FINAL REPORT

Eastern Mountain Avens (*Geum peckii*) *Ex Situ* Conservation Assessment Workshop

February 22-24, 2023

CANADIAN SPECIES INITIATIVE

IUCN SSC Species Survival Commission

CONSERVATION PLANNING SPECIALIST GROUP
Changing the Future for Wildlife

Government of Canada Gouvernement du Canada

NOVA SCOTIA

ACADIA UNIVERSITY

K.C. IRVING ENVIRONMENTAL SCIENCE CENTRE
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Land Acknowledgement:
The organizing team acknowledges that this workshop took place and discussed lands in Mi'kma'ki, the ancestral and unceded territory of the Mi'kmaq People. This land is governed by the treaties of Peace and Friendship, first signed by the Mi'kmaq, Wolastoqey, Peskotomuhkatiyik, and the British Crown in 1726. These treaties did not implicate or affirm the surrender or transfer of land to the British, but recognized Mi'kmaq and Wolastoqey title and set the rules for what was to be a long-standing relationship between nations, initially preventing war and facilitating trade. We recognize that we are all treaty people and have responsibilities to each other and this land.

Workshop organized by:
Canadian Species Initiative (CSI; host of the Regional Resource Center for IUCN SSC Conservation Planning Specialist Group in Canada), Wildlife Division of the Nova Scotia Department of Natural Resources and Renewables, and Environment and Climate Change Canada - Canadian Wildlife Service.

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[1]Canadian Species Initiative (CPSG Canada Regional Resource Center), [2]Wilder Institute/Calgary Zoo, [3]Wildlife Preservation Canada, [4]African Lion Safari

A PDF of Eastern Mountain Avens (*Geum peckii*) *Ex situ* Conservation Assessment Workshop: Final Report is available for download at www.canadianspeciesinitiative.ca and www.cpsg.org.

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Executive Summary

The Eastern Mountain Avens (*Geum peckii*) is a globally rare herbaceous perennial, geographically restricted in Canada to open peatland habitat in southwestern Nova Scotia. The Canadian population is one of only two global populations. Assessed as "Endangered" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2010), the majority of the Canadian population is found on private lands. The main threat is habitat loss and degradation through manipulation of water levels, encroachment of woody vegetation, expanding gull populations, climate change, and all-terrain vehicles. A federal Recovery Strategy (Environment Canada, 2010) and Action Plan (ECCC, 2018) have been developed that identify recovery goals and objectives and an implementation schedule for recovery activities. Major progress in restoration activities has been made and substantial new genetics information amassed, which warrant an update to the recovery plan. This provides an opportunity to apply a One Plan Approach to conservation planning for this species and consider the full spectrum of *ex situ* roles which may contribute to its recovery.

In 2020, the International Union for the Conservation of Nature (IUCN) World Conservation Congress ratified a resolution to make the One Plan Approach the global standard for species conservation. Developed by the Conservation Planning Specialist Group (CPSG) of the IUCN's Species Survival Commission (SSC), the One Plan Approach involves development of integrated species conservation plans that consider all potential conservation tools and partners, including both *in situ* (in the wild) and *ex situ* (in human care) conservation efforts where appropriate. Involving a diverse range of participants in the planning process ensures that the full complement of knowledge, skills, and strengths are brought together to identify the most effective and achievable conservation actions.

The Wildlife Division of the Nova Scotia Department of Natural Resources and Renewables in collaboration with the Environment and Climate Change Canada – Canadian Wildlife Service, invited the Canadian Species Initiative (CSI; Regional Resource Centre for CPSG in Canada), to plan and facilitate a participatory workshop process designed to use the IUCN SSC's international guidelines for evaluating the use of *ex situ* management (IUCN/SSC, 2014) and conservation translocation/reintroduction methodologies (IUCN/SSC, 2013) to identify intensive management strategies that could be considered as part of the provincial and federal recovery programs, including the potential of a One Plan Approach for Eastern Mountain Avens. The workshop was hosted by Acadia University on February 22 - 24, 2023 with financial support from the Southwest Nova Scotia Priority Place Fund, followed by two online half-day sessions on June 6 and 7, 2023. Twenty-two participants, including Recovery Team members, other relevant experts, and community stakeholders, attended either in person or online.

Following the five-step decision-making process for evaluating *ex situ* activities for effective species conservation outlined in the IUCN guidelines, CSI guided workshop participants through reviewing the status and threats impacting wild Eastern Mountain Avens population viability, creating concise objectives to address the groups' concerns around the species status and

recovery, identifying potential intensive management roles to address threats and objectives, characterizing alternative approaches/strategies, evaluating risk and feasibility of implementing alternative strategies, and deciding on final recommended approaches for *ex situ*/translocation programs. The workshop process adopted a 25-50 year timeframe, based on the most recent threat assessment.

Recommended intensive management strategies for Eastern Mountain Avens include the following, subject to implementation planning, and dependent on specific decision triggers or conditions being met:

1. Insurance population: Seed banking + seed orchard/outplanting program
2. Demographic and/or genetic reinforcement of current *in situ* population:
    a. Transplant plants and/or seeds from *ex situ* source
    b. Transplant seeds from *in situ* source
    c. Assisted pollination using pollen from *ex situ* or *in situ* source(s)
3. Assisted colonization:
    a. Wild-to-wild translocation of seeds from existing *in situ* population
    b. Introduction of *ex situ* propagated seeds or plants

Conservation-based education, research, and training were seen to have conservation value but require further discussion to properly define and assess the programs that would best support Eastern Mountain Avens recovery.

The results of this workshop identify the potential conservation value and feasibility of *ex situ* conservation roles for Eastern Mountain Avens, as well as decision triggers or conditions for each recommended strategy. Participants also identified data and knowledge gaps and prioritized these based on the degree to which they would hinder planning and implementation of actions. The development of action plans detailing next steps for moving ahead was also initiated.

This report summarizes the results of the workshop process, both the in-person and online components, and is intended to provide advice to the Nova Scotia Department of Natural Resources and Renewables and Environment and Climate Change Canada – Canadian Wildlife Service for evaluating all potential conservation options for Eastern Mountain Avens and provide the basis of more detailed intensive management discussion and planning.

1. Species Status and Challenges

1.1. Status of in situ and ex situ populations

The Eastern Mountain Avens is a globally imperilled perennial, endemic to North America. It occurs in the wild in only two, highly disjunct regions: Digby County in Nova Scotia (Canada) and the White Mountains of New Hampshire (USA). In Canada, the Eastern Mountain Avens is geographically restricted to open peatland habitat in a small number of sites on Digby Neck and Brier Island and has been assessed as "Endangered" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2010). Some sites have undergone substantial declines due to multiple critical and ongoing threats over decades including habitat loss and alteration through manipulation of water levels (i.e., historical artificial drainage and recent restoration), encroachment of woody vegetation in open bog habitat, nutrient enrichment, and disturbance by expanding gull populations, and climate change. Despite extensive collaborative research and conservation action, including *in situ* habitat restoration, recovery progress has been limited for this species and populations continue to decline. Further, emerging evidence of the negative and accelerating impacts of climate change on Eastern Mountain Avens habitat has heightened concern for the recovery of this species in the wild.

Ex situ collections of Eastern Mountain Avens are purportedly held in six institutions globally, including one in Canada (Acadia University, Nova Scotia), and a federal Recovery Strategy (Environment Canada, 2010) and Action Plan (ECCC, 2018) have identified several *ex situ* recovery activities for the species. However, these documents and the associated recovery objectives and feasibility assessment are outdated as recent progress has been made in restoration activities and amassing genetics information, warranting an update to the recovery plan and further consideration of *ex situ* conservation methods. An overview of the species' status follows in Table 1 and further information on status and challenges can be found in sections *1.2. Background Presentations - Baseline Information* and *4.1. Threat Assessment for Eastern Mountain Avens* of this report.

Table 1. Status, threats, and conservation actions for *in situ* and *ex situ* populations of Eastern Mountain Avens (*Geum peckii*) in Canada.

Wild Population
Two highly disjunct populations globally. The Canadian population consists of several sites on Brier Island and one on Digby Neck (Harris Lake) with a total population estimate of ~6000 mature individuals. The Brier Island sub-population consists of a small number of scattered sites of less than several hundred individual plants each, some declining substantially. Approximately 20% of known Eastern Mountain Avens sites are located on Nature Conservancy of Canada property on Brier Island. Plants on Brier Island continue to be seriously threatened by habitat shifting and alteration, an expanding gull colony and changes in drainage. The Harris Lake sub-population consists of ~300 flowering plants and at least as many vegetative plants. Plants are predominantly in a vegetative state and reproduce only episodically (i.e., produce seeds every year but recruitment does not occur annually). The plants reproduce both sexually and clonally, flowering in summer and entering dormancy in winter. (Environment Canada, 2010)

Threats and Stressors
An IUCN/COSEWIC Threat Assessment was completed by the Recovery Team in March 2022. Current threats affecting the species were identified as: ● high-medium impact: climate change - habitat shifting and alteration ● medium-low impact: dams and water management / use; other ecosystem modifications (succession, gulls) ● low impact: roads and railroads; recreational activities (ATVs); work and other activities (fieldwork); climate change - storms and flooding
In Situ Conservation Actions
A federal Recovery Strategy (Environment Canada, 2010) and Action Plan (ECCC, 2018) have been produced and a provincial Recovery Team was formed in 2019. Population monitoring is ongoing to track trends in numbers of plants and area of occupation. Several threat reduction/mitigation measures have been employed to varying success: ● Reversal of ditching to restore water levels in peatlands/fens - substantial declines observed in some lagg areas following increase in water levels; however, long-term effects of restoration (e.g., potential impact of changes in vegetative community composition and nutrient levels) as yet unknown ● Application of wooden stakes to deter establishment of gulls - no evidence of success ● Critical habitat identified/ongoing education and stewardship initiatives to protect habitat Research is under way to better understand species ecology and impacts of threats: ● Climate change, eutrophication due to gulls, genetics ● Assisted regeneration in the wild e.g., outcrossing vs self-pollination, germination techniques, seedling establishment, site treatment (mechanical scarification, vegetation management), disturbance regimes, transplantation techniques
Current *Ex situ* Status

Botanic Gardens Conservation International (BCGI, 2023) records six botanical gardens with Eastern Mountain Avens in their collections:
● Acadia Seed Bank with assistance from the E.C. Smith Herbarium and Harriet Irving Botanical Gardens, K.C. Irving Environmental Science Centre, Acadia University (collaborative entity hereafter referred to as the "Acadia Seed Bank")
    ○ ~100 000 seeds held in seed bank from 12-13 sites on Brier Island (none from Harris Lake)
    ○ Successful germination and growth from stored seeds
    ○ ~ 20 potted plants held in outdoor experimental garden
    ○ Previous research project on *ex situ* propagation (LaRue, 2016)
    ○ No active research; stock available for interested researchers
● Five other collections unknown, but likely in US (BGCI, 2023)
 	
Experimental outplanting of plants propagated from Acadia seed bank to Long Island in 2018 (Fancy 2017):
● While this site represented a similar environment to native habitat on Brier Island and Harris Lake, the species has never been found growing naturally at this site and there were indicators of poor environmental conditions
● Trials were aimed at testing outplanting of tissue culture material with different mycorrhizal treatments
● Some plants survived to 2021 but were stunted and not spreading/flowering

Recommended *Ex Situ* Conservation Actions
Recovery approaches from the Recovery Strategy for Eastern Mountain Avens in Canada (Environment Canada, 2010)**:** ● Determine feasibility for **seed banking and transplanting** ● Identify other possibilities for **population augmentation/expansion** Recovery measures from the Action Plan for the Eastern Mountain Avens (*Geum peckii*) in Canada (ECCC, 2018): ● Explore methods of **population enhancement** and determine feasibility for **seed banking and transplanting** within the Nova Scotia population ● Conduct genetic analyses to identify natural patterns and key areas of genetic importance for the long-term safety of the Canadian Eastern Mountain Avens population, and the possibility/feasibility for **human-assisted rescue** (i.e., **genetic reinforcement**) of Eastern Mountain Avens populations ● Apply the Eastern Mountain Avens predictive model from Brier Island to unoccupied fen land between Brier Island and Tiddville (Digby Neck) to determine the **suitability of unoccupied fen land** and its significance with respect to the longer term recovery of Eastern Mountain Avens ● **Planning for and mitigating impacts of climate change** on Eastern Mountain Avens

1.2. Background presentations - baseline information

While most workshop participants were familiar with the *in situ* status of Eastern Mountain Avens, plenary presentations were given by members of the Nova Scotia Plants Recovery Team and species experts to provide all workshop participants a common understanding of the current status, distribution, threats, recovery actions and research on the wild population. Additional presentations were given on the impacts of climate change and population genetics. Insights into the status of the *ex situ* population were provided in relation to seed collection, management, and research. A case study of the successful recovery of a similar endangered alpine perennial in the White Mountains of New Hampshire (Robbins' (Dwarf) Cinquefoil, *Potentilla robbinsiana*) through integrated *in situ* and *ex situ* conservation methods, was also provided. Summaries of the presentations follow in Table 2 and full presentation slide decks are available upon request.

Table 2. Summaries of background presentations from the Eastern Mountain Avens (*Geum peckii*) *Ex Situ* Conservation Assessment Workshop (February 2023).

Title and presenter	Summary
Status review, threats, recovery criteria/goals, and relevant existing recovery action recommendations for Eastern Mountain Avens	Recovery program to date: ● Provincially (2000) and Federally listed (2003) ● Provincial Recovery Team restructured (2019) ● Federal Recovery Strategy (2010) and Action Plan (2018) prepared with Critical Habitat - Nova Scotia adopted (2020) including core habitat ● Dated recovery docs – could be reviewed/amended when resources allow

Julie McKnight, *Environment and Climate Change Canada - Canadian Wildlife Service*	● Re-assessment by COSEWIC timing unclear Recovery Objectives (2010): 1. Maintain populations at occupied sites 2. Improve conditions and enhance populations at occupied sites (active vegetation management, seed banking, transplantation) 3. Improve conditions at previously occupied sites Preliminary Population and Distribution Objectives (new ECCC policy): *Stabilize the population above 2,500 mature plants and stabilize the species' IAO above 20* km^2. ● translocate to historically occupied areas, new suitable areas ● enhance genetic diversity through outcrossing (?) *Short-term statement* ● Improve habitat quality by mitigating the effects of nesting gulls and encroaching shrubs Planning Table: ● Include research into *ex situ* and conservation translocation measures to address threats Active Recovery Team: ● Research and Recovery Forum (Apr 2021) ○ mini-workshop with action items to support future recovery actions (translocation, habitat enhancement, facilitated migration)
Overview of Eastern Mountain Avens, Big Meadow Bog, actions undertaken / underway, and state of the science for intensive management Nick Hill, *Fern Hill Institute;* Brad Toms, *Mersey Tobeatic Research Institute;* Sherman Boates, *past researcher / biodiversity manager*	**Summary of 14 years of *in situ* research** - Nick Hill ● Streams, waterfalls, extreme sites elsewhere but more stable on Brier Island (basalt nutrients) ● Nutrient/gull/wetness interaction - Eastern Mountain Avens is a poor competitor, needs stressful environment to out compete shrubs/other plants ● Restricted to low biomass, low nutrient cool peatlands/fens found on Digby Neck. ● Ditching has resulted in reduced habitat availability in Big Meadow Bog; ditching was reversed in a bog restoration effort undertaken in 2018 ● Mitigation: removed shrubs (clipped) caused a reduction in photosynthetic efficiency - water did not help, maybe mycorrhizal? ● Raising water levels at Big Meadow Bog post-restoration - reduced Eastern Mountain Avens in the wettest areas of the bog that has facilitated shrub growth ● Crossing experiment - germination ~21%, up to 50% when crossed - so maybe inbreeding depression? ● Scarification plots - remove shrubs and peat and sow plants, plants grow in hollows; sphagnum smothers seedlings but is okay once plants are established ● Dispersal - limited animal dispersal as they have lost the ability to adhere to fur/feathers, etc., wind

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Population monitoring - Brad Toms

Spatial loss at northern Big Meadow sites; but other Big Meadow sites are increasing; extirpated from Little Pond
Trends vs. counts - overall counts relatively stable, found new ones but losses elsewhere
Looked at spatial correlates (within 3m accuracy) at sub-sites - showing 30-40% loss over 10 years for some sites; able to tease apart changes at specific sites over time whether subsite is stable, declining or increasing

Gulls and climate change - Sherman Boates

Used bamboo canes (originally used for deterring predation by gulls on terns) to see if could deter gulls in Eastern Mountain Avens habitat - 550 canes put up - did not deter the gulls and more nests were built near and within the cane grid
Gull issue is related to nutrient input, direct damage to plants and invasive species dispersal/introduction
Quantify climate change impacts on Eastern Mountain Avens using open-top chambers that mimic increasing temperature, other changes associated with climate change - May 2022 and 2023 data collected
Paired point experiment looking at recently extirpated sites vs. nearby extant sites - iButton data loggers deployed Dec 2022 and will be recovered Dec 2023
Global endemic - need to give proper priority to species

Possible that gull issue and climate change are impossible to manage or mitigate
Is recovery feasible? Situation is dire, urgent and time-sensitive
What will be saved/made? both plants and ecosystem they are found in - Have to try!

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Climate change on Brier Island and implications for Eastern Mountain Avens conservation

David Garbary,
St. Francis Xavier University
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Different from the rest of Nova Scotia (NS) - changing faster and in more/different ways

Roughly a 1 degree increase starting in 1998 (when step-change happened) to present in NS overall; Brier 2 degrees
Warmest place in spring, fall and winter, coolest in the summer compared to other NS sites
Brier used to be colder than Yarmouth (nearby location) and is now warmer
How is this relevant to Eastern Mountain Avens?
Increase in continuous frost-free days (additional ~3 week growing period); increase in the number of days above 20 C (almost double) and 25 C (more than double); decrease in the number of cold days; maximum winds are higher than in the rest of NS (wind stilling has been a global phenomenon - high in 1960s then “stilling” for several decades and increasing again ~2010); number of storm days higher on Brier.

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	Why is Brier Island different? ● Global oceans versus anthropogenically-induced climate change - namely the warming of the Gulf of Maine and the Atlantic Multidecadal Oscillation (AMO) that has repositioned the Gulf Stream that has restricted the Labrador current - ocean hot spots and the warming of the Gulf of Maine and influx in Bay of Fundy, extended during period of La Nina/El Nino. Will the climate continue to warm? ● What happens when AMO switches again to a negative phase? Will that change be overwhelmed by regional temperature increases? Will increasing winds impact wetlands and vegetation on Brier? ● Quick look at stability of temperatures in Newfoundland that might make it an appropriate climate envelope for Eastern Mountain Avens. Why is the Gulf of Maine such a hot spot? ● Restriction of the Labrador current and wind stilling which leaves the warm water on the surface. What are the more important impacts of climate change - indirect like shrubification or direct like temperature?

Population genetics of Eastern Mountain Avens (*Geum peckii*)
 	
Mark Johnston, *Dalhousie University*
	Assessed genetic differences between *Geum peckii* and *Geum radiatum*, between *G. peckii* in Nova Scotia (NS) and New Hampshire (NH), and among Nova Scotia sub-populations:
	● No difference in floral/vegetative characteristics in 1996
	  ○ RAPD markers showed differentiation between *G. peckii* and *G. radiatum* but not between *G. peckii* in NS and NH
	● Re-assessed using more advanced techniques
	  ○ *G. peckii* different from *G. radiatum*
	  ○ Difference between *G. peckii* in NS and NH (sites in NH very diverse)
	  ○ Two to five groups: Harris Lake different from other NS sites but overall, no differentiation among samples; NH did have differentiation
	  ○ Geographic distance correlated with genetic differentiation between and within NS and NH (stronger for NH).
	  ○ Conclusion: genetically, Nova Scotia is one single population (no evidence of really strong genetic differentiation, even including Harris Lake).
	● Clone size - genetically unique samples varied from 32-96%
	  ○ How does disturbance relate to clone size? Clonal richness highest, and fewest large individuals at least disturbed site
	● Mating system - 28% selfing rate in NS vs 45% in NH; adults vs progeny showing potential inbreeding depression; bigger the population, the lower the selfing rate/higher outcrossing rates - bigger population visited more/longer by pollinators
	● Inbreeding Depression - germination rates higher in crossed vs self, and as crossing distance increased (crossing plants from further away from each other produced higher germination rates).

Summary of Research on Eastern Mountain Avens at Acadia University Botanical Gardens Alain Belliveau, *K.C. Irving Environmental Science Centre, Acadia University*	● Foliar endophytic fungi - entire ecosystem of fungi on/associated with plants ● Mycorrhizal associations - improving techniques for growing plants ● Using charcoal for improving germination rates ● Outplanting success and using tissue samples for propagation - first time an endangered species has been retrieved from a seed bank and out-planted back into natural habitat ● Outplanting in Long Island in 2018 - some plants still alive in 2021 but not spreading/flowering and were stunted (habitat may not have been ideal) ● Seed collections and seed bank at Acadia University to retain genetic stock, conduct research, and support restoration efforts ● Seeds collected from Brier Island (not all sites possible however due to low number of plants) and experimental garden ● Experimental garden - 50% survival rate
Lessons learned in the successful recovery of Robbins' (Dwarf) Cinquefoil, *Potentilla robbinsiana* Kenneth Kimball, *Appalachian Mountain Club*	Robbins' (Dwarf) Cinquefoil, *Potentilla robbinsiana,* is an alpine/arctic perennial with a multi-decade lifespan with only two endemic populations and limited distribution. Threats include overcollection, recreation (hiking trails), and potentially climate change. Protection measures included: 1. habitat closure, trail diversion and better definition, hiker education ○ Flora in closed/restored areas exhibited considerable resiliency 2. seed collection, propagation, transplantation efforts to create four new 'buffer' populations ○ Summary: Best propagated for outplanting at high elevation restoration sites by treating seeds to increase germination and by outplanting non-dormant adult plants in soil matrix mimicking surrounding soils in mid-July ○ Many transplant sites failed (microclimate): successful at 2 new novel sites plus in degraded Monroe Flats habitat with viable populations (>50 adult plants with successful on-site reproduction) ○ Multi-year population monitoring and demographic analysis to develop Minimum Viable Population model (MVP) for main population and transplant sites and to understand the species biology ○ Increasing population trends in all three augmented populations and total population monitoring count of adult plants in 2007 (5-years after endangered species delisting) showed 3x fold increase from lowest population levels.

2. IUCN SSC *Ex Situ* Conservation Assessment Process and Conservation Roles

Effective species conservation planning should consider all options when assessing actions to address the conservation pressures facing a particular species. In addition to actions directed at reducing or eliminating particular threats, such as habitat loss or illegal collection, other management strategies may be needed to prevent severe decline or extinction, especially when wild populations are small and isolated. Addressing important knowledge gaps also can promote more effective conservation. *Ex situ* management is one possible option that can contribute to the conservation of threatened species. *Ex situ* conservation is playing an increasingly important role in the protection and recovery of North America's threatened plants (Kramer et al., 2011). The range of *ex situ* scenarios and tools is diverse and can target different conservation needs and roles and, therefore, serve various purposes.

Ex situ conservation activities can support species conservation and prevent extinction in a variety of ways (Traylor-Holzer et al., 2019), by:

<u>Offsetting the impact of threats</u> - *Ex situ* activities can improve the demographic and/or genetic viability of a wild population by counteracting the impacts of primary or stochastic threats on the population, such as reduced survival, poor reproduction and genetic isolation – for example, through head-start programs that remove juveniles from the wild for *ex situ* care and return them once they are less vulnerable, or through releases to genetically augment isolated populations.

<u>Addressing the causes of primary threats</u> - *Ex situ* activities can help reduce primary threats such as habitat loss, exploitation, invasive species, or disease through specifically designed research, training or conservation education activities that directly and effectively impact the causes of these threats – for example, through *ex situ* research to detect, combat or treat disease.

<u>Buying time</u> - Establishment of a genetically diverse and sustainable *ex situ* rescue or insurance population may be critical in preventing species extinction when the wild population is declining and primary threats are not under control – for example, populations facing widespread disease epidemics or decimation by invasive species.

<u>Restoring wild populations</u> - Once the primary threats have been sufficiently addressed, *ex situ* populations can be used to re-establish wild populations.

In order to be successful, *ex situ* programs need to be carefully assessed, planned and implemented in a way that provides conservation benefit. In addition, as conservation challenges become more complex and urgent, the need to further develop scientifically based and innovative approaches to *ex situ* conservation will increase. The key to effective conservation is ensuring that all actions - from planning to implementation - are integrated (Figure 1).

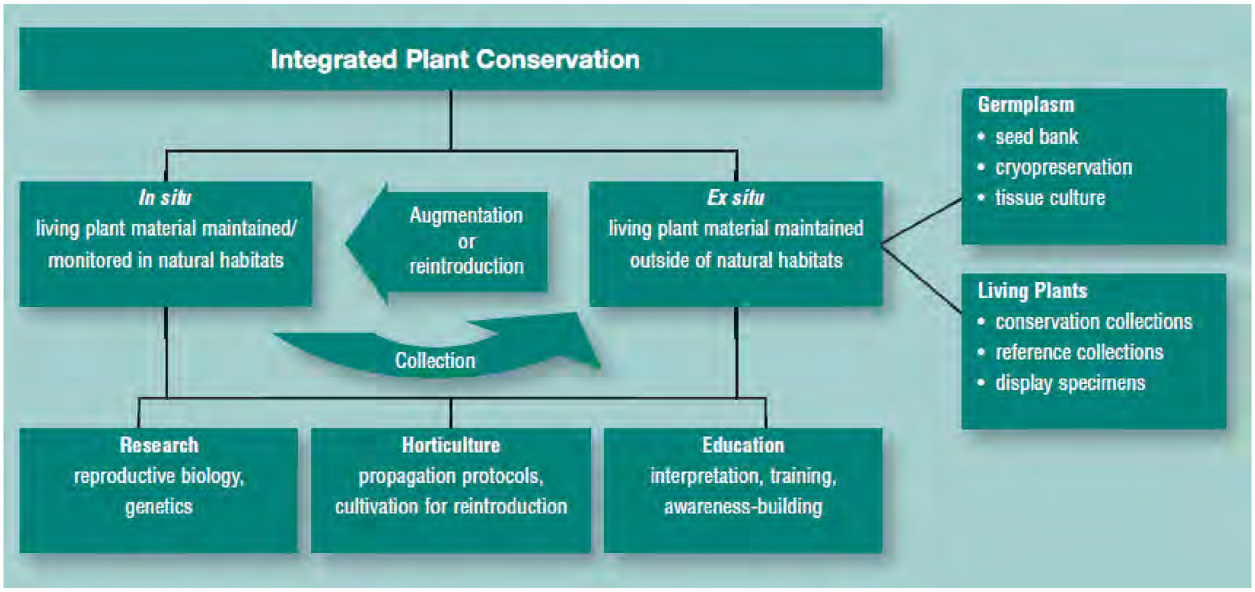


Figure 1. Integrated plant conservation may be supported by the main activities at botanic gardens and related organizations, as considered appropriate through a One Plan Approach to conservation (taken from Kramer et al., 2011)

This workshop focused on the assessment of *ex situ* activities for Eastern Mountain Avens and the ability of such activities to contribute effectively to its conservation and recovery in the wild. All intensive population management options requiring removal of individuals from the wild were considered in this process, such as wild-to-wild conservation translocations that may involve no or limited time *ex situ.* Conservation translocations are the intentional movement and release of a living organism where the primary objective is a conservation benefit. Many potential *ex situ* roles involve conservation translocations, and these movements can include individuals from wild and/or *ex situ* origins.

The workshop was structured around the IUCN SSC Guidelines on the Use of *Ex situ* Management for Species Conservation, which use a five-step decision process to determine if and which *ex situ* activities might be appropriate to be included in the overall conservation strategy for the species and ensure that these decisions are informed and transparent (IUCN/SSC, 2014; McGowan et al., 2017):

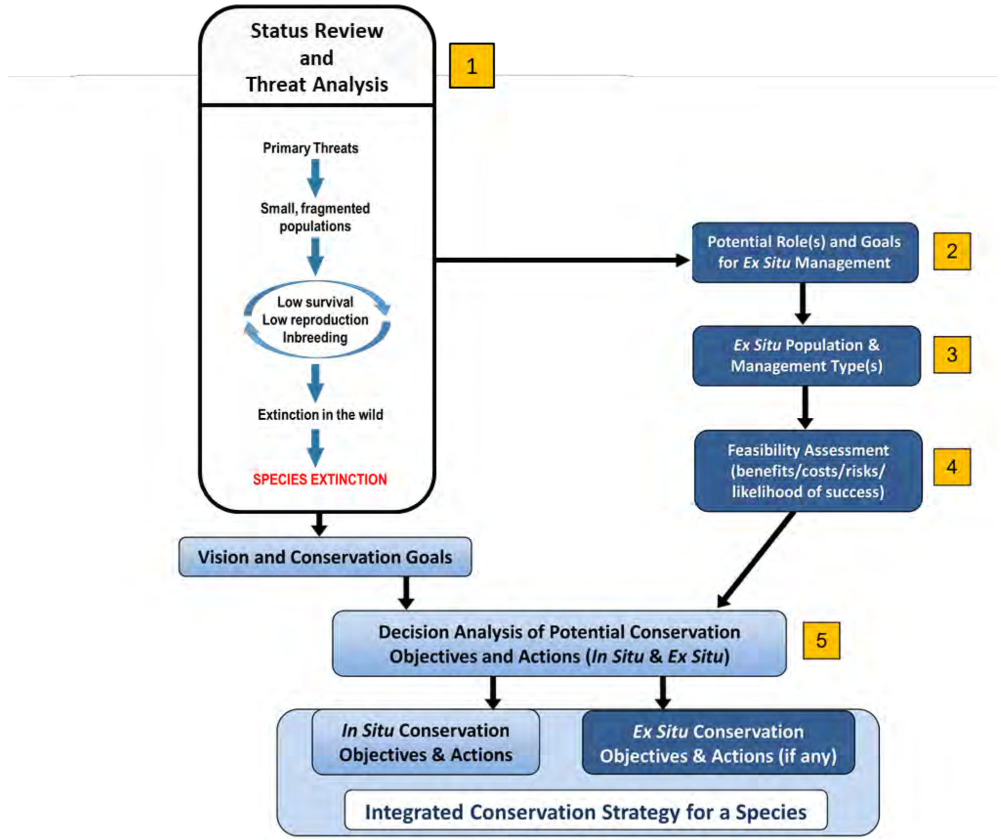
1. Conduct a thorough status assessment (of both *in situ* and any known *ex situ* populations) and threat analysis;
2. Identify potential roles that *ex situ* management can play in the overall conservation of the species;
3. Define the characteristics and dimensions of the program needed to fulfill the identified potential conservation role(s);
4. Define the resources and expertise needed for the *ex situ* management program to meet its role(s) and appraise the feasibility and risks; and
5. Make an informed and transparent decision as to which *ex situ* roles and activities (if any) to retain within the overall conservation strategy of the species.

Some additional concepts and tools were brought in from the decision-making framework of the IUCN SSC Guidelines for Reintroductions and Other Conservation Translocations (IUCN/SSC, 2013), focused primarily on the evaluation of alternatives.

This assessment supports a One Plan Approach to conservation of this species (Traylor-Holzer et al., 2019), and considers existing objectives, strategies and actions outlined in the Recovery Strategy (Environment Canada, 2010) and Action Plan (ECCC, 2018). An essential element of this process was the involvement of both *in situ* and *ex situ* species experts in all stages to fully evaluate conservation needs and opportunities.

Recommendations resulting from this workshop will inform future conservation planning for this species and support an integrated conservation strategy (Figure 2). Detailed action planning of the recommended *ex situ* strategies will be required prior to implementation. Where necessary, additional detailed conservation translocation planning should occur in adherence to IUCN guidelines; see Figure 3 for the full Conservation Translocation Cycle.

(a)



(b)

Figure 2. (a) The five step decision process of the IUCN SSC Guidelines on the Use of *Ex situ* Management for Species Conservation, and (b) the incorporation of the five steps into species conservation planning to develop an integrated conservation strategy (taken from McGowan et al., 2017).

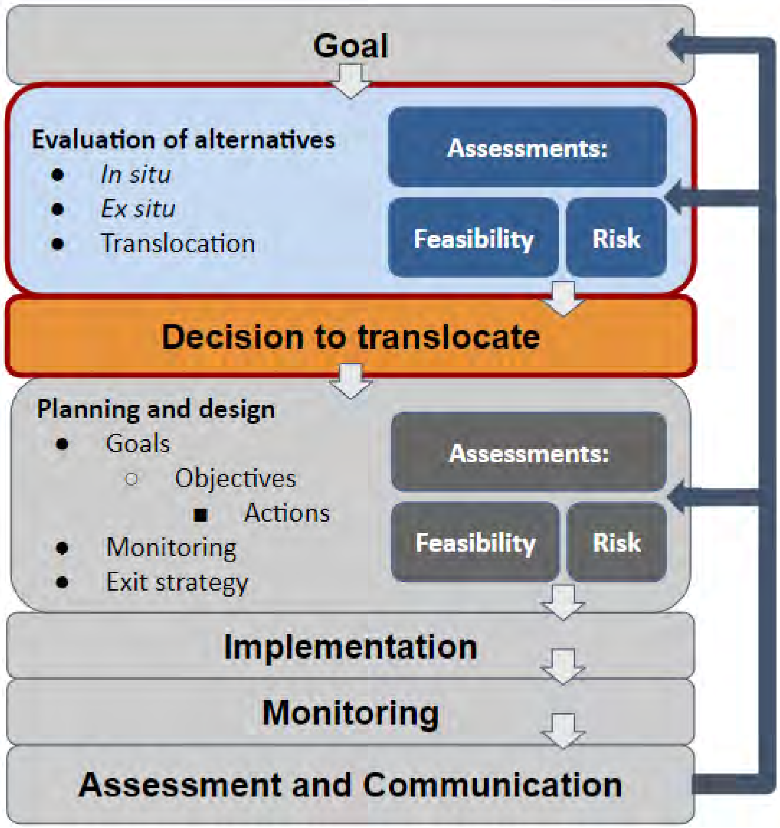


Figure 3. Overview of the Conservation Translocation cycle (modified from IUCN SSC Guidelines for Reintroductions and Other Conservation Translocations, 2013). The workshop for Eastern Mountain Avens (*Geum peckii*) included evaluation of alternative approaches to conservation translocations to benefit the recovery of the species, and developed recommendations on whether or not, and how best to apply this tool and other *ex situ* management options (red outline). Some additional planning and design were initiated.

3. Workshop Process for Eastern Mountain Avens

The Canadian Species Initiative, host of the Regional Resource Center for CPSG in Canada, was invited to plan and facilitate a participatory workshop process designed to use the *Ex Situ* Guidelines as an aid to evaluate the feasibility of incorporating an *ex situ* management element into the broader conservation activities for Eastern Mountain Avens. The workshop was held in two parts, including a 3-day in person session and two online half-day sessions. The in-person session was held at Acadia University on February 22-24, 2023 (see Agenda in Appendix I), and the two online half-day sessions took place June 6 and 7, 2023 (see Agenda in Appendix II). Facilitators led the participants through the application of the IUCN's *Ex Situ* Guidelines to the specific conservation issues facing this species. Twenty-two participants attended the in-person session, including experts on species biology and management as well as relevant interested parties, who joined either in person or online; many but not all these same individuals also participated in the online half-day sessions (see list of workshop participants in Appendix III).

The main objectives of the workshop were to:

1. Evaluate and recommend any appropriate role(s) of *ex situ* activities for the conservation of Eastern Mountain Avens and initiate the design of any recommended programs.
2. Identify key uncertainties that may be answered with *ex situ* population(s), in order to improve *ex situ* management and/or to inform Eastern Mountain Avens recovery actions.

Prior to the workshop, the following information was compiled:

1. Status of and threats to the wild Eastern Mountain Avens population;
2. existing federal Eastern Mountain Avens Recovery Strategy and Action Plan; and
3. existing expertise in *ex situ* management and reintroduction for avens species/alpine plant species.

This information was shared as briefing materials and/or introductory presentations at the start of the workshop during plenary presentations.

Participants then reviewed the threats to the species and discussed the impact of threats across the stages of the species' life cycle. Important knowledge gaps in species biology, threats and their impacts, and population management were noted.

Following review and discussion of the threats, participants were asked to identify major concerns regarding the recovery of the species. A small, understandable, non-overlapping and controllable set of fundamental objectives were developed, which addressed the compiled list of concerns.

Participants then reviewed the list of potential conservation roles for *ex situ* activities (see Appendix IV for full list) to identify those that might address the impact of threats, conservation challenges and/or priority knowledge gaps for Eastern Mountain Avens under a proposed recovery time frame of 25-50 years. Six *ex situ* conservation roles were identified as potentially applicable for Eastern Mountain Avens and meriting further assessment:

1. Insurance Population
2. Demographic/Genetic Reinforcement
3. Assisted Colonization
4. Conservation Research
5. Conservation Education
6. Conservation Training

Workshop participants discussed the relative conservation values of these potential six roles and how they addressed the previously developed objectives. While conservation-based research, education, and training roles were noted as having conservation value, it was decided to prioritize and focus on three roles (insurance population, demographic/genetic reinforcement, and assisted colonization) for the remainder of the workshop.

Participants then worked to identify the alternative strategies for achieving these roles, outlined how the program characteristics would differ among these alternatives, and discussed in detail the relative benefits, challenges, and feasibility of each strategy. Data and knowledge gaps continued to be identified throughout the process to inform the development of appropriate future conservation research objectives.

At the conclusion of the 3-day in-person workshop, after review of all considerations, three overall roles and several alternative strategies were recommended for further development and implementation to assist with recovery of Eastern Mountain Avens, subject to implementation planning, and dependent on specific decision triggers or conditions being met:

1. Insurance population: Seed banking + seed orchard/outplanting program
2. Demographic and/or genetic reinforcement of current *in situ* populations:
    a. Transplant plants and/or seeds from *ex situ* source
    b. Transplant seeds from *in situ* source
    c. Assisted pollination using pollen from *ex situ* or *in situ* source(s)
3. Assisted colonization:
    a. Wild-to-wild translocation of seeds from existing *in situ* population
    b. Introduction of *ex situ* propagated seeds or plants

During the first online half-day session, work focused on identifying conditions and decision triggers for implementation of recommended strategies, where required. Knowledge gaps were reviewed through the lens of whether they posed a significant barrier to implementation and prioritized accordingly.

For the second online half-day session, participants split into three working groups to begin initial action planning for each of the recommended roles: insurance population, reinforcement, and assisted colonization. Using a provided template as guidance, working groups began to identify specific objectives for each alternative strategy and develop detailed actions to inform implementation.

4. Species Specific Identification of Potential Population Management Options

4.1. Threat assessment for Eastern Mountain Avens

To assist with setting the stage to discuss the potential roles that *ex situ*/intensive management can play in conservation of Eastern Mountain Avens, workshop participants briefly reviewed a simplified diagram of species phenology (Figure 4) and were asked to consider previously identified threats to the species, and the aspects of the species' life history and/or population status that are targeted by those threats.

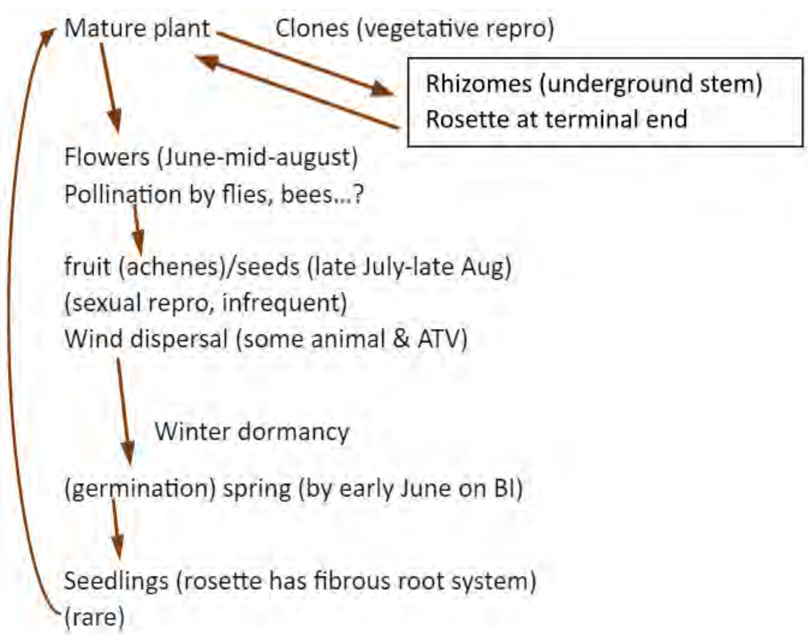


Figure 4. Life history and phenology of Eastern Mountain Avens (*Geum peckii*)
Repro = reproduction, BI = Brier Island

Important knowledge gaps were identified during review of the life cycle diagram, and the complexity of the system beyond the simplified diagram was emphasized:

1. **Recruitment rates:** The relative importance of the different reproduction methods (sexual vs vegetative) in maintaining species viability is unknown. What is the necessary recruitment rate and frequency (i.e., via sexual reproduction) required for a healthy population?
2. **Generation time:** The generation time of wild individuals is unknown, and it is uncertain how this could be measured. The COSEWIC assessment used 5-10 years and the planted specimens in the Irving Biodiversity Collection, Acadia University are 8 years old. Generation time was increased to 25-50 years for the most recent threat assessment and this workshop process.

The basis for the threat assessment was an existing threats calculator based on the IUCN-CMP (International Union for the Conservation of Nature–Conservation Measures Partnership) unified threats classification system (IUCN-CMP 2022; COSEWIC 2015) that was completed by members of the Recovery Team in March 2022, and which identified threats impacting the species and categorized the level of impact (available upon request). Results for that threat assessment are summarized in Table 3. The assessment considered a 25-50 year timeframe, which was then adopted for this workshop process.

Table 3. Summarized results of a threat calculator for Eastern Mountain Avens (*Geum peckii*), based on the IUCN-CMP/COSEWIC threats classification system, completed March 2022 by Recovery Team members.

Threat	**Impact (calculated)**	**Timing**
Climate change - habitat shifting & alteration	High-Medium	Short-Term , <10 years
Dams & water management / use	Medium-Low	Ongoing
Other ecosystem modifications (gulls, succession)	Medium-Low	Ongoing
Roads & railroads	Low	Ongoing
Recreational activities (ATVs)	Low	Ongoing
Work & other activities (fieldwork)	Low	Ongoing
Climate change - storms & flooding	Low	Ongoing - Short-Term
Logging & wood harvesting	Negligible	Short-Term
Garbage & solid waste	Negligible	Ongoing
Household sewage & urban wastewater	Unknown	Ongoing
Climate change - droughts	Unknown	Ongoing - Short-Term
Climate change - temperature extremes	Unknown	Ongoing - Short-Term
Fire & fire suppression	Not a threat	
Housing & urban areas	Not Calculated	Outside assessment timeframe / possibly in the long term
Gathering terrestrial plants	Not Calculated	Outside assessment timeframe / possibly in the long term

Threats for this workshop were then defined in terms of impact on specific life-history stages and demographic rates, as well as additional population-level characteristics that would be affected by the threats, specifically:

- Seed survival
- Seedling survival
- Mature plant survival and vegetative reproductive success
- Sexual reproductive success
- Germination
- Isolated populations
- Genetic diversity
- Restricted population size
- Pollination

The resulting threat assessment is summarised below in Table 4. Higher impact threats and those that clearly impacted multiple life stages via direct damage and/or disruption of critical processes were prioritized for this step. There were also interaction effects with some threats driving or exacerbating others, for example habitat shifting and alteration due to climate change is exacerbating habitat succession/shrubification which together impact plant survival as well as contribute to population isolation and disruption of pollination. Due to the complex interconnectedness of the various life stages and population-level characteristics, survival (seeds, seedlings, and mature plants), reproduction, and disruption of pollination and germination were grouped under “survival of plants” in the discussions which followed.

Note that the threat assessment here is neither exhaustive in its scope nor detailed in its treatment of specific mechanisms. The goal was to provide a high-level overview of the threats to the species, particularly in the context of their impact on the species’ life-history and how *ex situ* options can help address or mitigate the impact of those threats.

Table 4. Threats to Eastern Mountain Avens, *Geum peckii* (identified in March 2022 Threat Calculator) and the associated species stressors impacted directly by the threats or indirectly through other mechanisms impacted by the threat. Note: discussion was not exhaustive and absence of information here does not indicate lack of potential impact.

	Species Stressors							
Threats	**Loss of seeds**	**Loss of new seedlings**	**Loss of mature plants/ low vegetative reproduction (rhizomes)**	**Low sexual reproduction (achenes)**	**Disruption of germination**	**Isolated populations**	**Low genetic diversity (including impacts of inbreeding depression)**	**Restricted population size**
High-medium impact								
Climate change - habitat shifting & alteration (short term; including impacts of competition/ shrubification)	-	Direct impact & disruption of pollination → isolated pockets/ inbreeding depression	Direct impact	Disruption of pollination	-	Direct impact	Disruption of pollination → increase in self-pollination	Disruption of pollination
Medium-low impact								
Dams & water management / use (ongoing)	Direct impact	Direct impact	+/- flooding	-	-	-	-	-
Ecosystem modifications due to gulls (ongoing; higher in some populations)	-	Direct impact & disruption of pollination → isolated pockets/ inbreeding depression	Eutrophication → habitat loss (irreversible?) LONG TERM; Sphagnum killed	Disruption of pollination	-	Direct impact	Disruption of pollination → increase in self-pollination	Disruption of pollination

	Species Stressors							
Threats	**Loss of seeds**	**Loss of new seedlings**	**Loss of mature plants/ low vegetative reproduction (rhizomes)**	**Low sexual reproduction (achenes)**	**Disruption of germination**	**Isolated populations**	**Low genetic diversity (including impacts of inbreeding depression)**	**Restricted population size**
Ecosystem modifications due to succession (ongoing; higher in some populations)	-	Direct impact & disruption of pollination → isolated pockets/ inbreeding depression	Direct impact	Disruption of pollination	-	Direct impact	Disruption of pollination → increase in self-pollination	Disruption of pollination
Low impact								
Climate change - storms & flooding (Ongoing - Short Term)	Direct impact	Direct impact	Direct impact	-	-	-	-	-
Unknown impact								
Climate change - temperature extremes (Ongoing - Short Term)	-	Disruption of pollination → isolated pockets/ inbreeding depression	-	Disruption of pollination	Direct impact	-	Disruption of pollination → increase in self-pollination	Disruption of pollination

4.2. Fundamental objectives of ex situ program for Eastern Mountain Avens

The potential *ex situ* management strategies proposed should address one or more specific threats or constraints to the species' viability as identified in the status review and threat assessment in order to ensure they will help to improve conservation efforts. Objectives from the Recovery Strategy included: 1) maintain populations at occupied sites, 2) improve conditions and enhance populations at occupied sites, and 3) improve conditions at previously occupied sites. Since those objectives were established, many actions have been completed and new information has become available. It was therefore important to identify what the group hoped to achieve by engaging in *ex situ* management, and to clearly articulate the fundamental objectives before further decision making took place.

Participants were asked to consider fundamental objectives (those articulating what participants wanted to achieve) versus means objectives (ways of achieving an end result) and based on a set of guiding questions, participants were asked to identify their two greatest concerns. Guiding questions included:

- What are you trying to achieve by assessing *ex situ* roles for this species?
- What are the specific issues or concerns you would like to see addressed?
- What would be the best outcome (even if you consider it infeasible). Why?
- What would be a terrible outcome? Why?
- What do you want to avoid in making your choice?
- What are the hidden agendas or political "realities" that could thwart recovery?

Participants then assessed and grouped their responses, identifying where overlap occurred. From the group discussion, concise objective statements were developed that were complete, controllable, concise, measurable, and understandable and which addressed the compiled list of concerns (Table 5).

During the process of identifying potential population management roles (see following section *4.3. Potential* ex situ *population management roles to address threats and objectives*) it was determined that some concerns around actual implementation of resulting plan/actions (e.g., political will, funding) were outside the scope of influence of this group thus the 'implementation of plan' objective was deemed uncontrollable and not used to assess conservation values; however, developing a plan and not implementing it was still noted as a concern that threatens the species. It was also noted that the intention of the objective of 'maintaining the natural balance of the ecosystem' was unclear and resulted in uncertain assessments for that objective related to a lack of knowledge of the natural ecosystem.

Table 5. Fundamental objectives and concerns addressed for Eastern Mountain Avens (*Geum peckii*) recovery.

Fundamental Objectives	Concerns
Regain genetic variation	Small population; not a lot of genetic material to work with
	Population is spatially restricted
	Losing evolutionary history by focusing on numbers
Self-sustaining climate-resistant wild population	Trends of declining numbers at many sites
	Suitable habitat is too far for natural dispersal under climate change
Cost effective and sustainable recovery program	Uncertainty about sustainability/feasibility of constant action/recovery activities
Integrated One Plan Approach style recovery program	*Ex situ* may shift focus away from *in situ*/habitat restoration
Maintain the natural balance of the ecosystem	Community loses ecological indicator of ecosystem health
	Taking resources away from more ecologically important species
	We are intervening where we should not; species is at the end of its time
Knowledge and evidence based recovery program taking adaptive management approach	Knowledge/research gaps undermining recovery efforts (e.g., species resilience; effective seed banking for long-term management; end results of restoration projects)
Avoid extinction of the species in Canada	Losing the species and setting a precedent
	Canada not doing everything it can to keep the (global) species alive; society will not put enough PRIORITY or RESOURCES on species, and it will be FORGOTTEN
	Risk of inaction due to uncertainty e.g., addressing knowledge gaps (resource and time intensive/ overcautious) at expense of ACTION
	Already too late e.g., major threats to species cannot be managed/mitigated; causes of decline not fixable; habitat manipulation may not recover species; climate change making current habitat inhospitable
Implementation of Plan (uncontrollable)	Meeting our obligations i.e., call to ACTION/commitments honoured; taking a precautionary approach

4.3. Potential ex situ population management roles to address threats and objectives

Potential conservation roles of *ex situ*/translocation activities, and how they might impact wild population viability through addressing threats and stressors were discussed. All possible *ex situ*/translocation conservation roles (see Appendix IV for description of roles) were considered in a preliminary guided discussion to identify which roles may address current threats. To maintain consistency with the IUCN Threat Calculator used for the status assessment, a timeframe of 25-50 years was used to guide discussion.

A working definition of the population unit(s) was developed for the purpose of the discussion in this workshop (and only for this purpose). It was decided that the Canadian population would be considered as two sub-populations - Brier Island and Harris Lake (Figure 5). As no other sub-populations are known to have occurred outside of the current range within Canada in a recent timescale (i.e., without pollen core data, which was noted as a knowledge gap), these two sub-populations also represent the historic population range.

In 2018, 72 plants were propagated from the Acadia seed bank and experimentally outplanted as part of an M.Sc. project, to a site on Long Island that is not considered suitable habitat in the long-term (Figure 5). The objective of the project was to test tissue culture methods for propagating plants in a field setting and associations with arbuscular mycorrhizal fungi (Fancy 2017). While some of the outplanted individuals survived as of 2021, they were in poor health and did not show signs of reproduction; these were not removed but their current status is unknown. Given the short time frame during which the species was present at this location, and uncertainty and low likelihood of current persistence, Long Island was not considered an established *in situ* sub-population for the purpose of the discussion.

It was further recognized that the population in New Hampshire may be a possible source of material for *ex situ* recovery efforts in Canada, but a better understanding of the genetic population structure of NH and NS populations is required.

The following four *ex situ* conservation roles were determined to not be relevant at this time and eliminated from further detailed assessment:

- *Ark population* - the whole population of Eastern Mountain Avens is not so small that it is at threat from stochastic event(s)
- *Population rescue* - several subsites have steep negative population trajectories; however, are not currently faced with certain imminent threats that could be addressed through population rescue. *However further discussion is needed regarding uncertainty or contingency planning, for example, in the case of fire or flooding for* in situ *populations.*
- *Ecological replacement* - Eastern Mountain Avens is not fulfilling a vital ecological role that has been lost in other ecosystems

- *Reintroduction* - Based on the common understanding of population structure and current knowledge of historic range, reintroduction in Canada was not applicable at this time since Eastern Mountain Avens has not been lost from any previously occupied areas. If further research (e.g., pollen core data) clarifies the historic range, then reintroduction may be reevaluated.

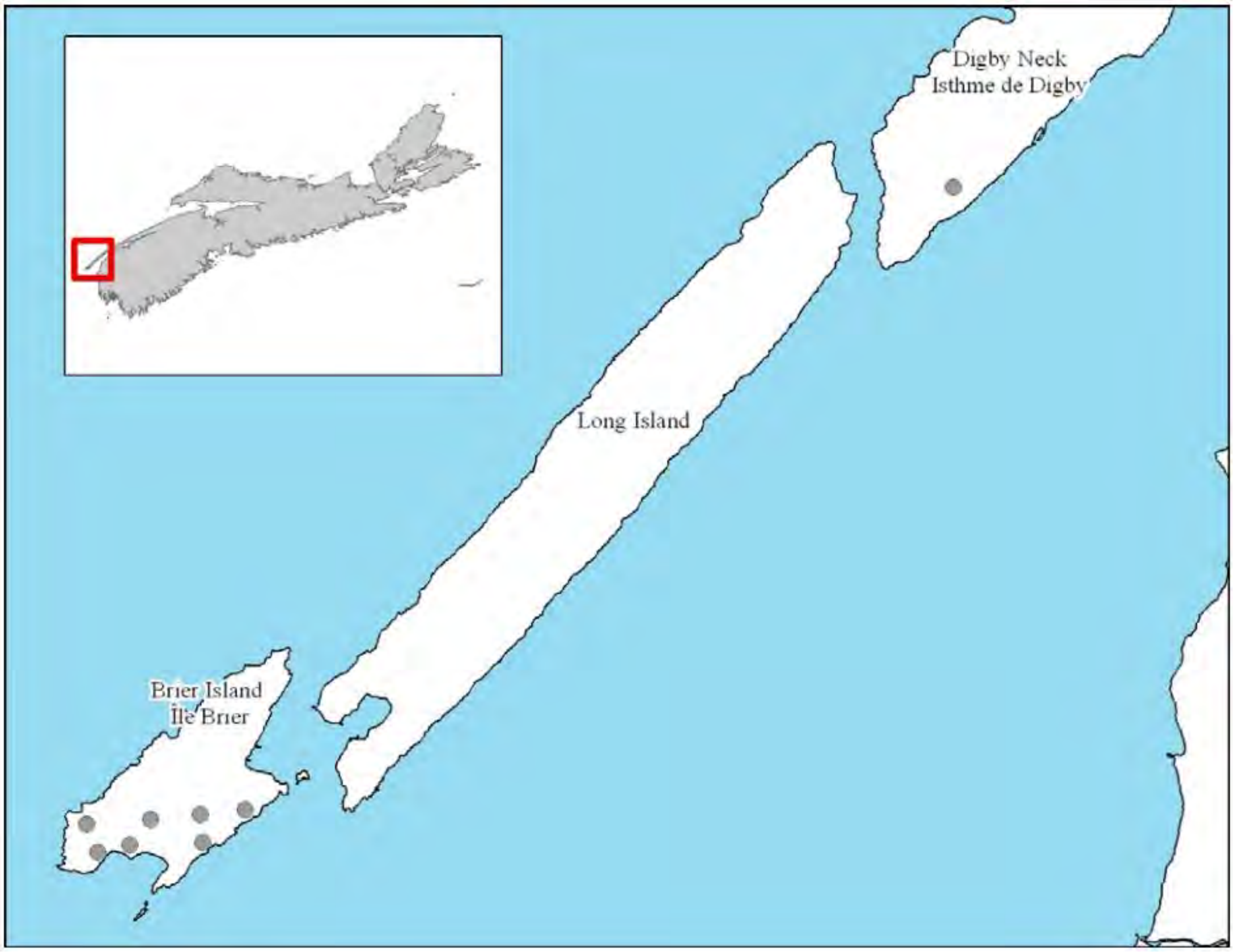


Figure 5. Map of Eastern Mountain Avens (*Geum peckii*) range within Nova Scotia showing the sub-populations, Brier Island and Harris Lake (Digby Neck). An experimental trial was planted on Long Island in 2018 – the status of the site is unclear, but it is likely that no plants remain. (Map from the Recovery Strategy for the Eastern Mountain Avens; Environment Canada, 2010)

Six *ex situ* conservation roles were identified as potentially applicable for Eastern Mountain Avens and moved forward for more detailed assessment (Figure 6):

1. Insurance population - Maintain a long-term viable *ex situ* population to prevent local, regional, or global species extinction and preserve options for future conservation strategies. Typically for threatened or declining species for which *in situ* threat mitigation is uncertain. Example: seed bank
2. Assisted colonization - Introduce the species outside of its indigenous range to avoid extinction of populations of the species in the wild using either wild or *ex situ* sources.
3. Demographic/genetic reinforcement - Improve a demographic rate (survival or reproduction) or status (e.g., skewed age classes) in the wild, often of a particular age, sex, or life stage. Can involve *ex situ*-propagation and subsequent release or transplantation of pollen, seeds, or individual plants as well as temporary removal from the wild and subsequent release/transplantation after some *ex situ* period (i.e., wild-to-wild translocation). Example: growing/hardening plants in nursery environment for several years to improve seedling survival
4. Conservation-based education - Education and awareness program that addresses specific threats or constraints to the species or its habitat. Education should address specific human behavioural changes that are essential for conservation. Primarily involves *ex situ* locations visited by the intended audience.
5. Conservation-based research - Use an *ex situ* population for research that will directly benefit conservation of species in the wild. Must address essential questions for the conservation strategy. Can include non-threatened species as a model for threatened species. Can include establishing expertise and protocols for future needs.
6. Conservation-based training - Use *ex situ* individuals for training that will directly benefit conservation of species in the wild. Must address skills essential for the conservation strategy. Can include non-threatened species as a model for threatened species.

The conservation value of each of these *ex situ* roles was assessed against the fundamental objectives and species stressors (Table 6).

Insurance population was selected as the first role to move forward with for further discussion of alternative strategies and program characteristics (see following section *4.4. Identification of alternative approaches/strategies*) as there is already an established seed bank and outplanting program at Acadia University. This provided a framework for discussion of an expanded insurance population program and the characteristics of *ex situ* programs for demographic/genetic reinforcement and assisted colonization were then built upon the insurance population program.

Conservation-based research, education, and training programs were recognized as being important but of lower priority for the current discussion, and so due to time constraints no time was dedicated to discussion of these roles. However, it was noted that conservation-based research and training addressed the fundamental objectives, albeit sometimes in an indirect, “multi-stepped” pathway (e.g., training with *ex situ* population to help mitigate threats or inform monitoring and protocols). Further, conservation-based education was hard to link directly to the individual fundamental objectives and population viability without knowing the scope or details of a specific education program.

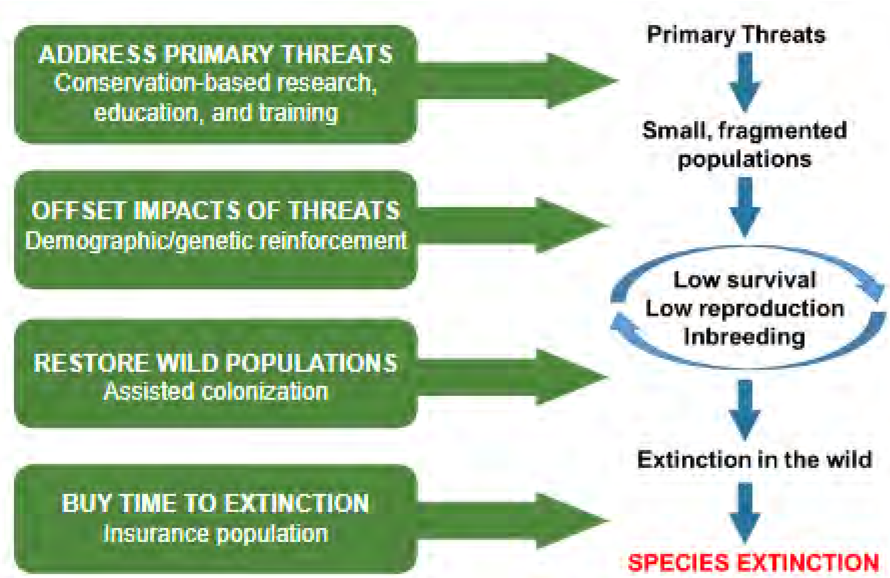


Figure 6. Identified *ex situ*/translocation roles with conservation value for Eastern Mountain Avens (*Geum peckii*) and where they have the potential to help in the context of the path to species extinction (i.e., the "extinction vortex" or the heuristic model of population decline brought about by demographic and genetic instability in small, declining populations).

Table 6. Anticipated ability of potential *ex situ* conservation roles to address fundamental objectives and impact *in situ* population viability for Eastern Mountain Avens, *Geum peckii* (Timeline 25-50 years; red = not discussed at this time).

	***EX SITU* CONSERVATION ROLES**						
OBJECTIVES	Insurance population	Assisted colonization	Demographic/ Genetic reinforcement	Conservation based education	Conservation based research	Conservation based training	Rescue population; Ark population; Ecological replacement
Regain genetic variation	yes	yes	yes	yes, there is value, but difficult to link to Objectives	yes	yes (monitoring)	n/a
Self-sustaining climate resistant wild population	yes	yes	uncertain		yes	yes	n/a
Cost effective and sustainable recovery program	yes	yes	yes		yes	yes	n/a
Integrated One Plan Approach style recovery program	yes	yes	yes		yes	yes	n/a
Maintain the natural balance of the ecosystem (uncertainties due to lack of knowledge / definition of what is "natural" balance / baseline)	yes / uncertain	no / uncertain	uncertain		yes	uncertain	n/a
Knowledge and evidence based recovery program taking adaptive management approach	yes	yes	yes		yes	yes	n/a
Avoid extinction of the species in Canada	yes	yes	yes		yes	yes	n/a
IMPACT ON *IN SITU* POPULATION VIABILITY							
Survival of plants (i.e., loss of seeds/seedlings/ mature plants and disruption/impacts on reproduction)	may help maintain *in situ* population, in combination with other roles	uncertain	yes	uncertain, depending on exact program	yes	yes	n/a
Restricted population size		yes	yes		yes	yes	n/a
Isolated populations		yes	yes, within population scale		yes	yes	n/a
Low genetic diversity		yes	yes		yes	yes	n/a

4.4. Identification of alternative approaches/strategies

Due to time limitations, workshop participants prioritized for further discussion the following subset of *ex situ* roles that could potentially be beneficial for the long-term conservation of Eastern Mountain Avens i) insurance population, ii) demographic/genetic reinforcement, and iii) assisted colonization. Each of these options was then evaluated in a thorough analysis, including a detailed characterization of each option, the requirements for their proper implementation, and the relative risks and feasibility of implementation.

In defining the characteristics of the program needed to fulfill each potential role, participants brainstormed and developed alternative approaches to delivering them, including consideration of different life stages, sources, etc. Discussion was not restricted to only *ex situ* options, and considered all intensive population management possibilities e.g., wild-to-wild translocation. Specific alternatives under each role were tailored for their application to the species. Careful consideration was given to how program attributes differed among the alternative approaches for each role. Participants then assessed the risks and feasibility of each potential strategy.

Figure 7 provides a general overview of the *ex situ* roles, potential alternative strategies considered, source and recipient sub-populations, and the potential interactions among these programs.

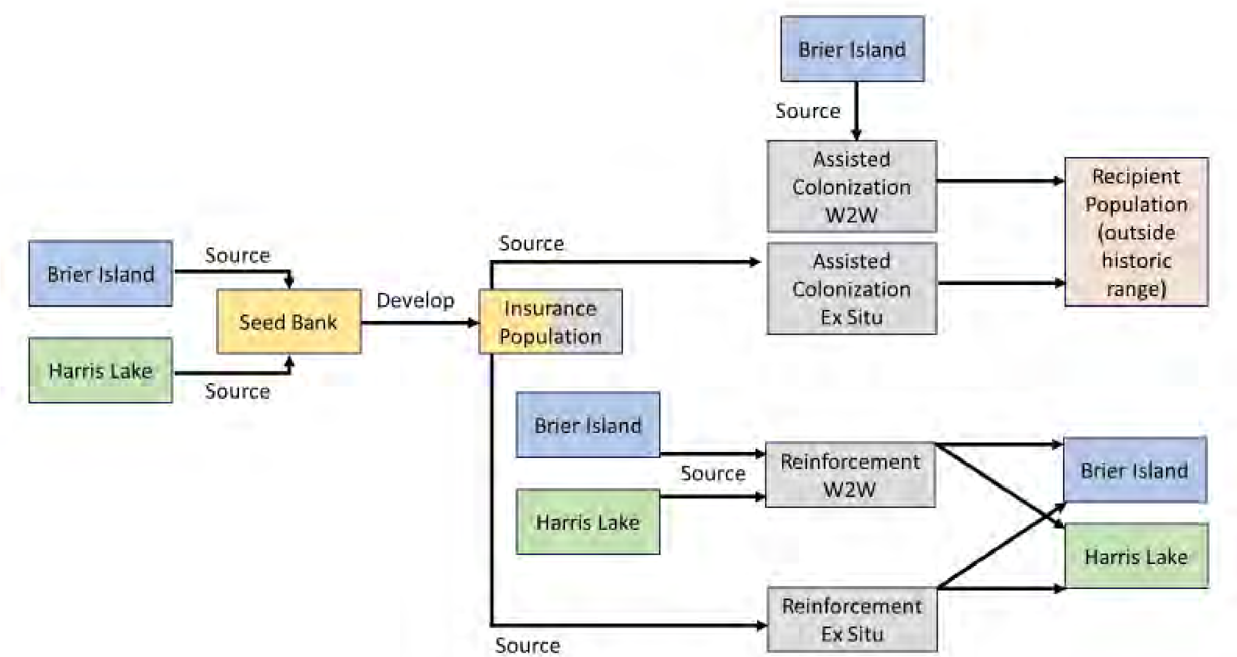


Figure 7. Overview of intensive management strategies assessed for Eastern Mountain Avens (*Geum peckii*) conservation (W2W = wild-to-wild translocation).

Following an evaluation of the conservation value, risks, and feasibility of each potential option, the group made recommendations on whether to adopt the program as part of a larger species conservation strategy.

For each role and strategy, participants identified triggers for action (i.e., the events that had to occur before work could move forward for a strategy), conditions for implementation (i.e., prerequisites before proceeding with strategy implementation) and exit decision points (e.g., indicators of lack of success, undesired or unacceptable consequences).

An overview of the assessment and discussion, by role and strategy, is provided below. Initial action planning is detailed in section *5. Preliminary Conservation Action Planning*.

4.4.i. ROLE 1: Insurance population

Role description: Insurance population - Maintain a long-term viable ex situ *population to prevent local, regional, or global species extinction and preserve options for future conservation strategies.*

To date, ~100,000 seeds from Brier Island are being maintained at the Acadia Seed Bank, Irving Biodiversity Collection, Acadia University. Currently, the Harris Lake sub-population is not represented in the collection. Viability of seeds will degrade over time, which impacts the strategies required to maintain a viable insurance population. In order to ensure long-term sustainability, it will be necessary to conduct out-planting trials to determine the long-term viability of seeds and inform appropriate collection frequencies for new founder stock. If loss of genetic variation is significant over time with banked seeds, then tissue culture, outplanting, and managed crossings would be necessary to ensure an appropriate level of genetic variation. Given these considerations, the group developed an outplanting program ("seed orchard") model for the proposed insurance population. This model includes a traditional seed bank but requires outplanting into gardens and/or potted nurseries in order to genetically manage the population, with seeds being collected back into the seed bank. This strategy could be undertaken at herbariums/botanical gardens where local environmental conditions are suitable.

As the existing *ex situ* facility and seed bank in Canada, it was recommended that Acadia Seed Bank and Harriet Irving Botanical Gardens be the 'hub' of this program, and lead coordination of the seed orchard/outplanting program with collaborating satellite facilities, including supply of seeds. Additional targeted funding would be necessary to ensure Acadia University has the capacity to manage this *ex situ* source population and coordinate the larger program with the other collaborating institutions, purchase necessary equipment/supplies, conduct outcrossing analysis and recommendations, and provide guidance/oversight, including in regard to storage, permits, etc.

Possible collaborators identified included the Southwest Nova Biosphere Reserve, University of Quebec at Abitibi, IRBV Montreal, or facilities in New Hampshire, where the remaining populations of Eastern Mountain Avens currently occur. Use of multiple locations would provide insurance against catastrophe at any one facility. Participants also suggested that mined peatlands (in collaboration with ongoing research out of Université Laval) could potentially be restored and used to propagate the species.

In order for an insurance population to represent the full range of genetic variation, seeds (i.e., genetic representation) are required from the Harris Lake sub-population. Further genetic analysis is needed to determine the structure of the founder population and subsequent genetic management of the insurance population, particularly whether out-crossing between the Harris Lake and Brier Island sub-populations would be beneficial or detrimental to these sub-populations. Ideally, out-crossing would be managed amongst institutions using a population management approach in which pairs are purposeful and informed to address inbreeding depression (i.e., 'plant studbook,' a database of plant breeding records, where "stud" is defined as genetically robust and/or appropriate individuals of *Geum peckii*).

Further considerations include "ownership" of *ex situ* plant materials, the need for specialized knowledge and training (e.g., tissue culturing and soil expertise) and permit requirements to both obtain and maintain seeds and plants. Permits are required for collecting, storage/possession, and interprovincial and international movements. Both 'source' and 'recipient' institutions must be permitted. Permitting must be considered across all relevant jurisdictions, including local, provincial and federal government jurisdiction, as well as landowner permission. While herbarium/botanic gardens such as Acadia Seed Bank and Harriet Irving Botanical Gardens are collaborative and support research and conservation, it may be prudent to develop a Memorandum of Understanding among partners to guide and formalize collaboration.

Table 7 summarizes the necessary characteristics and associated considerations of implementing a seed bank and seed orchard/outplanting program as an insurance population for Eastern Mountain Avens.

Table 7. Considerations for insurance population program for Eastern Mountain Avens (*Geum peckii*).

Strategy: Seed bank and seed orchard/outplanting program
Resource considerations
• $50-100K approx. for Acadia University to be a coordinating hub for insurance population, including materials and supplies for satellite facilities and supporting research (e.g., genetic research/analysis, seed bank methodologies) • Specialized expertise and training needed, especially in culturing and soil expertise - succession planning for staff required • Permits and permissions: provincial permit for collection and storage; research permit from NCC if collection on Brier Island; other private landowner permissions; receiving institutions need provincial permit to hold seeds/plants; federal and/or provincial permits required for transfers between provinces • Protocols needed for final fate of individuals (incineration)
Demographic and Genetic Management

• Founder population size and structure - information already exists to inform this
• Frequency of new founders from wild source population(s) depends on seed viability trials; estimate approximately every 5-10yrs
• Taxonomic scope
    ○ Need representation from each sub-population; Harris Lake represents a critical gap and obtaining seeds from that sub-population is high priority
    ○ Assess need for New Hampshire stock for Canadian insurance population
• As a means to maintain genetic viability and resilience of the *ex situ* population, plants should be reared outdoors across a range of natural conditions at different satellite facilities (e.g., in boreal environment)
• Genetic metapopulation management to avoid inbreeding depression, i.e., "studbook" genetic management (e.g., Hortis), making breeding recommendations (mandatory) for participating facilities.
    ○ Strategic cross-pollination in seed orchard gardens can be used to "create" particular strains necessary for the seed bank
    ○ Additional genetic analyses needed to inform appropriate genetic management

Location and Scale
• Acadia University as central coordinating hub for seed bank with additional facilities/satellite sites for out-planting in outdoor gardens/nursery sites (in ground) or nursery setting (in pots) • Collaborating facilities must be in appropriate environments to help build insurance population • RESEARCH - could use nursery sites as pilot plots to understand response to range of environmental conditions and determine site suitability; currently the climatic tolerance of the species is unknown • Expect good collaboration if it is conservation/research focused
Catastrophes
• Insurance: need >1 facility to protect from catastrophic loss

Tables 8 and 9 summarize the assessment of potential risks and feasibility of implementing a seed bank + seed orchard/outplanting program as an insurance population for Eastern Mountain Avens. Many of the risk and feasibility considerations concerned the outplanting component of the seed orchard since this necessitates finding satellite facilities with suitable environmental conditions and maintaining outdoor gardens where plants are in the ground. Overall, however, this strategy was considered to have relatively low risk and high feasibility.

Table 8. Risks of implementing a seed bank + seed orchard/outplanting insurance population for Eastern Mountain Avens (*Geum peckii*).

Potential Risk of Implementation	**Considerations for Insurance Population**
Risk to source population (Impact of removing individuals from the wild on the remaining wild source population)	Collection of seeds poses very little risk to wild populations.
Ecological risk (Major impacts at release site on other species, and/or on ecosystem functions)	Abandonment of nursery sites, unintended colonization of new sites and hybridization near the satellite facilities was discussed, however the risk of impact to other species or ecosystem at satellite gardens was considered low.
Disease risk (Risk of disease/ pathogen transfer from translocation stock having a negative impact on **other organisms** at the release site, including EMA wild population)	No known pathogens or parasites but impact of novel pathogens and parasites is unknown. Low risk of introducing potential pathogens to wild populations while collecting for seed bank, however this can be mitigated through appropriate sanitation protocols. Potential risk of disease at nurseries if kept at high density, or higher temperatures. Plants maintained in human care may be stressed and more susceptible to disease.
Could the species be **invasive** outside of indigenous range or is there an **Associated Invasion risk**? (Risk of potentially invasive species being accidentally released with individuals of the focal species)	Given characteristics of Eastern Mountain Avens, it is unlikely to pose an invasion risk.
Gene escape (Risk of hybridisation with closely related species or subspecies, which may possibly result in lower fitness of offspring and/or loss of species integrity)	Low risk of gene pool contamination from congregations of plants at nurseries and hybridization with other avens species.

Potential Risk of Implementation	**Considerations for Insurance Population**
Socio-economic risks (Potential direct and indirect negative impacts on human interests - dangers to people, indirect effects impacting food supplies, clean water, pollination; public against removing individuals in source area)	The risk of creating a demand for the species in private gardens was discussed. Although the species is legally protected, people may desire them for their gardens in an effort to “help”. Such a scenario could result in a significant adverse impact since it could lead to a loss of control and coordination in terms of propagation and proper genetic management. However, due to legal protections under the NS Endangered Species Act, permits for planting this endangered species in a home garden are not typically issued to the general public, and current permits do not allow seeds/plant material to be given to the general public, they can only be given to another permittee which makes this unlikely to become an issue.
Financial risks (IF the translocated species causes significant unacceptable consequences would there be a need for funding to discontinue the translocation or to apply remedial funding to any damage caused by the translocated species)	Considered low risk
The risk of **Catastrophes** impacting the *ex situ* population	Having multiple collaborating facilities lessens the likelihood of catastrophic loss of the entire seed bank from one event.
Artificial selection	The potential for artificial selection is a concern. Proper protocols and seed collection strategy will need to be developed to limit this risk; methods to assess and mitigate this do exist, e.g., modelling, plant studbook management. Research can help quantify and better understand this risk and inform management protocols accordingly.

Table 9. Feasibility considerations of implementing a seed bank + seed orchard/outplanting insurance population for Eastern Mountain Avens (*Geum peckii*).

Feasibility of Implementation	Considerations for Insurance Population
We have sufficient basic **Biological Knowledge** for this or a closely related species to implement the role	Yes. Acadia University's Harriet Irving Botanical Gardens has sufficient expertise through existing activities to manage a seed bank and seed orchard program. Further study of genetics and appropriate soil conditions can inform and improve husbandry protocols. Continued *in situ* and *ex situ* research could help improve plant fitness.
There is sufficient availability of suitable **Habitat**. That habitat is secure from incompatible land-use change over the long-term.	Satellite facilities would be selected based on availability of suitable environmental conditions. Potential to conduct research to increase our understanding of required environmental conditions by selecting sites across a range of conditions
The **climate** at release site(s) is suitable for this species for next 25-50 years	Satellite facilities would be selected based on suitability of climate. Potential to conduct research to increase our understanding of climatic tolerance by selecting sites across a range.
Disease/ Pathogens/ Parasites	Unknown. Risk is to nursery site plants.
Social Feasibility - There are no/low **social challenges/barriers** e.g., community opposition to collection/release. The program aligns with existing legal and policy frameworks, national biodiversity action plans or existing species recovery plans, i.e., we do not expect opposition	Expect high social acceptance of program with adequate and appropriate communication with communities at satellite sites and collections sites. Permissions for collection from private lands, especially Harris Lake, need to be pursued sensitively to avoid any potential negative ripple effects to the community (e.g., Landowner rights concerns).
Regulatory compliance - we are able to meet all regulatory requirements, including obtaining appropriate **permits** from all necessary jurisdictions for activities, e.g., collection, release, movements including across jurisdictions.	Moderate feasibility depending on location of outplanting/satellite facilities. Need to consider logistics and permit needs of collaborating facilities within vs outside of Nova Scotia.
We are able to obtain the **required resources/ expertise**, including technical experts, skilled staff and facilities. Do we know how to make happy plants?	With renewed interest and adequate funding, can hire people with the required expertise and provide training to ensure smooth succession, as well as transfer knowledge to collaborating facilities.

Feasibility of Implementation	Considerations for Insurance Population
Appropriate founders are available, and we have access	Appropriate founders are available from existing seedbank, however access to Harris Lake to collect seeds is currently unknown.
We have **assurance of funding** for all essential activities over an adequate period of time	Currently do not have adequate funding to implement this role, but there is opportunity to look for targeted funding. Funding is sparse with the numbers of endangered species needing attention.

Given the high conservation value of this strategy, and the low risk and high feasibility of implementation, the group recommended developing a seed bank + seed orchard/outplanting insurance population as a component of the conservation strategy for Eastern Mountain Avens. Additional genetic analyses will be needed to inform the appropriate genetic management of the population to ensure retention of genetic variation and any potential distinct lineages.

As there is an existing seed bank and associated work has already begun, no conditions for implementation were identified. The insurance population/seed bank is intended to exist in perpetuity based on global guidance for seed banking for biodiversity conservation and the anticipation that the species will always be listed as at-risk by COSEWIC. As such, an exit point was not identified for this strategy, rather the purpose and capacity of the seed bank + seed orchard/outplanting program should be scaled based on the needs of other *ex situ* conservation roles (i.e., population reinforcement, assisted colonization) to meet the fundamental objective of a self-sustaining climate resistant wild population.

4.4.ii. ROLE 2: Demographic/genetic reinforcement

Role description: Demographic/genetic reinforcement - Improve a demographic rate (survival or reproduction) or status (e.g., skewed age classes) in the wild, often of a particular age, sex, or life stage. Can involve ex situ-*propagation and subsequent release or transplantation of pollen, seeds, or individual plants as well as temporary removal from the wild and subsequent release/ transplantation after some* ex situ *period (i.e., wild-to-wild translocation).*

In discussing the characteristics of a population reinforcement program, the group considered two alternative strategies: i) wild-to-wild translocation, and ii) using the insurance population as an *ex situ* source. In both of these strategies, both transfers of pollen (assisted pollination) and plant material (seeds and plants) were considered. Use of an *ex situ* source would require the *ex situ* population to be established and scaled up to support the needs of the reinforcement program without jeopardizing its own viability. Therefore, the resource and population management considerations for this strategy include those previously discussed for the seed orchard, but with additional resource needs for field work/transplanting, as well as germination and growing of required numbers of plants for whole plant translocations. Table 10 summarizes the required characteristics of alternative approaches to population reinforcement discussed.

Table 10. Considerations for reinforcement programs for Eastern Mountain Avens (*Geum peckii*).

Strategies: 1) Wild-to-Wild, 2) *Ex situ* source, 3) pollen vs plant material
Resource Considerations

• In addition to resource needs for maintaining the insurance population, additional resource requirements for *ex situ* source include:
  ○ More staff at Acadia University to comb plants for pollen and germinate and grow the numbers of individuals needed for reinforcement efforts. Because of die-off at each stage, need to germinate many more seeds than needed.
  ○ Larger seed bank to supply program
  ○ Soil and tissue culture expertise to support plant translocations
• Field personnel for moving pollen/seed/plants between sub-populations (all strategies) and associated travel costs.
• Translocation of seeds requires preparation of habitat and scarification of seeds
• Movement of adult plants requires a shovel (assuming suitable recipient habitat)
• Monitoring costs. Monitoring will be needed to determine if transplanted individuals flowered / were pollinated / produced seeds

Demographic and Genetic Management
• Further research needed to understand genetic variation within existing wild populations, genetic distinction between populations/sub-populations (including those in New Hampshire), whether local adaptation may be occurring, and whether genetic outcrossing between sub-populations would have a positive or negative impact, particularly for Harris Lake. This research would also inform how the *ex situ* population would be managed in order to provide appropriate, resilient stock for reinforcement efforts. • Outcrossing between isolated sites within Brier Island has been shown to improve germination

Location and Scale
● Assisted pollination can be implemented both within and between sub-populations to improve germination ● *Ex situ* population would need to be scaled up to support reinforcement efforts. More seeds would need to be collected (from within the seed orchard with periodic new founders) and maintained in order to supply outplanting needs (seeds or plants). ● The effectiveness/success of seeds vs mature plants for outplanting/transplant requires further study
Catastrophes (not discussed)

There are currently two extant sub-populations in Canada: (A) Brier Island, and (B) Harris Lake (Figure 5). As Harris Lake is not currently represented in the existing seed bank, collection of seeds from Harris Lake is considered key and would assist in filling critical genetic knowledge gaps necessary to guide program implementation, e.g., whether Harris Lake would benefit from genetic reinforcement. Also, the suitability of potential recipient sites, particularly Harris Lake, requires evaluation, as there has been much alteration and degradation of habitat. Presence of pollinators and potential disruptions of pollination due to factors such as shrubification should be considered.

A threshold minimum viable population (MVP) size of less than 50 individual plants (based on the recommended MVP for *Potentilla robbinsiana;* Iszard-Crowley and Kimball, 1998) was considered a good starting criteria for determining when a sub-population should be a candidate for reinforcement activities, however ultimately this threshold is unknown and should be reviewed as well as different methods for monitoring population size (e.g., individual plants vs. square metre plots). It was noted that there is greater urgency regarding augmentation of the Harris Lake sub-population, as this sub-population may already meet this criterion, and participants noted that germination rates are assumed to be very low. Currently, the Harris Lake sub-population is small and not thriving, and has been subjected to habitat alteration. The efficacy of focusing on habitat restoration alone is unknown. Additionally, it is unclear how many individuals occur in this sub-population and the degree of differentiation among them (i.e., number of clones represented).

Research conducted to date suggests a good success rate for transplanting adult plants, while transplanting rhizomes appears to yield less successful results. Successful *ex situ* propagation from seed is difficult and resource intensive, especially in large numbers as there is die off at each stage. Moving plants or seeds does not guarantee population reinforcement is occurring, as individuals may persist but not flower, or sexually reproduce; however, there are ways this could be monitored. Further work is required to identify the most effective life stage to transplant. In general, success of transplants depends on the suitability of habitat and threats present at the recipient site.

While reinforcement, by definition, refers to movements between population units, there was some discussion on the transfer of pollen among plants within a sub-population. Pollen can be moved from individuals in a "core" area of the sub-population to pollinate more peripheral isolated individuals that are less likely to be pollinated in order to improve germination rates as compared to self-pollination (as seen in trials on Brier Island). This strategy can also be used between sub-populations, if determined appropriate with further genetic analyses. This strategy also requires very few resources, besides field personnel and travel expenses.

Wild-to-wild translocation of whole plants poses significant risk to the wild source populations, as these are already small and isolated, particularly Harris Lake; movements of seeds pose less of a risk. Uncertain access to Harris Lake currently impacts the feasibility of many options, and efforts to build a positive relationship with the property owners are a critical next step. Even if access was permitted, participants felt that reinforcement of Harris Lake from Brier was the least feasible option due to uncertainty around long-term habitat suitability of this site, and, as long as there was no urgency, movements into Harris Lake should not be considered due to the potential unique genetic diversity of this sub-population. Generally, within sub-population movements were preferred.

Translocations of seeds or plants from an *ex situ* source were considered overall low risk and moderate feasibility. The biggest concern was the potential risk of disease or pathogen transfer from plants grown *ex situ*, as the substrate would also be transplanted. Greater soil expertise within the Acadia University team was seen as a need to help address this issue, as well as improve the biological knowledge needed to propagate the species. The uncertain long term suitability of either recipient site also challenged the feasibility of these options, as well as securing sufficient funding to maintain an *ex situ* program capable of producing the numbers required for reinforcement, especially if using mature plants. Any movements of seeds/plants across provincial boundaries from satellite sites for use in reinforcement activities would also likely require more effort to secure appropriate permits.

Assisted pollination using pollen from either wild or *ex situ* sources was considered overall to have minimal risk and be extremely feasible.

Long term climate suitability within the existing range was a concern, reducing the potential feasibility of all options. Tables 11 and 12 summarize the assessment of risks and feasibility of the alternative methods for population reinforcement that were considered for Eastern Mountain Avens.

Table 11. Risks of implementing various strategies of population reinforcement for Eastern Mountain Avens (*Geum peckii*).

Potential Risk of Implementation	**Considerations for Population Reinforcement**					
	***Ex Situ* Source - Plants**	***Ex Situ* Source - Seeds**	**HARRIS TO BRIER Wild-to-Wild Translocation - Plants**	**BRIER TO HARRIS Wild-to-Wild Translocation - Plants**	**Wild-to-Wild Translocation - Seeds**	***Ex Situ* or Wild Source - Pollen (Assisted pollination)**
Risk to source population (Impact of removing individuals from the wild on the remaining wild source population)	n/a - *ex situ* source will be appropriately managed.		Risk to Harris Lake as source population is high, as it is already so critically small. Need to better understand the genetic relatedness between sub-populations to inform genetic management and selection of individuals/sites for transplant.	Less of a risk than removal from Harris Lake, but still a concern due to small population size. Need to better understand the genetic relatedness between sub-populations to inform genetic management and selection of individuals/sites for transplant.	Minimal	Minimal
Ecological risk (Major impacts at release site on other species, and/or on ecosystem functions)	Plants are a higher risk than seeds as they cannot be sterilized and could potentially transport other unwanted organisms.	Seeds are less of a risk than plants as they can be sterilized which removes potentially harmful organisms from the outside. Anything inside	Lower risk for movement of wild-to-wild plants compared to *ex situ* plants into wild		Lower risk than movement of plants from any source.	Minimal - Pollen from *ex situ* source could be an increased risk, compared to wild sources. Also, more risk in moving pollen, compared to seeds (i.e., can be

Potential Risk of Implementation	**Considerations for Population Reinforcement**					
	***Ex Situ* Source - Plants**	***Ex Situ* Source - Seeds**	**HARRIS TO BRIER Wild-to-Wild Translocation - Plants**	**BRIER TO HARRIS Wild-to-Wild Translocation - Plants**	**Wild-to-Wild Translocation - Seeds**	***Ex Situ* or Wild Source - Pollen (Assisted pollination)**
	Current biosecurity measures can minimize these risks.	the seed is likely beneficial or even necessary for proper germination. Current biosecurity measures can minimize these risks.				sterilized), but still considered minimal.
Disease risk (Risk of disease/ pathogen transfer from translocation stock having a negative impact on **other organisms** at the release site, including EMA wild population)	Same as above	Same as above	Minimal	Minimal	Minimal	Minimal
Could the species be **invasive** outside of indigenous range or is there an	Same as above	Same as above	There are no plant species at Harris Lake that are not found on Brier	Most of the plant species at the two sites are the same, however glossy buckthorn	Risk of moving plants is higher than seeds	Minimal

Potential Risk of Implementation	**Considerations for Population Reinforcement**					
	***Ex Situ* Source - Plants**	***Ex Situ* Source - Seeds**	**HARRIS TO BRIER Wild-to-Wild Translocation - Plants**	**BRIER TO HARRIS Wild-to-Wild Translocation - Plants**	**Wild-to-Wild Translocation - Seeds**	***Ex Situ* or Wild Source - Pollen (Assisted pollination)**
Associated Invasion risk? (Risk of potentially invasive species being accidentally released with individuals of the focal species)				and angelica transfer from Brier to Harris is possible (invasive); risk of introducing novel plant species brought in by gulls to Brier		
Gene escape (Risk of hybridisation with closely related species or subspecies, which may possibly result in lower fitness of offspring and/or loss of species integrity)	Minimal	Minimal	Concern with hybridization at the subspecies-level. There are current unknowns with how the genetic reinforcement would be informed - need more information from the existing genetic data and possibly more genetic research. Genetic analysis will inform appropriate selection of individuals to	Concern with hybridization at the subspecies-level. There are current unknowns with how the genetic reinforcement would be informed - need more information from the existing genetic data and possibly more genetic research. Genetic analysis will inform appropriate selection of individuals to	Minimal	Minimal

Potential Risk of Implementation	**Considerations for Population Reinforcement**					
	***Ex Situ* Source - Plants**	***Ex Situ* Source - Seeds**	**HARRIS TO BRIER Wild-to-Wild Translocation - Plants**	**BRIER TO HARRIS Wild-to-Wild Translocation - Plants**	**Wild-to-Wild Translocation - Seeds**	***Ex Situ* or Wild Source - Pollen (Assisted pollination)**
			minimize negative impacts.	minimize negative impacts.		
Socio-economic risks	Minimal					
Financial risks	Minimal					
The risk of **Catastrophes** impacting the *ex situ* population	Minimal	Minimal	n/a	n/a	n/a	Minimal
Artificial selection	Appropriate protocols can ensure selection of seeds from seed orchards is done randomly to try and mimic natural selection. Artificial selection research opportunity.		Risk unknown - more research needed to quantify and understand this.			Minimal

Table 12. Feasibility considerations of implementing various strategies of population reinforcement for Eastern Mountain Avens (*Geum peckii*).

Feasibility of Implementation	**Considerations for Population Reinforcement**					
	***Ex Situ* Source - Plants**	***Ex Situ* Source - Seeds**	**HARRIS TO BRIER Wild-to-Wild Translocation - Plants**	**BRIER TO HARRIS Wild-to-Wild Translocation - Plants**	**Wild-to-Wild Translocation - Seeds**	***Ex Situ* or Wild Source - Pollen (Assisted pollination)**
We have sufficient basic **Biological Knowledge** for this or a closely related species to implement the role	Lots of discussion and non-consensus around whether we have the biological knowledge to move plants or seeds from *ex situ* into wild, particularly around knowledge of soil requirements.	Using seeds is simpler than using plants - would require less skill and less biological knowledge that would lead to successful transplants, though recognizing using seeds would likely be less successful than using plants.	Generally, yes, we have sufficient knowledge to implement.			
There is sufficient availability of suitable **Habitat**. That habitat is secure from incompatible land-use change over the long-term.	Sufficient availability of suitable habitat at Harris Lake, especially long term, is concern (e.g., tussocks)					
The **climate** at release site(s) is suitable for this species for next 25-50 years	Unknowns around climate change impacts on the local environment, temperature increases, etc.					

Feasibility of Implementation	**Considerations for Population Reinforcement**					
	***Ex Situ* Source - Plants**	***Ex Situ* Source - Seeds**	**HARRIS TO BRIER Wild-to-Wild Translocation - Plants**	**BRIER TO HARRIS Wild-to-Wild Translocation - Plants**	**Wild-to-Wild Translocation - Seeds**	***Ex Situ* or Wild Source - Pollen (Assisted pollination)**
Disease/ Pathogens/ Parasites	Unknown					
Social Feasibility	Permission of landowner is required in order to access this site.					
Regulatory compliance e.g., obtaining appropriate **permits** from all necessary jurisdictions for activities.	Generally higher feasibility than insurance population but possible permit/ jurisdictional risks if out of province facilities involved.		Species at Risk permits are required to authorize possession, disturbance, or interference with a SAR for scientific purposes related to the conservation of the species. In this case getting a permit is likely; however, landowner permission will be required to meet the permit conditions.			
We are able to obtain the **required resources/ expertise**, including technical experts, skilled staff and facilities. Do we know how to make happy plants?	Translocation of plants will have higher success but requires more resources/expertise than working with seeds.	Seeds require fewer resources and expertise, but translocation success is less than moving whole plants.	Yes			
Appropriate founders are available, and we have access	n/a	n/a	Requires landowner permission to access site for founder collection			Access to pollen has higher feasibility than seeds or plants,

Feasibility of Implementation	**Considerations for Population Reinforcement**					
	Ex Situ **Source - Plants**	***Ex Situ*** **Source - Seeds**	**HARRIS TO BRIER Wild-to-Wild Translocation - Plants**	**BRIER TO HARRIS Wild-to-Wild Translocation - Plants**	**Wild-to-Wild Translocation - Seeds**	***Ex Situ*** **or Wild Source - Pollen (Assisted pollination)**
						except when moving to Harris - need to consider genetics.
We have **assurance of funding** for all essential activities over an adequate period of time	Lots of discussion about plants having higher resource needs than seeds.	More feasible than plants as requires less resources	Cost is very low; some similar work has already been done *in situ*.			Amount of funds required will vary if from *ex situ* or *in situ* sources

After weighing the conservation value, risks and feasibility of the various options, wild-to-wild translocation of plants was not recommended at this time. A better understanding of the site suitability and outreach to Harris Lake landowners is needed. Future discussion is necessary as there may be circumstances where movements of plants out of Harris Lake would be of benefit (e.g., if habitat at Harris Lake was under threat from development or declines to very few plants).

Conservation translocations of *ex situ* propagated plants and seeds, wild sourced seed, as well as cross-pollination techniques using either *in situ* or *ex situ* sourced pollen were recommended as options for population reinforcement with certain conditions:

- *Decision triggers are developed for initiating reinforcement of a wild population, and an* in situ *population is determined to meet those thresholds*. While specific criteria and thresholds were not identified at this time, it was suggested that these should focus on assessment of population trends (e.g., change in status criteria, number of mature individuals, number of locations, Extent of Occurrence (EOO), Index of Area of Occupancy (IAO)) with a scale, frequency, and methods appropriate for the Eastern Mountain Avens population in Nova Scotia. Current federal or provincial assessment processes and criteria may not be compatible but could be modified for these needs. There are opportunities to use existing demographic/genetic data to conduct an in-depth population study as well as coordinate with ongoing monitoring and research, although additional work may be needed to inform thresholds.
- *Habitat is suitable at potential recipient sites*
- *Updated genetic knowledge is incorporated into translocation and* ex situ *management decisions*. Further review of the genetic population structure between existing sub-populations is needed to determine level of distinction, which will inform suitability of sources (including *ex situ*) that can be used for reinforcement of each site.
- *Assurance of funding for monitoring of efforts must be in place for all options*.
- Ex situ *strategies are also reliant on the establishment of a viable* ex situ *population that can adequately supply program needs.*
- *Exit decision points (e.g., indicators of lack of success, undesired/unacceptable consequences, etc.) need to be determined*.

4.4.iii. ROLE 3: Assisted colonization

Role description: Assisted colonization - Introduce the species outside of its indigenous range to avoid extinction of populations of the species in the wild using either wild or ex situ *sources.*

In discussing the characteristics of an assisted colonization program, the group considered two alternative strategies: i) wild-to-wild translocation, and ii) using the insurance population as an *ex situ* source. Both transfers of seeds and adult plants were considered from an *ex situ* source, however only seeds from Brier Island were considered at this time for wild-to-wild translocation based on feasibility and risks of moving adult plants identified during population reinforcement discussions (previous section), as well as current lack of access to Harris Lake. Use of an *ex situ* source would require a viable self-sustaining *ex situ* population to be established that could supply the needs of the assisted colonization program without impacting its own viability. Therefore, the resource and population management considerations for this strategy include those previously discussed for the insurance population, but with additional resource needs for field work/transplanting, as well as germination and growing of required numbers of plants for whole plant translocations. Movement of seeds from either source would likely require scarification. Additional research is required in order to make translocation of rhizomes a viable option for assisted colonization. This research would also improve knowledge of adult plant requirements for survival/growth, including substrate, soil mixtures, microbiome, etc. which could improve the success of transplants; previous transplants of plants from the Irving Biodiversity Collection, Acadia University to Brier Island survived but had stunted growth.

In general, it was believed that assisted colonization would require similar resources to population reinforcement. Participants discussed the potential design of a pilot assisted colonization study, which would both assess recipient site suitability and increase our knowledge of suitable environmental conditions, pollination needs, and climatic tolerances for this species.

Table 13 summarizes the required characteristics of the alternative approaches to assisted colonization discussed, including the pilot study. Filling some of the identified knowledge gaps (see section *5.1. Knowledge gaps and research needs*) may inform the minimum number of sites and plants to be used in the pilot study.

Table 13. Considerations for assisted colonization program for Eastern Mountain Avens (*Geum peckii*).

Strategies: 1) Wild-to-wild (seed), 2) *Ex situ* source (seed or plants)

Resource Considerations

- Direct wild-to-wild seed with scarification, minimal resources required
- Similar to reinforcement from *ex situ* source, Acadia University would need more seeds and additional staff and resources to germinate and grow the numbers of individuals needed for assisted colonization. However, this would not be needed to start with a small pilot project.
    - Using adult plants is more costly than seed, due to losses during propagation so need to start with a greater number. Can use sterilized seeds.
- Start with pilot transplant study using five (5) sites within the identified "new population" area
    - Resource needs to set up those sites. Newfoundland and Cape Breton as options.
    - Ten adult plants, good selection of Brier Island genetics at each site. See if it works.
    - Two stages. After initial transplants, can gain knowledge on soil and hydrology needs and supplement sites that show the most success.
- Overlap with Seed Orchard concept - seed orchards outside of indigenous range could inform new population sites (or become new populations, if escape).
- Permits - provincial SAR permits required; SARA permits required if on federal lands, landowner permission.
    - If out of province, need receiving province permits.
- Critical Habitat considerations? (new populations not in native range not likely to be considered Critical Habitat; not considered as a population by COSEWIC, e.g., Thread-leaved Sundew)
- Travel out of province will require more resources.
- Requires an exit plan

Demographic and Genetic Management

- Moving seedlings not viable from any source
- Wild-to-wild source (Brier Island seeds)
- *Ex situ* source (adults, seeds).
- Requires appropriate genetic management as discussed for reinforcement, and to structure the pilot study
- Efficacy of rhizomes and understanding the plant microbiome are research needs to improve rhizome and adult plant rearing and transplant
    - Previous transplants of plants from the Irving Biodiversity Collection, Acadia University to Brier Island survived but had stunted growth; need to better understand soil/microbiome conditions
- Biosecurity considerations - likely restrictions on movement of soil and adult plants between provinces (bugs, fungi), especially to Newfoundland.
    - May need to obtain native soil from target sites, could also improve success of transplant
    - Seeds can be sterilized.

Location and Scale

- Additional jurisdictions and landowners out of province

Catastrophes

Not discussed

Section 4.4.iii. Identification of alternative approaches/strategies for Assisted Colonization

To help streamline the assessment of risk and feasibility of assisted colonization, the group assumed all translocations would be done in adherence to the IUCN Translocation Guidelines, including selection of recipient sites, and that landowner consultations would have been done beforehand.

Although wild-to-wild translocation may create loss of wild individuals at wild source populations, the overall risk was considered to be minimal if activity was limited to movement of seeds. Again, the greatest concern was the potential risk of disease or pathogen transfer from plants grown *ex situ*, as the substrate would also be transplanted. Appropriate biosecurity measures, such as sterilization of seeds, will be necessary to help mitigate risks during seed transplants. Further research is needed to assess the relative benefits of ensuring an appropriate microbiome for seeds/plants from native soil against the risk of possible introduction of pathogens, invasive species, or other unwanted organisms. Eastern Mountain Avens itself is not considered an invasive threat because they are slow growing and have relatively low seed dispersal distance compared to other avens species, although hybridization risk with closely related species present at target sites is unknown. Genomic impacts due to different selective forces at the recipient sites is also unknown. The possibility of breeding plants specifically adapted to selected conditions, e.g., warmer temperatures, was also discussed, but as a future consideration.

Overall feasibility of all three strategies was considered high. Appropriate selection of recipient sites and the pilot study would ensure availability of suitable habitat and climate. The biggest foreseen challenges were in securing appropriate permits, especially across multiple jurisdictions, as well as assurance of funding, especially as costs increase with distance between source and recipient sites. Additionally, further consideration is needed as to the legal status of the individuals and habitat at sites created through assisted colonization, i.e., would these sites be identified as Critical / Core Habitat?

Tables 14 and 15 summarize the assessment of risks and feasibility of the alternative methods for assisted colonization that were considered for Eastern Mountain Avens.

Table 14. Risks of implementing various strategies of assisted colonization for Eastern Mountain Avens (*Geum peckii*).

Potential Risk of Implementation	**Considerations for Assisted Colonization**		
	***Ex Situ* Source - Plants**	***Ex Situ* Source - Seeds**	**Wild-to-Wild Translocation - Seeds**
Risk to source population (Impact of removing individuals from the wild on the remaining wild source population)	n/a - *ex situ* source will be appropriately managed.		Minimal
Ecological risk (Major impacts at release site on other species, and/or on ecosystem functions)	Ecological risk of bringing a plant to a place it has never been before. Several examples provided of a rare species becoming a problem after being moved but the movements were very far (e.g., another continent). Consensus for low risk but methods for how plants are moved (with or without a medium, bare roots, etc.) need to be determined.	Effectiveness of seed sterilization (regardless of source) need to be determined.	
Disease risk (Risk of disease/ pathogen transfer from translocation stock having a negative impact on **other organisms** at the release site, including EMA wild population)	Higher risk than seeds as cannot control what is on/transported with plants to the same degree (i.e., cannot sterilize plants).		
Could the species be **invasive** outside of	Eastern Mountain Avens are not likely to be invasive due to low	Minimal	

Potential Risk of Implementation	**Considerations for Assisted Colonization**		
	***Ex Situ* Source - Plants**	***Ex Situ* Source - Seeds**	**Wild-to-Wild Translocation - Seeds**
indigenous range or is there an **Associated Invasion risk**? (Risk of potentially invasive species being accidentally released with individuals of the focal species)	seed dispersal distance (unhooked seeds) and slow growing.		
Gene escape (Risk of hybridisation with closely related species or subspecies, which may possibly result in lower fitness of offspring and/or loss of species integrity)	Probability of gene escape is low but need to choose sites carefully to minimize risk of hybridization with other species in the genus. Further research needed in potential *G. rivale* hybridization due to potential presence at suitable release sites.	Minimal	
Socio-economic risks	Minimal		
Financial risks	Minimal		
The risk of **Catastrophes** impacting the *ex situ* population	Minimal		n/a
Artificial selection	Artificial Selection could happen in the *ex situ* population. Proper protocols can ensure collection from seed orchards is randomized to mitigate this risk, especially with seeds.		This risk might be higher in the wild because collectors might unconsciously select the biggest, or closest/easiest to access plants -

Potential Risk of Implementation	**Considerations for Assisted Colonization**		
	***Ex Situ* Source - Plants**	***Ex Situ* Source - Seeds**	**Wild-to-Wild Translocation - Seeds**
			awareness of the issue and following well-established protocols will mitigate the risk. Potential for different selective pressures to act on individuals as the species has been moved out of its evolutionary context.

Table 15. Feasibility considerations of implementing various strategies of assisted colonization for Eastern Mountain Avens (*Geum peckii*).

Feasibility of Implementation	**Considerations for Assisted Colonization**		
	***Ex Situ* Source - Plants**	***Ex Situ* Source - Seeds**	**Wild-to-Wild Translocation - Seeds**
We have sufficient basic **Biological Knowledge** for this or a closely related species to implement the role	Yes		
There is sufficient availability of suitable **Habitat**. That habitat is secure from incompatible land-use change over the long-term.	Yes, there is sufficient habitat that is secure from incompatible land-use change over time, but need to consider whether pollinators would be present at new locations - Eastern Mountain Avens relies on generalist pollinators so considered low concern. Would preferentially be selecting sites on protected lands over private to help prevent future land-use change.		
The **climate** at release site(s) is suitable for this species for next 25-50 years	Yes - would be part of recipient site selection process and informed by pilot study.		

Feasibility of Implementation	**Considerations for Assisted Colonization**		
	***Ex Situ* Source - Plants**	***Ex Situ* Source - Seeds**	**Wild-to-Wild Translocation - Seeds**
Disease/ Pathogens/ Parasites	Unknown		
Social Feasibility	Preferentially select Crown lands that can be managed using existing mechanisms or establishing the sites in areas that are already protected (e.g., within existing core/critical habitat, provincial parks).		
Regulatory compliance e.g., obtaining appropriate **permits** from all necessary jurisdictions for activities.	Permitting requirements are going to vary based on where the transplanted population is going to be established. Permitting for locations farther from the native range will be more complicated and less assured than within the range.		
We are able to obtain the **required resources/ expertise**, including technical experts, skilled staff and facilities. Do we know how to make happy plants?	Less feasible than seeds, without additional research.	More feasible than plants.	
Appropriate founders are available, and we have access	Available from *ex situ* population once established		Yes, with caveat about Harris Lake access being unknown.
We have **assurance of funding** for all essential activities over an adequate period of time	More costly option than seeds; requires more resources to germinate and propagate the numbers required. Assurance of funding decreases as distance to recipient site increases due to increased costs.	More feasible option than whole plants, as it requires fewer resources. Assurance of funding decreases as distance to recipient site increases due to increased costs.	May be less costly than *ex situ* seeds, which requires *ex situ* population maintenance. Assurance of funding decreases as distance to recipient site increases due to increased costs.

After weighing the conservation value, risks, and feasibility of the various options, all three strategies for assisted colonization were conditionally recommended for incorporation into the overall conservation strategy for the species, taking a measured approach and as long as certain conditions were met. Further discussion to prioritize actions amongst these three strategies is still required. The following conditions for implementation were identified:

- Ex situ *population is established which can support the program (*ex situ *source only)*
- *More detailed assessment and planning using the* IUCN Conservation Translocation Guidelines*, in particular to ensure thorough feasibility assessment is conducted and all potential risks have been sufficiently addressed*
- *Appropriate consultations across jurisdictions and with relevant landowners*
- *Assurance of adequate funding for implementation and monitoring*
- *Suitable habitat sites are identified, including considerations of access and biophysical conditions such as climate*
- *All permits and approvals are in place, as needed, depending on recipient site*
- *While not required to initiate activities, a better understanding of the level of genetic distinction between Harris Lake and Brier Island sub-populations, and inbreeding considerations within these sub-populations, is needed to inform a genetic management plan for source and recipient populations.* Seeds from an *in situ* source should be prioritized over a propagated *ex situ* source until there is updated genetic knowledge.

Further discussion is required to refine exit decision points, but the following broad points were identified:

1) Recovery success - new healthy, self-sustaining population(s) established with mature, reproducing individuals (i.e., use COSEWIC definitions but take into consideration COSEWIC view regarding populations outside of indigenous range)
2) Extirpation (e.g., of original population and/or new site)

4.4.iv. Secondary roles: Conservation-based research, education, and training

The *ex situ* roles of conservation-based research, education, and training were previously assessed to be of conservation value to Eastern Mountain Avens in addressing knowledge gaps or behaviour changes but given time constraints were considered of lower priority for the current discussion than the three roles discussed above (see section *4.3. Potential* ex situ *population management roles to address threats and objectives*). As such, program characteristics, risk, and feasibility were not assessed.

The Harriet Irving Botanical Gardens already provides opportunities for research, training, and educational programs with the existing *ex situ* population. Research needs and knowledge gaps that can potentially be addressed through an *ex situ* program were noted throughout the workshop process (see section *5.1. Knowledge gaps and research needs*). Unlike general education, conservation-based education targets behaviour linked directly to the mitigation of a threat. The current *ex situ* population was considered to be too far away from the *in situ* sites to meaningfully address threats such as ATV use and trampling of Eastern Mountain Avens in the wild; however, there may be potential value in the future with an expanded *ex situ* program, included planted gardens *in situ*. Very little need for conservation-based training was identified and this role was considered the lowest priority. There are also indirect roles of an *ex situ* population that were not discussed in this workshop (e.g., general education, funding, awareness, etc.).

4.5. Final recommended approaches for potential **ex situ***/translocation programs*

Upon completion of the detailed assessments a final recommendation as to whether to proceed with further planning was made (Table 16). Assurance of funding was discussed in the feasibility assessment for each role; however, there was a high degree of uncertainty for all roles as funding availability is subject to factors outside the scope of the discussion and, as such, it was not considered at this final stage.

<u>Insurance Population:</u> This role was believed to have high conservation value, in particular as it was necessary in order to accomplish many of the other *ex situ* roles (Figure 8), as well as providing additional benefits (e.g., the ability to conduct research to address knowledge gaps). The focal strategy, a seed bank, and seed orchard/outplanting program, was felt to have overall low risk and high feasibility (Table 16). This work is already underway at the Acadia Seed Bank and Harriet Irving Botanical Gardens, however the discussion focused on enhancing this program and expanding it to satellite locations. Further analysis of existing genetic data was recommended to inform management of the insurance population, for example, determining a strategy for outcrossing, and setting minimum viable population size. Additionally, further discussion and planning was needed regarding the logistics of establishing satellite locations, either within and/or outside of Nova Scotia. An exit point was not identified for this strategy, but the scale of the program was linked to the needs of other recommended *ex situ* roles.

<u>Demographic/Genetic Reinforcement:</u> This role was identified as having moderate conservation value, with individual strategies varying in overall risk from low to high, and feasibility either moderate or high (Table 16). The moderate conservation value assessment was based on the fact that reinforcement would not address the main threats (climate change and gulls). Specific strategies to achieve this role were believed to have more/less risk and greater/less feasibility (see below). Further discussion and assessment of habitat suitability at recipient sites, and potential restoration needs, and likelihood is required. The group further noted that additional discussion was required with a goal of developing a decision-making tree that included specific decision triggers, i.e., *in situ* population thresholds that would need to be met before implementation (Figure 8). For all options, assurance of funding for monitoring of efforts is required before actions are initiated. The final recommendation for each strategy is as follows:

- Adult plants (*ex situ* source): Conditionally recommended, based on development of decision triggers.
- Seeds (*ex situ* source): Conditionally recommended, based on development of decision triggers.
- Seed (wild-to-wild translocation): Conditionally recommended depending upon further analysis and better understanding of the level of genetic distinction between Harris Lake and Brier Island sub-populations and development of decision triggers.
- Pollen (wild-to-wild translocation): Conditionally recommended depending upon further analysis and better understanding of the level of genetic distinction between Harris Lake and Brier Island sub-populations and decision triggers.

Strategies reliant on an *ex situ* source require the establishment of a viable *ex situ* population that can adequately supply program needs (Figure 8). Until there is a better understanding of population genetics and the degree and significance of differentiation between Brier Island and Harris Lake sub-populations, a precautionary approach regarding Harris Lake is recommended where it is preserved as a distinct lineage. This analysis could happen concurrently with other actions, but participants agreed that it should not delay implementation of recommended strategies. Regardless of the level of differentiation between Brier Island and Harris Lake, it was noted that the Recovery Strategy objectives include maintaining the species at these occupied sites.

<u>Assisted Colonization:</u> This role was believed to have high conservation value with overall low to very low risk and high feasibility as it would provide a means to deal with the impacts of climate change and gulls, which were felt to be the major threats to the species. Further discussions with the Recovery Team are needed for the purposes of advice and guidance on how to proceed, as well as the need to assess and ultimately gain provincial support, in particular if assisted colonization was to occur outside of Nova Scotia. Additional considerations included how COSEWIC would view populations derived from assisted colonization in the species assessment, and the need to better understand how climate change was likely to impact the extant populations, for example, in view of the new information presented on Day 1. Several considerations for pilot studies were identified to determine the likelihood of success of this management action and the anticipated impacts of climate change at the recipient locations (Table 13, Figure 8). The final recommendation for each strategy is as follows:

- Adult plants (*ex situ* source): Conditionally recommended.
- Seeds (*ex situ* source): Conditionally recommended, including need to identify appropriate source populations, specifically, the level of genetic distinction between Harris Lake and Brier Island sub-populations.
- Seed (wild-to-wild translocation): Conditionally recommended depending upon further analysis and better understanding of the level of genetic distinction between Harris Lake and Brier Island sub-populations.

Additional recommendations were made that need to be addressed before programs can be more fully developed. These represent conditions which must be fulfilled before assisted colonization can proceed, and include:

- A meta-analysis of the genetic work to date is completed to inform both additional genetic research required but also to better understand the degree and significance of differentiation between Brier Island and Harris Lake sub-populations.
- A viable *ex situ* population is established which can support the program. The *ex situ* management program includes an "Exit Strategy."
- More detailed assessment and planning using the IUCN Translocation Guidelines is completed, in particular to ensure all potential risks have been sufficiently addressed.
- Appropriate consultations across jurisdictions with relevant parties have occurred.
- Adequate funding for monitoring is assured.

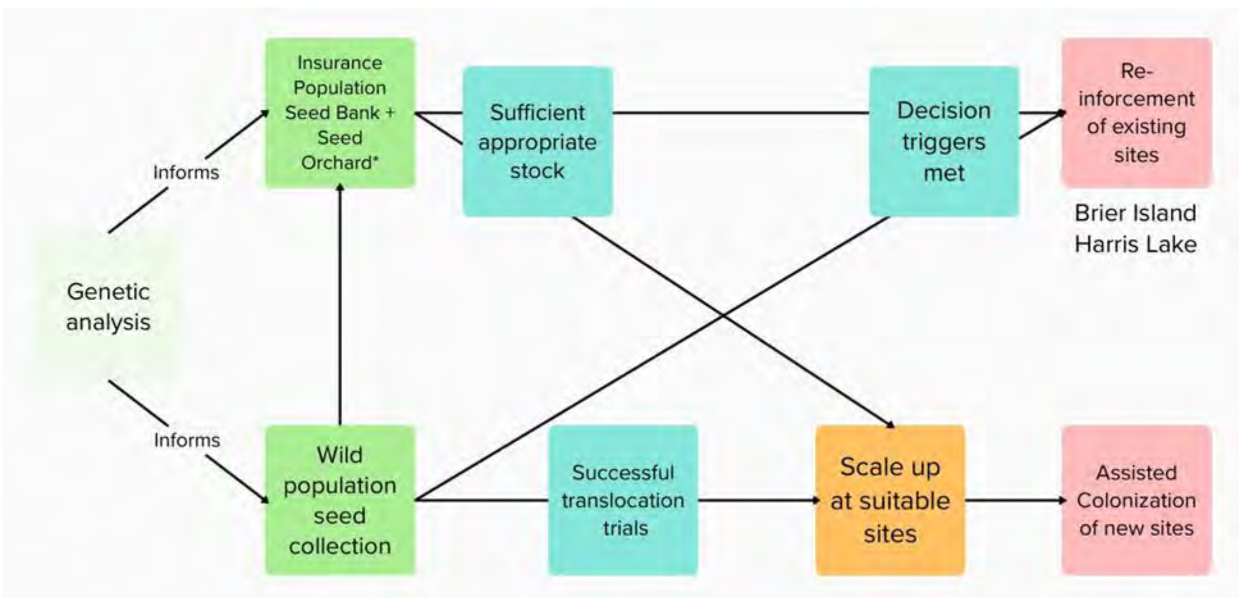


Figure 8. Simplified flow chart showing the relationships between the final recommended intensive management programs for Eastern Mountain Avens (*Geum peckii*) including the major conditions and/or triggers for implementation (blue squares). *Seed Bank + Seed Orchard is appropriately managed demographically and genetically to act as Insurance Population AND provide suitable source stock for other conservation strategies.

Table 16. Final decisions for recommended *ex situ* conservation roles for Eastern Mountain Avens (*Geum peckii*) based on conservation value, risk, and feasibility. See section *4.4. Identification of alternative approaches/strategies* for full details of conservation value, risk, and feasibility assessments.

Roles and Alternatives	FINAL OVERALL CONSERVATION VALUE SCORE	FINAL OVERALL RISK SCORE	FINAL OVERALL FEASIBILITY SCORE	FINAL DECISION
Insurance Population	High			
Seed banking and seed orchard		Low	High	**Recommended**
Demographic/Genetic Reinforcement	Moderate			
Plant (*Ex situ* source)		Low	Moderate	**Conditional role** (specific decision triggers from *in situ* population need to be met)
Seed (*Ex situ* source)		Very Low	Moderate	**Conditional role** (specific decision triggers from *in situ* population need to be met)
Plant (Wild-to-wild) - Harris to Brier		High	High	Not recommended at this time
Plant (Wild-to-wild) - Brier to Harris		Moderate	Moderate	Not recommended at this time
Seed (Wild-to-wild)		Very Low	High	**Conditional role** (specific decision triggers from *in situ* population need to be met)
Pollen (*Ex situ* or wild source)		Very Low	High	**Conditional role** (specific decision triggers from *in situ* population need to be met)
Assisted Colonization	High			
Plant (*Ex situ* source)		Low	High	**Conditional role** (specific conditions need to be met)
Seeds (*Ex situ* source)		Low	High	**Conditional role** (specific conditions need to be met)
Seeds (Wild-to-wild)		Very Low	High	**Conditional role** (specific conditions need to be met)

4.6. Integrated planning and adaptive management

Process and tool options for integrating *ex situ* recommendations with *in situ* activities in a holistic One Plan Approach (Figure 2) and applying an adaptive management framework (Figure 9) to address uncertainty and improve implementation were reviewed. A list of identified resources is provided below.

Kespukwitk Conservation Collaborative (KCC), a partnership of organizations working to improve biodiversity conservation in the Kespukwitk/Southwest Nova Scotia Priority Place identified under the federal Pan-Canadian Approach, is using the Conservation Standards as an adaptive management framework to support more coordinated, strategic action to achieve the shared conservation goals in Kespukwitk. The KCC uses Miradi software to manage the project and freshwater wetlands are one of the ecosystem-based conservation targets that the program is trying to conserve and restore. Species at risk that are supported by freshwater wetlands, including Eastern Mountain Avens, are the nested conservation targets. The possibility of collaboration between KCC and the Recovery Team to incorporate Eastern Mountain Avens recovery strategies, actions, and progress tracking into the existing Miradi project is an avenue to be explored.

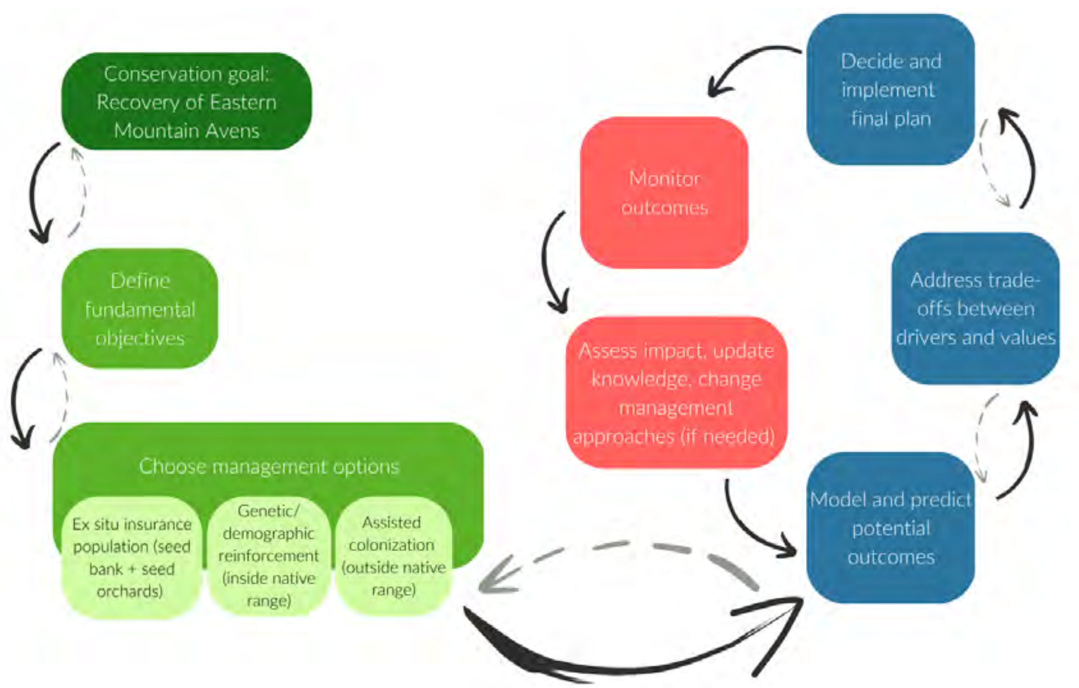


Figure 9. IUCN SSC Conservation Translocation Specialist Group's structured decision-making cycle (adaptive management) applied to Eastern Mountain Avens, *Geum peckii* (modified from Dalrymple et al., 2023).

Resources:

- Phillips-Mao, L., Galatowitsch, S.M., Snyder, S.A. and Haight, R.G. 2016. Model-based scenario planning to develop climate change adaptation strategies for rare plant populations in grassland reserves. *Biological Conservation*. 193: 103-114. https://doi.org/10.1016/j.biocon.2015.10.010
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- Compass Resource Management Ltd. 2023. Whooping Crane SDM Process: Whooping Crane Advisory Committee Summary Report. Final v1.0. Vancouver, BC.
- Center for Plant Conservation. 2019. CPC Best Plant Conservation Practices to Support Species Survival in the Wild. Center for Plant Conservation, Escondido, CA. https://saveplants.org/cpc-best-plant-conservation-practices-to-support-species-survival-in-the-wild/
- Commander, L.E., Coates, D., Broadhurst, L., Offord, C.A., Makinson, R.O. and Matthes, M. 2018. Guidelines for the translocation of threatened plants in Australia. Third Edition. Australian Network for Plant Conservation, Canberra. https://www.anpc.asn.au/translocation/
- IUCN – SSC Species Conservation Planning Sub-Committee. 2017. Guidelines for Species Conservation Planning. Version 1.0. Gland, Switzerland: IUCN. xiv + 114 pp. https://www.iucn.org/resources/publication/guidelines-species-conservation-planning-version-10
- Conservation Measures Partnership. 2020. Open Standards for the Practice of Conservation. Version 4.0. ii + 77 pp. https://conservationstandards.org/
- Miradi Software: https://www.miradishare.org/ux/home
- Kespukwitk Conservation Collaborative: https://kswnsconservation.ca/what-we-do/

5. Preliminary Conservation Action Planning

Preliminary action planning for each of the three recommended roles was initiated by working groups, using a provided template. Working groups identified specific short-term objectives (~5 year timeframe) for each alternative strategy and began to develop detailed actions to inform potential implementation. The preliminary action plans are available upon request.

As there is interplay between some of the roles (Figure 8), implementation of certain individual key actions may affect progress across multiple recommended strategies. For example, a comprehensive genetic analysis to better understand the existing population structure and consequences of mixing populations from across the species range will inform several strategies including, i) seed collection for the insurance population and its genetic management, and ii) selection of appropriate source stock for reinforcement and assisted colonization efforts (relevant to both *in situ* and *ex situ* sources). Actions to establish a viable and self-sustaining *ex situ* population, such as regular testing of banked seeds to understand seed viability/germination rates and breeding trials, are necessary not only to establish a healthy insurance population but also to ensure there is a sufficient and appropriate *ex situ* supply for strategies relying on this source. Participants recognized the need to further assess and prioritize amongst the recommended strategies, e.g., develop a hierarchical approach to decide which objectives to move ahead first.

The demographic/genetic reinforcement working group took a step back and discussed overarching strategies for demographic reinforcement and genetic reinforcement instead of focusing on *ex situ* to wild or wild-to-wild reinforcement strategies at this point. There is an urgent need to determine decision triggers for demographic reinforcement (as reflected in the rapid timelines for strategy 1) and if necessary, demographic reinforcement actions can be prioritized over those for genetic reinforcement. Several knowledge gaps need to be addressed before moving forward with either type of population reinforcement.

The assisted colonization working group prioritized action planning for direct wild-to-wild translocation but noted that much of the planning will be applicable to the other strategies (e.g., *ex situ* to wild) which can be incorporated into the same action plan. Additionally, it was noted that seed collection for this role could also help meet objectives of the seed bank / insurance population. The rapid timelines for these actions are based on the assumption that work can be undertaken within NS; however, timelines will need to be adjusted if this is not the case (i.e., suitable sites not available in NS and work required out of province). Estimated costs based on maximum required funds.

The preliminary action plans developed for the recommended roles only include work accomplished during the working group session on July 7, and as such are working documents. Further action planning will be required prior to implementation, to inform future conservation planning for this species and support the development of an integrated conservation strategy.

5.1. Knowledge gaps and research needs

Knowledge gaps were noted over the course of the assessment process and were compiled and organized within themes / roles to facilitate discussion. Participants reviewed the major knowledge gaps and prioritized them with respect to their impact on implementation of the recommended strategies, i.e., was the knowledge gap a major barrier, could it be addressed concurrently to implementation, or was it irrelevant to proceeding with recommended actions? This activity helped to identify priority next steps for action planning. Knowledge gaps surfaced during the workshop that require further discussion by the Recovery Team are summarized in Table 17.

Table 17. Summary and prioritization of major knowledge and data gaps related to the three recommended *ex situ* conservation roles for Eastern Mountain Avens (*Geum peckii*). Very High = must be addressed before activities can proceed; High = need to know but can address concurrently to management activities; Research focus = useful but not necessary to intensive management activities.

Relevant to multiple roles	
Level of genetic distinction between Harris Lake and Brier Island sub-populations. Will Harris Lake genetic variation be improved by introducing Brier Island material? Did Harris Lake come from Brier Island lineage or is it distinct? Local adaptation? Is it possible to make an experimentally grown seed stock to be resilient to put back into the wild at Harris Lake? Range-wide population structure/taxonomy? Risk due to hybridization at the subspecies (i.e., Brier Island vs Harris Lake sub-populations) or genus level?	Very High / High depending on strategy
Natural longevity and progression of Eastern Mountain Avens’s bog habitat	High
What is the minimum threshold population size at which self-pollination negatively affects genetic diversity and leads to inbreeding depression?	High
What is a healthy soil microbiome for Eastern Mountain Avens?	High
How is the soil microbiome impacted by threats such as succession and gulls?	High
What is the temperature tolerance of Eastern Mountain Avens and associated resilience to climate change?	High
Potential impact of novel pathogens or parasites	High / Research
Rhizome propagation methods	Research
What is the necessary recruitment rate and frequency via sexual reproduction required for a healthy population?	Research
Generation time of wild individuals and natural longevity	Research
Best methods for seed sterilization	Research focus but situation dependent – may not need to address

Insurance Population	
Inadvertent artificial selection (consciously or unconsciously selecting for specific phenotypes)	High
Ideal frequency of ongoing seed collection	High
Most appropriate structure of founder population and genetic management of the insurance population unknown, e.g., outcrossing, and setting minimum viable population size, etc.	High
Population Reinforcement	
Inadvertent artificial selection risk	Very High (W2W)
What is the best strategy for reinforcement (# seeds, # sites, etc.) considering flowering rate, pollination, seed set, etc.?	Very High / High
Better understanding of climate change impacts on the likelihood that demographic/genetic reinforcement can lead to a self-sustaining climate resistant wild population.	High
Best practices for translocation of plants (e.g., soil/no soil)	High / Research
Has pollination been disrupted on a local scale due to habitat changes?	Research (no evidence of specialist pollinators)
Assisted Colonization	
What is the minimum number of plants and sites for successful introduction?	Very High / High
Better understanding of climate change impacts on the local environment, temperature increases, etc.	High
Soil characteristics for successful transplantation	High
Best practices for translocation of plants (e.g., soil/no soil)	High
Inadvertent artificial selection risk	High
What is the historic range?	Research
Will transplanted plants be pollinated?	Research (no evidence of specialist pollinators)

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APPENDICES

Appendix I: Workshop Agenda - Session 1 (February 22-24, 2023)

Eastern Mountain Avens (*Geum peckii*)
***Ex Situ* Conservation Assessment Workshop**
22-24 February 2023
Acadia University, Wolfville NS

DRAFT WORKSHOP AGENDA

Meeting location: Acadia Room, 3rd Floor, K.C. Irving Environmental Science Centre, Acadia University, 15 University Ave, Wolfville, Nova Scotia.

Workshop Objectives (DAY 1-3): Evaluate and recommend any appropriate role(s) of *ex situ* activities for the conservation of *Geum peckii* and initiate the design of any recommended programs. Identify key uncertainties that may be answered with captive population(s), in order to improve *ex situ* management and/or to inform *G. peckii* recovery actions.

Facilitators: Amy Chabot & Jessica Steiner assisted by Stephanie Winton, Canadian Species Initiative/Conservation Planning Specialist Group Canada

DAY ONE: Wednesday, 22 February: Review of current situation and potential for *ex situ* conservation

9:00 Welcome, Land Acknowledgement and Workshop opening (Claire Wilson)
Acadia Covid-19 policies and considerations (Alain Belliveau)

9:15 Participant introductions

9:30 Introduction to workshop process.
Overview of the *IUCN SSC Guidelines on the Use of Ex Situ Management for Species Conservation* as part of the One Plan approach to conservation and potential *ex situ* conservation roles; Intro to *IUCN SSC Guidelines for Reintroductions and Other Conservation Translocations* (Amy/Jessica)

10:15 Coffee / tea break (provided)

10:30 Background presentations (~15 minutes each, w/ 5 min for questions)
1) Status review, threats, recovery criteria/goals, and relevant existing recovery action recommendations for *G. peckii* (Julie McKnight) (20 MIN) 10:30-10:50
2) Overview of *G. peckii*, Big Meadow Bog, actions undertaken/underway, and state of the science for *ex situ*/intensive management (Nick Hill, Brad Toms, & Sherman Boates) (1 hour) 10:50-11:50
3) Climate change on Brier Island and implications for *G. peckii* conservation (David Garbary) (20 MIN) 11:50-12:10
4) Population genetics of *G. peckii* (Mark Johnston) (20 MIN) - 12:10-12:30

12:30 Lunch (provided)

1:15 Background presentations (continued)

5) Summary of Research on *Geum peckii* at Acadia University Botanical Gardens (Alain Belliveau) (20 MIN) 1:15-1:35

1:35 Plenary discussion: Review of life history and phenology of *G. peckii*
Review and discussion of threat assessment calculator results, prioritization of threats and their impacts on viability in the wild.

2:45 Coffee / tea available (break as needed)

3:00 Plenary discussion: Confirm recovery goals and develop objectives. Review and identify potential *ex situ* conservation roles for *G. peckii*

5:00 Adjourn

Evening: Dinner together (optional)

DAY TWO: WEDNESDAY, 23 February: Proposed program structure

9:00 Welcome back and set-up discussion focus for the day

9:30 Presentation: Lessons learned in the successful recovery of Robbins'(Dwarf) Cinquefoil, *Potentilla robbinsiana* (Kenneth Kimball) (1 hour)

10:30 Coffee / tea break

10:45 Plenary Session: Review of potential conservation roles of *ex situ* and translocation activities, and how they might impact wild population viability; refinement, as necessary. Assess conservation value of roles against objectives.

12:30 Lunch (provided)

1:15 Plenary Session: Identify potential strategies for the *ex situ* or translocation role and define the characteristics of the program needed to fulfill each potential strategy or role, including factors such as:

- Number and source of any wild-origin individuals
- Population size to be maintained, life stage, and type of management
- Type of facilities and expertise needed
- Collection and transplanting techniques
- Anticipated length of program

Consider how these attributes differ among alternative approaches for each role.
Note (placeholder) any mention of feasibility or risks.

3:00 Coffee / tea break

3:15 Continue developing characteristics of each potential *ex situ* and/or translocation program, as needed.

5:00 Adjourn

<u>DAY THREE: THURSDAY, 24 February</u>: Evaluation of feasibility and risks and final recommendations on programs

9:00 <u>Plenary discussion</u>: Assess the feasibility and risks of each potential ex situ program and/or translocation program, including factors such as:

- Biological and Social feasibility
- Regulatory compliance
- Resource availability - existing expertise, staffing needs
- Likelihood of success
- Risk assessment, including:
    - o Risk to viability of source and recipient populations
    - o Disease and parasite risks
    - o Socio-economic and political risks (e.g. jurisdictional issues)
    - o Financial risk
    - o Likely future for wild population in absence of *ex situ* activities (risk of no action)

Develop recommendation regarding the best strategy or approach for each *ex situ* and/or translocation program based on evaluation of benefits, risks, and feasibility.

10:15 Coffee / tea break

10:30 Continue feasibility and risk assessment as necessary

12:00 Lunch (provided)

1:00 Review parking lot items.

1:15 <u>Plenary Session</u>: Finalize the recommended approach for each potential *ex situ* or translocation program, and determine which programs are recommended for development.

3:00 Coffee / tea break

3:15 Continue finalizing recommendations as necessary

4:45 Next steps and timeline for Day 4, and other activities

5:00 Workshop closing

Appendix II: Workshop Agenda - Session 2 (June 6-7, 2023)

Eastern Mountain Avens (*Geum peckii*)
***Ex Situ* Conservation Assessment Workshop**

JUNE 6-7, 2023 [online]

WORKING AGENDA

Facilitators: Amy Chabot, Jessica Steiner, & Stephanie Winton, Canadian Species Initiative/CPSG Canada

FIRST HALF-DAY SESSION: June 6

Objective 1 - Review and finalize recommendations; review and prioritize data and knowledge gaps identified during the workshop; and provide a review of options for integrating resulting recommendations into future planning and discuss how to proceed under an adaptive management approach, i.e. completion of planning cycle.

9:00	Welcome and meeting opening (Claire Wilson)
9:10	Presentation: Review of results from Days 1-3 (Stephanie Winton)
9:30	Plenary discussion and working groups session: Prioritize and finalize recommendations and ex situ management approach (Amy Chabot)
11:15	**Break**
11:30	Working groups session: Data and knowledge gaps (Amy Chabot)
12:25	Presentation and discussion: Process options for integration in a One Plan Approach, monitoring and adaptive management (Stephanie Winton)
12:50	Set-up second half-day session (action planning)
1:00	**Adjourn**

SECOND HALF-DAY SESSION: June 7

Objective 2 - Action Planning: identify critical next steps, for example, establishing a technical committee to ensure additional discussion continues to address data gaps, identifying monitoring data needs, supporting development of the seed bank, and additional analysis of the genetic information, etc., and associated timelines.

9:00	Plenary presentation: Action planning and directions for working groups session (Jessica Steiner)
9:20	Working groups session: Action planning **Break as necessary**
12:00	Plenary discussion: Summation of working group sessions. Working group presentations of *ex situ*/translocation program action plans, revision as needed.
12:45	Next steps/closing remarks (Claire Wilson)
1:00	**Workshop closing**

Appendix III: Workshop Participants

Participant Name	Organization	February 22	February 23	February 24	June 6	June 7
Facilitators						
Amy Chabot	Canadian Species Initiative (Conservation Planning Specialist Group Canada)	X	X	X	X	X
Jessica Steiner	Canadian Species Initiative (Conservation Planning Specialist Group Canada)	X	X	AM	X	X
Stephanie Winton	Canadian Species Initiative (Conservation Planning Specialist Group Canada)	X	X	X	X	X
Organizers and notetakers						
Julie McKnight	Environment and Climate Change Canada - Canadian Wildlife Service	X	X	X	X	X
Claire Wilson	Nova Scotia Department of Natural Resources and Renewables	X	X	X	X	X
Pam Mills	Nova Scotia Department of Natural Resources and Renewables	X	X	X	X	X
Kathy St. Laurent	Environment and Climate Change Canada - Canadian Wildlife Service	X	X	X		
Amy Marsters	Nova Scotia Department of Natural Resources and Renewables		X	X		X
Josie Rafuse	Nova Scotia Department of Natural Resources and Renewables	X	X	X		
Recovery Team members						
Alain Belliveau	K.C. Irving Environmental Science Centre, Acadia University	X	X	X	X	X
Sean Blaney	Atlantic Canada Conservation Data Centre	X	X			
Nick Hill	Fern Hill Institute	X	X	X	X	X
Jeremy Lundholm	Saint Mary's University / CB Wetlands and Environmental Specialists	X	X	X	X	X
David Mazerolle	Parks Canada	X	X		X	
Brad Toms	Mersey Tobeatic Research Institute	AM	AM	X	X	X
Relevant experts						
Donna Hurlburt	Nova Scotia Department of Natural Resources and Renewables	X	AM	X	X	
David Garbary	St. Francis Xavier University	X	X	X		
Mark Johnston	Dalhousie University	X				
John Brazner	Nova Scotia Department of Natural Resources and Renewables	X				
Sarah Adams	K.C. Irving Environmental Science Centre, Acadia University	X	X			
Emma Vost	Nova Scotia Department of Natural Resources and Renewables	X				
Sherman Boates	Acadia University	X	AM	X	X	X
Stakeholders and community members						
Doug van Hemmessen	Nature Conservancy of Canada	AM				
Jonathan Riley	Municipality of Digby	AM				
Jaqueline Journeay	Brier Island Trails Committee	AM				

Appendix IV: Workshop Companion Guide

WORKSHOP COMPANION GUIDE

This Guide provides a companion resource for participants of the Eastern Mountain Avens (Geum peckii) Ex Situ Conservation Assessment workshop. Here you will find useful reference information to support workshop discussions, such as descriptions of ex situ conservation roles.

ONE PLAN APPROACH

The 'One Plan' approach (OPA) to species conservation promotes the joint development of management strategies and conservation actions that considers all populations of a species and involves all responsible parties, both in situ and ex situ, to produce one comprehensive conservation plan for the species, with the ultimate goal of supporting its conservation in the wild (Byers et al. 2013).

Decision Process from the IUCN SSC *Guidelines on the Use of Ex Situ Management for Species Conservation*

Five-step decision-making process to decide if and how *ex situ* management is an appropriate conservation tool within the overall conservation strategy for a taxon:

STEP 1. Compile a status review of the species, including a threat analysis, to understand its conservation needs.

STEP 2. Identify the potential role(s) that *ex situ* management might play in the overall conservation of the species and its relative conservation value.

STEP 3. Determine the characteristics of the *ex situ* population and program needed to fulfill each potential conservation role.

STEP 4. Define the resources and expertise needed for the *ex situ* program to meet each potential role and appraise the feasibility and risks.

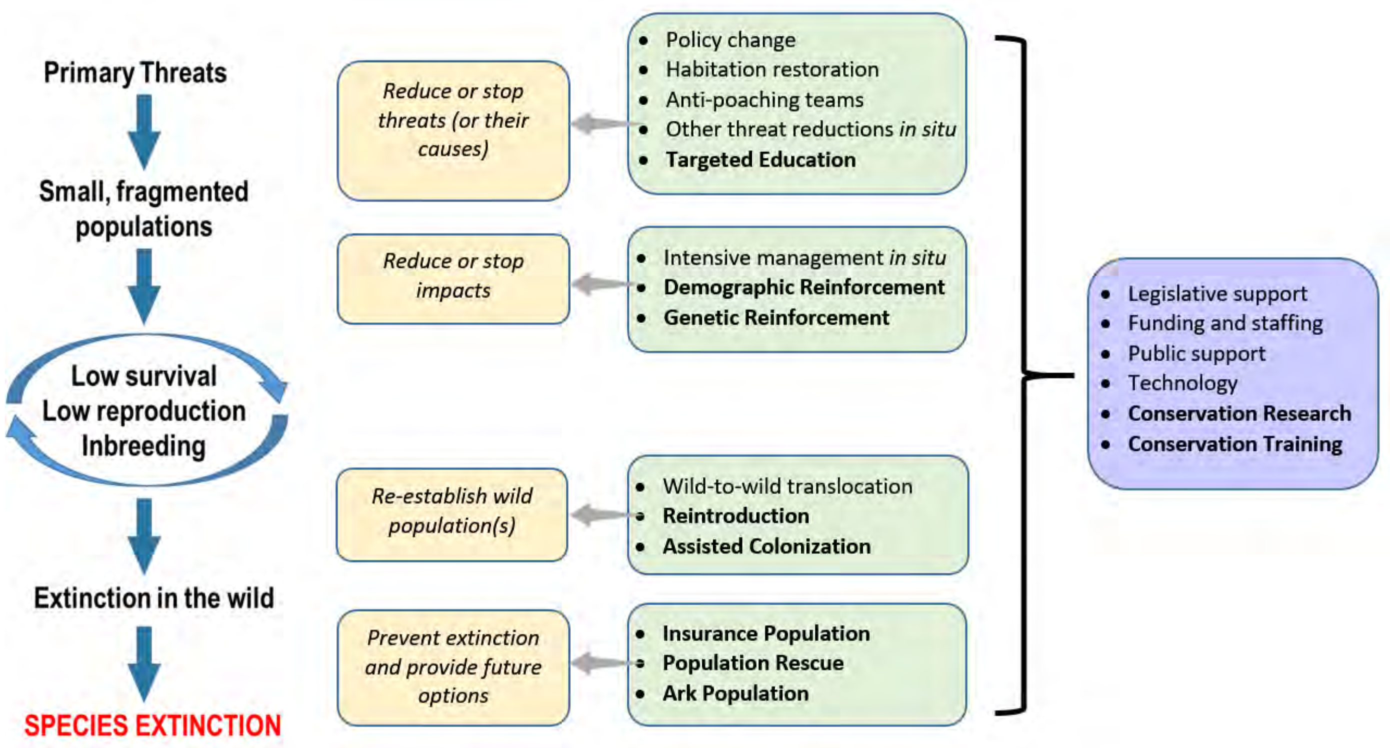
STEP 5. Make a decision that is informed (i.e. uses the information gathered above) and transparent (i.e. demonstrates how and why the decision was taken) regarding *ex situ* roles and activities, if any, to support conservation of the taxon.

COMMON DIRECT CONSERVATION *EX SITU* ROLES

Based information from the IUCN SSC Guidelines on the Use of Ex situ Management for Species Conservation, IUCN SSC Guidelines for Reintroduction and Other Conservation Translocations, Appendix I of the Amphibian Ark Conservation Needs Assessment Process, the IUCN SSC Conservation Planning Specialist Group's Ex Situ Conservation Assessment Course and the Canadian Species Initiative website.

In essence, *ex situ* management can support species conservation and prevent extinction by:

1) addressing primary threats and/or their causes;
2) counteracting the impacts of primary or stochastic threats on the population (such as reduced survival, poor reproduction, and genetic isolation);
3) using *ex situ* populations for population restoration or conservation introduction; and/or
4) preventing extinction by gaining time in situations where threats are not under control or mitigation is not successful (enough).



This list of 11 potential conservation roles for *ex situ* (or other population management) activities are the most common roles that address these four functions. It is often possible for an *ex situ* population to serve more than one role, simultaneously or sequentially, depending upon how it is structured and managed.

Research

Conservation-based Research uses *ex situ* individuals or their parts to address important data gaps for the implementation of the conservation strategy for the species. This does include research with another species that acts as a model for the focal species, and it can also include research work that establishes expertise and protocols for future conservation needs.

Training

An *ex situ* population can be used for training that will directly benefit conservation of a species, or a similar species, in the wild (e.g. train field biologists or wildlife managers in the safe restraint, handling or health assessment). This training must address skills that are essential for implementing the conservation strategy and can include another species acting as a model for the focal species. This can include non-threatened species serving as a model for threatened species.

Targeted Conservation Education

Targeted Conservation Education uses *ex situ* individuals, or their parts, to address specific human behavior changes in key audiences that directly affect the species in the wild. These audiences are the groups of people that potentially can make a change to the threats, the causes of the threats, or other constraints that the species is facing in the wild. It is essential that the message reaches the proper audience who can make effective behavior change. This usually means, but not always, that Targeted Conservation Education occurs in the range country of the species. It may be possible to use a different species as a surrogate, or model, for the threatened species.

Population Reinforcement

Population Reinforcement describes the release or placement of individuals into an existing wild population within the species' natural range. Which can be further broken down into Demographic Reinforcement and Genetic Reinforcement.

Demographic Reinforcement

Ex situ populations can be used as a source of individuals to either increase the size of the wild population, or to restore balance to the sex, age, or life stage structure of the wild population. These imbalances may occur when threats impact certain sex or age groups more than others.

Genetic Reinforcement

Similar to demographic reinforcement, Genetic Reinforcement may use *ex situ* populations as a source of individuals to either increase the genetic diversity of the wild population, or to introduce or restore particular alleles, allele frequencies or genetic traits – this can help wild populations combat inbreeding depression and maintain their ability to adapt to new conditions.

Population Reintroduction

This is typically considered as an *ex situ* role when an *ex situ* population serves as a source of individuals and gene diversity to reestablish a population in a part of the species' former range from which it has disappeared. Reintroduction is defined as the establishment of individuals in unoccupied habitat in the former range. The source of those individuals can be either an *in situ* or *ex situ* population.

Ecological Replacement

The purpose of Ecological Replacement is not to re-establish a species in the wild but to re-establish the ecological functioning of an area. In this case, the species or population is established outside of its natural range to provide an ecological role or function that has been lost due to the extinction of another taxon. The focus of this conservation action is not the translocated species itself but an ecosystem at risk due to loss of critical ecological functions. Ecological Replacement can be done with either wild or *ex situ* individuals and/or with use of *ex situ* management.

Assisted Colonization

In this case, *ex situ* individuals are used to re-establish populations of a species outside of its original range, for example, because their former area is forever lost to the species. This can be due to infrastructure development or climate change. Rather than lose the species or population in the wild forever, an alternative option is to consider establishing it in a new place. This raises questions related to feasibility and risk. One can use both wild or *ex situ* individuals and conditions for Assisted Colonization.

Rescue

Population rescue may be implemented for a population that is in *imminent* danger of extinction (locally or globally), for example, due to habitat conversion, wildfires, extreme weather events, disease, epidemics, etc. Taking the entire wild population, or a significant part of it, into *ex situ* conditions may be what is required to ensure survival. This rescue may be temporary – so just until the dangerous event has passed – or it can be long term if it is difficult to restore the situation in the wild. As the name of the role suggests, Population Rescue should be beneficial at the population level. This role is not meant to apply to the periodic rescue of injured or confiscated individuals for reasons of individual welfare when this does not significantly contribute to population survival.

Insurance Population

Insurance Populations may be established for threatened species for which successful mitigation of the causes and effects of primary threats will take a very long time and/or is uncertain – meaning that the population may well continue to decline and fragment. In addition, the population may be vulnerable to stochastic threats and may get into serious trouble before the primary threat reduction actions are effective.

Insurance populations are not only useful in case a whole species goes extinct in the wild; they are also valuable as potential sources to re-establish extinct subpopulations, restore genetic diversity that has been lost, address demographic instabilities, or other roles that improve population viability. In other words, they preserve a range of future conservation options for the species.

Biobanks – such as seed banks, cultures, cell lines, and cryopreserved gametes - provide another type of insurance for an increasing number of species, especially, though not exclusively, for genetic insurance.

Ark Population

An Ark Population is an *ex situ* population for a species that is extinct in the wild, and so the only surviving individuals are those in *ex situ* conditions. This role can be carried out proactively, by bringing an entire small wild population into *ex situ* conditions or may have happened spontaneously if the wild population went extinct while there were still individuals or populations present *ex situ*. In this case, the *ex situ* individuals, or live biosamples, are then the only hope for re-establishing wild populations at some point in the future, when conditions in the wild can be improved to make this possible.

KEY RESOURCES

Byers, O., Lees, C., Wilcken, J., Schwitzer, C. (2013) The "One Plan Approach": The philosophy and implementation of CBSG's approach to integrated species conservation planning. WAZA Magazine. 14:2-5. https://www.waza.org/wp-content/uploads/2019/02/waza_mag_14.pdf

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IUCN/SSC (2013). Guidelines for Reintroductions and Other Conservation Translocations. Version 1.0. Gland, Switzerland: IUCN Species Survival Commission, viii + 57 pp. https://portals.iucn.org/library/sites/library/files/documents/2013-009.pdf

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McGowan, P.J., Traylor-Holzer, K., Leus, K. (2017) IUCN guidelines for determining when and how ex situ management should be used in species conservation. Conserv Letters. 10:361-366 https://conbio.onlinelibrary.wiley.com/doi/pdf/10.1111/conl.12285

Botanic Gardens Conservation International (bgci.org)

CANADIAN SPECIES INITIATIVE

IUCN SSC Species Survival Commission

CONSERVATION PLANNING SPECIALIST GROUP
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