *R*. *macra*, and *R*. *pallida*. This may suggest KBR is likely to be fully or partially insect pollinated (Buddenhagen pers. comm 2023). Otherwise, there has been no update since the 2008 review.' (FWS 2024)

- Taxonomy
  - 'The *Rhynchospora* genus includes approximately 200 species that occur primarily in the warm regions of both hemispheres. Most of the North American species of this genus are confined to the Atlantic coastal plain from eastern Massachusetts southward (Gleason 1952). In New Jersey the genus is represented by 17 species. The genus name *Rhynchospora* is from the Greek *rhynchos*, meaning beak and *spora*, meaning seed, which refers to the beaked seed or fruit (achene) that is characteristic of the genus.' (FWS 1993)

- Relevant Potential Pesticide Use Sites
  - Pesticides are not listed as a threat to this species.

- Relevant Recovery Criteria and Actions
  - Proposed for delisting in 2024
    1. Due to the increased redundancy, relatively stable resilience as measured by EO persistence, positive response to disturbance, anticipated persistence of disturbance mechanisms, and 51 percent of extant and persistent EOs occurring entirely on Federal or State lands that require minimal management for long-term maintenance, we find that the species no longer meets the definition of either threatened or endangered under the ESA and is therefore recommended for delisting.
  - Recommendations for Future Actions (FWS 2024)
    1. Complete process for removal of ESA protections.
    2. Develop post-delisting monitoring plan in collaboration with State agencies.

3. Range

The Recovery Plan document includes a map showing the New Jersey municipalities in which the species was been observed to be extant (Figure 2). The most recent 5-Year Review document notes "Although additional [Knieskern's Beaked-Rush] occurrences have been discovered while some have been lost, no change in [Knieskern's Beaked-Rush] distribution or historic range has been identified since the 1993 recovery plan" (FWS 2024). Figure 3 shows the species' current range.

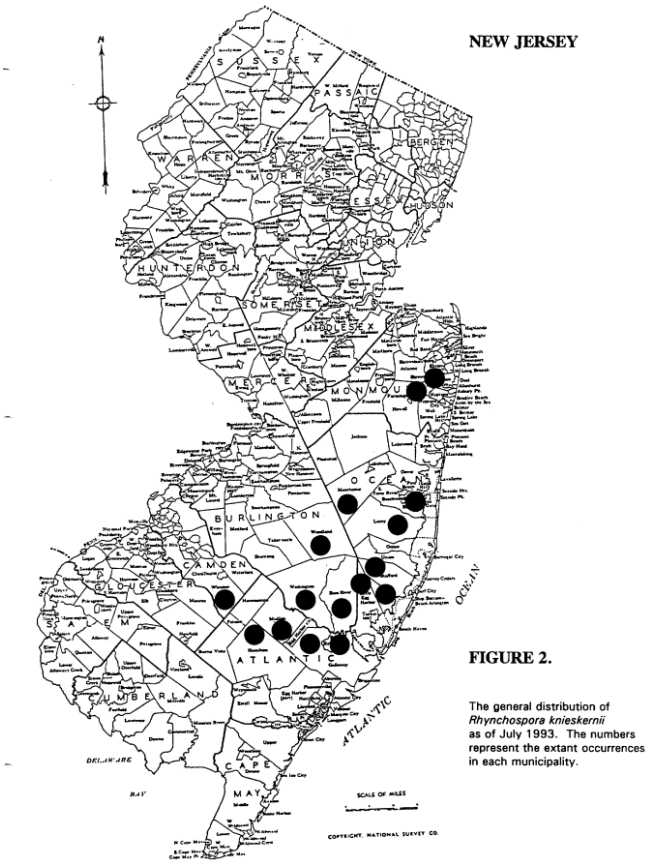

FIGURE 2.

The general distribution of *Rhynchospora knieskernii* as of July 1993. The numbers represent the extant occurrences in each municipality.

Figure 2. The general distribution of Rhynchospora knieskernii as of July 1993. Copied from Figure 2 of the Recovery Plan (FWS 1993).

Table 2. New Jersey Municipalities known to have extant occurrences of the Knieskern's beaked-rush (data taken from Figure 2 and Table 2 of the Recovery Plan (FWS 1993).

Municipality	**COUNTY**
Hamilton Township	ATLANTIC
Bass River Township	BURLINGTON
Washington Township	BURLINGTON
Winslow Township	CAMDEN
Woodland Township	BURLINGTON
Lacey Township	OCEAN
Berkeley Township	OCEAN
Manchester Township	OCEAN
Howell Township	MONMOUTH
Tinton Falls Borough	MONMOUTH
Colts Neck Township	MONMOUTH
Mullica Township	ATLANTIC
Wall Township	MONMOUTH
Galloway Township	ATLANTIC
Little Egg Harbor Township	OCEAN
Stafford Township	OCEAN
Eagleswood Township	OCEAN

'Although the historical range of [Knieskern's Beaked-Rush] included New Jersey and Delaware, it now occurs primarily in small, scattered, disjunct populations in New Jersey where it is listed as State endangered.'

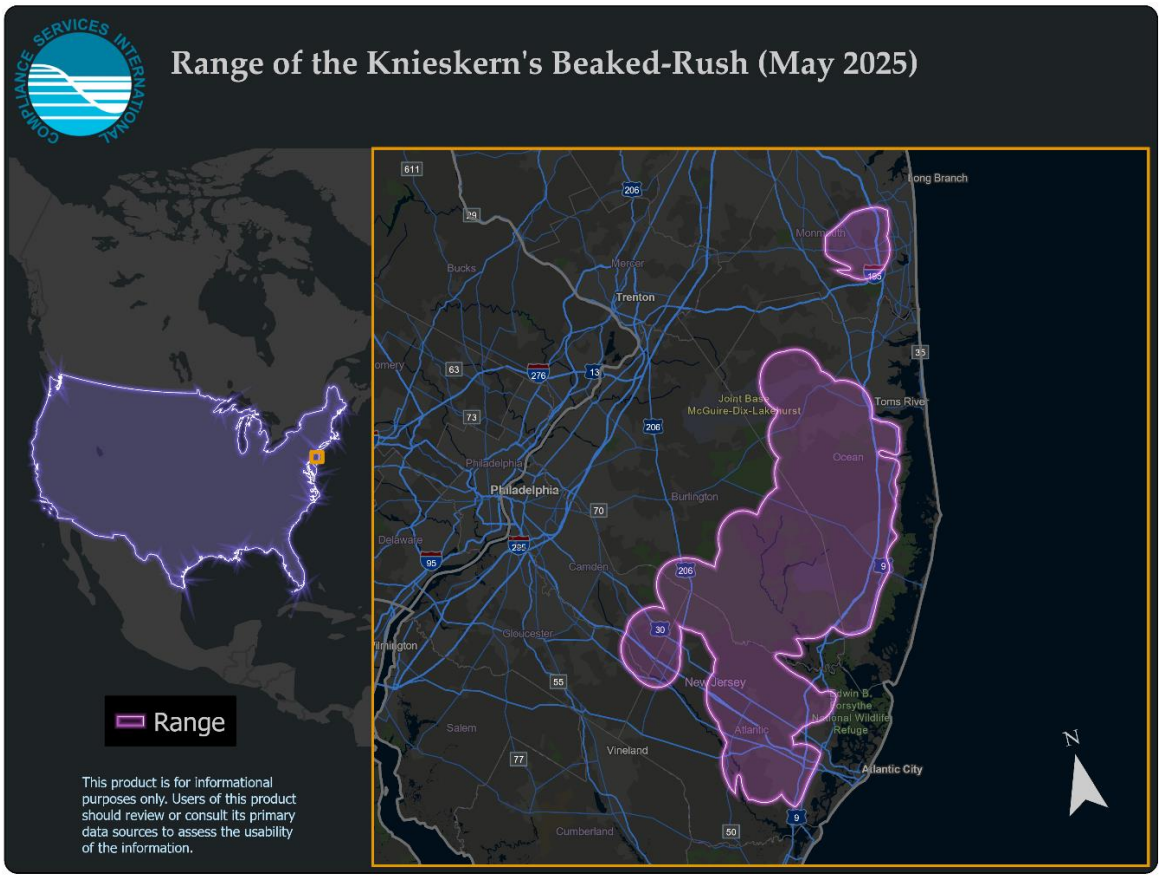

Figure 3. Range of the Knieskern's beaked-rush (FWS 2025).

4. Description of Critical Habitat

- Critical habitat has not been designated for this species.

5. Known Locations

- 'As shown [in Table 3] the number of known occurrences of KBR increased from 50 in 1993, 73 in 2007, 80 in 2012, 96 in 2019, and 105 in 2024. However, some occurrences of KBR are clearly declining (Gordon 2009, Bien et al. 2011, Palmer and Baumgarten pers. comm. 2012, Sobel pers. comm. 2017). These include one occurrence at WGR and three occurrences within the Middle Branch and South Branch watersheds of the Forked River and Crossley Preserve. As identified in the 2008 review, seven New Jersey occurrences have been confirmed extirpated. There are also KBR EOs that are likely to persist without maintenance and EOs that represent "natural sites," meaning those not created by some type of disturbance or human impact; be it road clearing, agriculture, or development' (FWS 2024).

Table 3. Summary of Knieskern's Beaked-Rush Occurrences, 1993, 2007, 2012, 2019, and 2024. Copied from the most recent 5-Year Review (FWS 2024).

1993:

State	Historic[2]	Extant[3]	Total
New Jersey	14	34	48
Delaware	2	0	2
Total	**16**	**34**	**50**

2007:

State	Historic	Extant	Occurrences unconfirmed	Total
New Jersey	21	45	5	71
Delaware	2	0	0	2
Total	**23**	**45**	**5**	**73**

2012:

State	Historic	Extant	Occurrences unconfirmed	Total
New Jersey	21	52	5	78
Delaware	2	0	0	2
Total	**23**	**52**	**5**	**80**

2019:

State	Historic	Extant	Occurrences unconfirmed	Total
New Jersey	21	68	5	94
Delaware	2	0	0	2
Total	**23**	**68**	**5**	**96**

2024:

State	Historic	Extant	Occurrences unconfirmed	Total
New Jersey	36	57	10	103
Delaware	2	0	0	2
Total	**38**	**57**	**10**	**105**

- GBIF: https://www.gbif.org/species/2721248
  - GBIF includes 329 occurrence records; seventeen of which are georeferenced (Figure 4). Six 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.
    - Relative recency (2010-present)
      - Must include date information.
    - No "preserved specimen" observations; only "human observation."
  - The six 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.

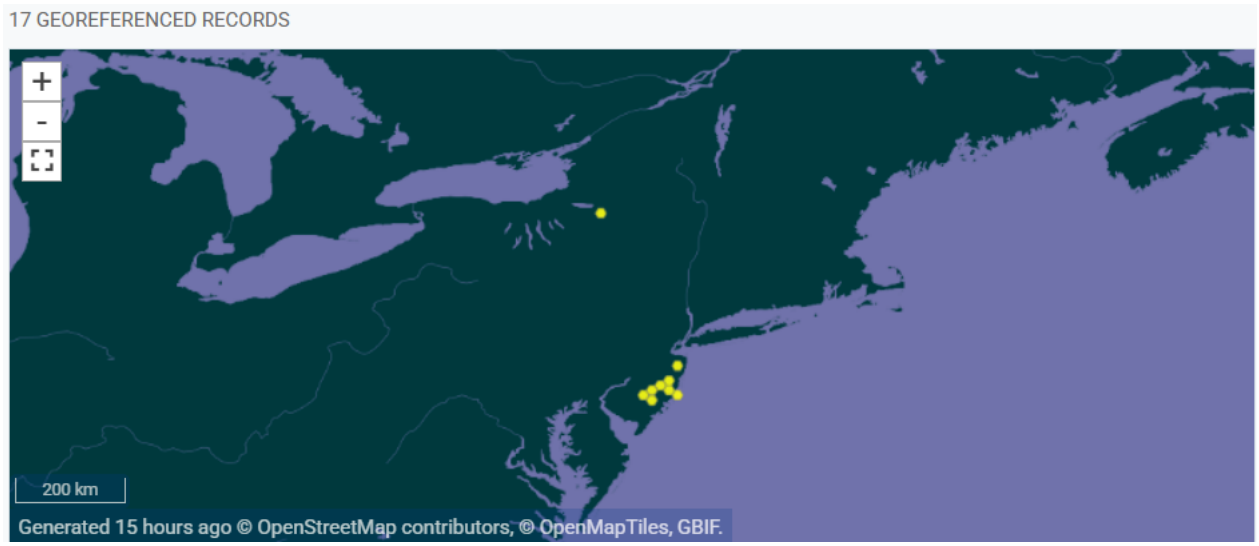

Figure 4. GBIF occurrences for the Knieskern's beaked-rush (GBIF 2025).

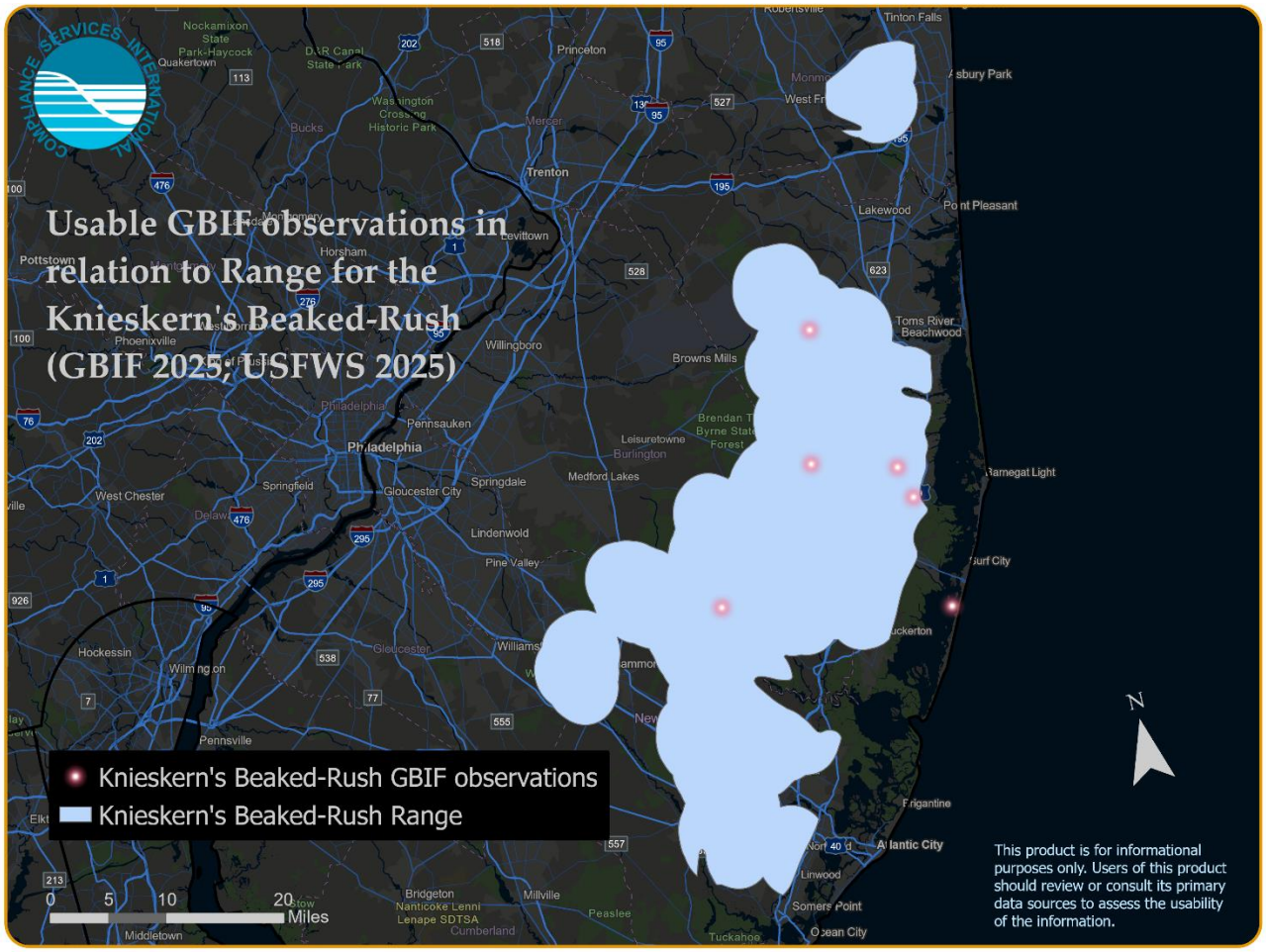

Figure 5. Usable GBIF occurrences (pink) in relation to the range of the Knieskern's beaked-rush (GBIF 2025; FWS 2025).

- iNaturalist: https://www.inaturalist.org/observations?taxon_id=167878
    - iNaturalist includes fifteen total observations (Figure 6), seven 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 [3]
            - This did not result in the exclusion of any records.
    - Locations are consistent with GBIF, which is expected because all the GBIF observations are imported from iNaturalist.
    - One iNaturalist location is just outside of the range of the Knieskern's beaked-rush; however, all the observations intersect the range when accounting for the PPA uncertainty value (Figure 7).
    - The iNaturalist data are neither comprehensive nor precise enough to be used in core map development. However, these data may provide insight into where the species is more commonly found.

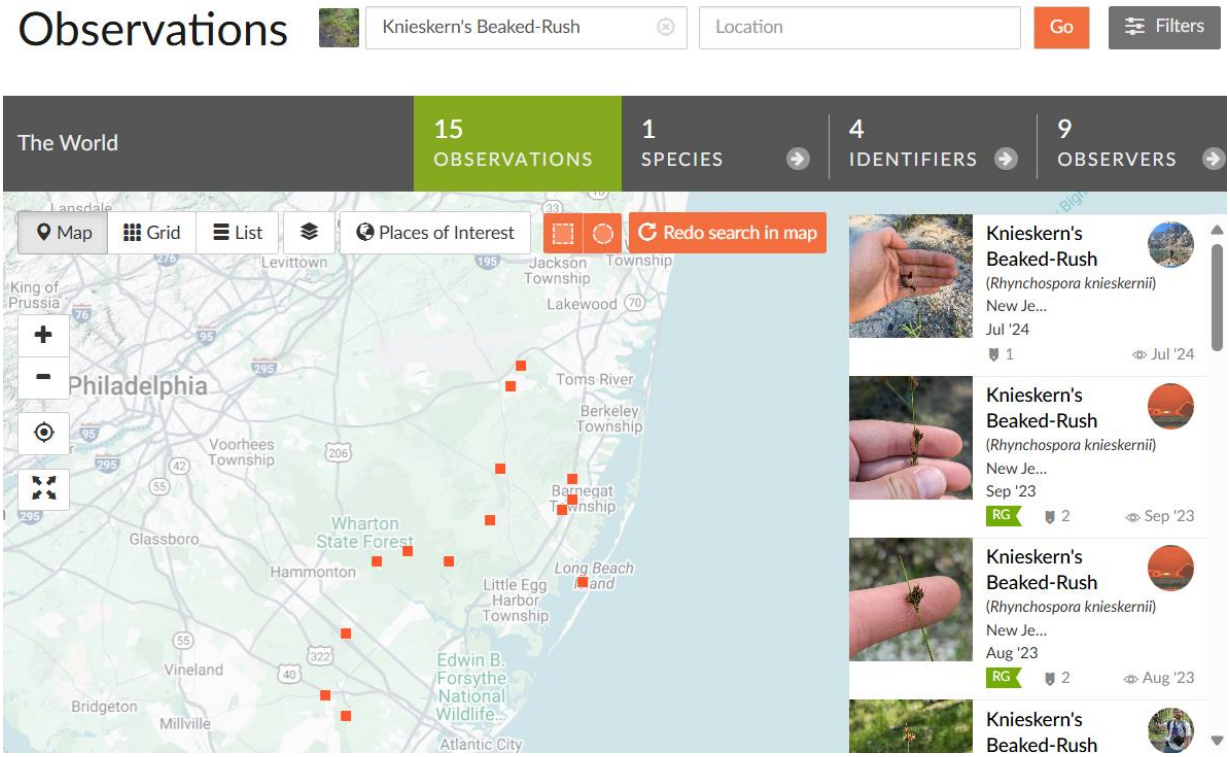

Figure 6. iNaturalist occurrences for the Knieskern's beaked-rush (iNaturalist 2025).

[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.

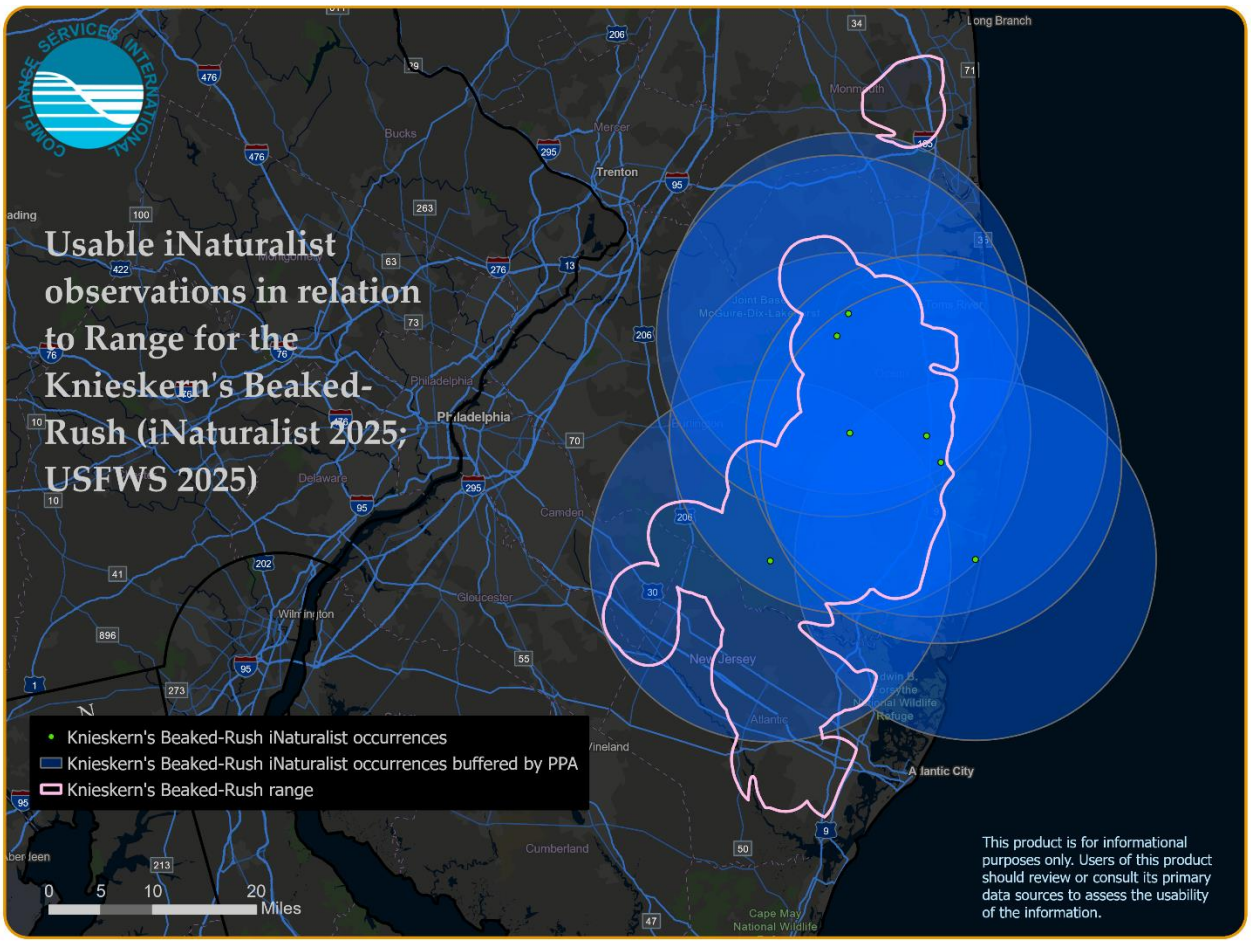

Figure 7. Usable iNaturalist observations, buffered by PPA, for the Knieskern's beaked-rush in relation to species range (iNaturalist 2025; FWS 2025).

- NatureServe Explorer: https://explorer.natureserve.org/
  - Available public occurrence information from NatureServe Explorer aligns with the information from iNaturalist and GBIF.
  - EOs were generally consistent with the range; however, these observations were not usable as a meaningful refinement of species range and therefore did not factor into the development of the core map.

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 selected New Jersey municipalities and species range. The core map identifies all areas within the extent (described below) matching the species habitat description from **Appendix 1**. Professional judgment was used to match "ATTRIBUTE" classes in the National Wetland Inventory (NWI) dataset as described below (FWS 2023). NWI is regarded as a high quality national-level dataset that is appropriate to identify aquatic habitat for plant species such as the Knieskern's beaked-rush.

1. References and Software

- New Jersey Geographic Information Network (NJGIN) Municipality Boundaries: https://njogis-newjersey.opendata.arcgis.com/datasets/municipal-boundaries-of-nj-hosted-3424/explore.
- Software used: ArcGIS Pro version 3.2.
- FWS 5-Year Review (2024): https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/21033.pdf.
- FWS Recovery Plan (1993): https://ecos.fws.gov/docs/recovery_plan/930929b.pdf
- FWS Species Range: https://ecos.fws.gov/ecp/species/3280.

2. Datasets Used in Core Map Development

2.1. Range

The range for this species was last updated by FWS on May 24, 2022. 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 1228 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 municipalities with known location information depicted in the Recovery Plan document (FWS 1993) and downloaded as spatial data from the New Jersey Geographic Information Network. The range was used to establish the outer boundary of the core map.

2.2. FWS Recovery Plan (1993) and 5-Year Review (2024)

The Recovery Plan document includes a map of municipalities in New Jersey in which the species was considered extant as of 1993 (Figure 2 of this document). Although this dataset is too old to be considered relevant on its own, the most recent 5-Year Review document explicitly states that "Although additional KBR occurrences have been discovered while some have been lost, no change in KBR distribution or historic range has been identified since the 1993 recovery plan." CSI inferred from this statement that the municipalities hosting extant populations of the Knieskern's beaked-rush have not changed since 1993 (See Appendix 1: Table 2 for list of municipalities). Therefore, municipality boundaries were used in core map development according to the textual descriptions and mapped municipalities from these FWS documents.

2.3. New Jersey Geographic Information Network (NJGIN): Municipality Boundaries

Textual descriptions and a map of New Jersey municipalities inhabited by the species are given in the 5-Year Review (FWS 2024). A spatial layer representing New Jersey municipality boundaries was obtained from the New Jersey Geographic Information Network, an open data resource. This layer was downloaded and imported into the working geodatabase using the preferred projection (WKID #102008).

2.4. National Wetlands Inventory (NWI) Dataset

The NWI dataset was preliminarily vetted to determine its appropriateness in representing aquatic areas matching descriptions of the Knieskern's beaked-rush habitat. The species inhabits wet bog-iron substrates near streams, and in some disturbed sites. CSI reviewed NWI attribute classes in relation to this description and determined that the species' potential habitat is best represented by emergent wetlands from palustrine and select riverine systems:

- Riverine (NWI code = R)
    - Subsystems: Intermittent (4) and Streambed (5).
    - Class: Emergent (EM).
- Palustrine (P)
    - Class: Emergent (EM).

The NWI was clipped to the species range, according to the procedure given in **Appendix 2** Section 3.2. This subset of NWI water bodies was queried for the riverine water body types listed above, according to the following SQL query:

- ATTRIBUTE LIKE '%PEM%' OR ATTRIBUTE LIKE '%R4EM%' OR ATTRIBUTE LIKE '%R5EM%'

The selected water body features were dissolved and had contiguous cultivated areas > 25 acres removed to represent potential habitat of the Knieskern's beaked-rush within the core map extent (selected New Jersey municipalities).

3. Creating the Core Map

3.1. Defining Extent

The core map for the Knieskern's beaked-rush was developed using municipalities known to include extant populations of the species (Appendix 1: Table 2). This is inferred from a catalog of such municipalities from the Recovery Plan document (FWS 1993) and a statement from the most recent 5-Year Review that "Although additional KBR occurrences have been discovered while some have been lost, no change in KBR distribution or historic range has been identified since the 1993 recovery plan" (FWS 2024).

The extent used for core map development was created as follows:

1. Load a layer of New Jersey municipality boundaries from NJGIN into a GIS ("NJ_muni"). Carefully inspect Figure 2 of the Recovery Plan (FWS 1993) to select corresponding municipalities from the spatial layer. Export selected municipalities as a new layer, "NJ_muni_sel".
2. Use the Pairwise Dissolve tool to dissolve the selected features from the previous layer ("NJ_muni_sel") into a feature class with a single shape, saved as "NJ_muni_sel_pd".
3. Use the Pairwise Clip tool to clip the previous layer ("NJ_muni_sel_pd") by the species range

("KBR_range") and save as a new layer, "NJ_muni_sel_pd_pcRange".
4. (Optional) Export the previous layer ("NJ_muni_sel_pd_pcRange") to a new feature class with a name that is easily recognizable as the core map extent ("KBR_extent").

3.2. Refinement based on Biological Information

The total extent of the Knieskern's beaked-rush core map—which comprises municipalities in New Jersey with extant populations clipped to species range—includes a significant area and number of different land cover types that do not align with descriptions of the Knieskern's beaked-rush 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:

2. Download the state-level dataset of NWI wetlands in New Jersey. Use the Pairwise Clip tool to clip all NWI wetlands in New Jersey by the species extent ("KBR_extent") and save as a new layer, "NWI_pcExtent".
3. Use the Select by Attributes tool to select only emergent wetlands from palustrine and riverine intermittent or streambed subsystems from the NWI wetlands layer from the previous step ("NWI_pcExtent"), using the following SQL query. Save output to a new layer, "NWI_pcExtent_sel".
    - ATTRIBUTE LIKE '%PEM%' OR ATTRIBUTE LIKE '%R4EM%' OR ATTRIBUTE LIKE '%R5EM%'
4. Use the Pairwise Dissolve tool to dissolve features from the previous shape ("NWI_pcExtent_sel") into a layer with a single feature, saved as "NWI_pcExtent_sel_pd".

3.3. Cultivated Lands-based Refinement

The Knieskern's beaked-rush is not expected to be found in agricultural areas, so a refinement to exclude areas of agriculture was applied. Here, agricultural areas are represented by EPA's modified cultivated layer, which includes areas spanning at least 25 acres. This was done as follows:

1. Use the Pairwise Erase tool to exclude cultivated areas > 25 acres from the previous layer ("NWI_pcExtent_sel_pd") according to a layer developed by EPA ("CultivatedAreas_Over25acres"). Save as a new layer ("NWI_pcExtent_sel_pd_peCultivated25ac").
2. (Optional) Export features from the previous layer ("NWI_pcExtent_sel_pd_peCultivated25ac") into a new layer recognizable as the Knieskern's beaked-rush core map, "KBR_CoreMap".

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