

**Knieskern's Beaked-rush
(*Rhynchospora knieskernii*)**

**5-Year Review:
Summary and Evaluation**



USFWS NJFO

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5-YEAR REVIEW
Species reviewed: Knieskern’s beaked-rush
(Rhynchospora knieskernii)

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5-YEAR REVIEW
Knieskern's beaked-rush / *Rhynchospora knieskernii*

1.0 GENERAL INFORMATION

1.1 Reviewers

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Cooperating Field Office:

None

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None

1.2 Methodology Used to Complete the Review:

This review was completed by the lead endangered species biologist for Knieskern's beaked-rush (KBR) in the New Jersey Field Office (NJFO) of the U.S. Fish and Wildlife Service (Service). Relevant State natural resource agency personnel—scientists/researchers, and botanists were contacted for updated information on occurrences, threats, and recovery activities (see Personal Communications under References). A 2022 rangewide survey for KBR in New Jersey was conducted by New Jersey Department of Environmental Protection (NJDEP), Office of Natural Lands Management staff Robert Moyer to inform the current status of KBR in New Jersey. All pertinent available literature, reports, and other documents used for this review are on file at the New Jersey Field Office.

1.3 Background

1.3.1 Federal Register Notice (FR) announcing initiation of this review:

89 *Federal Register* 942 (January 8, 2024): Endangered and Threatened Wildlife and Plants; Initiation of 5-Year Reviews of Five Northeastern Species. We received no information that explicitly responded to this announcement.

1.3.2 Listing history:

Original Listing

FR notice: July 18, 1991 (Volume 56, Number 138; Pages 32978-32983)

Date listed: August 19, 1991

Entity listed: Species

Classification: Threatened

1.3.3 Associated rulemaking:

None

1.3.4 Review history:

This 5-year review constitutes the fourth 5-year status review of KBR since its listing in 1991. The first review was conducted in 2008 and subsequent reviews were conducted in 2012 and 2019 (Service 2008, 2012, 2019). Information that has become available since the last review was incorporated to evaluate and assess the current status of KBR.

1.3.5 Species' Recovery Priority Number at start of 5-year review:

The recovery priority for KBR is 14, indicative of a species with a low degree of threat and high recovery potential.

1.3.6 Recovery Plan (Plan):

Name of plan: Knieskern's beaked-rush (*Rhynchospora knieskernii*) Recovery Plan (Service 1993)

Date issued: September 29, 1993

Dates of previous revisions, if applicable: Not applicable

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) Policy

2.1.1 Is the species under review a vertebrate?

No, the species is a plant; therefore, the DPS policy is not applicable.

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan containing objective, measurable criteria?

Yes

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

The recovery criteria are not current. Since the 1993 recovery plan, survey efforts have revealed many new occurrences of KBR. In addition, State and Federal regulatory programs have changed. Criterion 4 was not achieved during the timeframe specified, but new information

(presented in section 2.2.3) indicates that short-term population fluctuations are not a threat to this species but rather a typical life history trait. We address the intent of Criterion 4 in the context of current information.

2.2.2.2 Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?

No, the recovery criteria do not address factors B, C, D, and E (overutilization; disease or predation; inadequacy of existing regulatory mechanisms; and other natural or manmade factors) because these are not known threats to KBR. Although the impact of climate change was not considered, current information does not indicate the need for additional criteria (see section 2.3.2.5).

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

***Condition 1.** Permanent habitat protection is secured for a minimum of nine occurrences. This number represents the sum of known populations that are: (1) either self-sustaining or will require minimal management for long-term maintenance, and (2) already occur on public lands or meet any of the biological criteria, stated below that would warrant land acquisition for the primary objective of protecting the population. Habitat will be considered permanently protected when the *R. knieskernii* site, including an adequate buffer that ensures maintenance of the hydrological regime, is secured either through acquisition or conservation easement, and a formal commitment to long-range management is made by a government agency or conservation organization.*

Priority for protection will be given to occurrences that meet any of the following criteria pertaining to biological significance:

- a. The occurrence is found on a naturally maintained site such as a bog-iron deposit, a river or stream bank, or an area subject to natural wildfire.*
- b. The habitat is in excellent condition with, at most, only minor alterations or disturbances, none of which is directly impacting or significantly degrading the site. Population size consists of 1,000 or more plants in contiguous habitat.*
- c. The occurrence is key to maintaining the species' historical range limits or genetic variability.*

Footnote: An Element Occurrence (EO or occurrence) is the spatial representation of a species or ecological community at a specific location and represents the geo-referenced biological feature that is of conservation or management interest. Additionally, Nature Serve describes that the EO Data Standard provides a Default Separation Distance of 1 km (Nature Serve 2020). Based on this definition, most of the KBR sites are individual populations and distinct occurrences. However, it is unclear how many populations are at the Warren Grove Range (WGR) site in Burlington County, New Jersey, due to a lack of information on the degree of interactions between the occurrences (Baumgarten pers. comm. 2019, Bien pers. comm. 2019, Sobel pers. comm. 2019). In 2014, extensive surveys were conducted at the WGR and there were approximately 45 occurrences recorded or five distinct EOs using Nature Serve's definition (Sobel pers. comm. 2023). For the purposes of this review, all KBR occurrences on WGR were considered one EO.

This criterion has been met and exceeded. Moyer (2022) identified 26 persistent permanently protected sites requiring limited maintenance. Detailed information is provided in sections 2.3.1.2 and 2.3.2.1.

Condition 2. *The species is proven to be an efficient colonizer, as indicated by monitoring results, life history information, and/or the results of experimental introductions.*

KBR does colonize newly disturbed sites efficiently, and small populations have been observed in many areas of the New Jersey Pine Barrens, typically appearing after a fire in a moist area (Sobel pers. comm. 2023). Additional observations of KBR disturbance-associated emergence include road grading work, site disturbance within a utility Right-of-Way, and areas where white-tailed deer (*Odocoileus virginianus*; hereafter, deer) reduce plant competition by repeatedly bedding down in one area before moving on (Moyer pers. comm. 2023, Sobel pers. comm. 2023). KBR has also been observed along riverbanks, in wet meadows, and on bare roadsides, suggesting a moderate level of environmental diversity (Sobel pers. comm. 2023). Once other plants establish after KBR's colonization, KBR numbers decline. Overall, KBR appears to be an efficient postdisturbance colonizer but a relatively weak competitor, dependent on seed banking, achene dispersal, periodic fire and other disturbances as described in section 2.3.1.1, below.

Seed banking

A preliminary study in 2011 suggested that KBR achenes (small, thin-walled one-seeded dry indehiscent fruit) form a persistent seed bank (Sobel pers. comm. 2012). In 2013, 10 soil samples were collected at 5 sites using a hand soil corer (2.54 centimeters [cm] in diameter) to a depth of 2 cm. A total of 87 achenes were harvested from the 50 samples (1.74 ± 0.37 *R. knieskernii* achenes/core), of which 40 achenes were viable (45.9 percent). There was a high degree of total achene variability among sites (1 to 33 achenes/site) and within-site samples (0 to 13 achenes/soil sample). In 2013, sites with smaller seed banks had larger populations, suggesting that some seed banks may have more rapid turnover than others. One site had a significantly higher number of achenes ($p=0.05$), suggesting that site conditions facilitate seed bank persistence. Another site increased in population density from 258 to 1186 plants/m² following a prescribed burn, indicating fire disturbance plays an essential role for germination in persistent seed banks (Bien and Sobel 2015).

Achene Dispersal

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. Wind, water, and animals were examined as potential achene dispersal vectors because KBR achenes are small and lightweight and have surface bristles. Mean dispersal distance for achenes was greater by water (76.5 cm) than by wind (23.9 cm) (Sobel 2015). Deer were used to model animal dispersal since they are potential vectors for achene dispersal (Sobel 2015). Although a low number of achenes attached to deer legs (one to two achenes per site pass), they remained attached (78 percent) to deer legs up to 75 minutes and dispersed up to 396 m (Sobel 2015). The mean distance between known KBR occurrences on

Warren Grove Range (WGR) was 357 m. These data confirm that deer are an effective long-distance dispersing vector and potential vector for establishing a KBR founder population. Deer are uniquely capable of dispersing KBR more than about 300 m, and achenes do not travel far otherwise even under favorable conditions. Deer populations are increasing in the New Jersey Pine Barrens, which may offer more dispersal pathways for KBR (Hastings 1978). More movement of achenes should lead to colonization of a larger number of sites (greater redundancy), more opportunities for replacement of populations that suffer stochastic losses (resiliency), and greater genetic exchange (representation) (Sobel pers. comm. 2023).

Fire Effects

Fire has a complex relationship with KBR populations, but overall fire is positively correlated with population density, growth rates, and nitrogen (N) storage. The Laboratory of Pinelands Research examined the influence of fire effects on KBR. Three study sites (two in 2012 and one in 2013) were burned via prescribed burn (hereafter, “burned”) in March, and plant responses were studied throughout the growing season. Preburn and postburn plant and soil samples were compared for N and P (Bien and Sobel 2015). There was a strong correlation between N concentration in storage organs (roots/winter bud) and increased reproductive output at sites that were burned earlier in the year. Burned and unburned sites did not differ significantly in light availability, soil nutrients (N and P), or soil moisture. However, plant N uptake was greater at burned sites where plants were taller and populations were more dense (Bien and Sobel 2015). There was no difference in germination success between pretreated (heat, smoke, and charred wood) and untreated achenes (Bien and Sobel 2015). However, achenes broadcast on the soil surface had greater germination success than achenes buried below the surface (Bien and Sobel 2015). Community ordination analysis demonstrated that KBR and associate species were more clustered at recently burned sites than older burn sites and that KBR was more closely associated with pyrophilic species. Plants at burned sites exhibited significantly higher seasonal and annual total N concentration (Sobel 2015).

Condition 3. *A post-delisting strategy for monitoring the species’ population dynamics, as well as introducing (if and when necessary) the plant to suitable habitats, is in place.*

The Service currently develops post-delisting monitoring plans concurrent with proposed delisting rules. Therefore, development of a post-delisting strategy has not yet been initiated. Given the number of protected populations requiring limited maintenance, a plan for introducing KBR is not a recovery need.

Condition 4. *No evidence of decline in the species’ status is seen by 1996. This time frame takes into account the apparent stability or improvement in the status of the species seen since its listing 2 years ago [refers to listing in 1991].*

Evidence of KBR population decline was observed, and this criterion had not been met by 1996. However, this criterion may not have been an accurate indicator of KBR’s recovery as following the 2022 rangewide survey of KBR and recent additional confirmed presence survey data, there are presently 57 extant EOs, compared with 34 EOs in 1991. Over the period of 1994 to 1996, a field survey was conducted at each of 24 previously known occurrences to determine species status. Four occurrences were confirmed to be historical. Of the remaining 20 extant occurrences

surveyed, 12 had declined (60 percent) since the previously recorded survey, 6 occurrences were stable (30 percent), and 2 occurrences were increasing (10 percent).

Although the timeframe specified within this criterion for evaluating evidence of decline has passed, KBR populations were analyzed for overall trends since the 1991 approval of the recovery plan. Of eight KBR occurrences monitored at WGR from 2011 to 2014, significant seasonal differences occurred within and among populations over the study period. Significant density increases were documented during years of increased precipitation as well as burned sites. Conversely, years lacking precipitation had significant density declines. Although most KBR occurrences on WGR are small, low-density patches ($>35\text{m}^2$), these patch-size data are consistent with those reported for other patch sizes in New Jersey. There is a strong positive relationship between patch size and long-term population viability. Data for other plant species indicate that patch size is one of the most important variables in population dynamics (Matthies et al. 2004).

Additionally, eight KBR EOs were surveyed annually from 2008 to 2011 and again in 2015. Significant declines (four events) and significant increases (two events) were observed from year to year within EOs of KBR (although most variations were insignificant). All eight EOs remained extant through the years, though there was an overall declining trend (Baumgarten and Palmer 2022). These declines were attributed to either high all-terrain vehicle (ATV) traffic or successional change. Baumgarten and Palmer (2022) noted the eight EOs had an orders-of-magnitude difference, which can make it difficult to draw conclusions about KBR population health, as each EO needs to be considered within its own site history (Baumgarten and Palmer 2022). In studies that monitored KBR EO trends, there are natural fluctuations in density according to annual site characteristics. Depending on the timing of a disturbance regime or annual variations in site characteristics, KBR EO density may vary drastically.

Although previous studies detected an overall declining trend at several KBR EOs, this is expected within the context of KBR as a disturbance-dependent species (Baumgarten and Palmer 2022). Disturbance-dependent plant species typically experience temporary population increases due to a disturbance activating the seed bank. This is often followed by a gradual decline until the next disturbance triggers another increase in the plant population (Palmer and Bien pers comm 2022). As a result, an important part of KBR ecology is its “boom and bust” cycle. Following a peak in population after disturbance, populations tend to decline. When there is a resource pulse from disturbance (*e.g.*, fire), there is an associated dramatic increase in population density. This is often when new populations of KBR are discovered following an immediate decline, which is a common cycle with rare plants in fire-maintained ecosystems. Consequently, this cycle makes it more complex to assess population stability, or whether anthropogenic disturbances are inducing additive impacts (Sobel pers comm. 2023).

2.3 Updated Information and Current Species Status

2.3.1 Biology and habitat:

2.3.1.1 New information on the species' biology and life history:

Recent research has revealed new insights into KBR and associated plant species composition, relationships with mycorrhizae, soil moisture and nutrients, reproduction/growth, and annual variation in spatial occupancy and plant densities.

In 2011, research was conducted on the presence of beneficial or symbiotic fungi in the KBR root system (*i.e.*, mycorrhizal status). Five tufts of KBR were collected from Peter Knieskern Reserve in Ocean County, New Jersey and eight tufts were collected from WGR. When root samples were extracted, mycorrhizal colonization was estimated to occupy 10 to 20 percent of the root system from samples collected at WGR. Samples collected from Peter Knieskern Reserve did not contain mycorrhizal structures. Dighton et al. (2013) believe KBR is facultatively mycorrhizal because mycorrhizal colonization was found at one of the two sites surveyed. Additional research is needed to determine if edaphic factors (*i.e.*, factors influenced by the soil) or association with other plant species in the community influence the degree of mycorrhizal colonization (Dighton et al. 2013).

Monitoring efforts by the Laboratory of Pinelands Research at Drexel and Rutgers Universities suggested KBR populations show high spatial variability at the plot scale as well as year to year (Palmer and Baumgarten pers. comm. 2012).

The Laboratory of Pinelands Research examined the seasonal phenology and habitat physiognomy of the KBR from 2011 to 2014. Culms (stems) develop in May with most plants supporting a single culm with three to four spikelets (clusters of seeds); however, it is not unusual for some plants to have multiple culms in addition to the main stem. Typically, spikelets begin to form on culms in June and flower in early August. Achenes begin to form in late August and are dispersed from mid-September to late December. During the dispersal period, leaves senesce, and winter buds develop; buds remain photosynthetic until March.

Knieskern's beaked-rush on WGR 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 (Bien and Sobel 2015; Sobel 2015).

In a study on associate species composition at five KBR sites, KBR was found to be associated predominately with herbaceous communities. Additionally, data suggest there is a high diversity index among patches. Soil nutrients differed among the five sites, but root and shoot nutrient concentration (N and P) were similar among the six associate species. In 8 out of 20 plots, KBR had a greater plot biomass than associate species, especially at recently burned sites (Sobel 2015).

Soil N limitation potentially has several negative impacts on KBR. Soil samples were collected over 3 years (2011 to 2013) at five study sites within KBR occurrences and analyzed for soil N, carbon (C), phosphorous (P), ammonium (NH₄), and nitrite + nitrate (NO_x). Biomass allocation (milligram/plant dry mass) was highest in stems and lowest in reproductive organs. Soil N and P concentrations at WGR study sites were lower than that reported in the literature for other locations in the New Jersey Pine Barrens, indicating that the soil at these locations may be more nutrient limited (N and P). Plants at sites with higher soil N concentration had significantly higher concentrations of N allocated to plant reproductive organs. In contrast, there was no difference in P allocation in plant structures among sites and years, even though soil P concentrations were seasonally variable. Nitrogen allocation conversely was more variable, although higher soil N concentrations correlated with increased population density, plant height, reproductive output, and greater N allocation to reproductive organs. Additionally, greater soil moisture correlated with larger achene mass.

The Laboratory of Pinelands Research at Drexel University conducted research on the effects of fire on KBR seed banks and germination, seed dispersal mechanisms, and plant nutrient allocation. Sobel (pers. comm. 2017) also identified highly significant differences between wet weight and height based on sample month and between root length and wet weight. After 1 year of studying seed banking, Sobel (pers. comm. 2017) found the largest number of achenes occurred within sites that had a layer of pine needles. Sobel (pers. comm. 2017) believes that a long-term seed bank could exist under favorable conditions. However, results from resource allocation and seed banking studies should be interpreted with caution as they are based on a single year of sampling (Sobel pers. comm. 2017).

The Pinelands Field Station at Rutgers University, under a recovery subpermit, collected KBR individuals from 10 locations as well as other graminoid species within the Pine Barrens of New Jersey to better understand the connection between mycorrhizal colonization and population success. A nonmetric multidimensional scaling analysis indicated that plant species was a stronger driver of mycorrhizal colonization than site location. Additionally, preliminary analysis of DNA sequences showed that the mycorrhizal species differed significantly for both site and plant species identity. These results suggested that plant communities within which KBR survive have some reliance on mycorrhizae (Baumgarten 2022). Additionally, site visits from this study observed that site hydrology changed from various factors, which affected population growth. This included natural sediment movement drying out populations along road edges or causing roads to become too wet (*e.g.*, EO #031 Crossley, EO #002 Reega) and erosion along roadways due to ATV use (*e.g.*, EO #083 Old Forge Road). Baumgarten (2022) also reported that woody plant encroachment correlated with changing hydrology that affected KBR EOs (*e.g.*, EO #077 Warren Grove Gunnery Range, EO #021 Pond 74). Natural fluctuation of water tables also impacted hydrology and EO success (*e.g.*, EO #055 Hidden Pond). Although some factors are

beyond control, ATV use, unnatural erosion, and woody encroachment may be factors that could be managed to maintain favorable conditions for KBR.

Although populations of KBR can change significantly in time and space, significant declines are not predictive of probable extirpation. Population dynamics were studied by the Department of Ecology at Columbia University and the Pinelands Field Station at Rutgers University. Eight KBR EOs were surveyed yearly from 2008 to 2011 and again in 2015. Plant densities varied by site and year and examples of significant declines (four events) and increases (two events) were observed from year to year within populations. However, most variations were insignificant. All EOs remained extant but exhibited an overall trend of decline, which matched the expected patterns of a plant with life history traits acquired from living in disturbed areas (Baumgarten and Palmer *in prep*).

In 2014, all known occurrences of KBR on WGR were surveyed, with population estimates based on subsampling methodology (Bien and Sobel 2015). The mean areal size of these occurrences was 34.0 square meters (m^2) \pm 51.6 m^2 (mean \pm 1 SE [Standard Error]). Mean plant density was 5.46 plants/ 0.0625 m^2 \pm 7.05 plants, and the mean plant height was 10.3 cm \pm 7.14 cm. Common plant associate species in descending order of importance included *Dichanthelium* spp., *Aristida longespica*, *Drosera intermedia*, *Andropogon* spp. (both *A. virginicus* and *A. glomeratus*), *Muhlenbergia uniflora*, and *Hypericum* spp. (both *H. canadense* and *H. gentianoides*). Eight occurrences were monitored from 2011 to 2014 using the transect/quadrat method (as described in Bien and Sobel 2015). Mean density ranged from 50 to 373 plants/ m^2 , and mean number of plants with fruits (=achenes) ranged from 36 to 283 plants/ m^2 . Over the 2011-2015 study period, all occurrences exhibited annual variation in population size. Seven of eight occurrences had decreased population sizes and percent fruiting in 2012 but then increased in 2013 (Bien and Sobel 2015). A survey conducted at WGR (Bien and Sobel 2015) of all known KBR occurrences revealed high population variation among sites with population size ranging from 16 plants/ m^2 to 666 plants/ m^2 (mean=91 plants/ m^2).

Another study monitored population trends at eight extant KBR sites annually from 2008 to 2011 and in 2015 (Crossley Preserve (EO#31): Fox Run (EO#028), Greenberg Property (EO#049), Old Forge Road (EO#083), Pond 74 (EO#021), Reega (EO#002), Warren Grove (EO#077), and Whiting Clay Pits (EO#029)). Populations were monitored with a combination of permanent plots along an established transect and spatially randomized supplemental plots (Palmer and Baumgarten pers. comm. 2012, Baumgarten pers. comm. 2019). The methodology for monitoring KBR sites involved counting plants in established plots to evaluate population size and plant morphology. The plots provided a reliable basis for documenting annual variation (Palmer and Baumgarten pers. comm. 2012). Results showed plant densities varied considerably by site and by year (Baumgarten 2022). At the plot scale, populations ranged from 0 to 234 plants per plot. All eight EOs surveyed remained extant through the years. There were two significant increases and four significant decreases in plant density within plots through the years and an overall declining trend (Baumgarten and Palmer 2022).

2.3.1.2 Abundance, population trends, demographic features, or demographic trends:

Data from the 2022 rangewide survey and recent additional positive surveys show there are an estimated 57 extant EOs, including 6 previously unidentified EOs discovered in New Jersey. An additional previously unidentified EO was discovered in New Jersey in 2018 (EO # pending, Tuckerton RR at South Branch), although there was no KBR found at the site in 2022, and the habitat was degraded. This brings the total number of nationwide EOs to 105: 38 historic, 57 extant, and 10 occurrences unconfirmed. The presence of all 57 extant occurrences were surveyed and confirmed within the last 6 years. The 10 EOs categorized as “occurrences unconfirmed” did not have KBR present at the time of the survey. However, the portion of New Jersey surveyed was at times abnormally dry or in a moderate drought, which likely affected growth. All “occurrences unconfirmed” EOs occur in protected areas with suitable habitat, and most of them are in fire prone ecosystems. Additionally, the plant communities in some of these 10 areas are not subject to the escalated natural succession found at other sites where KBR is not likely to persist. Overall, these sites could persist given the right conditions; it would be premature to say they are no longer viable for growth of KBR.

For the 2022 rangewide survey, Moyer visited 78 KBR element occurrences (EOs). Moyer recorded KBR presence (and quantity), the current habitat narrative (*i.e.*, ecosystem type, associated plant communities, etc.), his deduction if the EO would persist based on environmental conditions and KBR population health, and if maintenance was needed to support the EO’s persistence. Of the 78 sites visited, KBR was present at 52 EOs, and Moyer determined 42 of these EOs were persistent. Additionally, nine EOs were not surveyed during the rangewide survey effort but had sufficiently recent survey data to reasonably declare their presence and persistence. Overall, 51 EOs were determined to be persistent. Persistence indicates that, unless disturbed by humans or climatic conditions, EOs will remain viable for some time until conditions are no longer suitable for their existence. Of these 51 EOs, 37 (73 percent) occurred on publicly managed State or Federal lands. Whereas 37 EOs are on publicly managed State or Federal lands, no specific agreements exist to manage and/or ensure protection of the species (*i.e.*, establish buffer zones; conduct prescribed burning; reduce human-induced disturbance). Moyer’s evaluation determined 26 (51 percent of extant and persistent EOs, 70 percent of extant and persistent EOs occurring on publicly managed State or Federal lands) of these EOs required minimal management for long-term maintenance (Moyer 2022 and Figure 1).

Additionally, Moyer considered 7 of these 26 EOs to be “natural sites,” meaning those not created by some type of disturbance or human impact, such as road clearing, agriculture, or development (EO #022 Batsto Macrosite – Big Doughnut, EO #055 Hidden Pond, EO #063 Round Pond, EO #091 Southwest of Aserdaten, EO # 093 Stafford Line Pine Plains, EO # 098 East of Bear Swamp Hill, and EO #067 Bear Swamp Hill Lowland) (Moyer 2022).

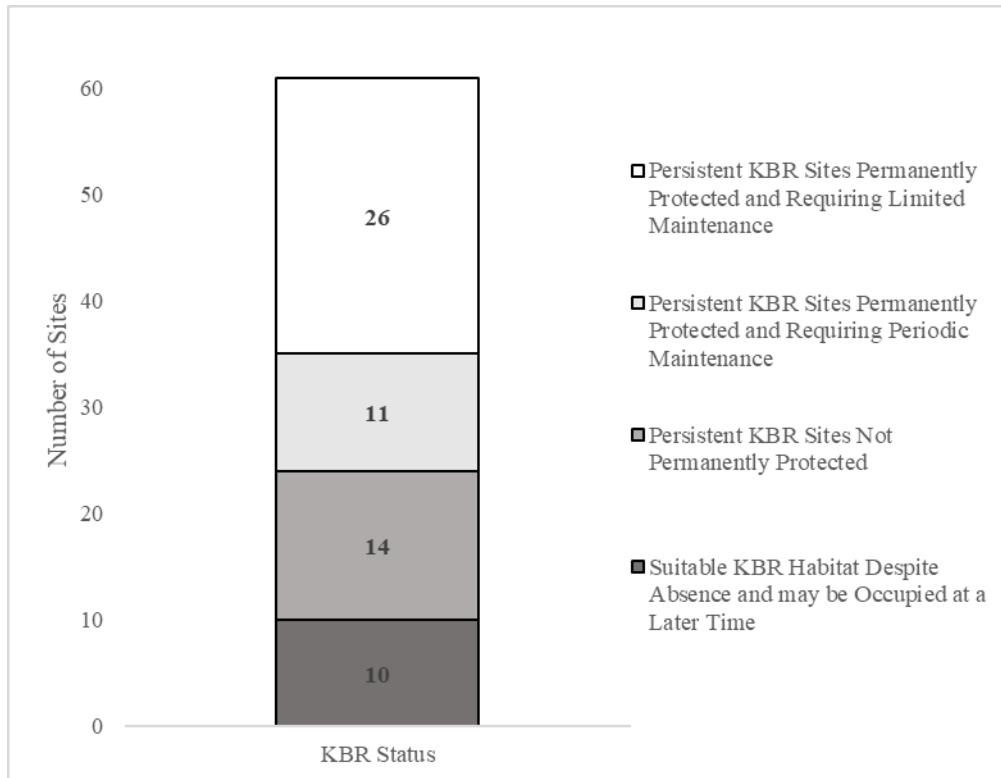


Figure 1. KBR site status based on persistence, permanent protection, and maintenance requirements.

Although the historical range of KBR included New Jersey and Delaware, it now occurs primarily in small, scattered, disjunct populations in New Jersey where it is listed as State endangered. The Service’s 2008 review estimated that there were 50 EOs (16 historic, 34 extant) in 1993, and 73 EOs (23 historic, 45 extant, 5 occurrences unconfirmed) in 2007 (table 1) (Service 2008).

When additional data became available to the Service in 2012, 7 previously unidentified EOs were discovered in New Jersey, bringing the total number of nationwide EOs to 80: 23 historic, 52 extant, 5 occurrences unconfirmed (table 1) (NJDEP 2010, 2019). Although 5 of the 80 EOs were categorized as “occurrences unconfirmed” by surveyors unable to locate plants previously identified in surveys (Berlin Avenue Bogs (EO#006), Roosevelt City (EO#014), Harry Wright Lake (EO#030), Drosera Street (EO#033) and Atsion Burn (EO#056)), it was reported that suitable habitat remained that had the potential to support KBR (NJDEP 2010). In 2019, there were 16 previously unidentified EOs discovered in New Jersey, bringing the total number of nationwide EOs to 96: 23 historic, 68 extant, and 5 occurrences unconfirmed (Service 2019).

It may be assumed that EOs (based on age of last observation 50 to 100 years ago) have become extirpated if current surveys do not identify a population at historic locations. Recent surveys suggest that several historic sites no longer have suitable habitat conditions to support KBR (Sobel 2015 and Moyer 2022). Although KBR once occurred in Delaware, no extant EOs have been found in recent years during annual surveys (McAvoy pers. comm. 2017, 2019, Keller pers. comm. 2019).

Abundance and Trends

As shown in table 1, 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, as described in section 2.2.3.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation:

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 (Sobel pers. comm. 2023).

2.3.1.4 Taxonomic classification or changes in nomenclature:

Buddenhagen (2016) used a sequencing methodology to examine beaksedge (tribe Rhynchosporaeae) 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.

2.3.1.5 Spatial distribution, trends in spatial distribution, or historic range:

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.

2.3.1.6 Habitat or ecosystem conditions:

Habitat Loss and Degradation Due to Development

Wetlands within the range of KBR continue to be lost, but at a declining rate and a trend of reduced conversion rates to urbanization indicates a positive trend overall for KBR. From 1972 to 2001, New Jersey lost about 190,000 acres of wetlands, a decline of about 20 percent. Wetland loss averaged about 11,000 acres/year between 1972 and 1984 (Lathrop 2004a). More recently, the rate of wetland conversion to developed areas has slowed dramatically, from about 2,000 acres/year between 1986 and 1995 to about 1,000 acres/year from 1995 to 2000. Rates of wetland conversion to agriculture have likewise dropped significantly (Lathrop 2004b). The New Jersey Department of Environmental Protection (NJDEP) (2002) estimates a cumulative permitted net loss (*i.e.*, acres of permitted impacts minus acres of compensatory mitigation) of 718 acres of freshwater wetlands from 1989 to 1999, suggesting that additional losses over this time period occurred in coastal wetlands and/or from unpermitted activities (Lathrop 2004a). In 2002, Lathrop (2008) estimated New Jersey was losing wetlands at a rate of approximately 2.5

acres/day. Although the annual net rate of all wetlands lost to development increased moderately from 1,442 acres/year from 1986 to 1995 to 1,573 acres/year from 1995 to 2002, the rate of loss of “natural” (*i.e.*, coastal, freshwater emergent and forested wetlands) wetlands to urbanization declined. The loss for “natural wetlands” to development decreased from 1,035 acres/year from 1986 to 1995 to 843 acres/year from 1995 to 2002 (Lathrop 2008). Wetland loss continued due to urban growth in 2007, with the net acreage of wetland loss totaling 8,652 acres statewide during 2002 to 2007. From 2002 to 2007 (1,118 acres per year urbanized), there was a 30-percent reduction in wetland conversion into urban classes than compared to 1995 to 2002 (1,601 acres/year urbanized) (Lathrop 2016). This trend continued from 2007 into 2012 where there were 1,773 acres of wetlands lost to urbanization, with forested wetlands accounting for over half the loss. Compared to 1995 to 2002, years 2007 to 2012 had a 68-percent annual reduction of wetlands converted to urban areas (Lathrop 2016). From 2012 to 2015, there was only a net change of 14 percent (378 acres) of natural wetlands lost to urbanization (Lathrop 2020).

Some occurrences of KBR are within small (<1 acre) early succession wet areas such as spring seepage areas, saturated gravel pits and borrow areas, clay pits, roadsides, streamside scour areas, wet bog iron deposits, or other isolated wetlands that are often too small in scale to be identified and mapped on State or Federal wetlands inventories. Due to the inconspicuous nature of the plant, any such areas that have not been previously documented are likely to be missed during regulatory reviews where a site inspection is not conducted by a biologist familiar with the species. Some of these small sites are known by local botanists but may not have been reported to the New Jersey Natural Heritage Program or may not have yet been mapped or included within the New Jersey Natural Heritage Program database due to State staffing shortages. Loss of such sites continues to be reported by local botanists (J. Arsenault pers. comm. 2005; W. Bien pers. comm. 2005; G. Juleg pers. comm. 2005; T. Gordon pers. comm. 2005; R. Moyer pers. comm 2023). Such site loss may also occur if KBR is removed from the federal list of endangered species. While losses of unmapped sites in small wetlands are of general conservation concern, the current number of persistent permanently protected sites suffice to buffer the risk to persistence of the species.

2.3.1.7 Other:

None.

2.3.2 Five-factor analysis (threats, conservation measures, and regulatory mechanisms):

The purpose of a 5-year review is to recommend whether a listed taxon continues to warrant protection under the ESA and, if so, whether it should be reclassified (from threatened to endangered or from endangered to threatened). This task requires that the analysis of the threats to the species be performed while assuming that the species is not receiving the regulatory protections, funding, recognition, and other benefits of ESA listing. Summaries of ongoing applications of ESA protections may elucidate future activities that constitute threats to the species. However, the analysis under Factor D focuses on the availability of alternative (*i.e.*, non-ESA) mechanisms to address the continuing and foreseeable threats.

2.3.2.1 Factor A. Present or threatened destruction, modification or curtailment of its habitat or range:

As of 2024, permanent habitat protection has been secured for 26 sites. These sites are located on publicly managed State or Federal lands and although no specific agreements have been developed to manage and/or ensure protection of the species, Moyer's (2022) evaluation determined these sites require minimal management for long-term maintenance. Natural succession and resulting competition with woody and herbaceous species continue to be a major cause of loss of KBR habitat, particularly at disturbed sites (Radis 1995; Gordon 1996). Baumgarten (2022) noted that tree growth had been encroaching on previous KBR habitat at WGR. In the 2022 range-wide survey, Moyer (2022) reported several sites where succession has been evident or posed a threat to the EO (e.g., EO #024 Reading at Harmstadt, EO #060 3 Foot Headwaters Pond, EO #1 Two Miles from Manchester, EO #061 Eagle Staff, EO #021 Pond Seventy-four, EO #047 Ocean Acres, EO #027 West Br. Wading River Macrosite-Hawkins Bridge, EO #025 Frankfurt Avenue Bog, EO #054 Melrose, EO #91 Southwest of Aserdaten, and EO #058 Eastern Plains Fireshed Macrosite). Succession changes the availability of open, wet habitat and negatively impacts KBR growth and survival. This suggests seed bank persistence is critical in understanding the species (Baumgarten *in prep*). Seed bank persistence may also mitigate threats to habitat if a KBR EO's seed bank persists through unfavorable conditions until habitat conditions are suitable again for KBR to emerge. Additionally, although there are threats to KBR habitat from succession, this is primarily mitigated by prescribed burns conducted in the Pine Barrens and at WGR. As mentioned previously, there may be annual variations in KBR density depending on when a previous burn has been conducted. If prescribed burning continues on the regular maintenance cycle, KBR EOs should not only continue to persist, but also have increased habitat availability in the future.

Use of off-road vehicles (ORVs), which includes ATVs and motorcycles, continues to cause both deleterious and beneficial effects to KBR EOs. Erosion, soil compression, and rut creation caused by ORVs also continues to be a significant threat causing habitat degradation (Radis 1995). In 2009, Gordon visited four KBR sites within the Middle and South Branch watersheds of the Forked River. Three of these sites showed significant population declines from ATVs. One site was observed to contain approximately 6,000 individuals in 1996. In 2009, approximately 300 individuals remained. More recently, ATV impacts were related to population decline at Crossley Preserve (EO #031), Old Forge Road (EO #083), and Reega (EO #002) (Baumgarten *in prep*). In the 2022 rangewide survey, Moyer (2022) reported EO habitat had been damaged due to ORV use (e.g., EO #042 North of Lazarus, EO #71 Forked River Mountain, and EO #087 Webb's Mill Branch Headwaters). Similar to the impacts of succession, ATV use reduces the availability of open, wet habitat. ATV use alters hydrology and either desiccates populations along road edges or renders the ground too wet through excessive disturbance (Baumgarten *in prep*).

In contrast, while identifying ORVs as detrimental at some sites, Gordon (1996), found that KBR "demonstrates a remarkable resilience" to ORVs at other sites, and in some instances, benefits from the disturbance. For example, Moyer (2022) reported some EO habitat had benefited from ORV use (e.g., EO #70 Forked River Mountain Macrosite, EO #90 West of Aserdaten, EO #99 Southeast of Roosevelt City, and EO #97 Southeast of Webb's Mill). In the areas where KBR habitat had benefitted, occasional ORV use created openings to allow for KBR colonization and

created drainage swales and deep cuts to allow wetland species to thrive (*e.g.*, EO #70 Forked River Mountain Macrosite and EO #97 Southeast of Webb's Mill). Moyer (2022) predicted that some EOs may not persist if ORV use did not continue because succession would follow (*e.g.*, EO #90 West of Aserdaten and EO #99 Southeast of Roosevelt City).

There have been efforts to manage ORVs in the Pine Barrens. Some counties have implemented regulations authorizing law enforcement to seize unlawfully operated ATVs and dismantle them (Gilbert 2023). A first offense for illegal ORV use and damage can carry a fine from \$250 to \$500 and up to \$1,000 for a third offense in New Jersey (Kummer 2023). Although all ORV use is considered illegal on public lands in New Jersey except for special permit events that require review to avoid sensitive species and wildlife habitats, enforcement is virtually nonexistent (Burger et al. 2022). ORVs, such as ATVs and motorcycles, are utilized in wooded areas because they can navigate and traverse through forests, which are inaccessible to most other vehicles, including law enforcement ones. Moreover, law enforcement and wildlife conservation officers are restricted from pursuing ORVs due to the dangers of pursuit. Incidents involving poachers or ORVs damaging habitats are often captured by hidden cameras. However, the lack of visible identification or registration on ORVs makes it challenging to identify the individuals involved (Burger et al. 2022). Thus, it is unlikely intervention will significantly change ORV use in potential KBR habitat.

Activities that severely degrade or destroy KBR plants and/or habitat continue. Road maintenance, particularly bulldozing and mowing, were identified as major threats to roadside occurrences (Gordon 1996; Dodds and Cartica 1998). Dumping of trash directly onto plants at roadside sites or within clay pits was also identified as a concern; in some cases, trash buries plants and/or habitat (Radis 1995; Dodds and Cartica 1998). Many of these threats were considered under Factor E at the time the species was listed.

Although habitat destruction and modification due to succession, ORV activity, road maintenance, and trash dumping are current threats to KBR, these threats present minimal risk to the species. The greatest threat, habitat succession, is primarily being mitigated through prescribed burning in the New Jersey Pine Barrens. As discussed, ORV activity has been shown to be beneficial at minor frequencies and is needed by some EOs for their persistence. While road maintenance and trash dumping are threats to individual EOs, the current mitigation is satisfactory in minimizing impact to the species.

2.3.2.2 Factor B. Overutilization for commercial, recreational, scientific, or educational purposes:

At the time of listing, most collections had been for scientific purposes and at relatively low levels. No new information relevant to this threat has been identified.

2.3.2.3 Factor C. Disease or predation:

Disease was not known to be a threat and the role of herbivory had not been determined at the time of listing. The only new information (summarized below) indicates that disease, insects, and herbivory are not threats to KBR.

There was no evidence of disease or severe insect infestation observed on plants monitored in research plots on WGR (2010-2014). Although a few plants had aphids, they did not appear to cause any detrimental effects. However, late in the growing season (September to November) several plants exhibited signs of animal herbivory. Several plants were incised just below the terminal achenes. It is thought that deer and/or rabbits were the most plausible herbivores since their scat was commonly observed at research sites (Sobel 2015).

2.3.2.4 Factor D. Inadequacy of existing regulatory mechanisms:

Regulation of Wetlands

In 1993, after publication of the KBR recovery plan, New Jersey assumed the Federal regulation of freshwater wetlands under section 404 of the Clean Water Act (33 U.S.C. 1344 et seq.) (CWA). Regulatory jurisdiction for all wetlands that support KBR was assumed by the State, eliminating Federal authorization by the U.S. Army Corps of Engineers (Corps) and thereby also removing the protections afforded by section 7 of the Endangered Species Act (87 Stat. 884, as amended; 16U.S.C.1531 et seq.) (ESA). To avoid the loss of Service review under the ESA, a Memorandum of Agreement (MOA) was signed by the Service, the NJDEP, and the U.S. Environmental Protection Agency (EPA) concurrent with State assumption to serve as a functional equivalent of section 7 consultation. Under the MOA, the Service reviews State wetland applications in municipalities with known occurrences of KBR.

The Freshwater Wetlands Protection Act (N.J.S.A. 13:9B-1 et seq.) (FWPA) and its implementing regulations (N.J.A.C. 7:7A) are the basis for State assumption and must therefore be at least as protective as the Federal 404 program. The FWPA includes several provisions that are more restrictive than the CWA. For example, the FWPA regulates essentially all activities in wetlands (*e.g.*, disturbances to soils, vegetation, or the water table), while the CWA regulates only the placement of fill material. The FWPA also regulates "transition areas," or upland buffers, either 50 feet or 150 feet wide depending on resource value, while the CWA provides no regulation of uplands. As a State law, the FWPA retains full jurisdiction over isolated and nonnavigable waters and wetlands, while Federal jurisdiction over these areas under the CWA has been curtailed by recent court decisions as discussed below.

KBR is State-listed in New Jersey as endangered under the New Jersey Endangered Plant Species List Act (N.J.A.S. 13:1B-15.151). The FWPA requires the larger, 150-foot buffer on wetlands that support federally listed species or State-listed wildlife, but not State-listed plants. If delisted, KBR would remain a State-listed species. Under current regulations, delisting KBR would limit the State-mandated buffer to a maximum of 50 feet (or 150 feet if a State-listed animal or plant also occupies the same area). In contrast, with the current protection of the ESA, 300-foot buffers are often negotiated on wetlands supporting federally listed plants through the MOA process.

Although State laws do not prohibit the collection or destruction of Federal or State-listed plants on private lands with permission of the landowner, collection and deliberate destruction have not been identified as threats to KBR (see section 2.3.2.2.)

Although wetlands do receive a high level of protection in New Jersey, many KBR populations are found in environments that may not be considered traditional wetlands. This includes small,

anthropogenically created ditches and depressions and saturated soils that do not usually pond (e.g., tire tracks from ORV use). Although KBR has been referenced as an obligate wetland species in the recovery plan, KBR is generally found only in moist mineral sites along the edges of wetlands. These sites may be impacted by indirect habitat disturbance and may not be considered protected habitat since they are not within any habitat classification schemes. Given that populations are often clustered in one area, it is critical to maintain and preserve the hydrological relationships that are within central zones where KBR is located (Sobel 2015).

Pinelands Region

The New Jersey Pinelands Protection Act of 1979 (N.J.S.A. 13:18-1 et seq.) prohibits development within the Pinelands Area unless it is designed to avoid irreversible adverse impacts on habitats that are critical to the survival of any local populations of threatened or endangered species. The 1993 recovery plan erroneously stated that the Pinelands Protection Act prohibited such development within the boundaries of the Pinelands National Reserve. However, the protections afforded by the Pinelands Protection Act apply only within the "Pinelands Area," specifically that area encompassed by the Pinelands Comprehensive Management Plan. Although the Pinelands National Reserve totals 1.1 million acres, the Pinelands Area covers 938,000 acres. Land east of the Garden State Parkway and to the south bordering Delaware Bay are omitted from the Pinelands Area. While many KBR populations are located within the Pine Barrens ecosystem, but outside of the Pinelands Area, they are not afforded protection under the Pinelands Protection Act (T. Korth pers. comm. 2002). However, these populations still benefit from the prescribed burning regime in the Pine Barrens. Although populations do occur outside of the Pinelands Area, there are sufficient populations (approximately 87 EOs) afforded protection and support within the Pinelands Area so that KBR persists).

Regulation of Stormwater Management

In 2004, the NJDEP adopted a new set of State-wide stormwater rules (N.J.A.C. 7:8 and 7:14A). The primary focus of these rules is to steer management practices away from stormwater collection and point discharge; and encourage groundwater recharge and less concentrated discharges. To the extent that these rules are implemented, they should reduce localized groundwater or water table modifications and stormwater surges, which are known to degrade KBR habitat. However, for those populations already in urban and suburban landscapes where past stormwater practices dominate, the rules provide minimal benefit. While retrofitting and improving old systems is encouraged, negligible funding for major overhauls of existing systems is provided.

WGR

Overall, WGR has the most numerous KBR EOs. Although the exact number of KBR EOs that occur on WGR is uncertain, there were 45 occurrences in 2014 (approximately 5 EOs). As long as there is a prescribed burning program on WGR, it is likely the EOs will remain stable. New EOs may be found given KBR's naturally high population fluctuations and tendency to persist in exceptionally nutrient-poor soil. KBR may also but undergo population surges concomitantly with nutrient pulses (Sobel 2015) (e.g., fire or periodic flooding). The purpose of the prescribed burning at WGR is to reduce the fuel load and maintain sight lines for target practice. These burns will continue regardless of KBR presence/absence and are not a component of any KBR management practices. Development on WGR is unlikely while the range is active and is within

the Pinelands Area, where development is highly restricted. Additionally, WGR follows an Integrated Natural Resources Management Plan (INRMP) as a guidance document and tool for natural resource management. The INRMP ensures WGR adheres to relevant environmental laws and regulations and supports sustainable, healthy ecosystems. Within the INRMP, WGR plans to contract for surveys for KBR and plans to follow the recommended approach to continue to conduct prescribed burns to open the canopy and cycle nutrients into the soil (NJANG 2023). Even if WGR were to close, WGR occurs within the Pinelands Area and is afforded protection under the Pinelands Protection Act, and the area would still be subject to prescribed burning administered by the NJFFS (see Factor E for more details on the prescribed burning regime in New Jersey). Additionally, there is a large population of northern pine snake (*Pituophis melanoleucus*) and a small population of timber rattlesnakes (*Crotalus horridus*) on WGR, both of which are protected by the State of New Jersey and reduce the potential for development in the area (Sobel pers. comm. 2023). Thus, development in this area is unlikely to be approved, and prescribed burning will continue regardless of WGR's status and KBR's listing status.

2.3.2.5 Factor E. Other natural or manmade factors affecting its continued existence:

Climate change was not considered in the recovery plan. At the time of listing, changes in the water table related to extremely wet or dry periods were documented to affect KBR populations. KBR tends to respond positively to periodic flooding for maintaining sites as early succession habitat and reducing competition, but populations can decrease rapidly following extended periods of flooding (Sobel and Bien 2015). KBR viability is dependent upon hydrological conditions and can be negatively affected by high temperatures, which are predicted to increase with climate change (Ngoy and Shebitz 2020). Specifically, climate change in the New Jersey Pine Barrens is expected to increase the frequency of forest fire and alter precipitation regimes and temperature (Sobel 2015). The EPA indicated that over the past century, the average annual precipitation in New Jersey has risen by 5 to 10 percent, and this trend is expected to continue. The EPA forecasts a 70-percent increase in precipitation from intense storms in the Northeast over the last 60 years, with projections suggesting further increases during winter and spring but minimal changes in summer and fall. Concurrently, rising temperatures are anticipated to accelerate snowmelt in spring, causing river floods, yet dry the soil in summer and fall, resulting in drought during the growing season (EPA 2016). Another climate change study revealed that the temperature rise is expected to increase rain and flooding in February and March in New Jersey, while higher temperatures are likely to increase evaporation and lead to drier soils, which may impact KBR survival (Ngoy and Shebitz 2020). During the KBR rangewide survey, Moyer (2022) noted that portions of New Jersey were abnormally dry from drought, which affected KBR growth. This trend may be more frequent with predicted climate change trends. Although climate change may increase unfavorable conditions for KBR, KBR has persisted (and many populations have increased) through periodic drought and flooding since listing. As discussed, seed banking and achene dispersal also provide buffers against extirpations and improve colonization of KBR. Overall, KBR can withstand a range of conditions and has intrinsic characteristics that allow it to repatriate/colonize new sites.

Germination of KBR was shown to benefit from stratification of seeds under cold and wet conditions. The plant was also found to be perennial when overwintered in a protected cold frame (Yurlina 1998). As such, predicted changes in climate may affect germination and growth

of KBR, although it is unknown if these changes will pose a threat to KBR or the extent of such potential threats.

Sobel (2015) indicated that fire suppression in the New Jersey Pine Barrens is a threat to KBR populations outside of WGR. The prescribed burning and fire maintenance cycles that occur on WGR are not influenced by KBR management and are based on fuel loads. However, current fire maintenance regimes support KBR recovery and the persistence of the multiple populations on the range. Observations from site population monitoring indicate that fire return intervals ranging from 6 to 8 years result in KBR increases. These increases may be necessary for the temporary revitalization of local site populations and the dispersal of the species to new areas with suitable microhabitat. The NJFFS is permitted to carry out prescribed burning under the jurisdiction of New Jersey Statutes, Title 13:9-2, general authorities of the department, and in accordance with the regulations outlined in the NJ Air Pollution Control Code (Title 7, Subchapter 27). On average, the NJFFS conducts prescribed burning on an annual average of 4,000 to 6,000 hectares on public lands and 2,000 hectares on private lands. The New Jersey Pinelands National Reserve is the most extensive contiguously forested region in the coastal plain of this area and sustains the highest level of fire activity in the region, with most forested regions in the New Jersey Pine Barrens undergoing prescribed burns at least once every 11 years (Oehler 2003). However, some peripheral KBR populations are situated in developed areas where prescribed burning is likely restricted (Sobel 2015). Although some EOs may be ephemeral due to fire suppression, KBR is likely to persist or colonize elsewhere in the New Jersey Pine Barrens in areas of prescribed burning and on WGR. Additionally, other KBR habitat that has been referred to as secure regardless of fire maintenance includes power line rights-of-way occurring in areas with Woodmansion soil and/or clay pits and occurrences on the Franklin Parker Preserve (Sobel pers. comm. 2023).

2.4 Synthesis

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.

As of 2024, permanent habitat protection meeting the recovery criterion outlined in condition 1 has been secured for 26 sites. These sites are located on publicly managed State or Federal lands, and although no specific agreements have been developed to manage and/or ensure protection of the species, Moyer’s (2022) evaluation determined these sites require minimal management for

long-term maintenance. Of these 26 sites, Moyer (2022) considered 7 to be to be “natural sites,” meaning those not created by some type of disturbance or impact by man; be it road clearing, agriculture, or development (EO #022 Batsto Macrosite – Big Doughnut, EO #055 Hidden Pond, EO #063 Round Pond, EO #091 Southwest of Aserdaten, EO # 093 Stafford Line Pine Plains, EO # 098 East of Bear Swamp Hill, and EO #067 Bear Swamp Hill Lowland).

To summarize, KBR is primarily located within the Pinelands National Reserve, an area protected by the Pinelands Commission with restricted development. This ecosystem is maintained through controlled burns by the NJFFS at least once every 11 years. KBR responds positively to these burns, although its density decreases after the initial resource pulse from the fire (Sobel pers. comm. 2023). Additionally, the species thrives after flooding, and climate change predictions indicate more frequent flooding (although long periods of flooding would negatively affect KBR). Thus, the disturbance mechanisms driving population increases are expected to persist. Although Service records indicate a total of 1,702 consultations under section 7 of the ESA for Federal agency activities that may affect KBR among other species, in all cases the Service concurred that the activities in question were not likely to adversely affect KBR. Hence, removal of ESA protections is not likely to increase threats to the species. A total of 51 percent of extant and persistent EOs occur entirely on Federal or State lands that require minimal management for long-term maintenance. The most uncertainty is associated with the effects of climate change in the future. Changes in temperature, precipitation, and frequency and length of droughts may decrease some availability of suitable habitat for the species but overall is expected to increase habitat suitability.

KBR is distributed along the eastern edge and some central portions of the Pinelands National Reserve, with small occurrences lasting for decades. Population densities naturally fluctuate, and while individual occurrences may vary, formal and informal surveys over the past two decades suggest stability in several areas, notably WGR. Although populations do occur outside of the Pinelands Area, there are sufficient populations (approximately 87 EOs) afforded protection and support within the Pinelands Area that KBR does not meet the definition of threatened (*i.e.*, likely to become an endangered species within the foreseeable future). Any post-delisting strategy should involve monitoring WGR, especially if there are changes in its utilization, and coordination with the Science Office of the New Jersey Pinelands Commission for an effective post-delisting monitoring strategy (Sobel pers. comm. 2023).

Overall, recovery criteria 1 and 2 have been achieved to date for reclassification, and an improved understanding of life history traits of the species has refined our evaluation of criterion 4.

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.

3.0 RESULTS

3.1 Recommended Classification:

Downlist to Threatened

Uplist to Endangered

Delist (*Indicate reasons for delisting per 50 CFR 424.11*):

Extinction

The species has recovered to the point at which it no longer meets the definition of an endangered species or a threatened species

No longer meets the definition of a species

No change is needed

3.2 Recommended Recovery Priority Number:

Not applicable.

3.3 Recommended Listing/Reclassification Priority Number:

Reclassification (from Threatened to Endangered) Priority Number: _____

Reclassification (from Endangered to Threatened) Priority Number: _____

Delisting Priority Number: 6

Brief Rationale:

There is a low management burden associated with the current listed status of KBR; as noted above, none of the 1,702 section 7 consultations in the Service's records required formal consultation on KBR. The recommendation to delist is not a result of a petitioned action.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

- Complete process for removal of ESA protections
- Develop post-delisting monitoring plan in collaboration with State agencies

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Table 1. Summary of Knieskern’s Beaked-Rush Occurrences¹, 1993, 2007, 2012, 2019, and 2024

1993			
State	Historic²	Extant³	Total
New Jersey	14	34	48
Delaware	2	0	2
Total	16	34	50

2007				
State	Historic	Extant	Occurrences unconfirmed⁴	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

- 1 An elemental occurrence is the spatial representation of a species or ecological community at a specific location and represents the geo-referenced biological feature that is of conservation or management interest (NatureServe 2012). Occurrences may or may not represent biologically distinct populations.
- 2 Historic sites are presumed extirpated based on age of last observation (50-100 years ago) and/or absence of plants and suitable habitat conditions at most recent site visit.
- 3 Extant sites are those in existence based on presence of plants at most recent site visit (usually within the past 20 years).
- 4 Sites categorized as Occurrences unconfirmed are those sites where the species was not found during the last known survey, possibly due to drought conditions, but where suitable habitat remained.

Table 2. Knieskern’s Beaked Rush Sites Recommended for Future Surveys

EO#	Site Name
2	Reega
3	Mackenzie Swales
21	Pond Seventy-Four
22	Batsto Macrosite-Big Doughnut
23	West Br. Wading River Macrosite-Evans Bridge
26	Reega Row
28	Fox Run
29	Whiting Clay Pits
31	Crossley
32	Sacred River-5 Points (1 small tuft)
34	Pits And Pond
37	Hockhockson Swamp
38	Shark River Station Site
39	Parkway Gravel Pits
40	Northwest Of Northfield
42	Micaja's Pond A.K.A. North of Lazarus
43	Laurel Street (N. Jack Pudding)
45	West Plains: Sykes Branch Headwaters
46	West Plains: Plains Branch Headwaters
47	Ocean Acres (all but #2)
48	FAA Tower Site
49	North Of Reega/Greenberg Property
53	Yellow Dam Branch-At& T
54	Melrose
55	Hidden Pond
58	Two Foot - Old Forge
59	Log Swamp

EO#	Site Name
60	3 Ft. Headwaters Pond
61	Eagle-Staff
62	Below Hill 90
63	Round Pond
64	East Plains - Watering Place Pond
65	Sheffield Pit
66	South Branch Headwaters
67	Bear Swamp Hill Lowland
68	Bauer Pond
69	Lakehurst Naval Air Station
70	Forked River Mountain Macrosite
71	Forked River Mountain
72	Port Republic
74	South of South Branch Forked River
75	North of South Branch Forked River
77	Warren Grove Gunnery Range
78	Middle Branch: Robbin's Cabin Trail
80	Stafford Forge
82	Hawkin's Bridge: Confluence
83	Old Forge Road
86	Southeast Of Warren Grove
87	Webb's Mill Branch Headwaters
90	West Of Aserdaten
91	Southwest Of Aserdaten
92	Howardsville
93	Stafford Line Pine Plains
94	West Plains
95	Chamberlain Branch at Route 539
97	Southeast Of Webb's Mill
98	East Of Bear Swamp Hill
99	Southeast Of Roosevelt City
Pend.	Heritage Minerals: Union Branch Tributary
Pend.	Middle Branch Forked River - West
Pend.	Southeast Of Pine Crest

**U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of Knieskern's Beaked-rush**

Current Classification: Threatened

Recommendation resulting from the 5-Year Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Appropriate Delisting Priority Number: 6

Review Conducted By: Ross Conover and Rebecca Klee, New Jersey Field Office

LEAD REGIONAL OFFICE APPROVAL

Assistant Regional Director, Region 5 Ecological Services, Fish and Wildlife Service

Approve _____ Date _____