Native seed bank in Yukon: State of the art

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Yukon Research Centre, Yukon College
500 College Drive, PO Box 2799
Whitehorse, Yukon Y1A 5K4
867.668.8895 or 1.800.661.0504

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PROJECT TEAM

Authors

Nina Vogt	Student Research Assistant, Yukon Research Centre, Yukon College
Amelie Janin	Industrial Research Chair in mine Life Cycle, Yukon Research Centre, Yukon College

Contributors

Andrijana Djokic	Na-cho Nyak Dun Development Corporation
Ann Smreciu	Wild Rose Consulting, Inc.
Bonnie Burns	Laberge Environmental Services
Bruce Bennet	Yukon Conservation Data Centre
Dave Polster	Polster Environmental Services Ltd.
Jean-Marie Sobze	Boreal Research Institute, NAIT
Judy St. Armand	Yukon Government
Justin Straker	Integral Ecology Group
Kai Woloshyn	Alexco Environmental Group
Katherine Stewart	Department of Soil science, University of Saskatchewan
Kirstie Simpson	Yukon Government
Lindsay Robb	Alberta Tree Improvement & Seed Centre
Maureen Huggard	University of Victoria

Mike Keefer	Keefer Ecological Services
Mitchell Heynen	Alexco Environmental Group
Pat Tobler	EDI Environmental Dynamics Inc.
Randy Lewis	Partner R.L. Resource Management
Sukie Sidhu	Selwyn Chihong Mining Ltd.
Tim Brigham	Professional and Continuing Studies, Royal Roads University

Twin Sisters Native Plant Nursery

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EXECUTIVE SUMMARY

The revegetation needs in the Yukon are projected to grow in the next few years as new mining projects go through the environmental assessment process, and plans for the revegetation of large-scale abandoned mines begin to take shape. Revegetation strategies and needs vary within the Yukon, but when dispersing seed or using seedlings, the use of native species that are locally produced is considered best practice. The lack of a clear source for this type of material was indicated as a barrier to the implementation of these best practices in the Yukon. To explore this topic further, industry, consultants, and experts involved in seed collection, storing, sourcing, and propagation initiatives were interviewed. This report is based on those interviews and examines the state of revegetation in the Yukon, current options for native seed sourcing, and potential future options that would increase access to native seeds in the territory. These options include the development of seed collection, banking, and propagation initiatives, as well as educational programming to support these initiatives. Several case studies are included, both covering local initiatives and initiatives in other jurisdictions that are relevant to the Yukon and could be used as a model for local seed and plant sourcing initiatives.

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1 BACKGROUND

The Yukon has many different revegetation needs, both from industry and government. These needs are projected to grow over the next several years as new mines come online and development in the Yukon increases. Revegetation is defined as "the re-establishment of the self-sustaining vegetation of land, which previously had vegetative cover" (Energy, Mines and Resources, 2013), and is required any time a vegetated area is disturbed (Energy, Mines and Resources: Minerals , 2013). There are several different methods of achieving this but when planting seedlings or dispersing seed, it is considered best practice to use native species that are sourced as close to revegetation sites as possible. This allows for the re-establishment of an ecosystem that resembles the ecosystem present before the area was disturbed. Access to this type of plant material on a commercial scale in the Yukon has been indicated as a barrier for industry trying to implement these best practices. This project was developed to examine the state of revegetation in the Yukon, and to determine potential opportunities that could improve access to locally sourced native seeds for revegetation purposes. It explores the past, present, and future options for the production and sourcing of native seeds in the Yukon.

More specifically, the purpose of this project is to:

- Determine whether the lack of access to native seeds is a perceived issue or a true issue;
- Examine what barriers are preventing the development of a local seed sourcing industry; and
- Determine how these barriers could be circumvented to bring a reliable native seed source to the Yukon.

This report is primarily based on the interviewing of practitioners in the field of revegetation. Topics including regulations for revegetation experiences sourcing seeds in the Yukon, requirements for seed in the Yukon, barriers faced in seed sourcing, options for the development of a local seed industry, and recommendations to improve access to local native seeds were discussed. We also spoke to people involved in seed banking, collecting, and nursery propagation initiatives within the Yukon or which have applicability to the Yukon, and examined educational opportunities with the potential to build capacity for local communities to be involved in the sourcing of native seeds for reclamation in the Yukon.

1.1 Yukon revegetation regulations and guidelines

There are regulations governing the revegetation of disturbed areas, and in the case of mining, any time a vegetated area is disturbed it must be left in "a condition conducive to revegetation by native plant species or other species adaptable to the local environment to encourage revegetation comparable to similar, naturally occurring, environments in the area" (Yukon Government, 2003). These regulations also state that "If adequate seed stock or root stock is not naturally available, re-seeding or transplanting of vegetation is required". These regulations indicate a need for ready access to appropriate seeds and plant material for mine reclamation work in the Yukon. However,

there about it is somewhat unclear what is actually required for revegetation. The Yukon Government's Yukon Mine Site and Reclamation Closure Policy: Financial and Technical Guidelines (2013), indicates under guideline #T-12, that decommissioning of a mine should focus on natural revegetation, stating that "vegetation is to be self-sustaining, comprising native seed mixes, unless otherwise specified in an approved reclamation and closure plan". The "unless otherwise approved" section of these regulations gives leeway for the approval of mixes that are not fully native, and there is no set approval mechanism in place to guide these situations. When it comes to the approval of seed mixes for quartz mine reclamation and closure plans, there are usually requirements for a percentage of the seed mix to be a native species, but often non-native species are also accepted.

An interpretive bulletin was developed by the Yukon Government Mineral Resources Branch, Department of Energy Mines and Resources with the intent of guiding proponents through the regulations required for revegetation of placer and quartz mining sites. This bulletin recommends that the primary goal for revegetation should be to prepare the site in a way that encourages natural re-establishment of native plants, stating that the objective for revegetation should be to "leave the ground in such a way as to provide a good chance for successful revegetation by plant species native to the site and the area". Although this is recommended as the primary solution, it states that approaches will be varied depending on the conditions, and that "assisted" revegetation may be required in an area "unsuited to natural revegetation but which had significant vegetative cover before the land was disturbed". It continues that if seed is to be used, it should consist of native species ((Energy, Mines and Resources, 2013). In the case where seeding is required, the advice provided by YG is usually to collect seeds from a local zone and use these to revegetate the area. In the past, it has also been suggested that mines start nursery plots on-site to serve the dual purpose of determining appropriate species and conditions for revegetation, as well as providing an eventual seed source. These suggestions are not reflected in issued permits but it is understood that they will be carried out.

The YG interpretive bulletin was partially developed in response to the publishing of the 2013 Yukon Revegetation Manual. This manual is not supported by the Yukon government due to some contradictions to Yukon Government regulations and recommendations for revegetation. However, opinions on the manual's success are mixed. It is still used by some as a guide for species choice when revegetating different areas in the Yukon and is the guide to revegetation suggested by the Yukon Environmental and Socio-Economic Board. The Yukon Revegetation Manual is an updated version of The Guidelines for Reclamation/Revegetation Vol. 1 (1993) and Vol. 2 (1996), which were the first real attempts to develop seed mixes for revegetation that would be functional in the Yukon. These mixes were based on associations between vegetation, soils, and topography of different areas in the Yukon, working to link successful species to these areas. The goal was to provide information to professionals who did not have a background in revegetation, assisting in the planning and implementation of a successful revegetation project. As per existing mining regulations and this interpretive bulletin, seeding is generally only suggested by the Yukon Government in an effort to push a site towards the correct ecological trajectory or in areas with conditions that do not favor natural revegetation. This makes monitoring of these sites more

complex as it requires knowledge of the site and what an appropriate ecological trajectory for an ecosystem should look like. Seed mixes are generally suggested by the Yukon Government Agriculture branch of Energy Mines and Resources or the Department of Environment in the event that reseeding is required.

In contrast to this, several participants felt that often times in the revegetation of disturbed sites, the requirements are simply to "make it green", whether for erosion prevention or aesthetic reasons. Regulations that push for quick coverage can lead to the seeding of aggressive agronomic species rather than the use of appropriate native plants, which often take longer to grow. This can impede the return of a site to its natural state and prevents any native species from colonizing the area (Polster, 2015). It was indicated that there is a persistent idea that as long as a site is green it has been successfully revegetated and that seeding is always good. Many participants suggested that this is not the case, and each situation must be addressed individually. Revegetation goals for an area need to be determined in order to define what the actions are appropriate for a site. When asked why inappropriate seeding happens, Participants stated that most revegetation projects are done with good intentions, however, there is a substantial lack of information on when and how seeding should be done. Although the regulations in the Yukon suggest that native species should be used, there are still opportunities for alternative mixes including non-native species. Furthermore, there is nothing that says these native species must be sourced locally. This means that species that are native to the Yukon but are sourced from outside the Yukon can be used, which comes with its own set of challenges.

1.2 A REVIEW OF REVEGETATION PRACTICES IN YUKON

Revegetation practices have progressed significantly over time. Originally, revegetation followed an agricultural model, striving for thick coverage of agronomic species. This was thought to prevent erosion and eventually allow for the colonization of native species. As revegetation science has progressed, there has been a move away from this methodology and towards other methodologies, including planting locally collected native species. Revegetation practices in the Yukon are varied, but a trend towards planting locally sourced native species has brought more attention to species choice and provenance. There are many examples of projects where local plant material was collected to revegetate disturbed sites in the Yukon.

1.2.1 Use of agronomics species

There are many instances where agronomic species are still used for reclamation purposes in the Yukon, and revegetation models are often heavily based on agricultural models. Many participants brought up the importance of differentiating between the goals of agricultural seeding which aims towards dense growth, and seeding for revegetation where the aim is to establish plant growth that will allow for further natural colonization with native species. For example, it was indicated that recommendations for seeding rates should be much lower than those used for agricultural purposes when doing reclamation work. Heavy seeding with agronomics is generally done with the intent of stabilizing a slope and eventually allowing for natural colonization of native species. Although this accomplishes the objective of slope stabilization, agronomic species are often far too aggressive to

allow for native species to colonize an area. This leads to successional stagnation rather than recolonization of native species (Polster, 2015). Erosion control is largely less of a problem than it is thought to be, and it was indicated by several participants that quick seeding for this purpose is sometimes used as an excuse to seed whatever mix is readily available. If seeding is required to temporarily stabilize a slope, there are agronomic species that can be used without the risk of being persistent, like annual rye. Alternatively, using well rooted early colonizing species like fireweed or goldenrod or using native grass species work to both stabilize a slope and put a site on the path of natural succession. Having some native grasses banked for this purpose was recommended as worthwhile.

1.2.2 Use of non-local native species

Due to the lack of commercially available locally sourced native seeds in the Yukon, seed mixes composed of species that are native to the area, but not locally sourced are sometimes used. Opinions varied on this practice, but the common consensus was that it is always best to use locally sourced native species. However, it was indicated by a participant that given the choice between a native species with a non-native provenance and a non-native species, a native species with a non-native provenance would be preferable. How locally collected is a contested topic. It is difficult to suggest an exact distance as geographical features can prevent dispersion of genetics between two very near populations. However, the larger the distance between an area of collection and an area of dispersal, the larger the chance that a genetically different population will be introduced (McKay, Christian, Harrison, & Rice, 2005). Many mine sites in the Yukon have difficult growing conditions, including a short growing season, lack of organic material, dry soils, and high metal concentrations. Sourcing seeds from, or very close to these sites is thought to give them a selective advantage as they are already adapted to grow in these conditions. Although it is likely that native species sourced from outside the territory will be able to grow in the Yukon, reduced viability was an expressed concern. This was identified by some as particularly important for later successional species like woody species that will remain in the area for a long time, versus early successional species like native grasses that will be gone after a short period of time. Another reason provided to support the use of locally sourced plant material is the potential for the influx of foreign genetic material. Although the species are the same, genotypes are different when sourced from outside, or even from a different region within the Yukon. Additional concerns included the lack of certainty of the contents of a non-local seed mix, as well as the potential of introducing invasive species that could be present in the mix, even if the seed has been properly certified.

1.2.3 Local seed sourcing

It is relatively recent that revegetation has moved away from agronomical processes and toward the use of locally sourced vegetative material, and we are beginning to see a positive trend towards this in the Yukon. The initiative to properly revegetate disturbed sites is there, and improving the ability of practitioners to source native plant material, as well as improving access to information on successful revegetation strategies in the Yukon would go a long way to improve practices. This being said, there are many examples of innovative revegetation projects in the Yukon, including those where seeds have been collected, shipped to a nursery for propagation, and returned for

planting, as well as projects that have developed their own on-site outdoor nurseries to provide a seed source for future revegetation. There is a significant amount of revegetation research happening in the Yukon, and partnerships exist between consultants, researchers, and mines where research for best practice is being carried out. Collecting seeds and directly seeding them or sending them out for propagation is currently the best possible practice considering the lack of commercially available local seeds or nursery plugs. The location of seed collection was indicated as being more critical to success than the location of propagation. However, logistical issues emerge with the shipment of large numbers of seedlings to areas where there is often nowhere to appropriately store them. Many mine sites in the Yukon are remote and abandoned with no amenities. Keeping seedlings viable in these conditions during the time required for planting can prove to be challenging.

2 ISSUE STATEMENT

The lack of commercially available locally sourced native seeds was almost universally recognized as an issue among participants. The only reliable source for this type of plant material was identified as on site seed collection. Many participants had ordered native species, but they were not all locally sourced. It was pointed out that there is a lot of native seed naturally produced in the Yukon, it just needs to be collected. However, this requires proper planning, knowledge, and time, and for larger scale projects, a storage facility. Several participants stated that they wouldn't know who to speak to when trying to source local, native plant material. This indicates not only a lack of local seed sources but also a lack of information and knowledge transfer. In addition to the interviews carried out, the Yukon Revegetation Manual, which although contested is the most recent consolidated effort on revegetation in the Yukon, indicates in its introduction that the commercial sourcing of appropriate seed in the Yukon is challenging and that shipping distance and cost complicates revegetation projects. This was echoed throughout interviews.

2.1 Revegetation needs in Yukon

There were several different needs identified for revegetation in the Yukon, related to both the types of vegetative material as well as facilities that would be required to improve access to locally sourced species. Operating mines will rarely have more than 10 hectares of reclamation needs, so the requirements for mines in this stage are different than those in the closure stage, or for the reclamation of abandoned mines. During the active life of a mine, there are several small-scale revegetation needs for disturbed sites, for example, road sides and construction sites. For these situations, the identified need was a source for a native seed mix to revegetate small disturbed areas. The need for seed is more immediate and more generic than for larger scale closure, where reclamation and closure plans have been developed and there is more time to plan the use of native plant material. For larger scale mine reclamation, a need for a nursery supplying seedlings propagated from a larger variety of species local to the area of disturbance was identified. The needs for reclamation at this point are more varied, and less than ideal soil conditions can call for seedlings rather than a seed mix. There are specific needs for areas like waste rock piles, which can be capped with a membrane before being topped with soil and revegetated. This requires shallow

rooting plants which will not puncture the membrane with their roots. In contrast, other areas may require woody species with deeper roots, like willow or alder. This being said, there are active mines in the territory with an immediate need for both seeds and vegetative stock.

Abandoned mines in the Yukon have various large scale revegetation needs. The District of Keno requires about 50 hectares of reclamation starting in approximately 2023. Revegetation of the Faro mine is scheduled to start in 5 years, and will likely be a large driver of revegetation needs in the Yukon. This site has over 600 acres that will need to be revegetated over a 10 to 15-year period. Depending on the decided revegetation strategy and timeline, this was estimated to potentially require 100,000 – 200,000 seedlings per year. Outside of mine reclamation, Highways and Public Works was identified as being the largest user of seeds in the Yukon with a need for mostly native grass species. The volume of seed required for roadside revegetation projects is large and frequent, with projects ranging from small scale culvert replacements to large scale roadside revegetation projects. With the consideration of these needs combined, it appears that there is a definite need for both seed and nursery propagated seedlings in the territory. In addition, there are more projects requiring restoration in future years that we have not listed in this section and the table below. Refining the projection for revegetation needs in the Yukon would be valuable and a required step to further develop a seed sourcing initiative in the territory.

Table 1. Estimation of potential requirements for locally sourced native seeds or seedlings in the Yukon*

Project	Estimated Timeline	Requirement for seeds/seedling
Minto	Ongoing	Revegetation of areas disturbed during construction but no longer required for operation
	3 years, starting 2018	Active Closure
	15 years, starting 2021	Post Closure
Faro	10-15 years starting after 2022	600+ hectares Estimated at 100-200,000 seedlings/year
Keno	Starting approximately 2023	50 hectares
Coffee Gold	Main reclamation starting after 2030	Reclamation and closure
Selwyn Chihong	Ongoing	Drill pad/exploration reclamation
Highways and Public Works	Ongoing	Very large/ongoing

*Does not include all projects and is a rough estimation of potential needs

2.2 Options for native seed sourcing in Yukon

In the Yukon, there is currently no commercial producer of locally collected seeds. Previously, Arctic Alpine Seed Ltd produced locally propagated seeds for revegetation in the Yukon. The seeds would be collected and planted in 50-meter rows. These rows were then planted out into 1-acre test plots, and subsequently 10-acre production plots. This business model was challenging in the Yukon due to the overproduction of seeds and the limited need for reclamation. A single business producing seeds for reclamation may not be the ideal model but the potential exists for the development of a different model. For example a seed collection and banking initiative, or the collection of seeds and subsequent nursery propagation. The existing options for revegetation are to source species that are found in the Yukon but not locally sourced, to hire a contractor to collect local seeds and send them to a nursery outside the Yukon for propagation or to have trained staff collect seeds for a project and send them out for propagation. Direct seeding is also an option with collected seeds depending on the species and its ease of germination. In most cases, when deciding what seeds to collect or ordering seed mixes for revegetation, industry will work with a consultant to determine the appropriate species based on surrounding vegetation.

Options for the sourcing of native species that are not local to the Yukon exist in several locations. Seeds can be sourced from Alaska, which has a good variety of native seeds but lacks the appropriate quality control certification (Canada No.1). However, these seeds can be purchased and certified before use. Within Canada, seeds are often sourced from large scale seed sourcing companies in Alberta or British Columbia. An inventory of species can be done at a site and a seed mix ordered accordingly. To avoid outsourcing seeds, companies will often work with consultants to collect seed locally. This seed is sometimes directly seeded, but will often be sent down to nurseries in British Columbia, like NATS nursery, to be propagated and shipped back up to the Yukon. The seedlings are then planted at disturbed sites in the Yukon.

2.3 Revegetation barriers in Yukon

Participants identified barriers in the revegetation industry which are preventing the use of local native plant material. Several barriers were recurring between participants, including a lack of communication of revegetation successes with native plants in the Yukon, the lack of a clear regulatory framework dictating what is planted for revegetation purposes, lead time for sourcing native plant material, cost of native plant material, and a shortage of trained people to collect, process, and store native seeds. These barriers are discussed below and addressed throughout the Opportunities and Solutions section of this report.

Knowledge about the collection of native seeds and how to seed with native plants is limited, as is the understanding of good practices for re-vegetation in boreal and sub alpine tundra. How native species perform is not well known, and there is a widespread false perception that native species cannot grow on disturbed sites. Many participants identified the short growing season as a potential barrier for revegetation with native species. Smaller companies generally do not have the budget to hire someone who understands ecological land classification and can recommend the appropriate species for a site. This knowledge deficit limits the use of native plant material in

revegetation projects. Without readily accessible information and demonstrations of successful revegetation projects using native species, their use in the Yukon will remain limited. There is no centralized location in the Yukon to seek information on revegetation, and much of this information remains proprietary or unpublished, making access difficult. The knowledge gap extends to the monitoring of revegetation projects, where those inspecting sites generally do not have specific training to identify what each site should look like. This includes differentiating between a site that is on the correct ecological trajectory and a site that has successfully established vegetation but is not on the correct successional path. Due to this, sites may be classified as successfully remediated when this is not actually the case.

The suggested use for reclamation in the Yukon are native species, but it is not specified that they should be sourced locally and there is the option for the approval of other seed mixes. There is no invasive species act in the Yukon and no policy about where seed must be sourced from and can legally be planted. If it is legal in Canada, it is legal in the Yukon. This reduces the incentive to follow best practices. Industry initiative only goes so far, and if it is excessively expensive or difficult to source local native plant material and there are other, easier options available, these will most likely be chosen. Although the need for native seed is there, the regulatory pressure leading to the economic feasibility of a native seed sourcing initiative may not be. Industry needs to fully commit to the use of native seeds, and this is usually brought about by regulatory pressure. Jurisdictions with flourishing native seed industries also tend to have strict guidelines as to where seeds must be sourced, requiring the use of seeds sourced within the province/state, or even within specific seed zones in a province. Revegetation projects in the Yukon are not obliged to source seeds from within the territory, and this is thought to factor into the lack of commercially sourced native seeds in the Yukon.

Some projects do not have clear revegetation objectives or long range plans in place for the sourcing of native plant material, leaving a short window of time when seed sourcing happens. Local seed collection and propagation takes time, especially for large scale projects. If this lead time is not considered at the start of a project, windows of opportunity for sourcing required seeds or seedlings can be missed. This often leads to the purchase of inappropriate seed mixes. In addition to requiring increased levels of planning to source, nursery plugs grown in the Yukon would likely be of higher cost than those produced at large scale operations down south. However, this could be somewhat offset by the reduction of shipping costs. Native seed collection is very time consuming, and the cost of native seeds would be significantly higher than the cost of commercially sourced seed mixes. The collection of seeds also requires people who are trained in correct and ethical seed collection techniques. There are limited people in the Yukon with these skills, and concerns of lack of capacity to run a seed collection initiative in the Yukon were expressed. The opportunity for training exists, but several participants expressed concerns of having consistent participants in a training program.

3 OPPORTUNITIES AND SOLUTIONS

Throughout this study, opportunities and solutions for the Yukon to move forward and improve access to locally sourced native seeds came to light. Participants shared valuable insight on how seed collection, storage, and nursery initiatives could be set up, as well as providing alternative methods of sourcing seeds. Pathways for the development of knowledge to support the use of native species in revegetation, including the development of educational programming were also discussed. This ranged from opportunities to build capacity in the Yukon, especially in communities affected by operating industry, to developing a forum to further educate proponents and regulators on revegetation goals.

Seed collection, storage, and propagation are all interrelated. For small revegetation projects, seeds can sometimes be collected and immediately dispersed. However, this does not work for all species, some of which need processing in order to be viable. For larger projects, it is beneficial to have a facility in which to store seeds over the development of the project, keeping seeds viable over time and allowing for the responsible and feasible accumulation of enough seed to revegetate a large area. Many species do not germinate effectively in nature or are very expensive to collect. These seeds are best germinated in a nursery and planted as seedlings. This is also beneficial in areas that do not have ideal conditions, making the establishment of seeds more difficult. Most participants felt that development projects in the Yukon would benefit from a native seed or seedling sourcing initiative and that seeds and seedlings would be quickly purchased for the purpose of revegetation.

3.1 NATIVE SEED COLLECTION

Access to locally sourced seeds was brought up by many participants as being critical to the effective and appropriate revegetation of disturbed sites in the Yukon. Native seed collection is an essential part of local seed sourcing, and the potential for seed collection in the Yukon is abundant. As will be discussed in sections 3.1.3 and 3.1.4, seed collection initiatives exist on a contract basis or within individual corporations. Although progressive, these initiatives are isolated and require individual resources from each project. The consolidation of these efforts into a territory-wide seed collection initiative would lead to the more regulated and efficient collection of native seeds and subsequently, increased accessibility to locally sourced seeds. The development of such an initiative requires the consideration of potential issues, including the ethics of seed collection, access to trained individuals to collect seeds, and the feasibility of collection for large projects.

3.1.1 Ethical considerations and seed ownership

There are ethical considerations associated with a native seed collection initiative, including appropriate collection volumes, the timing of collection, and ownership of seeds throughout their lifetime. The over-collection of seeds in one area can put pressure on a population and lead to the loss of genetic diversity. Participant's suggested ethical collection rates for a single population, ranging from no more than 10% annually to no more than 50% over no more than two years. Fluctuations in the productivity of species due to annual variations in climatic conditions need to be considered when determining collection volume. If a population is experiencing a particularly low

yield, collection efforts should be halted or reduced until yield increases. However, an opportunity for massive seed collection arises if plans are put in place to strip an area of seed before it is cleared for development. This provides a project with a lot of seeds from appropriate species to re-establish populations that will be lost by development. The timing of seed collection is essential to germination success. Collection of unviable seeds is unethical, reducing seed dispersion in a population without the benefit of re-establishment of vegetation in another area. Native species ripen at different times throughout summer and fall, meaning several collection efforts may be necessary to obtain desired species. Community involvement in protocol development is vital to ensuring ethical seed collection. First Nations communities have a traditional understanding of how to collect plant material, and sites where collection might potentially occur lie on First Nations traditional territory or settlement land. This needs to be considered in regulations regarding ownership and permission to collect seeds. This includes who has ownership of seeds while they are growing and how that changes when they are collected, banked, and stored. For example, in Alberta, the regulations state that the seeds growing on crown land belong to the Alberta Government before they are collected, then belong to the collector once permission to collect is granted and while they are stored in the seed bank. If they are purchased, they belong to the client purchasing the seed, and once they are dispersed, they once again belong to the Alberta Government. This is an important conversation that should include all affected parties.

The connection of a seed collection program with a seed bank would mean that seeds could be collected in multiple, smaller collection efforts and stored over the lifetime of a project. This would reduce the collection stress from the combined collection efforts for several projects, or that of a large project. Using a seed bank as a venue for a seed collection program would also allow for the regulation of seed collection. A seed bank could reject the storage of unviable seeds and reduce over-collection through regulations regarding collection volumes. A training and certification program associated with a seed collection initiative would ensure those collecting seeds for banking had an understanding of how and when to collect seeds, as well as the regulations surrounding seed collection. This measure would provide an avenue for engagement, instill an understanding of conservation ethics, as well as reduce the potential for unethical seed collection. Sessions to check in with seed collectors and ensure they are collecting and handling seeds appropriately could be put in place to ensure the quality of the collection. For more information on potential training programs see section 3.6.

3.1.2 Definition of seed zones

Seed zones indicate boundaries within which seeds can be collected and dispersed. They are based on area, climate, elevation, and geographic barriers that could prevent seed dispersion. Collecting and dispersing seeds within a seed zone reduces or eliminates the introduction of foreign genetics into populations which could swamp out local genetics, and increases the likelihood of planting well-adapted plant materials (Bower, Clair, & Erikson, 2014). Seed zones can vary in size, dependent on how they are established and what the goals of the seed zone are. For example, Alberta has relatively small seed zones developed by forestry. These zones are based on the dispersion capabilities of pollen from coniferous species but have been effectively adopted by the revegetation

industry. The potential for variance within these seed zones also exists. The use of seeds in one zone further north or one zone higher in elevation than the zone of seed origin can be allowed upon request. The rationale for this is the northward and upward migration of plant species as the climate changes. Even with this consideration, it was not recommended that seeds be moved more than one seed zone over, as species need to be allowed to adapt to changing conditions locally.

Several participants indicated that if the Yukon is serious about seeding with native species and maintaining local genetics, seed zones need to be defined in the territory. There is evidence that several species in the Yukon show different characteristics based on their area of origin. Many of the species in the Yukon are at the northern edge of their range, and care should be taken not to move seeds over too great a distance when revegetating an area. The establishment of seed zones would ensure plants are well-suited to the area they will be dispersed in and preserve these variations within species. It was indicated that placing jurisdictional boundaries on these zones could limit seed sourcing in areas close to borders. The balance between practical use and genetic conservation and reclamation success needs to be established in order to define effective seed zones.

3.1.3 Case Study: Faro Mine

In preparation for the reclamation of Faro Mine, Environmental Dynamics Inc. (EDI) has been doing several different types of revegetation trials on the Grum Sulphide Cell at Faro Mine. These include trials with purchased native seeds, locally collected native seeds, as well as agronomic species. Trials conducted with locally collected seeds included the collection of alder seeds. Seeds were collected by three EDI staff members in a 3 to 4-hour period during a field work session. About 4 or 5 sandwich bags worth of seed was collected during this time. These seeds were stored in Ziploc Bags in a freezer for approximately 2 years before they were shipped to NATS nursery in Langley, BC to be propagated as plugs. These plugs were started in the nursery in late winter, then planted in trial plots in June/July to determine success. During later monitoring, the plugs had established quite successfully.

A lot of seed was successfully collected in a relatively short amount of time for this trial. It was however acknowledged that alder seeds are easy to collect and do not require special processing which may not be the case for all species. For example, those with fluffy seeds may take longer to collect and species like berries require more processing. The seeds were collected by EDI biologists who knew the appropriate method and timing for seed collection. This is important as the timing between species varies. This seed collection trial displays the potential for the collection, storage, and propagation of alder seedlings in the Yukon.

3.1.4 Case Study: Historic Keno Mine

Alexco Environmental is in the process of developing a plan for reclamation of the Historic Keno Mine site. Among other reclamation activities, there is revegetation of waste rock piles required. Several test plots have been done with both non-native and native species, as well as different soil amendments. A trial was conducted with seeds collected around the area to be reclaimed. This seed collection was done through a seed collection training program that was run over three years (2013 – 2015). This included a 1-day workshop with several expert speakers. The goal of this program was not only to train participants how to identify and collect seeds of native species but also to speak to the principles of ecological restoration and develop an understanding of the purpose of seed collection.

Due to the short time period and educational nature of this program, seed collection was limited. About 2-3 kg of seeds were collected over the three years it was run. These seeds were stored in Ziplocs over this time. In 2015, about 90% of them were broadcasted on test plots. As of spring 2017, not a lot of growth has been observed at these test plots. Native species can be slow to establish, but it was suggested that if nothing has established after two growing seasons it is unlikely that the effort was successful. There could be several reasons why establishment has not been seen yet, including the lack of a facility to appropriately process and store seeds. Regardless of the success of these trial plots, this seed collection effort displays the potential for educational programming related to seed banking. There are professionals in the Yukon with experience running this type of educational programming and students that have taken these courses. Although the curriculum for this program was not formalized, it has potential to be used as a basis for the development of formal educational programming associated with a seed collection and banking initiative.

3.2 NATIVE SEED BANKING

The majority of participants in industry, research, and consulting indicated that a seed bank would be valuable, both for the purpose of storing seeds that they have collected over the lifetime of a project for the purpose of reclamation and for the convenient purchase of locally sourced native seeds. This being said, several requirements were brought up by potential seed bank users, including the need for a business model displaying that sourcing seeds from a local seed bank is economic. This included a comparison of the cost of outsourcing versus the cost of local sourcing, as well as a timeline of seed bank establishment and seed availability. Additionally, potential buyers specified that seeds local to their area would need to be available and that they would need to be confident that seeds were of high quality, i.e. good germination rates and free of invasive species. If these conditions could be met, support for sourcing from a local native seed banking initiative, especially one that supported community economic development and education, was strong.

3.2.1 Viability and quality of stored seeds

Issues of seed viability and quality were a common concern amongst potential users of a seed bank. Experts in seed banking indicated that if steps are taken to ensure seeds are properly handled and promptly dried and stored in airtight containers, most seeds have very long shelf lives. There are exceptions to this, for example, birch and alder. These species often create large quantities of poor quality, wet seeds. If they are not properly handled, these seeds generally have a shelf life of only 3 years. However, it was indicated that even these species can be stored for up to 15 years if handled and processed correctly. Most often, banked seeds fail to germinate due to an error or inadequate regulations regarding protocols for collection and processing, storage, and/or germination. If proper protocols are established and followed, many species can be simply and effectively stored for a very long period of time.

It was recommended that seeds be tested for viability once they have been dried and frozen. This will ensure that they are viable in the state that they will eventually be used. One method of viability testing involves the germination of a small percentage of a seed lot to determine germination rate and purity. This requires an understanding of germination techniques for all species in the seed bank which may require some research, potentially spanning many years for more challenging species. Germination protocols should be such that a large enough percentage of a seed lot (i.e. a large enough percentage of the genetics) are germinated to ensure resiliency on the landscape. Another method for viability testing is the tetrazolium chloride method. This method is not as accurate as the germination method but is a quick way to estimate seed viability (Verma & Majee, 2013). An understanding of these methods is vital to the ability to differentiate between germination failure due to poor methodology and germination failure due to unviable seed lots. Viability testing can also be used to inform the number of seeds required per cavity for nursery germination based on the percentage of viable seeds present in a seed lot. If proper protocols were developed for a seed bank in the Yukon, this viability testing could easily be done.

3.2.2 Infrastructure requirements

Seed banks exist in a broad range of size and complexity, from massive seed banks like the Millennium Seed Bank in England, to small community run seed banks. Many participants agreed that the capacity does not exist in the Yukon for a complex operation, but starting a small scale seed bank would be feasible. Based on expert opinion, it was estimated that a seed bank could be set up with a relatively low initial investment of approximately $30,000. This is based on the purchase of equipment to test, process, dry, and store seeds and the assumption of access to building space to do this. If space was not available and a facility needed to be built, costs would increase dramatically. Participants suggested that a seed bank could be started on a very small scale with the potential of growing as the capacity to collect, store and use native seeds increased. This could be achieved through access to basic facilities and the purchase of the equipment outlined below.

A seed bank requires an area to dry and process seeds, as well as a way to store seeds in a temperature and humidity controlled environment. In a region with low relative humidity (RH) during fall & winter processing times, like the Yukon, seed drying can be accomplished in a ventilated room that is reasonably well sealed, allowing for the monitoring of RH and exposure of

seeds to air flow. This allows for the relatively accurate assumption that the RH of seeds within the room is at equilibrium and therefore equivalent to that of the surrounding air. This can be more accurately monitored and tested before banking with the use of a water activity meter. A water activity meter is a nondestructive method of testing the RH of seeds, allowing for the accurate testing of even very small seed lots. Combined with strict limits for seed drying, this would ensure the maximum longevity of seeds in freezer storage, thereby maximizing their usage time and minimizing costs.

Seeds can be cleaned before drying to decrease bulk and reduce the percentage of unviable seeds by removing those that are empty or infested. A seed blower was indicated as a vital piece of equipment to speed up seed cleaning times and reduce manpower costs, as well a good stereo microscope and basic lab equipment to carry out viability testing (scalpels, Petri dishes, etc.). After cleaning and drying, seeds must be properly packaged in hermetically sealed containers. Plastic lined, heat sealed foil bags were suggested as the best way to store seeds. This type of packaging is proven to maintain its seal and keep seeds dry during storage, which has an even greater effect on longevity than keeping seeds cool. However, cold storage of seeds can increase longevity further in a good quality deep freezer between -18 and -20 ^{o}C. It was recommended that freezers be outfitted with data loggers and an alarm system to detect fluctuations in temperature, ensuring seeds are not lost in the event of unit failure. Walk in freezers are often used to store seeds, especially research collections, but prices for these run exponentially higher. The lower cost of chest freezers provides the advantage of easy addition or replacement of units and are used successfully in Australian seed banks. Due to their small size, many seeds can be stored in one chest freezer with an adequate catalog system and additional freezers can be purchased as is required. A seed storage database that includes seed zones (Section 3.1.3 for more details), the location of collection, and collection details including collection date, collector name(s) and owners(s), cleaning methods and banking date needs to be established. This will ensure availability of seeds for all areas of the Yukon and maintain an understanding of the contents of the seed bank, deposits, and withdrawals in the future, as well as where the seedlings are being deployed. Microsoft Access was suggested as a low cost, easy to manage system for this purpose; however, advanced database skills would be required to set up and maintain the system.

Infrastructure for a seed bank is relatively simple to acquire. A more accurate determination of cost could be established by seeking out potential venues for a seed bank and developing a budget for equipment requirements. The greater challenge is the acquisition of trained and knowledgeable staff to follow seed processing and storage protocols, carry out viability testing, and curate a seed bank. Seed bank staff need to have a scientific understanding of seeds and how they are affected by handling to maximize the viability of stored seeds. There are professionals in the Yukon with experience in seed collection and germination, and training programs could be established to build a larger knowledge base. See section 3.6 for more information on the potential for training programs.

3.2.3 Development of protocols

One of the most important aspects of seed banking is the development of appropriate protocols to ensure proper collection, processing, and storage of seeds. Several participants stated the need to build off of existing information to help reduce unnecessary effort in creating these protocols. Other seed banks and research institutions have already developed protocols for many boreal species existing in the Yukon, and the use of these protocols as a foundation would drastically reduce the effort required to create collection protocols for the Yukon. For example, the NAIT Boreal Research Institute has protocols for the collection, processing, and storage of native species. These protocols include recommended best practices for ethical seed collection, seed harvest, proper identification of a seed lot, minimum population size for collection, appropriate handling of seeds, seed processing and storage, seed registration, and plant deployment (Boreal Reclamation Program). Additionally, protocols indicating the differences in the collection, handling, processing, and storage of different groups of species are required. For example, berries require the removal of pulp from seeds before they can be dried, while alder seeds can be shaken from their cones and dried as is. The identification of a list of Yukon species of importance that are successful in revegetation for different ecozones would be beneficial to guide the development of these protocols. For the collection of seeds, technical information sheets that are filled out by seed collectors need to be developed, which include information about when the seeds were collected, where the seeds were collected (GPS location), who collected the seeds, the species collected, how they were collected, and the volume collected, among other information.

Protocols outlining permission to collect native seed also need to be established. This includes policies surrounding the right to collect seeds for the seed bank, deposit seeds at the seed bank, and withdraw seeds from the seed bank, as well as ownership of seeds throughout these stages. This includes who has ownership of the seeds when they are growing, collected, banked, and purchased, as when as what to do with leftover seed. These policies may be dependent on the management and ownership of the seed bank. Regulations regarding the dispersal of seeds need to be created, especially if seed zones are established.

3.2.4 Seed bank management

A commonly discussed topic was the potential management of a seed bank. Many participants saw an issue with a seed bank being privately owned. A seed bank is a long-term project which requires stability. This could be compromised by the potential for a private owner to leave the territory or go bankrupt, leading to the loss of seed banking efforts. For this reason, most participants thought that the initiative should be government run or run by a well-funded research institution. However, third party funding common in research institutes is often unsteady, which could lead to similar issues as private ownership. Whether or not a seed bank was run by the government or an academic institution, many participants stressed the importance of maintaining academic input and research support. A seed bank should be managed in a way that allows for the continued development and dissemination of knowledge.

Another consideration is the management of seeds coming through a seed bank. Several models exist and could be further explored and adapted for suitability to the Yukon. A model exhibited by the Alberta Tree Improvement and Seed Centre is government ownership of a seed bank, where industry, researchers, and seed collectors can store seeds free of charge. In this scenario, the seed bank exists simply as a storage facility, and government developed policy determines the regulations associated with the banking of seeds. A private company can store seeds at the seed bank for personal use or for future sale to a nursery or revegetation project. The seed bank keeps track of where seeds come from, their quality, and their distribution. A second model is a seed bank which pays seed collectors up front for seeds collected and these seeds can subsequently be sold to industry, researchers, and consultants. In this model, the seed bank would own the seeds stored there, and there may be a larger potential for those wishing to collect a smaller amount of seeds to generate some revenue from seed collection. Both these models maintain the seed bank as a location that safely stores seeds and allows for the generation of revenue by seed collectors and the withdrawal of seeds from industry.

3.2.5 Additional values of seed banking

Having a local seed bank ensures availability of local varieties of species, reduces shipment required to bring seeds to mine sites and creates a venue for the easy access of appropriate seeds for revegetation in the Yukon. However, a seed bank has value beyond this. Many seed banks act as a repository for species at risk, endangered species, and species of special importance. They can serve as a centralized location for access to information regarding species choice for revegetation and support the planting of species most suited to survival in an area. It was pointed out that there is not always enough of a connection between those revegetating areas and those who are involved in vegetation removal, for example in highway corridors. Consultation on species choice to avoid requirements to mow in right of way areas could save costs and increase safety.

Monitoring of what species are currently available in a seed bank, who has withdrawn what species, and what requirements for revegetation exist in the Yukon leads to increased information and resource sharing. There is enormous research value to a seed bank, including the potential for development of molecular libraries of Yukon species, research on how genetics are changing over time and with changing climate, preservation of genetic material, and the availability of a local source for research on species best suited for revegetation in the Yukon. Several participants felt that the development of a seed bank should work to facilitate these opportunities as well as banking for revegetation, although the argument was also made that this could be facilitated by sending seeds to banks in other jurisdictions.

As the public becomes more aware of the benefits of planting with native species, the interest in landscaping with native species is increasing. A native seed bank or nursery could provide native species for this purpose and help increase awareness of the benefits of growing native species in Yukoners' back yards. For example, reduced water usage, reduced risk of the introduction of invasive species, and the creation of bee habitat for a declining species. This would be beneficial to the Yukon by creating micro-habitats in people's yards.

3.2.6 **Case Study: Oil Sands Vegetation Cooperative**

The Oil Sands Vegetation Cooperative (OSVC) is a seed collection initiative which works to provide seed for oil sands revegetation projects in the Northern and Southern Athabasca Oil Sands as well as the Cold Lake region. This cooperative was built to address the issue of lack of commercially available locally sourced native seeds. Industrial projects in Alberta will not be approved if they do not have clear plans to revegetate sites with native seeds that are sourced locally, from the appropriate seed zone of the development upon closure. OSVC began in 2009 with 9 companies who came together with the help of Wild Rose Consulting to start a consolidated effort for the collection and banking of seeds for revegetation of their sites. Since 2013, it has included all 13 Canadian Oil Sands Innovation Alliance (COSIA) members and has banked seed from 43 different species. The impetus of this cooperative was the collaboration between innovative industry and consultants who were engaging in native plant revegetation trials. The positive results from these trials were communicated and interest in using native species increased. Oil companies began to add native species to their reclamation and closure plans to improve their chance of approval. This lead to discussions about how a seed banking program could be developed to support industry in the use of native species. Now, companies will not be approved without the use of native seeds from the correct seed zones in their reclamation and closure plans.

The OSVC hires a head harvester who works with Wild Rose Consulting to collect target species on an annual basis. These target species are based on an evaluation of species for use in reclamation done by Wilde Rose Consulting. Originally this collection was more opportunistic but has evolved into a collection based on the needs of each of the COSIA members. However, if there is an especially good year for a target species, more will be collected due to annual fluctuation in seed yield of different species. Rules for responsible harvesting are followed, which include the harvesting of no more than 50% of seeds for no more than two consecutive years in any given area. The exception to this rule is if a site is going to be cleared, which allows for the stripping of seeds from an area before development occurs. The head harvester hires a harvesting team, who go through a brief training program on how to collect native seeds mostly by hand. The training program was developed from a knowledge base which has expanded over the years, benefiting from everything from scientific knowledge to experiential knowledge, to local First Nation traditional knowledge.

After collection, the seeds are cleaned and processed to be stored at the Alberta Tree Improvement and Seed Centre (ATISC) in Smoky Lake, Alberta, where they are tested for viability, registered (where and how they were collected, seed zone, collectors, etc.), and banked. This facility is curated by the Alberta Government, and stores seeds underground at -18°C to -20°C in humidity and temperature controlled conditions. The Alberta Government has many regulations regarding the use of native seeds, including the requirement to disperse seeds only within the seed zone which they were collected. The OSVC has companies in several seed zones, which requires the harvest of seeds in each of these zones. Seeds are distributed among these companies based on financial contribution to the cooperative, with larger contributions equating to larger volumes of seed. All seeds harvested and stored by the OSVC are monitored in a cross-company database even after

withdrawal from the bank, allowing for the trade or buying and selling of species between companies if they are currently unavailable in the bank. When a company withdraws seeds from the seed bank, they are prepared for germination and sent to a nursery. They are then used to revegetate disturbed areas as required by companies.

3.3 Native seed propagation

Native seed propagation was a common topic of discussion. Many participants felt that producing plugs locally would be beneficial to revegetation in the Yukon and that a local nursery would be well supported by industry with revegetation requirements. If a revegetation project requires plugs, seeds must be shipped down south to a nursery, and seedlings are then shipped back to the Yukon. A local nursery could cut down this shipping, and allow the sourcing of plugs as needed. Due to the need for long distance shipping, large quantities of seedlings are often shipped at a time. This can cause problems with appropriate storage of these seedlings before they can be used. Another topic that was discussed was the on-site propagation of species for the purpose of seed generation. This provides an on-site nursery for the species of interest at a development site and allows for the harvest of seeds to create seed mixes.

3.3.1 Nursery propagation

Many participants identified the development of a nursery initiative in the Yukon as extremely beneficial for the revegetation industry. If proper germination protocols are established, the propagation of native seeds in a nursery requires less seed per established plant than the direct dispersion of seed. This is especially true for species that do not germinate well in nature and is beneficial in the efficient use of seeds from species with small populations. Additionally, a smaller seed collection effort is required to revegetate a given area. Participants had similar requirements for the development of a nursery as for a seed bank. Many indicated the requirement for a better understanding of the economic feasibility of a nursery, including the time and cost required to establish a nursery, the cost of seedlings, and the ability of a nursery to supply the demand for seedlings. This included having staff with the skills to work at a nursery. A nursery would need to be reliable and eventually have the capacity to produce enough seedlings for large projects.

Infrastructure requirements for a native plant nursery would vary, depending on the presence of a local seed bank and its ability to process seeds. Some nurseries process their own seeds and keep them in cold storage until they are needed. This means the nursery would require processing equipment similar to that described in section 3.2.2. However, if a seed bank existed with the capacity to process seeds this would significantly reduce the infrastructure requirements for a native plant nursery. The main infrastructure requirement would be a greenhouse to germinate and grow plugs. The cost of this could be quite significant, but existing infrastructure could be used if a community had interest in using a community greenhouse for the purpose of producing plugs for revegetation. There are projects that could benefit from a small-scale nursery in the near future and supplying these could be a starting point which could be built upon until capacity exists to supply larger projects. The Faro Mine remediation project is scheduled to start 5 years from now, and revegetation of this site will likely only begin a few years after remediation has begun. This timing

would give a nursery a chance to build capacity before having to supply a project of this scale. Additionally, projects of this scale usually have progressive reclamation plans, meaning several smaller yearly requirements from a nursery.

As is the case with seed collection and banking, protocols need to be in place for a successful nursery initiative. There is the potential of sharing protocols with a seed bank initiative. For example, germination protocols developed for a seed bank could potentially be shared with a nursery with minor adjustments, and vice versa. The growth of native species can be difficult and time-consuming, and a nursery requires capable staff that are committed to carefully following protocols required to germinate these seeds. This would likely require access to educational opportunities to develop the capacity for this in the Yukon (more information in section 3.6). The short growing season in the Yukon was identified as a potential barrier to the use of native species for revegetation. However, local species are adapted to growing in this time frame and a greenhouse would allow for the early start of plants, giving them a head start for use in revegetation. When it comes to woody species, they could be started in the spring and planted in fall. These species can also be allowed to go dormant over the course of the winter and spend a second season in a nursery before they are used in revegetation. There is also the potential for a partially heated greenhouse to start seedlings early in the season.

Participants also brought up the need for someone to champion this type of initiative. Several different opportunities for this were discussed, including industry investment into an affected community willing to take on the development of a nursery initiative, a community with existing infrastructure and access to federal or territorial government support, or a mining corporation taking on the development of a nursery to support their eventual revegetation needs. The preferred scenario by most participants was one with community involvement, where affected First Nations communities could build capacity and benefit economically. There are very successful and positive examples of this, for example, the Twin Sisters Native Plant Nursery, which is further discussed in section 3.3.1.1). Participants felt that in order for a community nursery to be economically lucrative, there would be a requirement for some sort of funding, whether that is from industry or government. The production of native plant plugs for revegetation is time-consuming and labor intensive, and a nursery may not make a profit initially. This is dependent on available infrastructure, revegetation requirements, and buy in from industry to support a community nursery. However, support for a local nursery would likely be strong. Most participants felt that it would be more likely that a nursery would have trouble keeping up with demand, especially at first.

3.3.1.1 **Case Study: Twin Sisters Native Plant Nursery**

The Twin Sisters Native Plant Nursery is 100% First Nations owned native plant nursery in Moberly Lake, Northern British Columbia. It was started as a partnership between Water Energy and the Saulteau and West Moberly First Nations. Both these First Nations groups experience cumulative impacts on their territory from industry, including access roads, pipelines, and seismic lines. One of these companies was Walter Energy, who was having trouble getting good germination rates from plants sent to nurseries down south. In addition to this, having seedlings delivered in a timely fashion can be expensive and difficult to coordinate. Industry is required to consult with local First

Nations groups when developing their treaty lands. These groups were requesting the use of native species by industry, and this was putting pressure on industry to find a better way to source native species. This lead to a partnership between Walter Energy and the Saulteau and West Moberly First Nations in 2012, and a contribution from Walter Energy of $1.4 million to build two 7,000 square foot greenhouses. These were then handed over to the First Nations, who fully own and run the nursery. The nursery has been bringing in a profit since it opened its doors and is set to bring in approximately 1.5 million dollars in 2017.

The Nursery currently produces one crop of 500,000 seedlings per year and has just started using the second greenhouse. At full capacity, up to 1.5 million seedlings per year could be produced. The Nursery is 85% First Nations staffed. The only two staff members who are not First Nations are the manager and the head grower. Most of the staff went through the Growing Our Futures: Native Horticulture Program that was developed in association with the development of this initiative. For more information on this training program see section 3.6.2. The nursery has previously employed 5 staff including the manager and head grower but has this year raised that number to 8. The Twin Sisters Native Plant Nursery started off just supplying seedlings but has built capacity to play a consulting role in the revegetation industry. Companies will bring species requests to the nursery who will collect the seeds of these species, process them and germinate them as plugs. However, the nursery will also suggest species of importance to an area if they have been missed. The two First Nations worked within their communities on behalf of the nursery, speaking with elders to develop a list of species that have traditional importance. If the nursery suggests species to be added to a revegetation plan, industry understands that it is important to the communities and makes changes accordingly. This is an avenue for traditional knowledge to inform revegetation of disturbed sites without compromising this knowledge. The nursery will also consult on species that are appropriate for an area for other reasons. For example, in some areas, it is desirable to attract ungulates while in others it is not. Twin Sisters ensures that the species being planted in an area take this into consideration and are appropriate. Ideally, the nursery will do a pre-disturbance site assessment to determine what needs to be returned to the area. If this is not possible, adjacent sites or mountain sides can be examined instead. A solid team and the development of the right contacts help the nursery play all of these roles.

The seedling supplied to revegetation projects in the area have an 80 to 90% survivorship rate. This high rate is attributed to the fact that they are northern plants being grown in their original habitat. The first plants from the nursery were supplied in 2014, and monitoring in 2016 showed that the plants had done very well. Another contributing factor is that these seeds are collected as close as possible to the site where they will be planted, which is considered a key factor in their survival. Twin Sisters currently collects 75 different species. This collection effort begins with scouting for collection areas in May and lasts well into the fall months. Seed collectors carry a form with information like who collected the seeds, GPS coordinates, collection date, population, and other important information about the collection area. The seed lot is then assigned a 6-digit code to reference each seed lot. This information is put in a database at the end of each season.

Seeds with short shelf lives like willow and aspen are immediately germinated while others are stored until needed. The seeds are stored in good quality refrigerators which are only opened when necessary to keep temperatures stable. The nursery does all of its own processing and germination procedures. A head grower was brought in with experience working in a nursery and germinating seeds, and research to develop germination protocols for more difficult to grow species is constantly being done. Much of the seed processing equipment is very simple. The nursery has so far only bought two pieces commercially, and all other equipment has been hand built. For example, berries are cleaned using blenders whose blades have been dipped in rubber paint to dull them. The main goal is to get the seeds as clean and dry as quickly as possible. The speed at which this needs to be done varies between species. Berries must have their pulp removed immediately, while grasses can wait slightly longer to be processed. When seeds are ready to be used, they are grown in forestry trays to create plugs for use in revegetation.

Twin Sisters Native Plant Nursery is continually building capacity. There are plans to work towards building a seed vault to store seeds for longer periods of time, and the nursery plans to diversify into the landscaping business as well. Native species grow very well in gardens and there is a growing interest for people to use native species in their yards. Shell Oil is currently sponsoring reclamation training to help build capacity in this area. Having good reclamation planters was cited as being extremely important. There is a lot to consider in this work, like differences in microclimate and how to plant to maintain diversity that results in a fully functioning ecosystem. The Twin Sisters Native Plant Nursery is a great example of a partnership between industry and First Nations communities leading to improved industry revegetation standards, capacity building within communities, and economic benefits to these communities.

3.3.1.2 **Case Study: Yukon Energy Corp**

Yukon Energy Corporation (YEC) developed a Liquid Natural Gas plant to provide backup power for the Whitehorse Hydroelectric dam, which opened its doors in 2015. The development permit for this plant was issued by the City of Whitehorse and required the use of native tree and wildflower species to be used for revegetation of the disturbed areas around this plant. With no clear local source of native wildflowers, YEC put out a call for proposals to accomplish this.

Yukon Gardens responded to this call for proposals and was granted the contract. The facility already grows white spruce for the purpose of landscaping and these were used to revegetate the site. With no local source of native wildflower seeds, Yukon Gardens collected the seeds of native species and propagated them in their greenhouse. These were then planted along with the white spruce trees to effectively fulfill the revegetation requirements. This project is an example of how native species can be successfully propagated in the Yukon and used for the purpose of revegetation. However, this was a relatively small project and it is unlikely that Yukon Gardens would have the capacity for large scale projects like mine closure. This model could be followed on a larger scale with a greenhouse dedicated to producing native plant seedlings for the use in revegetation.

3.3.2 On-site selection nursery

The option of collecting native seeds from surrounding areas has been discussed in section 3.1, but this can be time-consuming and often requires multiple collection efforts. It also requires a seed bank to store seeds if a large quantity of seed is required for a project. This is an effective method under some circumstances, but an alternative method to seed collection and propagation was brought forward by several participants. A potential strategy is the development of on-site seed banks, allowing for the production of revegetation materials while mine operations are taking place. This would build capacity within mines themselves and remove the issue of purchasing seeds altogether. Relatively few resources would be required to achieve this. A baseline survey of vegetation would be required, allowing for the determination of colonizing species in the area. These species could then be grown in nursery plots consisting of 50 m rows, which could eventually be extended to 1-acre test plots and potentially 10-acre production plots depending on the final area requiring revegetation. This would be a low-cost solution, which could be done in partnership with local First Nations communities. Seed mixes could be harvested as needed from these plots for the revegetation of the site. This method also allows for the determination of successful revegetation strategies. If plants are not establishing successfully in a nursery plot, experimental amendments can be made until the best method of growth is found. This will assist revegetation efforts when the time for revegetation comes.

Opinions on the effectiveness of this type of initiative were varied among participants. Some felt there was not enough evidence of this being functional in the Yukon to support its use, while others thought that it was a very effective method of seed generation for revegetation. It was also indicated that for remote exploration projects this may not be a feasible option. In areas where there are inconsistent water sources and personnel on site, it would be challenging to maintain a plot like this. Having this type of program in a nearby community and being able to purchase seed from the community was thought to be preferable for revegetation of these types of development projects.

3.3.3 Case Study: Coffee Gold project

Kaminak Gold (Now owned by GoldCorp) began an on-site nursery initiative. A vegetation survey was completed and early colonizers were identified. These were harvested selectively and each species was seeded individually in pots. The intention was to then pick selection plots, plant these species out and eventually have the ability to create seed mixes from these nurseries. In conjunction with this, the mine had revegetation trials in progress. This included the demonstration of revegetation of locally collected seeds on drill pads with a seed mix collected from the surrounding areas. The soil on the drill pads was made rough and loose before planting to help the collection of water and establishment of seeds. Seeds were collected from areas around the drill pads and placed in the same bag. This resulted in a seed mix that was almost identical in species composition to the surrounding vegetation. The majority of the seed mix was dispersed directly onto the drill pad. The remaining seed was analyzed for species composition. This seed mix established well on the drill pads and resulted in their successful revegetation.

3.4 Development of knowledge

As well as suggestions for sourcing native seeds, participants suggested research topics that would support the use of local native seeds in the Yukon. There is very little readily available literature on local native seed use in the Yukon. Increasing research support and making results accessible would increase confidence in the use of native species in the revegetation of disturbed sites. Research surrounding the use of native species, what species are best suited for revegetation, and where seeds should be sourced from for the revegetation of different areas will also support the effectiveness of a native seed sourcing initiative. The next sections discuss these research suggestions and how they would benefit revegetation in the Yukon.

3.4.1 A Review of historical revegetation projects: successes and failures

A topic brought up on several occasions was the lack of long term monitoring of revegetation projects in the Yukon. Participants noted that research in the Yukon highlighting the successes and failures of historical revegetation projects would benefit future projects by providing insight into the methodology and species choice to achieve the desired revegetation goal. This could be achieved through a comparison of conditions and species at historically revegetated sites to develop an understanding of the long-term outcome of different techniques and support the choice of appropriate revegetation strategies. This type of study could provide information on the expected time lines of succession under different circumstances, as well as the functionality of the ecosystem establishing in the revegetated area in comparison to its surroundings.

A study of this nature was conducted by Mougeot Geoanalysis and S.P. Withers Consulting Services in 2000, examining five mine sites between 3 and 15-years post-revegetation. The choice of sites for this study encompassed a variety of ecosystems and techniques, providing insight on the long-term effects of revegetation at each. A second study with a similar goal was done in 2009 by EDI Environmental Dynamics Inc. This study covered twenty-five sites, including those in the 2000 report by Mougeot Geoanalysis and S.P. Withers Consulting Services. The revisited sites were categorized into five different revegetation techniques, and the success of each technique was summarized in a report. Similar results were gleaned from these studies, which do a good job of comparing existing historical site and displaying that agronomics can slow the recolonization of native species. However, there was limited data for sites showing the long-term results of methods like seeding with non-grass/native species, transplants, and root cuttings (EDI Environmental Dynamics Inc. , 2009). As revegetation techniques shift away from agronomics and towards the use of these methods, the Yukon could benefit from a similar study examining more recently revegetated sites.

3.4.2 Demonstration and communication of successful use of native species

Many participants stated that there is not enough evidence in the Yukon displaying the success of revegetation projects using locally sourced native seeds or seedlings. Although several projects of this nature exist in the Yukon, the success of these projects is often not well monitored or shared. The Yukon needs an efficient method to share these success stories both between revegetation

experts in the Yukon, with industry, with regulators, and with communities that have an interest in the success of revegetation efforts. A suggestion to increase information sharing between those managing revegetation projects was the creation of a database with information on different mining companies that have broken ground. Information could include location, conditions, successful species, etc. This would provide an avenue to share material and help build the knowledge base of successful revegetation techniques specific to the Yukon. Another suggestion was for the development of an annual conference where local consultants and industry could share results of revegetation projects. Keeping the conference local would allow for a Yukon focus and participation from smaller projects as well as larger ones. A conference could also provide an access point for those who are unsure of who to talk to and where to start when looking to source local seeds for revegetation.

The communication of successful revegetation results is only beneficial if there is long-term monitoring of these projects in place. The success or failure of revegetation with locally sourced native species cannot be determined without long-term monitoring to provide information on the establishment of vegetation over time. There is a need for research-based evidence demonstrating that the use native species is effective in revegetation, and conversely, that the use of agronomics does not necessarily achieve the desired result. In order for a large-scale shift towards the use of local native plant material to occur, evidence of the success of these techniques needs to be readily available to those making decisions about the sourcing of plant material for revegetation.

3.4.3 When to seed

Although the primary topic of this study was the sourcing and use of local native seeds, a subject that came up on several occasions was the importance of knowing when to seed, what the goal of seeding is, and the importance of having a good understanding of revegetation goals for a project to guide revegetation actions. The importance of this becomes clear when considering an action that could be extremely harmful in the achievement of one goal while being the best course of action in the achievement of another. For example, there are certain occasions when successional stagnation is the goal, and in this case, hydro-seeding agronomic grasses may be the best course of action. However, this same action in an area where the goal of revegetation is a return of self-sustaining vegetation that has the same ecological function as its surroundings would be extremely counterproductive. The goal of a revegetation project is not always to return a site to its previous condition, and this is ok, as long as this is the clear goal and all parties, including those who will take over the land after reclamation, are in support of this.

In many cases, seeding is done strictly for cosmetic reasons. This can be both a waste of resources and harmful to an ecosystem. Areas which have seed sources within approximately 500 m will often revegetate naturally in a very short amount of time if the soil is prepared in a way that allows for the re-establishment of vegetation. This includes roughing the surface of soils to create microsites where moisture collects, promoting the recolonization with species being naturally dispersed. The addition of fertilizer to these surfaces can help support natural recolonization. There are times when seeding or planting of vegetation is necessary, but these need to be assessed and species choice should be carefully considered based on the ecosystem and its successional path (Polster,

2015). Participants brought up the need for the increase in knowledge regarding when seeding is actually necessary, and an increase in the demonstration of positive examples of sites that have successfully revegetated on their own. Non-native species have been introduced and the re-introduction of native species has been slowed by the seeding of inappropriate species in many areas that would likely have revegetated relatively quickly on their own if properly prepared. There are many species in the Yukon that are well adapted to dry climates, poor soil, and colonizing in disturbed areas. The dry climate reduces the risk of erosion to minimal levels, and the texturing of soils to create microsites assists this further.

The attitude towards revegetation is shifting in the territory and there are many well-informed revegetation specialists, but there is still a prevailing attitude that green is good and seeding is always necessary. This can only be changed by increasing the awareness of those revegetating sites, those monitoring sites, and the communities getting sites back after development. Not actively revegetating may not seem like the best course of action to a community who will eventually have a site returned to them, but if evidence can be provided supporting this then community support will follow. Changing climates also require us to look at things differently. It was brought to light that "the way it was" looked very different 10 years ago versus 100 years ago. Forest and shrub cover is increasing as temperatures rise, and this should be taken into consideration when determining revegetation goals. In summary, participants communicated that in some cases, revegetation practitioners need to be thinking differently and exploring ideas other than seeding, which sometimes means leaving an area bare. This requires an expanded knowledge base, communication of positive results, a clearly defined revegetation goal, and an understanding of why that goal is appropriate.

3.4.4 **Case Study: NAIT Plant and Seed Technologies Program**

The NAIT Plant and Seed Technologies Program is the first in Alberta which specifically focuses on understory seeds in the boreal forest. A large part of the program is dedicated to the study of the storage, viability, and propagation of native seeds for reclamation purposes, as well as the development of associated protocol material. It runs in conjunction with two other programs, the Forest Reclamation Program and the Peatland Restoration Program, and was developed with a combination of a grant from Alberta Innovates, an IE grant from NSERC, and CFI funding which was mainly used to build the lab and 2500 square foot greenhouse used to germinate seeds. This program began in 2008 and was born from an existing partnership between NAIT and the forestry industry. With the beginnings of a shift towards the use of native seed in the province came a push for coordinated seed research. A strong partnership between industry and the program still exists, and industry works very closely with the center while undertaking revegetation projects.

In 2010 and 2015, new regulations came into effect in Alberta, requiring the use of native seeds sourced from the correct seed zone for the revegetation of forested upland and peatland, respectively. A seed zone dictates an area within which seeds can be collected and distributed. The goal of this is to ensure seeds used in reclamation are as local as possible to preserve local genetics and maximize revegetation success. Before these regulations were put into place, a disturbed area was considered revegetated if it was green. This lead to heavy grass seeding that restricted growth

of native species in these areas. An industry initiative to use native seeds existed prior to these regulations, but their introduction pushed all companies developing in Alberta to use native species for reclamation. In addition to this, a company must reclaim a percentage of their existing sites before they can open a new project. These regulations were born out of industry initiative, consultants pushing for better practices, and a desire to improve the PR of the Alberta oil industry. The province is now very advanced in its revegetation regulations and practices.

The NAIT Plant and Seed Technologies program obtains its native seeds by sending out a team of harvesters to collect species (excluding conifers as these are readily available from forestry) for reclamation research. Before this can be done, a proposal for seed collection must be approved by the Alberta Government, including collection areas, species collected, and estimated amount to be collected. The program's native seed collection includes 50 species (80 including sedges). Tree and Shrub species are sent to the Alberta Tree Improvement and Seed Centre (ATISC) seed bunker for storage, while forbs and graminoids are stored at the program's center. All seeds to be stored are tested for germination and moisture content before long-term storage. The seeds are tested for viability every two years to help build a better understanding of the shelf life of native seeds. ATISC allows anyone collecting seeds on crown land in Alberta to store their seeds in the seed vault free of charge. There are regulations governing the storage of seeds at this bank, and these help create quality control measures for seed collection. Seeds must be registered upon banking, and a professional forester, agrologist, or biologist must certify that the information accompanying each seed lot is correct.

3.5 Economic development opportunities

A common topic of conversation was economic development opportunities associated with the development of native seed sourcing or nursery propagation initiatives, especially for the Yukon's First Nations Communities. Many of these communities are experiencing the largest effects from development projects in the Yukon, with these projects falling on traditional territory or settlement land. The outsourcing of both seeds and nursery propagated seedlings causes a large part of the economic gain from revegetation projects to leave the territory. This section explores how these gains could be channeled to the communities feeling the greatest effects of development in the Yukon, and how this can help them play a role in improving the process to reclaim these areas.

Several participants brought up that a native seed collection initiative may not be a good business venture for both economic and ethical reasons. If seed collection is turned into a business, revenue generation can overshadow ethical seed collection. Additionally, the collection of multiple small seed lots requires more effort than the collection of one large seed lot. This needs to be considered in the development of a native seed collection initiative. However, many participants also agreed that a seed collection initiative could be set up in a way that would provide community members with an opportunity to generate some income in a way that was land based and on their own schedule. This would generate small amounts of revenue for community members to collect seeds while not turning seed collection into a revenue generating business. Seed collection would be attractive to those who wish to work seasonally and on the land.

3.5.1 Community involvement

There are many projects in the Yukon that would benefit from the supply of locally collected seeds or seedlings, but the capacity does not currently exist to do this. Participants felt that communities and/or First Nations governments could be instrumental in the development of local native seed sourcing and propagation initiatives. Many communities are directly affected by industry in the Yukon and should be involved in initiatives that could provide economic gain, training opportunities, and an avenue to be involved in the responsible revegetation of disturbed sites. The capacity to source large projects could be achieved by beginning with a small community-based initiative that has the ability to source smaller projects and building up trained personnel and infrastructure required to source larger up and coming projects. The need for local plant material exists and if a well-promoted community-based initiative was developed to fill this need, seed and/or seedlings would be purchased by local consultants and industry.

Several participants felt that this type of initiative should involve multiple communities rather than an individual community. Industry is spread across the traditional territory of multiple First Nations in the Yukon, and all of these communities should be given the opportunity to be involved in and benefit from a seed collection or nursery initiative. The goal is to have seeds sourced as close to the site of revegetation as possible and if each interested community could work to provide seeds for mines in their area, this would make the challenge of collecting seed from all areas more feasible. Several participants felt that nursery initiatives could also be taken on by individual affected communities to source reclamation projects in their area, or have cooperative ventures between communities affected by the same development projects. Having affected communities take on this type of initiative could increase community economies and build capacity within these communities. There is also a great opportunity for a partnership between industry and communities to build an initiative that benefits both; providing plant material to industry and economic benefits to a community. There are many jobs associated with seed collection, banking, and nursery initiatives. If training programs were associated with these initiatives to provide communities with relevant skills, this could provide economic gain to individual community members. A seed collection initiative could provide community members wishing to work seasonally and on the land an opportunity to do this, while also providing industry with the tools to better revegetate disturbed sites on their traditional territory. Community involvement in a native plant material sourcing initiative would also provide an avenue for these communities to have an influence in species choice for banking and reclamation, including species of traditional importance. Opening a conversation with communities to discuss the potential benefits, both to a community and to the environment around them, as well as to determine their desired involvement and outcomes from a native plant material sourcing initiative would be a first step to developing a successful initiative.

3.5.2 Projection of revegetation needs

Many participants indicated that planning for revegetation needs to happen earlier in a project in order for the successful sourcing and use of locally collected native seeds, especially if these seeds will be propagated in a nursery. An early understanding of revegetation needs would also assist the development of a native seed sourcing initiative in the Yukon. This study has determined that there is a need for native seeds in the territory and the incentive to use them, but it was suggested that a more accurate prediction of the future revegetation needs in the territory be done. This would more clearly define the extent of the need for seeds in the Yukon and provide data to support the need voiced by revegetation practitioners. A prediction of the revegetation needs for the next 10 years could guide the development of a business plan for a seed sourcing initiative and create a timeline for the building of capacity for sourcing native plant material. It helps support an initiative that is needed for revegetation, research, and conservation purposes but may not be economically lucrative. Table 1 shows a rough prediction of several projects that may require seed in the future. This could be refined to develop a better understanding of the revegetation needs in the territory and help inform the development of a seed sourcing initiative in the Yukon.

3.6 Training and education

Many participants indicated that there is a great opportunity and value for including educational programming in the establishment of a local native seed sourcing or nursery initiative. There have been small scale training programs in place for native seed collection, but in order to support the revegetation need in the territory, this programming would need to be formalized and many more individuals would need to be trained. Educational programming would build capacity in the Yukon to successfully implement a local native seed sourcing initiative by training locals to collect and/or propagate native seeds. There are also opportunities to bring in training programs, for example, the Growing our Futures: Native Plant Horticulture program from Royal Roads University, which offers community-based training programs on a contractual basis. In addition to the potential for formalized training programs, participants suggested several other opportunities that a native seed sourcing initiative could provide to the Yukon. There is the potential to create a program where high school students interested in more hands on learning could participate in some seed collection or work in a nursery for a learning credit. This would build enthusiasm for restoration and create a connection to the land while providing learning opportunities. Another potential opportunity suggested was the creation of a co-op position at a seed bank or nursery, where university students interested in reclamation could complete a training program and then work as a seed collector or in a nursery. This would help build the number of trained individuals who have the skills to work in these positions.

Although there is no formal seed collection training in the Yukon, there have been several examples of successful seed collection workshops. These workshops focused not only on plant identification and the collection of seeds but the importance of restoration with locally collected native species. The programs lasted for varying amount of time, but those involved in these workshops felt that a training program could be relatively brief, lasting from a few days to a few weeks depending on the content. These workshops could be formalized into a seed collection training program where

interested participants could be trained and certified to collect seeds for a seed bank. The Yukon College has recently developed an Environmental Monitoring program with the intent to build the skills in communities which are required to work as environmental monitors in the natural resource industry or for First Nations, territorial or federal governments. This course is being delivered in one to two-week modules to accommodate the schedules of students as well as aligning the course with ongoing environmental monitoring projects. The majority of modules will be camp-based, with some classroom modules. The goal of this program is to align the course content with the needs of the potential employers. This style of delivery would be ideal for the inclusion of a module on seed collection.

3.6.1 **Case Study: Coffee Gold project**

Kaminak Gold Corporation, in collaboration with Yukon College and the Tr'ondek Hwech'in, established a research project to determine target species for restoration of mine sites in the north. Both scientific and traditional knowledge was used in the creation of a seed source map of significant species in the area. In conjunction with this, a 12 day Northern Terrestrial Restoration course was developed to build capacity within the local community. The course gave local First Nations students an opportunity to develop skills in restoration and learn about the challenges faced in a northern environment. This included experimental design, field sampling techniques, native seed collection, preparation and storage techniques, and the traditional uses of local native plants. This research program is an example of the successful combination of research, education, and community involvement to work towards identifying plant materials for restoration and build capacity within a community to have involvement in the Coffee Gold Site. For more information on this project see:
https://www.yukoncollege.yk.ca/research/project/developing_protocols_and_capacity_for_northern_restoration_with_local_nativ

Goldcorp took over the Coffee Gold site in early 2016 with the intent of developing an active mine. The current environmental monitoring team for this site were students in the Northern Terrestrial Restoration program who also received additional individual training. The monitors are given target species to both guide their seed collection efforts and ensure appropriate information is recorded during collection. These sheets are based on protocols in BC and Alberta. Currently, environmental monitors collect seeds on their down time. The ad-hoc nature of this seed collection means that it does not create much of an added cost. This means cost is not a barrier in this initiative, but the lack of somewhere to store seeds that have been collected is. There is concern that these seeds are not being properly stored, leading to a loss of viability and a wasted collection effort. The Coffee Gold Mine is not likely to start closure reclamation until 2030, by which time many of these seeds will likely have lost viability if they have not already. Projects like this call for a centralized storage facility in the Yukon, where native seeds collected for future revegetation projects can be properly processed and stored. This initiative has goals to formalize the training and collection process, which could be accomplished through the development of a seed collection and banking initiative for the Yukon.

3.6.2 Case Study: Growing our Futures: Native Plant Horticulture

Growing our Futures was established in response to the development of the Twin Sisters Native Plant Nursery (section 3.3.2.1). The successful establishment of a native plant nursery as a community venture required the addition of educational opportunities for involved communities. This program was developed in partnership with Royal Roads University, Keefer Environmental Services, West Moberly First Nation, and Saulteau First Nation and was piloted at the Twin Sisters and Tipi Mountain Native Plant Nurseries with significant success. Most of the current Twin Sisters staff went through the program, and the nursery is 100% First Nations owned and 80% First Nations staffed. It is now delivered on a contractual basis to Aboriginal communities who are interested in the collection of native seeds, propagation of native species, and native plant nursery management. The program is flexible and can be adapted to suit the needs and interests of the community. For example, it was recently delivered to a First Nation focusing on landscaping with native species.

Although not currently a credentialed program, participants receive a certificate of completion of the program. There is a movement to have a university credit associated with the program for those wishing to continue their education. Entry to the program is based on an application and interview process to determine interest and suitability for the program. The goal of the program is to be accessible to those with an interest and the acceptance policy is very open with no educational prerequisites. The program always strives to work with a local partner within a community to help make the program accessible to community members as well as provide support for the duration of the program. Recruitment for this program is done through different venues, including connections with community education or employment coordinators, community sessions speaking to what the course offers, developing connections with community members to assist in promotion, and promotional material in communities and on social media to raise awareness.

The complete program is 12 weeks long, but there are options for the delivery of shortened 2-3 week modules. This increases accessibility and allows communities to trial the program before committing to 12 weeks of training. This program focuses heavily not only on training for seed collection and nursery propagation of plants but also to build career readiness and find a personal niche for participants. The goal is to ready participants to successfully enter a career in the reclamation industry, whether that means working seasonally as a seed collector or working in a nursery propagating native species.

4 CONCLUSION

The lack of a commercial source of native seeds and seedlings is an issue in the Yukon, but the issue is more complicated than this. There are many projects in the Yukon where seeds have been collected and used for revegetation, but the lack of a seed storage or propagation facility make these more difficult and direct economic benefits to other jurisdictions. The need for research and demonstration of the use of native species in the Yukon needs to exist to support a native seed industry in the Yukon. This information needs to be shared between industry and consultants in order to build the existing knowledge base of native species use in the territory. The development of a native seed collection and sourcing initiative can support all of these things, but it must be approached carefully and developed in a way that involves affected communities and accesses the resources available in the Yukon. In short, the focus of a native seed initiative should be not only on the sourcing of native seeds to development projects, but on the potential educational, economic, and research opportunities that support the development of such an initiative. There are many opportunities for capacity building not only within communities in the Yukon but for the territory as a whole. From our interviews with practitioners, several opportunities were identified, including:

- The development of a local native seed collection initiative
- The development of a native seed bank run by government or a well-funded research program
- The development of a community nursery to bring economic benefits to communities affected by industry
- The development of on-site selection nurseries at mine sites to produce enough seed of relevant species for the revegetation of a site upon completion of development
- A review of historical revegetation projects in the Yukon to demonstrate the success or failure of different revegetation strategies
- The development of a Yukon-specific revegetation conference for consultants, researchers, and industry to increase communication of knowledge in the Territory
- The development of a database to facilitate the sharing of success stories, species choice, and other information to build the knowledge base of revegetation with native species in the Yukon
- The development of clear revegetation goals and the understanding of why these goals are chosen
- Increasing understanding of when seeding is required in revegetation projects and exploring alternative options
- Developing a connection with communities who have an interest in a seed collection, banking, or nursery propagation initiative
- The projection of future revegetation needs in the Yukon to support the development of a local native seed initiative

- The development of educational programming associated with a seed collection, seed banking or nursery initiative to build capacity in the Yukon and train future staff for these initiatives

These suggestions provide many opportunities for the future development of initiatives to source native plant materials, research initiatives to support the use of native species, and the educational opportunities to build capacity in the Yukon to support these initiatives. This report is intended to provide an overview of the state of revegetation and native seed sourcing in the Yukon, and to present future opportunities to support the use of native species in revegetation of disturbed areas. It is a summary of the knowledge and expertise shared by various experts across industry, consulting and research.

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