Recovery Plan for the Furbish's Lousewort (*Pedicularis furbishiae*)

Second Revision

Painting by Kate Furbish from *Plants and flowers of Maine: Kate Furbish's Watercolors, courtesy of Rowman & Littlefield*

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Approved: _____

Regional Director
North Atlantic - Appalachian Region
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The first uses of technical terms are in **bold text** and are defined in the glossary on pages 13-14.

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I. Introduction

In 1978, the Furbish's lousewort (*Pedicularis furbishiae*) was among the first plant species listed as endangered on the United States List of Endangered and Threatened Plants, and in 1980 it was federally listed as endangered in Canada by the Committee On the Status of Endangered Wildlife in Canada (COSEWIC). It was Maine's first officially state-listed endangered plant species, and it is listed as endangered by the province of New Brunswick.

The U.S. Fish and Wildlife Service (USFWS) completed a recovery plan for the Furbish's lousewort in 1983 (USFWS 1983), which was revised in 1991 (USFWS 1991). The revised recovery plan included criteria for reclassifying the species to threatened, but there were no criteria for removing the species from the List of Endangered and Threatened Plants (delisting). A 5-year status review (USFWS 2007) included a recommendation to reclassify the species from endangered to threatened, but no listing actions were implemented. In 2018, the USFWS developed a Species Status Assessment (SSA) that resulted again in a recommendation to reclassify the species as threatened (USFWS 2018). A proposed rule to reclassify the species as threatened is scheduled in 2019. The USFWS announced the availability of a Draft Second Revision of the recovery plan on August 6, 2019 (84 FR 38288-38291); no comments were received during the public comment period. This revised recovery plan incorporates the research and monitoring data acquired for the Furbish's lousewort over the last four decades and establishes criteria for removing the species from the List of Endangered and Threatened Plants (List).

Development of this revised recovery plan was a team effort by USFWS biologists and Maine Natural Areas Program ecologists. Structured decisionmaking and modeling were not used, but were identified as tools that may inform future recovery strategies, priorities, and actions. This streamlined recovery plan is built upon the 2018 SSA and focuses primarily on the elements required under section 4(f)(1)(B) of the Endangered Species Act (ESA):

> (i) a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species;
> (ii) objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this section, that the species be removed from the list; and
> (iii) estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

Information and conclusions that we used to develop the recovery criteria are in the SSA, which was peer reviewed in August 2018. Since no new information or analyses had become available since completion of the SSA, a separate peer review of the draft recovery plan revision was not conducted.

In cooperation with the Maine Natural Areas Program, we also prepared a Recovery Implementation Strategy (RIS), which serves as an operational plan for stepping down the higher-level recovery actions into specific tasks (USFWS 2019). The RIS is a separate document from this Recovery Plan and can be modified if new information becomes available or monitoring or adaptive management reveals that expected results are not being achieved, therefore maximizing flexibility of recovery implementation.

The ESA requires that listing of plants and invertebrate wildlife be determined on the basis of the species' rangewide status. Therefore, this recovery plan provides a strategy for recovery of the entire range of the Furbish's lousewort, albeit implementation of site-specific actions is limited to the United States. The province of New Brunswick and COSEWIC have recovery plans and goals for the Canadian portion of the species' range (Furbish's lousewort recovery team 2006; Environment Canada 2010). We recognize the importance of international cooperation and communication for the future conservation and recovery of the Furbish's lousewort. Recovery of Canadian populations may depend on large, healthy subpopulations immediately upriver in Maine.

Species biology and stressors

The SSA (USFWS 2018) provides the basis for this recovery plan. It represents a thorough review of the Furbish's lousewort taxonomy, natural history, habitats, ecology, populations, and range. The SSA analyzed the species' requirements at the individual, population, and species level. It also documented the factors affecting the species' **survival** and its current and future viability in terms of the conservation biology principles of **resiliency**, **redundancy**, and **representation** (the 3Rs).

Detailed information on the life history, biology, and current status of the Furbish's lousewort is found in the SSA (USFWS 2018, pp. 4-28) and summarized briefly here. The Furbish's lousewort is an herbaceous **perennial** plant that occurs on the intermittently flooded, ice-scoured banks of the Saint John River in northern Maine and northwestern New Brunswick, Canada. It is found nowhere else in the world. The **metapopulation** of the Furbish's lousewort comprises about 20 subpopulations associated with patches of suitable habitat that occur within a 225-km (140-mile) section of the St. John River. The number of flowering stems has been monitored since about 1980 and is currently at or near a 40-year low; about 2,240 flowering stems occur in Maine (2016-2017 census) and about 167 total plants occur in New Brunswick.[1] Six of 15 subpopulations in Maine have been extirpated (5 within the last decade), all in downriver portions of the species' range.

The Furbish's lousewort most typically occurs in a narrow margin between the forest and riverbank in shaded, moist, sloped areas primarily along the south bank of the St. John River. The species cannot compete with dense growth of tall perennial herbs and woody shrubs and requires periodic disturbance from ice scour and flooding to reduce competition. At least a decade is needed between ice scour events to achieve optimal seed production. Ice scour that occurs too frequently reduces reproduction and survival. Ice scour intervals that are too long allow woody competition to outcompete the Furbish's lousewort. Plants take at least 3 years to mature and reproduce, and longevity is typically less than 15 years. The species is **hemiparasitic** and requires a perennial host plant, and it has a single pollinator, the half-black bumble bee (*Bombus vagans*).

The stressors most likely to affect the viability of the Furbish's lousewort are (1) development that causes habitat loss, erosion, and fragmentation and (2) climate change and the associated

[1] Flowering plants have on average 1.4 flowering stems per plant. Flowering stems have been counted in Maine censuses since 1980. Therefore, 2,240 flowering stems represent about 1,600 flowering plants. All plants (immature and adults) are counted in censuses in New Brunswick, Canada.

trend of warmer winters that affect the ice dynamics, flooding, and overall disturbance regime of the St. John River (USFWS 2018, pp. 21-28). Summer temperatures may eventually exceed the **climate envelope** of the species and reduce plant vigor, pollination, seed production, and germination. Other stressors were identified (herbivory, seed predation, invasive plants, and declining status of bumble bees), but were considered to have lower or unknown effects and were not analyzed further in the SSA. We predicted the effects that development and climate change would have on the distribution and abundance of plants in the future. We assessed the ability of the species to withstand environmental stochasticity and perturbations, catastrophes, and novel changes in its environment in the context of future resiliency, redundancy, and representation.

At present, the Furbish's lousewort has good to fair resiliency in upriver subpopulations, but poor resiliency in downriver subpopulations (including those in Canada). Redundancy has been reduced, especially in downriver subpopulations, many of which are extirpated or have low numbers. The species has little genetic or ecological diversity, and therefore is assumed to have low **adaptive capacity**. We anticipate that without directed conservation efforts, the primary stressors of climate change and development will lead to further declines in resiliency and redundancy, and that by 2060 the species is unlikely to remain viable. The SSA can be obtained at https://www.fws.gov/XXXXX.

Recovery vision

The recovery vision for the Furbish's lousewort is to secure the species' long-term viability so it can be delisted from the List of Endangered and Threatened Plants (50 CFR 17.12). Long-term viability requires a sufficient number of highly resilient subpopulations that:

- each have a high probability of surviving and recovering from stochastic events (periodic, local ice scour and flooding) (=resilience), and
- are distributed throughout the historical range of the species so the species can rebound from catastrophic events (extensive ice scour and flooding) (=redundancy).

Species' viability and recovery also requires that genetic diversity be maintained by sufficient **gene flow** throughout the range of the species (=representation).

Recovery strategy

Achieving the recovery vision of enhancing the resiliency, redundancy, and representation of the species such that it will have enduring viability will require a strategy that improves population health and vigor. This will be accomplished by addressing threats, restoring subpopulations where the plant is extant, as well as extirpated. Healthy subpopulations are large (greater than 440 flowering stems), are able to persist through ice scour and flooding events of varying magnitude, have adequate rates of seed production and germination, and maintain **connectivity** (the potential for gene flow between subpopulations). The metapopulation will fluctuate, but the overall trend is stable or increasing over several generations. The more numerous and healthy the individual subpopulations are, the more likely the Furbish's lousewort is to achieve the recovery vision.

To recover the Furbish's lousewort, we will work with our public and private partners to implement actions that address the three principles below.

Principle 1: To enhance the Furbish's lousewort resiliency and redundancy and maintain current representation, recovery efforts will focus on improving the **demographics** and health of extant subpopulations, reestablishing extirpated subpopulations, and enhancing connectivity and gene flow between subpopulations. If these actions fail or are insufficient such that the metapopulation continues to decline, it may be necessary to establish new subpopulations in unoccupied areas with suitable habitat or implement contingency actions to prevent extinction.

For the Furbish's lousewort species to be resilient, a sufficient number of individual subpopulations must be capable of persisting in the face of stochastic events. Subpopulations are considered resilient when they are sufficiently large to rebound from periodic episodes of mild and moderate ice scour and flooding and remain stable or increase over several generations without excessive human intervention. Subpopulation size is the key measure of resiliency, because large subpopulations are most likely to have some plants that survive ice scour and flooding and produce sufficient seed for post-scour regeneration. Also, large subpopulations indicate the presence of favorable environmental conditions (e.g., shaded forested buffers, moist soils) essential to germination, establishing seedlings, and growth of young plants that will constitute the next generation. The Furbish's lousewort is a long-lived plant that occurs in a dynamic environment, and subpopulations are expected to fluctuate in response to mild and moderate ice scour and flooding in the future.

Sufficient redundancy will be achieved when the number of well-distributed, resilient subpopulations is large enough that most subpopulations are highly likely to persist through and rebound after catastrophic ice scour and flooding. The metapopulation rebounded from catastrophic ice scour and flooding in 1989 and 2003 when there were 14 to15 subpopulations in Maine (USFWS 2018, figure 6, p. 20), but it has not rebounded from more frequent ice scour and flooding that occurred about 2010 following a decline to just 9 subpopulations. We have no census information pre-dating 1980, but there may have been more than 15 subpopulations in the past (especially in the 13-mile gap in the species' range between the subpopulations at St. Francis and Fort Kent and 40-mile gap between the subpopulations at Fort Kent and Van Buren, Maine). To achieve long-term resilience and redundancy, it is important to retain most, if not all, of the nine extant subpopulations in Maine and the five extant subpopulations in Canada; restore the six extirpated subpopulations in Maine, and possibly create new subpopulations where there is suitable habitat (figure 1, USFWS 2018 table 5). Because we anticipate increasing frequency and severity of ice scour events in the future (USFWS 2018, pp. 23-25, 43, 47-48, 49, 58) and the Furbish's lousewort has a long generation time (one generation is about 10 years) (USFWS 2018, p. 40, 42), the criteria for delisting will be assessed over the timeframe of three decades to assure that long-term viability has been achieved.

To maintain the species' adaptive capacity, recovery actions will focus on maintaining its extant genetic diversity, which will be conserved by restoring the resiliency and redundancy of subpopulations. Restoring resiliency and redundancy of subpopulations will reduce the risk of further loss of subpopulations, and thus their contribution to genetic diversity, and increase natural gene flow within and between subpopulations, reducing loss of genetic diversity from genetic drift associated with small populations. Future genetic studies may identify the need for additional activities to conserve the species' genetic diversity or genetic structure.

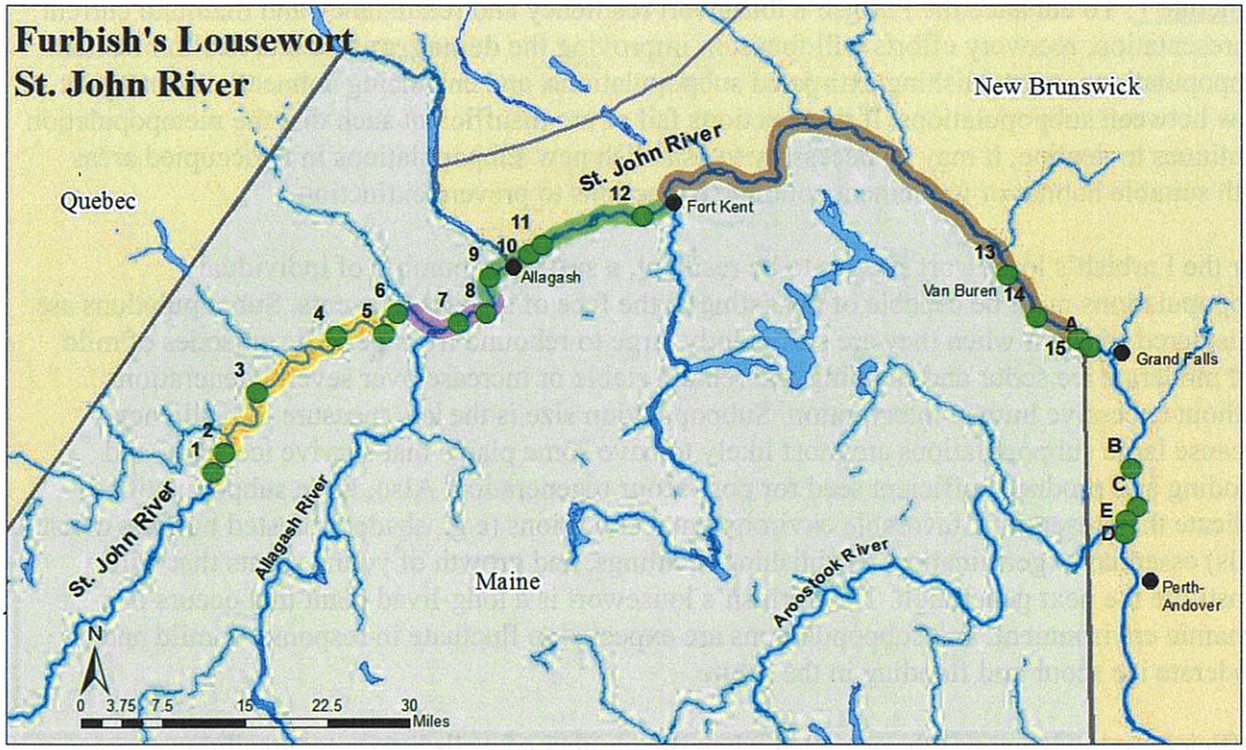

Figure 1. Locations of the 15 subpopulations of the Furbish lousewort in Maine and 5 in New Brunswick, Canada. In Maine, subpopulations 1-6 are considered "upriver," and subpopulations 7-15 are considered "downriver." Subpopulations A-E are in New Brunswick, Canada.

Principle 2: Recovery efforts will focus on addressing threats to the species. Recent declines and local extirpations of the Furbish's lousewort are best explained as a consequence of climate change (increasing frequency and severity of ice scour and flooding) (USFWS 2018 pp.23-27) and habitat loss and degradation from development (USFWS 2018 pp. 22-23). Numerous large, healthy subpopulations will be more resilient to the increased frequency and severity of ice scour and flooding caused by climate warming and development (Principle 1). Therefore, to address threats, near-term recovery efforts will focus on restoring subpopulations that have declined, re-establishing those that have been extirpated, and protecting habitat. Near-term recovery efforts will also include research to better understand the effects of increased ice scour frequency and to document the temperature and drought tolerance of the species.

Recovery actions to protect habitat will require different strategies in the upriver and downriver areas. We anticipate little development in the upriver area in the next 40 years (USFWS 2018, pp. 43, 48, 50-52). Currently, this is a managed forest landscape where about 8 percent of the metapopulation is permanently protected by conservation easements and fee title lands. The recovery strategy in upriver areas is to protect the six extant subpopulations. We will work with Maine forest landowners and easement holders to maintain a 250-foot forested buffer along the river and to protect additional habitat through conservation easements or fee title if opportunities arise. We anticipate moderate development to continue in the downriver area where six of nine subpopulations were extirpated since about 2009. The recovery strategy in the downriver areas is to prevent further habitat loss, restore habitat, and restore subpopulations. This includes reducing shoreline erosion and invasive plant species and restoring a 250-foot forested riparian buffer.

Degraded habitats will be restored to suitable conditions when and where appropriate, and extirpated populations will be restored with seed or propagated plants. Long-term habitat management and protection must be assured to protect downriver subpopulations. There is currently no permanent habitat protection in the downriver area. Habitat protection strategies may include long-term management plans and agreements, municipal zoning to protect the forest buffer and prevent shoreline erosion, and permanent habitat conservation (fee title, easements). The USFWS' National Wildlife Refuge System protects important endangered and threatened species habitats across the country and is a potential partner, along with other land management agencies and nongovernmental organizations, in securing protection of Furbish's lousewort sites.

As described above, efforts to reduce threats will initially address the effects of climate change and development. Future monitoring and research will improve understanding of the species' vulnerability to these stressors and may identify additional stressors. For example, declines of the half-black bumble bee in the St. John River valley could reduce pollination and seed production of the Furbish's lousewort[2]. Herbivory by snowshoe hares (*Lepus americanus*) and seed parasitism by plume moths (*Amblyptilia pica*) could also reduce seed production (USFWS 2018, p. 27). As new information becomes available, recovery activities may require an adaptive management approach, potentially including actions to be implemented if conditions identified under Contingency Planning (below) occur. Structured decision-making, modeling, and other tools will be used to evaluate management options and priority.

Principle 3: An important element for achieving recovery is establishing and maintaining collaboration with landowners, municipalities, the Maine Land Use Planning Commission, and conservation partners (the Maine Natural Areas Program, the Maine Chapter of The Nature Conservancy, and other land trusts). Most of the species' habitat is located on privately owned lands, managed forest lands in the upriver subpopulations and small private landowners in the downriver subpopulations. Collaboration with landowners and other partners will require clear and frequent communication about the species' needs, planned conservation efforts, and the potential implications of specific recovery actions. It is important to ensure recovery goals are met in concert with the missions, objectives, and aspirations of local partners. Because the range of the Furbish's lousewort extends into New Brunswick, communication and collaboration with Canadian partners will also provide key contributions to recovery of the species.

Contingency planning

The most recent census (2017) documented that the metapopulation is near the lowest number since 1980 (USFWS 2018, figure 6, p. 20, 38, 41).[3] Since the 2010-2011 census, the metapopulation declined an average of about 10 percent per year. The decline is most evident in downriver populations that did not rebound from the widespread, severe ice scour and flooding in 1989 and the frequent, severe ice scour that occurred in 2010. Six of nine downriver

[2] Although declines in the half-black bumble bee are not currently identified as a primary stressor, periodic monitoring is included in recovery actions to provide baseline conditions and identify any future declines in bumble bee populations, pollination, or seed production.

[3] Two subpopulations were discovered since 2005; the most upriver subpopulation in Maine at Blue Brook and the most downriver subpopulation at Hamlin Corners) (USFWS 2018, appendix 2). Even with the addition of these subpopulations, the 2016-2017 census of flowering stems in Maine is nearly the lowest recorded since 1980 (USFWS 2018, figure 6).

subpopulations were extirpated (USFWS 2018, figure 8, p. 21, table 5, pp. 36-37). The near-term recovery strategy (above) is to reverse these trends and restore large, healthy subpopulations throughout the historical range. Contingency actions would be implemented to achieve the recovery vision, if the metapopulation declines below 1,200 flowering stems for 2 or more consecutive biennial censuses OR if there are 4 or fewer extant upriver subpopulations OR if there are 2 or fewer extant downriver subpopulations OR if seed production is not sufficient to achieve a stable or increasing metapopulation. Contingency actions may include establishing new populations in previously unoccupied but suitable habitat, storing seed, establishing captive populations, ameliorating factors that reduce seed production, and other strategies to prevent extinction. In 2019, our Canadians counterparts determined that they had already reached a critical low population threshold for the Canadian portion of the metapopulation and began to initiate these types of recovery actions. In a worse-case scenario, the species may need to be established on rivers further north in Canada where the disturbance regime and climate are suitable.

II. Recovery Criteria

Recovery criteria serve as objective, measurable guidelines to assist in determining when an endangered species has recovered to the point that it may be downlisted to threatened, or that the protections afforded by the ESA are no longer necessary and a species may be delisted. Delisting is the removal of a species from the Federal Lists of Endangered and Threatened Wildlife and Plants. Downlisting is the reclassification of a species from an endangered species to a threatened species. The term "endangered species" means any species (species, subspecies, or Distinct Population Segment (DPS)) that is in danger of extinction throughout all or a significant portion of its range. The term "threatened species" means any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Revisions to the Lists, including delisting or downlisting a species, must reflect determinations made in accordance with sections 4(a)(1) and 4(b) of the Act. Section 4(a)(1) requires that the Secretary determine whether a species is an endangered species or threatened species (or not) because of threats to the species. Section 4(b) of the ESA requires that the determination be made "solely on the basis of the best scientific and commercial data available." Thus, while recovery plans provide important guidance on methods of minimizing threats to listed species and measurable objectives against which to measure progress towards recovery, they are guidance and not regulatory documents.

Recovery criteria will help indicate when we would anticipate that an analysis of the species' status under section 4(a)(1) would result in a determination that the species is no longer an endangered species or a threatened species. A decision to revise the status of or remove a species from the Lists, however, is ultimately based on an analysis of the best scientific and commercial data then available, regardless of whether that information differs from the recovery plan. When changing the status of a species, we first propose the action in the *Federal Register* to seek public comment, followed by a final decision announced in the *Federal Register*.

The following recovery criteria are based on information recently compiled in the SSA (USFWS 2018). The criteria are premised on the entire metapopulation as the representative unit, but

provide for distribution between the upriver and downriver areas to assure conservation across the species' historical range. The following criteria describe the conditions indicative of a recovered species. In light of the recommendation to reclassify the Furbish's lousewort as threatened, downlisting criteria in the 1991 Recovery Plan (USFWS 1991) are now obsolete.

Recovery criteria

Criterion 1. The metapopulation is viable, comprising a 30-year median of 4,400 flowering stems or greater, and distributed as follows:

- **Upriver: a 30-year median of 2,800 flowering stems or greater in at least 6 subpopulations with at least 3 good and 3 fair subpopulations;**
- **Downriver: a 30-year median of 1,600 flowering stems or greater in at least 9 subpopulations with at least 3 good and 6 fair subpopulations.**

Once the upriver and downriver criteria are reached, the median number of flowering stems for each respective river section will remain stable or increase over a period of at least 30 years (three generations) without augmentation, reintroduction, or hand-pollinating of plants. Additionally, in New Brunswick there is a 30-year median of 1,100 plants distributed among at least 5 subpopulations (Resiliency and Redundancy).

We calculated several measures of central tendency (median, mean) from census data collected from 1980 to present (USFWS 2018, appendix 1). The median census counts 1980-2015 were adjusted upward by 500 flowering stems prior to 2004-2005 (to account for the recently discovered subpopulations #1 Blue Brook) and adjusted upward 300 flowering stems prior to 2008-2009 (to account for the recently discovered subpopulation #15 Hamlin Corners). We truncated the census data at 2015, after which the metapopulation entered a substantial decline. We selected the recovery criterion of 4,400 flowering stems. A median metapopulation of approximately 4,400 flowering stems demonstrated resilience in the past (i.e., the metapopulation recovered from severe ice scour and flooding events in 1989 and 2003) (USFWS 2018, figure 6, p. 20).

"Upriver" represents subpopulations 1-6 and "downriver" represents subpopulations 7-15 in Maine as depicted in figure 1 and described in the SSA (USFWS 2018, table 5, pp. 37-38). We reviewed the peak and median counts for the six upriver and nine downriver subpopulations. We selected a recovery criterion of 2,800 flowering stems in upriver subpopulations that exhibited resilience in the past (USFWS 2018, figure 8, p. 21). A population of approximately 1,600 flowering stems in downriver subpopulations exhibited resilience in the 1980s (USFWS 2018, figure 8, p. 21).

Descriptions of what constitutes good and fair subpopulations of Furbish's lousewort are described in the SSA (USFWS 2018, table 4, pp. 32-33). These qualifiers are based on three attributes of the subpopulation (abundance, density, and current status compared to the site history) and three habitat criteria (the amount of potential habitat, the condition of the forested riparian buffer, and the prevalence of erosion events). The suitable habitat supporting each subpopulation need not be contiguous, but the habitat patches should be within the dispersal distance of the half-black bumble bee. Patches of flowering plants should be less than 1 mile apart.

Achieving the overall abundance and goals for upriver and downriver subpopulations alone is not sufficient to achieve Criterion 1. It is critical to demonstrate that after reaching the trend for both the upriver and downriver subpopulations each remain stable or increase for 30 years without augmentation, reintroduction, or hand-pollinating of plants. Three generations (30 years) represents the minimum number of generations and population cycles required to detect demographic trends for this species. A metapopulation that is stable or increasing for three generations (30 years) would be expected to remain resilient to ice scour and flooding forecasted under a RPC4.5 climate scenario (USFWS 2018, pp. 44-48), but the metapopulation may not be resilient to ice scour and flooding under higher emissions scenarios (e.g., RPC8.5). A longer time frame may be necessary to ensure population viability if a stable or increasing trend has not yet been observed. Additionally, a longer time period may be required to further reduce threats and demonstrate the effectiveness of management.

The recovery criterion of 1,100 total plants is from the Canadian recovery plan for the Furbish's lousewort (Environment Canada 2010).

Genetically robust subpopulations will be sufficiently large such that no further loss of heterozygosity and diversity of alleles are likely. The **climate envelope** needed to maintain current genetic diversity has not been determined at the subpopulation or metapopulation scale. Future genetic studies may better inform the populations needed to maintain current genetic diversity (or the subpopulation sizes needed to maintain genetic structure within the metapopulation, if it exists). If larger numbers are needed to maintain genetic diversity, then this population recovery criterion may need to be revised.

Criterion 1 is needed to restore the species' resilience, redundancy, and maintain the breadth of its genetic and ecological diversity, thereby maintaining the species' ability to adapt to a changing environment (representation).

We based the metapopulation goal in Criterion 1 on the past performance of the species. However, if the effects of changing river behavior because of climate change are more severe than expected (i.e., more frequent and more severe ice scour and flooding), then a larger metapopulation and more than 15 subpopulations may be necessary for the species to remain viable.[4]

Criterion 2. There is long-term habitat protection for all subpopulations in Maine that provides for the species' needs throughout its life cycle.

Long-term habitat protection mechanisms must assure important species' needs:

- forest overstory shade conditions (about 50-percent sunlight) by protecting or restoring a forested riparian buffer of 250 feet adjacent to suitable habitat;

[4] Note that in some instances, creating new populations between existing subpopulations could cause subpopulations to become continuous. (Currently, our definition of a subpopulation is a collection of Furbish's lousewort plants that are separated from other Furbish's lousewort plants by one mile of more.) Establishing new Furbish's lousewort sites may be desirable for recovery but some subpopulations could be merged, thus reducing the number of subpopulations. This will be taken into account when evaluating progress toward achieving recovery criteria.

- moist soil conditions and seeps by limiting further shoreline erosion and bank slumping, and restoring suitable habitat where it has been damaged from past events;
- native vegetation that newly germinated Furbish's lousewort plants can parasitize;
- site conditions without excessive plant competition, especially from tall shrubs and robust herbs;
- populations of the half-black bumble bee sufficient to assure pollination and subsequent seed production.

Long-term habitat protection mechanisms must assure access to subpopulations for monitoring, research, and management.

"Long-term" means that species' needs and access is assured for at least 50 years. Long-term habitat protection must be assured for all 15 subpopulations that are needed to provide redundancy. The mechanism of long-term habitat protection will be relevant to each subpopulation and may be achieved through memoranda of agreement, municipal and forestry zoning, or permanent conservation (fee title or conservation easement).
Achieving Criterion 2 will ensure that there is a long-term commitment to meet the biological needs of the species, and there is long-term access to Furbish's lousewort subpopulations for monitoring, management, and research.

Recovery criteria and the factors for listing the Furbish's lousewort

The Furbish's lousewort was originally listed because of threats related to Factor A (present or threatened destruction, modification or curtailment of the species habitat or range). At the time of listing, the proposed Dickey-Lincoln Dam presented a significant threat to the species, but the dam proposal was decommissioned in 1986 by Congress negating this threat. Development was recognized as a threat at the time of listing and continues to be a primary stressor. It is being addressed through the habitat protection strategies in Criterion 2.

Since listing, herbivory, seed predation, reduced pollination, and the proliferation of invasive species have been identified as possible stressors (Factor C, Disease or Predation). However, their current influence on Furbish's lousewort populations is unknown. Demographic monitoring and research associated with Criterion 1 will indicate whether these potential stressors or other disease and predation factors have population-level effects that warrant investigation and amelioration.

Climate change (Factor E, Other natural and human made factors) was first identified as a significant stressor in a 5-year status review for the Furbish's lousewort (USFWS 2007). The near-term strategy to address climate change is to restore resiliency and redundancy by increasing the extant subpopulations and restoring extirpated subpopulations to levels observed in the 1980s and 1990s (Criterion 1).

III. Recovery Actions

The actions identified below are based on our current understanding of the recovery needs of the Furbish's lousewort. When fully implemented, we believe these actions will result in a viable metapopulation of the Furbish's lousewort comprising many resilient subpopulations protected

from threats. Each action has a priority ranking and estimated cost for its completion.[5] Specific activities and tasks required to implement these recovery actions and estimates of their costs are detailed in the RIS (USFWS 2019b).

Recovery Actions	Estimated Cost in $1000s for each 10 Year Period					Priority
	2019-2028	2029-2038	2039-2048	2049-2058	2059-2068	
Recovery actions that will be implemented immediately.						
1. Monitor the Furbish's lousewort population and demographics and periodically assess the status of the bumble bee pollinator to document trends.	250	250	250	250	250	1
2. Improve the health and viability of extant subpopulations and restore extirpated subpopulations throughout the historical range.	565	365	190	190	190	1
3. Achieve long-term habitat protection for each subpopulation.	135[6]	60	60	60	60	1
4. Conduct scientific investigations to improve understanding of stressors, viability, propagation, restoration, and genetic needs.	1,300	60	335	60	335	1
5. Periodically review progress toward achieving recovery criteria and employ strategic conservation and adaptive management to address threats.	55	30	30	30	30	3
Contingency recovery strategies will be implemented if the metapopulation in Maine falls below 1,200 flowering stems OR if there are 4 or fewer upriver subpopulations OR if there are 2 or fewer downriver subpopulations OR if seed production is not sufficient to achieve a stable or increasing metapopulation.						
6. Establish new subpopulations in unoccupied areas having suitable habitat.	0	300	100	100	100	1
7. Store seeds and establish captive populations.	0	250	250	250	250	1

[5] Recovery actions are assigned numerical priorities to highlight the relative contribution they may make toward species recovery (48 FR 43098):
Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly. Although actions 6-9 are not intended for implementation unless the specified conditions occur, they would then become urgent.
Priority 2 – An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction.
Priority 3 – All other actions necessary to provide for full recovery of the species.
[6] The cost of habitat protection may be significant and is yet to be determined (see the Recovery Implementation Strategy for further details).

8. Enhance seed production.	0	350	350	350	350	1
9. Work with Canadian partners to implement strategies that prevent extinction.	0	TBD[7]	TBD	TBD	TBD	1
Total	2,305	1,665	1,565	1,290	1,565	
Total Estimated Cost: $8,390,000						

Date of Recovery: If all actions are fully funded and implemented as outlined, including full cooperation of all partners needed to achieve recovery, we anticipate delisting could be achieved by 2068.

Estimated Cost of Delisting: The estimated costs associated with implementing recovery actions for delisting are $8,390,000 ($5,390,000 if contingency actions are not needed). Cost estimates reflect costs for specific actions needed to achieve recovery. Some costs for recovery actions are not determinable at this time; therefore, the total cost for recovery may be higher than this estimate.

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Date: February 12, 2019

IV. Literature Cited

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Furbish's lousewort recovery team. 2006. Recovery strategy for Furbish's lousewort (*Pedicularis furbishiae*) in New Brunswick. New Brunswick Department of Natural Resources. Fredericton, New Brunswick.

U.S. Fish and Wildlife Service (USFWS). 1983. The Furbish lousewort recovery plan. U.S. Fish and Wildlife Service. Newton Corner, Massachusetts. 31pp.

U.S. Fish and Wildlife Service (USFWS) 1991. Furbish lousewort (*Pedicularis furbishiae*) revised recovery plan. Prepared by Susanna L. von Oettingen, New England Field Office, U. S. Fish and Wildlife Service, Concord, New Hampshire.

[7] To be determined. Costs associated with assisted migration could be substantial. Costs will be greater if it is difficult to find rivers having the right environmental conditions and disturbance regime to meet the Furbish's lousewort's needs. Costs will be greater if candidate river systems are in remote parts of Canada.

U.S. Fish and Wildlife Service (USFWS). 2007. Furbish's lousewort (*Pedicularis furbishieae*) Five-Year Review: Summary and Evaluation. Mark McCollough, author, U. S. Fish and Wildlife Service, Maine Field Office, Old Town, Maine.

U.S. Fish and Wildlife Service (USFWS). 2018. Species status assessment for the Furbish's lousewort (*Pedicularis furbishiae*).Version 1.1.Ecological Services Maine Field Office, East Orland, Maine. 60 pages plus 3 appendices.

U.S. Fish and Wildlife Service (USFWS). 2019. Recovery implementation strategy for the Furbish's lousewort (*Pedicularis furbishiae*). Ecological Services Maine Field Office, East Orland, Maine. 14 pages.

Glossary

Climate envelope – Statistical correlations between an existing species distribution and environmental variables to describes a species' tolerance to temperature and moisture. Species may have a maximum or minimum temperature or amount of rainfall beyond which they cannot survive.

Connectivity – Landscape connectivity in ecology is the degree to which the landscape either facilitates or impedes movement of individuals (or seeds, pollen) among resource patches.

Demographic - Any statistical factors that influence population growth or decline. Some of the more important demographic factors include population size, density, age structure, birth rates, death rates and the ratio of males to females.

Effective population size – The number of individuals in a population that are breeding or contribute offspring to the next generation. The effective population of the Furbish's lousewort is the individuals that flower, successfully pollinated, and produce seed.

Hemiparasite – A parasitic plant that carries our photosynthesis but also obtains food from its host. Sometimes hemiparasites can also live independent of the host plant.

Metapopulation – A group of populations that are separated by space but consist of the same species. The spatially separated populations interact as individual organisms move from one population to another.

Perennial – A plant that lives more than two years.

Resiliency - the ability of populations to sustain themselves in the face of environmental variation and stochastic events.

Redundancy - the ability of a species to withstand catastrophic events.
Representation - the ability of a species to adapt to near and long-term changes in the environment; it's the evolutionary capacity or flexibility of a species.

Survival – The ability of an organism to survive from one time period to another (typically a year).