City of Calgary Seed Mixes

Recommendations and guidelines to inform revegetation work in Calgary

2018 Version 1.1

Publication Information

CITY OF CALGARY SEED MIXES: recommendations and guidelines for seed mixes, handling procedures, timing and methodologies for The City of Calgary to inform revegetation work.

INTENT: This document provides detailed information and recommendations to inform restoration plans as per the *Habitat Restoration Project Framework* (The City of Calgary Parks 2014) and provide necessary information and factors to consider during the design of the seed mix portion of the plan.

PREPARED BY: The City of Calgary, Parks, Urban Conservation

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http://www.calgary.ca/CSPS/Parks/Pages/Construction/Park-development-guidelines.aspx

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The *City of Calgary Seed Mixes* must be used in conjunction with the document *Habitat Restoration Project Framework* (The City of Calgary Parks 2014), as referenced throughout the framework, and is made available for use in The City of Calgary effective as of the date below.

January 15, 2018

The 2018 *City of Calgary Seed Mixes* is presented as accurate and complete as of the date indicated above. Use of this document does not absolve any user from the obligation to exercise their professional judgment and to follow good practice. Nothing in this document is meant to relieve the user from complying with municipal, provincial and federal legislation. Should any user have questions as to the intent of any procedure found in this publication, the user is advised to seek clarification from the lead of Urban Conservation, Parks.

Revision Notice

Revision number	Edits
2018 1.1	Edits to title page and Publication Information to reflect version 2018 1.1
	Includes corrected addition for % by weight in Appendix 1: Fresh Water Riparian Seed Mix at or Above 1:5 Flood Water Surface Elevation; subsequent minor repagination

Subsequent revisions will be released as required.

Cover photograph and Table of Contents photograph taken by The City of Calgary.

Executive Summary

This document provides guidance on seed mixes and methodologies used when revegetating natural environment parks, challenging landscapes (e.g., saline boulevards) and other areas where mowing is generally not part of the maintenance regime. It outlines various things to consider when designing a seed mix for an urban area such as appropriate timing, short term seed storage solutions, site preparation, seed handling and the importance of clean seed, seeding methodologies and seeding rates. The usage of various cover crops is also discussed. In addition, using seed in erosion control applications and how to procure quality seed is outlined. Example seed mixes that have shown to be successful in the Calgary area are provided; however, positive results when using these seed mixes are not guaranteed due to the complex nature of site-specific factors and the unpredictability of managing biological systems. Although these concepts are appropriate for the Calgary climate, *City of Calgary Seed Mixes* focuses on the urban environment and the associated land use pressures that are associated with municipalities.

This document is meant to inform restoration plans as per the *Habitat Restoration Project Framework* (The City of Calgary Parks 2014) and provide necessary information and factors to consider during the design of the seed mix portion of the restoration plan. The goal of *City of Calgary Seed Mixes* is to provide information to increase the effectiveness of this type of restoration work to save maintenance and labour costs, both in the short term and in the long term. This information is intended to decrease costs associated with granting CCC and FAC approval and internal operational costs. This document is located at: http://www.calgary.ca/CSPS/Parks/Documents/Construction/habitat-restoration-framework.pdf?noredirect=1

An area in South Glenmore Park previously colonized by the invasive shrub Caragana restored back to native grassland within two years (Photograph date August 10, 2016). Photograph is taken looking down at the vegetation.

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Section I: Rationale for City of Calgary Seed Mixes

Introduction

In March 2015, Council approved Calgary's 10-year strategic plan titled *Our BiodiverCity* (The City of Calgary Parks 2014) and the Biodiversity Policy. Within the strategic plan, restoration, the process of assisting recovery and management of ecological integrity (Alberta Environment 2002), is cited as a way to improve the city of Calgary's ecological functions.

The Habitat Restoration Project Framework (City of Calgary 2014) provides detailed requirements and guidelines for conducting and reporting on habitat restoration projects in existing and future Natural Environment Parks. This Framework is considered an addendum to that document and intended to be used for projects outside of and in Natural Environment Parks. This *City of Calgary Seed Mixes* informs the seed mix portion in a restoration report: it contains seed mixes that have proven successful within Calgary and thus can assist executing restoration needs.

Purpose

The majority of restoration sites are in natural environment parks. Native restoration is difficult in an urban environment. Effective methods in rural areas do not translate into a city setting due to the additional pressures that cities put on landscapes such as high usage, land fragmentation and invasive species.

Native (e.g., indigenous to the area) seed does not perform the same way as agronomic species do. Unfortunately, there is a knowledge gap when dealing with native species and many common mistakes can make a seeding project fail. As such, seeding timing, methodologies and rates are discussed in this document. Also, the usage of covers crops is examined in multiple habitat types. Another step in the process that is often overlooked is the procurement of clean seed. This is often a limiting factor in restoration work as the actual purchase of the seed tends to be a last consideration. Information on sourcing native species is provided.

Due to the characteristics, physiology and biology of native seed and the usage pressures within an urban environment, many restorations do not perform very well which increases consulting costs, staff time and maintenance, both in a short term and long term context. This document is meant to provide information to internal and external stakeholders in order to decrease costs and staff time spent on developing, implementing and maintaining various landscapes.

Finally, in some cases, restoration using native species is not possible or desired and as such, this document also discusses situations where the use of non-native species for a

landscape type is preferred. This application differs substantially from seeding turf mixes. In these cases, turf mixes are generally designed to be mowed on a regular basis and form a thick shallow-rooted sod layer that is commonly utilized for lawns and playfields. In this document, non-native species are used in a naturalization setting or used to revegetate a challenging landscape.

Document outline

A brief outline of the various sections in this document is provided below.

Section I discusses the need for this type of information to be amalgamated into a document accessible for all persons involved in seeding work with The City of Calgary. Many common mistakes can make a project fail. A large knowledge gap exists across all industries regarding the use of native plants in seed mixes, how to design a seed mix and how seed mixes perform, especially in an urban environment. Section I addresses the higher level information gaps common in the industry and some of the challenges associated with the built environment.

Section II discusses information that should be collected prior to designing a seed mix, various considerations to make when creating a seed mix and various factors to increase the success of the seed mix. For example, site preparation and the various biology of common Calgary grasses are discussed.

Section III goes into detail regarding the actual mechanics and methods of seeding. Various techniques of ensuring that the seed stays in place after seeding are discussed along with the usage of cover crops.

Section IV outlines what to look for when procuring seed. Multiple situations regarding which form the seed is available in are contrasted and compared so that the best product for the application is used.

Section V concludes the document and reiterates the document's purpose.

Section VI contains references used to support experience and the information provided.

Section VII contains Appendix 1 which is a very large part of the *City of Calgary Seed Mixes* document. Appendix 1 identifies various habitat types found in the city of Calgary and many of the common project scenarios and desired outcomes encountered in the seeding component of restoration work. These seed mixes have been taken from restoration projects within Calgary that have shown to be effective when the other recommendations and considerations have been incorporated into the seeding plan (e.g., timing for native species seeding, site preparation, seeding method, etc.). The habitat types that are cited in Appendix 1 go into more depth than The City of Calgary's GIS habitat layers to account for differences in light penetration of the area, surrounding land use and habitat types, soil moisture and what pressures exist on the project area, among other things.

Who should use this plan

This framework is meant to guide environmental consultants in their design of restoration plans on City property. It is also meant to inform and assist project managers, land managers and environmental professionals, both internally and externally in day-to-day seeding work within Calgary.

Disclaimer

City of Calgary Seed Mixes does not replace restoration expertise, experience or professional qualifications. Nothing in this document is meant to relieve the user from complying with provincial and federal legislation. This document provides example seed mixes and information regarding rates, methodologies, cover crops and seed storage obtained during the undertaking of restoration work within the urban environment of the Calgary area. It does not replace a site-specific approach to restoration, which is critical in achieving successful projects. The use of *City of Calgary Seed Mixes* does not guarantee results due to the complex nature of restoration and the difficulty associated with managing biological systems.

Using an example seed mix listed in this document does not equal obtaining required approvals from City of Calgary staff, as per the review processes indicated in *Development Guidelines and Standard Specifications: Landscape Construction* (The City of Calgary Parks current edition); these guidelines indicate mixes that are not outlined through the indication of species and percent by weight in the *Development Guidelines.* Lastly, the use of this document does not absolve the proponent of the approval processes required in other Departments and Business Units or other stakeholder engagement with key personnel.

Should any user have questions as to the intent of any procedure found in this framework, the user is advised to seek clarification from the lead of Urban Conservation, Parks.

Restoration in the City of Calgary

The City of Calgary is continuously striving to mitigate the effects of development, disturbance and fragmentation of its sensitive ecosystems. Calgary is unique in the sense that it is located at a transition zone which encompasses the boundaries of the Foothills Parkland, Foothills Fescue and Central Parkland Natural Subregions. In addition, Calgary experiences Chinooks which adds to the complexity of the ecosystems in this area.

Urban Versus Rural Restoration

Restoration is much different in urban areas versus rural areas. Fragmentation and lack of connectivity, smaller sized parks, surrounding land use, usage pressure, constant sources of invasive species introduction (e.g., adjacent roads, dogs, bikes, etc.) make the re-establishment of native species and often revegetation in general very difficult. In addition, the lack of top predators that are more numerous in rural areas cause issues with seed and

vegetation predation by smaller herbivores/omnivores such as Richardson ground squirrels, Canada geese, domestic “wild” rabbits and white-tailed jack-rabbits. Also, deer can problematic in vegetation establishment in more remote urban areas.

Due to non-native landscapes such as playfields and lawns, the goal of restoring an entirely native landscape may not be possible. Also, usage pressure and land use may require the use of non-native species to build soil in areas which are compacted and lack topsoil such as undesignated trails. Without the use of a fast-establishing seed mix, the site may only serve as habitat to invasive species. The colonizing weeds may require control under the *Alberta Weed Control Act* (2010) if they are listed in the legislation or the invasive species may not be listed in the legislation and in which case, control is optional and at the discretion of the land owner.

Time Limitations

Due to the development process and urban environment as a whole, the disturbance of adjacent lands along with construction activity in all or part of lands that are designated to stay in a natural state (e.g., Environmental Reserve), restoration becomes even more complicated. In order to develop communities, various timelines exist which do not generally go longer than 5 years from construction start to construction completion. Many projects have even shorter timelines. Due to this, restoration back to a native reference plant community (The City of Calgary Parks 2014) can be virtually impossible without much longer periods of ongoing maintenance than The City has the ability to require or provide after the community is built.

Infrastructure Protection

Finally, infrastructure protection, which is directly related to public safety, will prioritize a repair over a native restoration. For example, in the event of other erosion and sediment controls failing, quick establishing species may be required for immediate erosion control and slope stability along a road. Although the vegetation community will end up being significantly different than in the past, the safety of the users changes the restoration goal.

Areas that remain free of vegetation for the course of over one year may experience significant soil loss if no other erosion and sediment control measures are in place. This is due to the changing seasons which can significantly compromise infrastructure due to soil loss. For example, erosion during Chinook winds in winter, heavy spring rains and runoff during spring ground thaw may lead to undercutting of trails and other access routes that are commonly used by citizens. In this case, revegetation would take precedence over ecosystem health.

Public Perception

A lot of past restoration work both in urban development and private industry focused on establishing strata layers of graminoids (e.g., grass-like plants which include grasses, sedges and rushes) and woody vegetation. Ensuring that a seed mix contains early

successional grass species is crucial in order to achieve weed control; however, long grass in an urban environment can appear unkempt to the public. Using a mix containing wildflowers native to the Calgary area can both increase biodiversity while ensuring pleasant aesthetics for citizens. For example, early successional grass species and aggressive native wildflowers such as blue flax (*Linum lewisii*) can ensure both an ecological and public perception win.

A point worth noting is although vegetation cover can be achieved early on in some cases, many restorations take a long time to reach their full potential. Even after they begin to resemble reference vegetation communities, areas that have a high threat of weed invasion (e.g., small size, large "edges," locations along transportation rights-of-way, fragmented landscapes, areas adjacent to other areas that provide sources of weed seeds, etc.) will still require maintenance from an ecological, regulatory and aesthetics standpoint. This can be achieved in many ways through various means of weed control and reintroduction of wildflower species.

Seed Calculators

Benefits and Limitations

Environmental professionals are increasingly using seed mix calculators to ensure that the site, seed and seed lot specific factors are accounted for on a site-by-site basis. Seed mix calculators are very beneficial as they have many capabilities built into the calculator that can decrease common errors which are often present in seed mixes. Ideally, especially when working in a complex environment such as a large urban area, the most effective calculators will contain modifiers or allow the user to input modifiers to account for erosion concerns, the threat of weed colonization both from adjacent lands and the existing seed bank (e.g., the existing seeds present in the soil that can become viable once appropriate conditions arise), how aggressive the plant species is/successional growth order and seed lot variations such as percent live seed. Even without modifiers, the mathematics required to calculate percentage by weight of seed within the seed mix is very advantageous as large seeds are often underrepresented while smaller seeds are often overrepresented. The seed mix calculator ensures that seed size and weight are factored into the mix composition.

Tannas Conservation Services Ltd. (2016) outlines the importance of using these calculators to account for the many factors that need to be considered in making a seed mix. For example, the calculator will allow one to input desired species percent cover and using the percent live seed, modifiers based on grazing response/aggressiveness/ successional order/seeding method, seed weight and pure live seed, it will calculate the weight of seed required and percentage of species by weight in the mix. In addition, depending on the erosion potential and weed invasion threat of the site, the calculator will provide seeding rates. This allows for cost savings as the appropriate amount of seed is used. Seeding at too high of a rate may not allow for the later successional species, such

as various native fescue species, to germinate as they have already been outcompeted by a very high number of early successional aggressive species. In addition, as native seed is more difficult to produce than various non-native and native cultivars, using more seed than what is necessary will increase project cost while decreasing restoration success.

Although seed calculators have many benefits, they do not replace the professional expertise of a restoration specialist. Since seed mixes should be designed on a site specific basis and because each project has its own challenges and constraints, one should not be reliant on a blanket approach or the use of a calculator alone. A seed mix calculator should be thought of as a form of quality control and assurance and not a device designed to make seed mixes.

In any type of restoration design, including seed mix design, it is important to know what plants commonly grow where, what their general characteristics are and what their biology is like. It takes many years to achieve this level of knowledge and even with the calculator and associated reference material, if the details of the adjacent communities and species biology are unknown, the chance of a successful restoration is low. For example, the incorporation of reference vegetation community species and various species that fit the habitat type in a seed mix will likely not be successful unless the environmental professional has knowledge of what grows in the area, where these plants grow, what generally grows together and how species respond to various conditions.

Seed mix calculators often do not have the option to add forbs for increased biodiversity, aesthetic appeal and soil conditioning. For example, adding a legume to a seed mix generally seems to increase the success of the seed mix due to the nitrogen fixation capabilities and the associated soil conditioning that occurs. These species can be added into the calculator design. If common forb species are used in seed mixes for a certain area, they should be initially put into the seed mix calculator.

Seed mix calculators often do not take into account the difficulty that large seeds have penetrating existing plant litter and thatch to gain seed to soil contact. This is why it may be important in some circumstances to artificially increase the percentage by weight of large seed, especially in areas that have a lot of plant litter. Again, this is site specific but needs to be considered in the seed mix design.

The use of coated seed also affects seed mix calculations as coating affects seed weight. Seed lot information is determined prior to coating. Also, seed will not be coated completely uniformly and will vary with individual seed characteristics and as such, it is almost impossible to account for the coating weight and how it changes the seed characteristics in the seed calculator. Generally, coating seed is not recommended for native seed as native seed relies so much on fluctuating conditions such as cycles of cold and hot temperatures and varying precipitation for germination. The coating reduces the sensitivity to this and due to this, germination and percent live seed numbers are again not accurate.

Seed weight will also change regarding whether the seed has been processed (e.g., cleaned) or not. Ideally, seed should be cleaned but very few vendors have the equipment and expertise required to clean seed, especially native seed. This results in the requirement to purchase seed that has not been cleaned. It needs to be noted that clean seed and unprocessed seed will differ in weight and as such, this needs to be accounted for in seed mix calculations (Majerus *et al.* 2013).

Also, as aforementioned, large seeds have more difficulty penetrating thatch and leaf litter so the percentage of large seed often needs to be increased from what the seed calculator indicates. On the contrary, using a seed calculator to calculate seed number per unit area for very small seeds likely artificially decreases the amount of seed required. This is because large seeds tend to have a higher survival rate due to their significant carbohydrate reserves (Majerus *et al*. 2013). In opposition, many smaller-sized seeds often die before they are able to germinate (Majerus *et al*. 2013). This is due to the fact that they have small carbohydrate reserves and often tend to get planted too deep where they cannot adequately take advantage of moisture and sunshine. Again, knowledge of various plant characteristics and physiology is important. In addition, sometimes certain species are very difficult to germinate and triggers for germination are generally unknown such as in the case of rough fescue (*Festuca campestris*). The seed calculator will increase the amount of those species based on that information but if the factors that contribute to germination are unknown, then the calculator can only artificially up the percentage based on those species-specific challenges. If the intent of the restoration is not to restore a site back to a reference community or the landscape likely will not allow it, it might be best to leave those species out and focus on species that are more apt to colonize the site. If the project goal is restoration to a reference vegetation community, then those species should be present in the seed mix; however, if there is a high likelihood is that this type of restoration will fail on that specific site or the intent is only about revegetation, then it may be best to not include those costly species. Seed producers can provide intimate knowledge regarding germination success. For example, propagation of hairy wild rye (*Elymus innovatus*) and Parry's oat grass (*Danthonia parryi*) has failed numerous times for no apparent reason and as such, wild collection with proper permitting and approvals outside of City limits is relied upon for sources. As these plants are usually not dominant on sites when present and combined with the germination issues, careful consideration of the usage of these challenging species is crucial.

Informing Vegetation Community Composition

Species assemblages and desired percent canopy covers can be determined from a range health inventory of an adjacent healthy reference vegetation community (Tannas Conservation Services Ltd. 2016). In the event that an adjacent healthy reference community is not available, which is common in urban centres, Grassland Vegetation Inventory (GVI), range health assessments of the site itself or assessments of adjacent areas, combined with Plant Community Guides, can provide tools to inform the input of species and canopy cover. A lot of this data could potentially be collected during the

Biophysical Impact Assessment, if one is required (The City of Calgary Parks 2010). This is discussed in more depth in the following section of this document.

In challenging landscapes which are becoming more frequent due to development, fragmentation and invasive plant colonization, the importance of restoration, taxonomy and natural history knowledge is crucial. For example, it would be inappropriate to base the restoration of a challenging landscape on the species present in a late successional plant community only. This is because those species are generally outcompeted in many environments, such as urban environments, and the earlier succession species that would have led to the formation of the plant community are not present in the later successional stage. These late successional species can be included to add the seed to the seed bank but with constant anthropogenic disturbances, it is unlikely that this landscape will be transformed into a climax community such as a mountain rough fescue (*Festuca campestris*) grassland.

Section II: Initial Considerations

Biophysical Impact Assessments and Restoration Plans

In the initial stages of project planning prior to breaking ground, an environmental review is required in any areas that may disturb native habitat and/or rare species/species-at-risk, are in potentially sensitive areas (e.g., waterbodies, wetlands, Natural Environment Parks, etc.), are in or adjacent to Environmentally Significant Areas or that are large projects that will cause changes in land use. The *Biophysical Impact Assessment Framework* (The City of Calgary Parks 2010) provides a consistent process of review and approval and guides environmental consultants to what level of scrutiny is needed based on environmental triggers that correspond to three reporting levels. Generally, the level of environmental review becomes more in depth as the complexity and size of the project increases.

As discussed in the Seed Calculators section, range/riparian health assessments, Grassland Vegetation Inventory and plant community guides can inform seed mix design, as they provide information on preferred vegetation as related to ecosystem health, vegetation community responses to disturbance and plant community composition related to successional stage. Regardless, in an urban environment, reference vegetation communities are difficult to find. Also, restoration to a reference vegetation community may be unrealistic depending on the site conditions. This is where a botanical inventory of the site as part of the Biophysical Impact Assessment can provide information that can be utilized in seed mix design. This assessment is especially important when soils are to be reused on site as the conservation of the seed bank will ultimately influence the final vegetation community. The environmental review is also important in identifying what site

pressures are present that will influence the establishment of the vegetation. The Biophysical Impact Assessment essentially informs the *Habitat Restoration Project Framework* (The City of Calgary Parks 2014). *City of Calgary Seed Mixes* aids in implementing the seed mix design portion and supports the development of the restoration plan as indicated by The City of Calgary Parks (2014).

Height

Something that is rarely mentioned in seed mix design is ensuring that plants are compatible with each other. This factor is included when replicating an adjacent reference vegetation community but as previously mentioned, especially in urban environments, this is often not possible. When designing a seed mix, one should strive to have structural variability which contributes to a healthy plant community. Regardless, during the seed mix design one should be careful not to over-represent tall species and under-represent smaller species.

Maintaining structural variability in the seed mix while not over-representing tall species is very important. Many aggressive grass species are taller in stature. If these tall species are seeded with numerous seeds occurring per unit area, they could potentially shade out the shorter species before they have a chance to mature. This consideration is crucial when using mixes that contain tall cool season grasses (e.g., grow in cooler temperatures) and shorter warm season grasses (e.g., grow in warmer temperatures) as the tall cool season species will have a significant aggressive advantage over the shorter warm season species.

Cool Season versus Warm Season

It is important to know whether a species is a cool season or warm season species. This is essentially when the species begins to grow. Many cool season grasses tend to be aggressive and early successional as they begin to grow early in spring. Warm season grasses do not start growing until temperatures increase in the summer. Taking these differences, along with height, into consideration is important when designing a seed mix, as this will strongly affect the outcome of the plant community. This can also save money in project costs as many warm season species are often seeded but never actually come up as they are outcompeted before they even get a chance to germinate.

Increasers versus Decreasers

These terms are most commonly used in grazing management although they can apply to plants in an urban context. Plants termed “increasers” tend to be less palatable to wildlife and do not experience grazing or browsing pressure unless there is a limited supply of more palatable species present for wildlife in the area. Increasers tend to exhibit characteristics that prevent grazing and browsing such as awns (e.g., long spike-like appendages) or thorns. These species also tend to increase under a lack of natural disturbance regimes such as flooding and wild fires and also increase with anthropogenic

disturbance. Increasers tend to be more early successional and not as deep rooted as decreasers.

Species termed “decreasers” are quite palatable to wildlife and are their preferred food so they tend to get grazed and browsed extensively. These species also tend to fill a niche in the ecosystem’s food web by providing food at times that other food is unavailable. For example, many agronomic forage species were introduced into the region as they provide early spring forage; however, their forage value decreases dramatically after early spring (e.g., crested wheatgrass [*Agropyron cristatum*]). Decreasers usually provide food to wildlife during critical times such as in winter. For example, rough fescue (*Festuca campestris*) holds its protein content in winter whereas other forages provide very little nutrients in winter (Pavlick & Looman 1984). Unfortunately, as in the case of rough fescue, decreaser populations often decline when the environment lacks its natural disturbance regimes and under increased anthropogenic disturbance; therefore, if the site will likely support these decreaser species, it is important to include them in the seed mix.

Storage

Considerations

This document is not meant to guide the production of seed from harvest to sale, including optimal harvest conditions, determining seed maturity, seed drying, etc. Long-term seed storage is not discussed in depth here, as most landscaping contractors are buying their seed the same year they plan on seeding or at a maximum, one growing season prior to seeding. Although freezing seed for long-term storage is encouraged, this will not be outlined in depth as most contractors do not have the facilities capable for freezing large amounts of seed at a consistent temperature with low humidity. Instead, this section discusses the type of seed storage that is most commonly encountered by restoration work personnel which is short-term storage. Ideally, the vendor should hold the seed until it is required to ensure it is stored properly, as any company in the seed selling industry should be outfitted with optimal seed storage infrastructure.

As with every living species, characteristics vary between species and among species. Seed viability (e.g., alive and capable of germination) versus storage time is no exception as different species will exhibit different limitations in the length of how long they can be stored before seed essentially becomes dead. While working with seed, it is crucial to remember that seeds are in fact living organisms that use their stored energy to remain alive until external conditions trigger germination.

Generally, seed that is intended for and grown in terrestrial environments will remain viable when it is harvested under dry conditions and kept dry. Seed should be dry when it is purchased; however, if it is stored in an area with high humidity such as a basement, viability will tend to decrease due to the ability of seeds to pick up moisture from the air. Increasing seed moisture contributes to seed death by increasing metabolic activities and

respiration, heating and weakening the seed and making the seed susceptible to fungal infection (Elias *et al.* 2017). Fortunately, Calgary has a fairly dry climate with low humidity. In areas where the outside conditions are cool and dry, viability of seed is maintained through storing in packaging that allows for air exchange. This prevents the seed from molding and prevents respiration from occurring. In areas with high humidity, sealed containers that prevent the influence of outside air on the seed are encouraged; however, in the Calgary area, storing in a cool, dry environment within a breathable packaging such as a woven bag or paper bag is ideal. A storage container that does not have high air humidity and is temperature-regulated is ideal for storing breathable bags of seed. High humidity in the Calgary area will generally only occur in basements as or in areas next to waterbodies. The ideal conditions for seed storage consider both moisture and temperature as the temperature in degrees Fahrenheit plus the humidity should be less than 100.

Another storage issue is consumption of seed by wildlife. This can be a problem, especially in the winter months, when other food is unavailable and a large cache of seed is irresistible. Mice are very good at squeezing into the tightest areas so it is important for the storage location to be very secure without any openings such as small cracks under the doors, etc. Mice easily chew through seed bags but mice predation can be minimized by secondary containment such as storing seed bags in sealable containers. Once mice get into stored seed, they can eat a substantial amount and the seed becomes contaminated with mouse droppings. For additional information, see: **https://www.seedquest.com/id/r/rogers/pdf/seedstorage.pdf**.

Recommended Longevity Guidelines

As mentioned, seed longevity varies substantially between species and seed lots; however, environmental professionals who are in the business of storing seed are able to provide some very general rules (Table 1). In Alberta, the majority of native forbs (e.g., herbaceous wildflowers), shrubs and wetland plants have a hard seed coat. This means that gas exchange and the absorption of moisture is prevented by the intact seed coat. In addition, the embryo is also prevented from growing through the mechanical barrier of the seed coat. This is why native seed requires conditions that break the seed coat such as extreme temperature and moisture fluctuations and stratification.

Table 1 Seed viability guidelines for storage

Common Name	Botanical Name	Viability Estimate	Notes
grass	Gramineae Family	-Up to 10 years -May experience significant loss of germination ability between years 5 to 10	-Germination results should be less than 2 years old to ensure accurate reflection of viability
sedge	Cyperaceae Family *Carex spp., Kobresia spp., Cyperus spp., Eleocharis spp.,*	-Variable but similar longevity to grasses	-Some botanical names have been changed due to increased phylogeny information related to genetic analysis

	Rhynchospora spp., Scirpus spp., Eriophorum spp. The majority of sedges are *Carex spp*.		-Older names cited as most seed suppliers do not use the most recent names as they have changed drastically in the last few years due to genome sequencing
rush	Juncaceae Familiy *Juncus spp., Luzula spp.* The majority of rushes are *Juncus spp.*	-Variable but similar to grasses	
legume	Leguminosae (Pea) Family -many genera and species	-Variable -Percentage of dormant seed decreases with time -Often the amount of dormant seed decreases from years 1 to 5 with non-dormant seed being highest in seed that is over 5 years old	-Germination often peaks after 5 years due to the disintegration of the hard seed coat and the decrease in dormant seed
oil seed (e.g., a crop grown for the oil contained in the seeds) such as cultivated sunflowers, canola, flax and soybeans	*Helianthus spp.* (cultivar developed for seed oil) *Brassica spp.* (cultivar) *Linum spp*. (usually *Linum usitatissimum*) (United States Department of Agriculture-Natural Resources Conservation Service 2017)	-viability similar to legumes	-likely not going to be utilized in restoration as these are crop species
shrubs	Various families, genera and species Shrubs are woody, smaller than trees and are often branched at the base	-viability similar to legumes	-often do not use shrub seed in restorations as potted material is readily available through cuttings while shrub seed collection is very time consuming
forb	Various families, genera and species	-similar to legume except in aster (daisy-like) family	-most native forbs have a hard seed coat which prevents gas exchange and absorption of water
-Any “daisy-like” flower -Flower-heads are composed of many single flowers of 2 different types which may look	Compositae (Aster) Family Many genera and species	-generally less viability than other species -many species not viable for more than 5 years	-due to the drop in viability after 5 years, it is important to use this seed right after purchase -if purchased from a vendor, germination results should be recent

like a single flower (daisy) or of many single flowers of the same kind on one head such as in the case of a dandelion -Seeds are usually crowned with a pappus which means they are “fluffy” or have scales			
submergent and emergent wetland plants (e.g., plants that are adapted to have their roots in standing open water all year long)	Various families, genera and species	-similar to most native forbs with hard seed coats -storage requirements much different and outlined in notes	-generally cannot have seed dry out -conditions need to mimic nature -seed should either be stored in water or in ice, depending on species

Site Preparation

Note, topsoil preparation only is covered in brief here, as detailed information on soils handling and soil condition is covered in the *Soil Handling Guidelines* (The City of Calgary forthcoming).

When seeding any type of species, seed to soil contact is very important. A common mistake that is often made in restoration is seeding directly into the dead plant material such as leaf litter, thatch or wood chips/mulch. Some very aggressive species may be able to colonize areas with heavy leaf litter or mulch but in general, germination will always be better when seed is in contact with soil. Areas with rocky subsoils are also challenging to seed as these areas favour species with shallow roots. These species are often weedy and, as such, rocks and debris that prevents seed to soil contact should be removed prior to seeding, if feasible.

Weed control, both through chemical and/or mechanical means, prior to seeding is always beneficial in promoting the establishment of the seed mix. After chemical weed control has been performed, seeding should occur shortly after but not directly after in order to allow the herbicide to take effect and to mitigate any temporary changes in the soil. These soil changes depend on the active ingredients in the herbicide and as such, the information on the product labels should be used to guide the decision on when to seed after application. Although product labels are informative, seed producers have experienced some negative effects on seed germination within approximately one week of application, even when the label has advised otherwise. As previously mentioned, revegetation is optimized when seed to soil contact occurs and as such, weeds that have been treated, pulled or cut should be removed from the site to reduce thatch.

In order for a seed mix to establish successfully, one has to be aware of the species of seed the soil contains (e.g., seed bank). Often the seed bank can be anticipated through the results of the Biophysical Impact Assessment or at the very least, a site visit prior to performing the work. Multiple years of weed treatment may increase the chances of restoration success as the weedy species in the seed bank may get depleted with multiple control efforts. In some cases, multiple control efforts may not be effective if the area is next to a source of constant weed introduction (e.g., highway, railway, etc.).

Lastly, prior to seeding, regardless of the method, the upper surface of the topsoil should be firm, not overly compacted and stable enough so that soil loss will not occur during wind and precipitation. For example, one should be able to make a footprint in the soil but not sink. Also, a slightly uneven/roughened surface is also beneficial. This keeps the seed in place much better so that seed loss through various causes of erosion is minimized. In addition, the surface variations create microclimates that work to promote germination. For example, the roughening of the topsoil surface creates very small dips which collect water and aid in increasing germination.

Section III: Methods

Timing

Timing is crucial when seeding species that are native to Alberta and the Calgary area. As mentioned in Section II: Storage Guidelines, the seed of most indigenous species has a hard seed coat and as such, will not germinate until that seed coat is broken.

Generally, contractors and environmental professionals working for The City of Calgary are not going to pre-treat their seed to induce germination. Treating seed to trigger germination is very species-specific and requires a lot of time, storage space and plant physiology knowledge. Also, seed treatment can involve anything from scarification (e.g., scratching the seed coat) to the application of chemicals/plant hormones or smoke. Due to the constraints regarding seed treatment to induce germination, recommended seeding times are used instead. The timing ensures that the environmental conditions of the Calgary area breaks the seed coat and induces germination.

Native seed generally requires drastic fluctuations in temperature and moisture to induce germination. In addition, some type of scarification (e.g., roughening/scratching the seed coat) is usually required. This may occur during the cleaning process or in the field. Ideal seeding time maximizes these fluctuations and as such, early spring after ground thaw and late fall prior to ground freeze are the best times to seed to optimize germination rate and establishment.

When seeding is done during the mid-summer months, there is a chance that germination will occur but the root will not be developed enough to withstand dry, warm conditions. This

leads to die-off and as such, often causes project failure when vegetation cover is absent allowing weed species to colonize the site.

The timing of the seeding activity alone can make a project a success or failure, even if everything else is done correctly. Seeding times of native seed are discussed in Table 2. It also should be noted that many forb species do not bloom until the second growing season even if they germinate successfully.

Table 2 Seeding time frame information assuming no maintenance activities*

Seed Type	Time Frame	Preferred Seeding Time	Notes
Native	After ground thaw (April))	Yes	Ideal for late spring germination and establishment prior to fall.
	May	Yes	The earlier in May, the better the chance of establishment during the same growing season.
	June	Not ideal but may provide coverage	Germination may occur but there is a likely chance of die off during the summer months; Early June is preferred over late June.
	July to mid-August	Risky	If any precipitation occurs during these months, germination is likely. Hot weather post precipitation is anticipated and die off of seedlings will be large. Vegetation cover will likely not establish.
	mid-August through September	Not recommended	High likelihood that warm dry fall days will cause die off prior to enough root establishment; Fall precipitation and hot days are very poor conditions to ensure seedling survival; Very weather dependent.
	October to ground freeze	Yes	Very high chance that seed will stay dormant and germinate the following spring; Seeding can occur into winter if ground is still thawed; A very light snow cover may be beneficial in holding seed in place.

*All seeding methods assume watering is not implemented; during years of severe drought watering the site before seeding and misting after can be done to mimic natural precipitation and aid in vegetation establishment.

Clean Seed Importance

There are few vendors that have the capability to clean native seed, especially seed that has awns (e.g., bristles) or a pappus (e.g., fluffy appendage or thorny appendage at the seed crown). Unfortunately, readily available commercial equipment does not cater to the native plant market but instead, is aimed towards agriculture. Luckily, some vendors have been able to modify existing equipment and build new equipment to perform this task. In addition, several vendors are also very adept at cleaning seed by using various screen sizes and screening techniques.

Seed that is cleaned prior to seeding has many advantages. An important reason to clean native seed is to ensure that weed seeds are sorted out of the seed lot. Even common crop species can become problematic in a restoration scenario when they are seeded along with the desired seed mix. This is why it is important to thoroughly examine the Seed Certificates of Analysis prior to seeding as indicated in the *Development Guidelines and Standard Specifications: Landscape Construction* (The City of Calgary Parks current edition).

Besides reducing the weed issues, cleaning seed also reduces the miscellaneous organic material in the seed lot. For example, the presence of stems, soil particles and leaves are reduced by cleaning. This is beneficial in seeding so that seed to soil contact is maximized. Also, seed is sold by weight. Eliminating inert organic material allows for additional product purity and may reduce project costs by providing a more pure product per unit weight.

Clean seed makes seeding more efficient since the awns and pappus are mostly removed. Often the purpose of these structures is to promote dispersal and when these structures are left on the seed, the seed tends to fly away from the intended site either before or after it comes into contact with the ground.

Seed cleaning also allows for easier seed handling. For example, during hand broadcast seeding, seed tends to stay put in place more when the awns and pappus are removed. Seed that is not cleaned tends to be problematic during drill seeding, as it does not come out of the machine evenly and may cause the machine to clog. The same principal applies to hydroseeding, as clean seed will be distributed more evenly within the slurry and not cause the machine to malfunction.

Lastly, seed that has been cleaned has been agitated in some fashion to remove the organics and seed appendages. This triggers germination as indicated in the previous section on Timing. Since the seed coat has been slightly compromised, the seed will often germinate within one growing season. If the seed is not cleaned, it may take many growing seasons in order for the hard seed coat to weaken enough to allow for germination. In an urban environment, this is especially important due to the invasive species pressures and often unrealistic expectations of the public and industry that expect revegetation within one growing season.

Seeding Methods

In every situation, one must examine how the seed flows (e.g., evenly passes through) to ensure even coverage of all species in the mix. Depending on the terrain and associated access routes, the ability to procure clean seed and seed cost, a decision on what method to use can be made. A summary of the benefits and limitations of each seeding method and when they are most appropriate to use is outlined below in Table 3. Detailed information regarding each seeding method follows Table 3.

Table 3 Seeding methods summary

Seeding Method	Advantages	Limitations	Recommendations on Usage
Hand broadcast	• Can access remote areas and other locations where equipment cannot access • Cost efficient for small areas as labour is the only requirement • Can ensure seed is constantly mixed (e.g., by hand) to allow for even coverage • Can use seed that has not been cleaned/debearded • Can mix seed with amendments such as worm castings, perlite, etc. to increase seed flow and aid in keeping the seed in place • Can seed in places that would be unsuitable for other machinery (e.g., forested areas) • Can adjust seeding rate based on microclimate • Belly grinder (e.g., hand held seed spreader) can assist in ensuring more even coverage	• Manually raking in seed does not allow for even seed to soil contact • As seed is not evenly covered and/or buried in the soil, there is a risk of erosion and seed loss • Large areas require a lot of labour • Require soil that is loose enough to rake seed in • It is easy to seed at a higher rate when hand broadcasting • Cannot separate seed into size groups while seeding	This method is ideal for smaller areas in hard to access locations and areas that limit the use of any equipment such as forested habitats. Hand broadcast seeding should be used in level areas where there is a low risk of erosion and seed loss. Seed that has not been cleaned can be used although there will be more risk that it will not stay in place.

	• Can ensure small seed is not covered too deeply		
Brillion seeder	• Buries seed into soil and allows for more uniform seed to soil contact • As seed is consistently buried in soil, less erosion potential is present • Can seed large areas quickly • This methodology encourages evenness as seeding rate is not influenced by human error • Equipment is easily available • Can use less seed versus hand broadcasting as lower erosion potential	• Cannot traverse steep slopes • Cannot easily travel between trees • Requires soil free of rocks and debris • Seed that has not been cleaned will not flow through the equipment as easily which may cause uneven distribution of the seed mix • Cannot separate seed into size groups or groups based on whether the seed has been cleaned or not while seeding • Small seed may be buried too deeply which can result in decreased germination for the smaller seeds in the mix	This method is commonly used in areas that are level and have fairly homogeneous habitat (e.g., no large rocks, no deadfall, etc.). Less seed is required as erosion and seed loss is minimized versus the hand broadcast method. Small seeds may be buried too deep which can decrease germination for the small seeds in the mix. The flow of the seed mix will be better with clean seed and clean seed will allow for more even coverage of seed mix.
Land Pride Seeder	• Same advantages as Brillion seeder • Differs from Brillion seeder as multiple seed holding	• Cannot traverse steep slopes • Cannot easily travel	This method is commonly used in areas that are level and have fairly homogeneous habitat (e.g., no large rocks, no deadfall, etc.). This method is most efficient for seeding mixes with a wide

	compartments are present • Various seed boxes allow for the separation of seed sizes (e.g., small, medium and large) which leads to better seed flow and more even coverage • This can mitigate for small seeds being buried too deep leading to a decrease in germination • This allows for better flow and more even coverage • There is a custom third seed box modified for unclean seed • The native seed that has not been cleaned is seeded in a way to reduce seed loss	between trees • Requires soil free of rocks and debris • Clean seed always flows better through seeders • Extensive knowledge of how to separate seed into size groupings and use the settings that provide the most effective seeding is required	variety of seed sizes and a portion of unclean or partially unclean seed cleaned by hand. The least amount of seed is required for this method as erosion and seed loss is minimized, especially for unclean seed. Seed is evenly distributed and seeds are buried at the appropriate depths.
Hydroseed	• Can revegetate slopes • Can revegetate areas that contain rocks and woody debris as this type of seeding does not work the soil, although seed loss will occur due to lack of seed to soil contact • Most large projects require hydroseeding for escarpments and as such, equipment will likely be on site • Innovations in slurry amendments are increasing the	• Slurry interferes in seed germination, especially with native seed, as the seed coat is protected by the slurry • Germination of native seed is reduced • Settling issues occur with mixes that have a wide variety of seed sizes • Seed that has not been cleaned	This method should be used on steep slopes that cannot be seeded using any other method. Hydroseeding may be warranted in a level site within a project where bringing in another piece of seeding equipment would not offset the expense of the additional seed cost. This method should not be used to seed rare species and/or species that are hard to procure due to the high seed requirement.

	effectiveness of this method • Erosion potential is less than using the hand broadcast method	causes coverage of species to not occur as intended in the seed mix design as unclean seed interferes with seed flow • Slurry decreases seed to soil contact • A lot of seed is needed to ensure germination and coverage • The drying out of the slurry can cause decreased vegetation coverage due to die off or interference with germination • Erosion potential exists because seed is not buried • Most hydroseeding equipment is not thoroughly cleaned of other seed mixes	

Hand Broadcast

Hand broadcast seeding is just that, seeding by hand. This technique is good in situations where small areas need to be seeded or access is problematic. Certain tools can aid in

seeding such as seed and fertilizer spreaders called “belly grinders.” Seed is fed into the top and as the lever is turned, seed is spread out from underneath. This can assist in ensuring even coverage.

As mentioned in Site Preparation, topsoil should be scarified prior to seeding for methods that do not involve a mechanical component designed to keep seed in place. Prior to hand broadcasting, topsoil should be slightly raked and scarified. After the seed is put down, either by hand or by a belly grinder, the seed needs to be lightly raked in to maximize soil to seed contact and help maintain the seed in place. After the seed is raked in, lightly rolling the soil can assist in further preventing erosion and encourage germination. If a roller is not practical, stepping on the area will confer the same results.

It should be noted that a small harrow-like object can also be pulled over the soil instead of a rake before seeding to increase seed to soil contact. After the seed is put down, again either a light roll or stepping on the soil will ensure light soil coverage.

Brillion Seeder

Seeding using a Brillion seeder is effective due to its ability to handle clean, native seed. Seeding using this method optimizes seed to soil contact as depressions in the soil are made for the seed to fall into and then the seed is lightly covered due to the rolling wheels on the seeder.

This technology has stood the test of time and has not changed since 1948. See http://landoll.com/content/index.php/products/farm_equipment/brillion-farm-equipment/agricultural-seeders/ for more details. A large front roller makes divots in the soil and the seed box disperses the seed. The smaller back roller then presses the soil around the seed.

This method of seeding saves costs as rates can be reduced as seed loss is minimized. If the site is on a steep slope, very small and not worth the machine transport costs or it is too difficult to bring in the equipment due to access constraints, this method should not be utilized.

Land Pride Seeder

Land pride seeders work similar to Brillion seeders as they open and break up the soil surfaces by discing the soil or by using spiked front rollers. The seeds are then spread while rollers simultaneously press the seeds into soil contact. A large advantage that Land Pride seeders have is that they have up to three different seed boxes for various seed types. Seeds can be separated by size (e.g., small, medium and large) or by whether seed has been cleaned. There is a special seed box that can be used for “fluffy” unclean seed. This method would be appropriate for seed mixes that have a wide range of seed sizes or any seed mix containing native unclean seed.

More details on Land Pride seeders can be found here: http://www.landpride.com/product-search/seeders/37

Hydroseed

Hydroseeding is the practice of mixing seed with wood mulch slurry and spraying it on a prepared site. Hydroseeding is the most common method of seeding within Calgary. Its popularity seems to come from the fact that the slurry can be easily sprayed onto steep hillsides and escarpments in order to control erosion by essentially sticking the seed to the hillside. Since hydroseeding can reclaim slopes, it is often the only method of seeding involved in a project as just that one piece of equipment is required. The difficulty of seeding slopes and the additional cost to bring in another type of seeder for more level areas often outweighs the extra seed costs and as such, that is why it is utilized on so many projects.

Although hydroseeding can reach areas where other seeding methods would fail either due to access, slope or because the seed would migrate down the slope, it does have its disadvantages. Hydroseeding can cause germination issues for species with hard seed coats. Since many native species have hard seed coats, this can be problematic as the slurry provides an additional barrier that the seed has to deal with in order to germinate. The slurry may cause a lack of stratification and scarification and prevent the uptake of water and as such, germination may take much longer and by that time, the seed may have already migrated down the slope. Also, in certain instances the slurry may wick water away from the seed itself and prevent germination. In addition, the moistening and then drying of seed may also decrease germination.

Although hydroseeding has its drawbacks, there are new and improved methods coming out on a regular basis. Recent beneficial additions to the slurry have proved to increase germination and the success of hydroseeding. In summary, it is very important to research how the hydroseeding is going to be performed so that success can be maximized.

Rates

Rates can be determined by a seed calculator; however, to properly determine seeding rates one must have the Seed Certificates of Analysis for the particular seed lots they will be using. Since restoration plans are often prepared prior to seed sourcing or even at a Request for Proposal (RFP) stage, understanding general seeding rates based on methodologies and site conditions is advantageous. See below for recommended seeding rates for areas that are not being seeded to turf grass. Although these rates are effective baseline rates, rates need to be determined on a site by site basis and ideally, should be double-checked by running the mix through a seed calculator.

Brillion Seeding and Land Pride Seeding

Since these are the most effective methods of seeding, a lower seeding rate can be used. Generally, on an average site within Calgary, a native seed mix is seeded at **30 kg/ha**; however, that rate should be raised in areas that are highly susceptible to erosion, weed

invasion, foot traffic, etc. In areas that are connected to healthy ecosystems such as in more remote areas of Weaselhead Flats, the seed rate can be reduced with the aid of a seed calculator.

Hand Broadcast Seeding

When seeding by hand, uneven coverage is a large risk and typically, a site tends to be accidentally seeded at a higher rate when using this methodology. When hand broadcast seeding, it is common to feel that you are not using enough seed for the area which is often why seed is put down heavier than intended. As mentioned, a belly grinder can assist with ensuring more even coverage but it is not necessary. Typically, hand broadcast seeding at **40-45 kg/ha** in Calgary is effective. Again, using a seed calculator can assist in determining the rate but this can be used as a baseline for an average site.

Hydroseeding

As mentioned, hydroseeding is a very common method of seeding but it tends to not be as successful as the other methods and is utilized more due to convenience and access limitations. Due to the aforementioned reasons, an effective hydroseeding rate is quite high at **50-60 kg/ha.** Again, the rate should be altered on a site-specific basis but generally this rate is effective in Calgary for restoring slopes to native vegetation.

Cover Crops

Cover crops are very poorly defined as the terminology seems to point to an initial monoculture cover followed by eradication. Sometimes this is the case but more often than not, cover crops are misused and misunderstood. Generally, cover crops in an urban context are used to build soil, prevent erosion and weed establishment and provide vegetation cover. Unfortunately, cover crops are often used erroneously and tend to persist in restoration activities although they are expected to die off. This can be quite problematic in situations where the intent is to restore an area to a native plant community and the site becomes dominated by the cover crop instead.

Native species can be used as a type of cover crop but the pressure to eradicate them from the site after they have served their purpose is absent. More or less, native cover crops are early successional perennial species that discourage weed colonization during the initial stages of revegetation. Native species have often been used improperly as cover crops. For example, seeding a native early successional aggressive perennial grass then seeding the desired seed mix in the next appropriate time window may be the best course of action for soil building in a particular situation but choosing an appropriate seeding rate will make the difference between the desired and actual outcome. If the initial species is seeded at a high rate and takes well, it may shade out any seedlings that germinated from the second mix leading to a monoculture. Guidelines for cover crop usage are provided below.

Annual Ryegrass (*Lolium multiflorum*)

There are two types of annual ryegrass that are very different (Bagg 2014). Unfortunately the varieties are often intermixed, both in the literature and when buying the product, which can lead to unwanted results. To further add to the confusion, annual ryegrass is termed Italian ryegrass in the Alberta Conservation Information Management System (ACIMS) list of vascular plants confirmed for Alberta (ACIMS 2016).

In addition, the annual **Westerworld ryegrass** tends to be cheaper so most often, at least some of the seed lot will contain the annual variety Westerworld. Some growers indicate that pure Italian ryegrass is not available due to cross pollination and that annual ryegrass tends to overwinter better than perennial ryegrass.

Westerworld ryegrass is an annual that produces many seeds the year of seeding, like most annual plant species. Westerworld ryegrass may spread when mowed due to the plant's response to produce more rhizomes while the mower essentially disperses the seed. Although this variety is supposed to experience winter kill, documentation about annual ryegrass in general indicates that snow pack may prevent winter kill (Sustainable Agricultural Research and Education [SARE] 2007). There may be an opportunity to prevent seed set the first year but careful monitoring of maturity would be essential as well as multiple mows prior to the end of the growing season. Regardless, ensuring that mowing is of the right height and seeds are immature may be challenging. This action may actually cause this variety to become thicker and denser.

Italian ryegrass is a winter annual and requires a cold period to flower and set seed and as such, does not produce seeds the first year. This species is often confused with an annual when it is killed in winter; however, newer varieties are ensuring persistence through winter (Bagg 2014). For those that are used to using this species as a non-seed producing annual, the variety improvement combined with the lack of current knowledge about its performance are causing it to persist in areas where it is not wanted such as in restored native grasslands and hillsides. Pure Italian ryegrass is almost impossible to procure due to cross pollination which may cause issues when restoring natural environment parks with the use of a ryegrass cover crop.

When utilizing annual ryegrass for a non-persisting cover crop, ensure:

- The variety of the annual ryegrass is known (e.g., Westerworld or Italian);
- Ask for the Italian variety and the history of the variety's performance;
- Mow the first year prior to seed maturity (e.g., likely contaminated with Westerworld); and,
- Mow the second year prior to seed maturity.

When utilizing annual ryegrass for a non-persisting cover crop, possible management techniques can include:

- Seeding late in the year to encourage die-off with cold weather (although it is not guaranteed);
- Generally, repeated mowing prior to seed maturity; and,
- Ensure that if mowing is planned that it will not disrupt the growth of other desirable species in the area.

There are techniques that allow for some persistent annual ryegrass cover within a native vegetation community which will generally die off, leaving the desired native plant community. A useful technique that can be employed is adding a small amount of annual ryegrass to a seed mix that will likely be successful. Another recommendation is to add in annual ryegrass at no more than 5% by weight to the seed mix (Hannaway et al. 1999). Annual ryegrass will persist but ideally, it will get outcompeted by the early successional native species and die off which will lead to the desired later successional vegetation community.

Canada Wild Rye (*Elymus canadensis*)

Various industries that are involved in restoration within native plant communities often recommend Canada wild rye as a cover crop; however, being a perennial, it will persist unless herbicide use is implemented. Since it is native to the Calgary area, its persistence in the plant community is not problematic. Canada wild rye should not be used as a cover crop as it is a perennial and instead, put into the seed mix at an appropriate percent by weight.

Issues occur when Canada wild rye is first seeded at a high rate and left to mature and the preferred seed mix is then seeded into the area where the Canada wild rye has been left standing or has been cut and removed. Since Canada wild rye is fairly aggressive, tall, cool season and an increaser species, if the seeding rate is high enough and the second mix is not compatible, there is a chance that it will form a monoculture. Using Canada wild rye in a seed mix is advantageous as it has the aforementioned qualities but it does not have to be used initially as a cover with a second mix seeded subsequently after its growth. It can be incorporated into the mix at an appropriate percentage to perform its function of weed suppression and early vegetation cover. This saves costs as labour is reduced and a subsequent application of seed is not required.

Winter Rye (*Secale cereale*)

Winter Rye is an annual cool-season cereal crop. If a season of cover is all that is desired, this cover crop may be effective as it can be seeded in fall and tilled/disked the next spring before it sets seed. Like all cover crops, monitoring for maturity is very important as year to year weather deviations will influence vegetation growth. Since winter rye has allelopathic properties (e.g., prevents other vegetation growth), it is especially important to get the cover crop off of the area, including the thatch, four weeks prior to planting anything else (SARE 2007).

Triticale (durum wheat and rye hybrid)

This species can be used as a cover crop similarly to winter rye but it has some advantages over winter rye. Firstly, it does not have the same allelopathic properties and as such, seeding can occur after spring tilling without a lag time. A disadvantage of this may be that weeds are not as effectively controlled, especially at a low seeding rate. Similar to other cover crops, if it is not cut prior to seed maturity, it will self-seed and potentially persist in areas where it is unwanted.

Annual Sunflower (*Helianthus annuus*)

There are some anecdotal recommendations regarding the usage of the native annual sunflower (*Helianthus annuus*) as a cover crop; however, due to the horticultural industry, sourcing the native annual sunflower has not been successful as commercially available seed are cultivated annual sunflower varieties. In a sunny naturalized setting, the cultivated annual sunflower may be appropriate if the intent is to let it self-seed. Due to its forage value for birds, seed spread may be limited in some areas where it is heavily utilized as wildlife food.

Although there are many anecdotal recommendations about the performance, usage and benefits of annual sunflower cover crops, various Alberta growers have never observed one successful application of this species as a cover crop. It may be more beneficial to include in the seed mix as an early successional companion to other species.

Hairy Vetch (*Vicia villosa*)

Hairy vetch is an annual winter legume that is non-native but is often used as a cover crop in agricultural applications. This species is fairly easily eradicated by close mowing at mature flower stage and discing if plants persist (Verhallen 2012). As with other legumes, it is a nitrogen fixer and will increase the biologically available nitrogen in the soil. It can also handle extremely cold conditions and can experience root growth during dormancy (Verhallen 2012). It does tend to require significant moisture so it can deplete the soil moisture if not eradicated early enough in the season. Another benefit of this species is that it is very inexpensive to procure as it is a common agronomic species.

American Vetch (*Vicia americana*)

There is a lot of antidotal information regarding the use of American vetch as a cover crop or it being included as a companion crop as a means of preventing weed establishment and soil conditioning (e.g., nitrogen fixation). It has been included in seed mixes in the restoration of mesic grasslands and forested areas. Since this species is native to the Calgary area and provides forage for many wildlife species, the long-term presence of this species is environmentally beneficial. Generally, the cost and the general lack of availability of this species make it better suited to be included in the final seed mix.

Slender Wheatgrass (*Elymus trachycaulus ssp. trachycaulus*)

Slender wheatgrass is a species native to the Calgary area. It is well adapted to drought, saturation and saline soils as it is a dominant vegetation cover in the peripheral low prairie zone of prairie and parkland wetlands (Stewart and Kantrud 1971). Slender wheatgrass tends to get root bound and begins to die off after approximately four years. It makes an excellent early succession native cover which generally outcompetes weeds and with time, allows the later successional species to colonize. In order to ensure that slender wheatgrass does not continue to dominate the site, use caution when determining the percent by weight of this species in the seed mix. In sites with very little weed competition, a lower percentage can be used. Also, the origin of the supply should be checked and if this species is used to restore a pristine natural area, it should be grown from wild harvested stock native to the project area or as close to the project area as possible. The regulated agricultural variety is much more robust and aggressive than the native species; however, it is easily procured at a low cost. Slender wheatgrass can also be used in vegetating heavily mulched areas as it will grow directly in coarse wood chips.

Awned wheatgrass, a subspecies of slender wheatgrass, performs similarly to slender wheatgrass but generally is not as aggressive. This could be due to the fact that awned wheatgrass is not a registered crop and has not been bred extensively. Due to the lack of commercial breeding, it has retained more of its natural genetics and has not become artificially competitive. Others contradict this idea as they feel the presence of awns and the associated difficultly in seed handling is responsible for the lack of germination. When a local seed producer tried to grow the awned species, both awned and unawned plants resulted from the awned seed. The genetic information on the awned versus unawned seeds also appeared to be identical after analysis.

Blue Flax (*Linum lewisii*)

The commonly observed blue flax that is native to this area is a perennial and readily self-seeds; however, as a monocrop, such as in seed production, it starts to die out after a few years. Blue flax, when incorporated into a seed mix, ensures a good early vegetative cover, even on poor soils or in mulch itself. Blue flax also withstands drought and saline soils and tends to attract pollinators and be pleasing to the public due to its aesthetics, which are especially important in an urban environment.

Rocky Mountain Fescue (*Festuca saximontana*)

Rocky mountain fescue is an early successional native grass that can tolerate drought, such as in xeric prairie environments, and periodic saturation, such as in riparian areas. Rocky Mountain fescue is small in stature and stays green for a long portion of the growing season, unlike most native grasses. In an urban environment where fire risk and aesthetics are strongly considered in project planning, this species performs in both those aspects. Unfortunately, Rocky Mountain fescue seed is identical to the non-native sheep's fescue

(*Festuca ovina*) and therefore, genetic analysis and origin information must be considered when using this species. Although the plant is quite small, it can be larger in favourable conditions such as conditions with additional moisture or high nitrogen in the soil (e.g., planted after a legume cover crop). Due to this, genetic analysis is the most conclusive in species determination. Sheep's fescue, its European counterpart, is much more competitive and will tend to form a monoculture. This species used to be quite difficult to procure but presently, it is much more readily available.

Methods of Erosion Control

Erosion and sediment control measures will not be discussed in depth, as it is outside the scope of this document; however, methods related to seeding and erosion control are touched upon below in point form. The continued improvement in erosion and sediment control satisfies the *Erosion and Sediment Control Policy* within The City of Calgary (The City of Calgary 2003) and as such, discussing this in the context of seed mixes and seeding works to further increase knowledge and add more options to satisfy erosion control methods during construction.

Recommendations for Erosion Mitigation

- Do not directly hand broadcast, harrow or Brillion seed onto a slope steep enough where precipitation will wash the seed downhill.
- The majority of lawn grasses, which are mostly rhizomatous non-native species developed for turf, have limited ability in preventing erosion as the roots and underground stems are too shallow to bind the subsoil. Generally, rhizomatous species have the bulk of their root system in the first 10 cm of soil.
- Deep rooted tufted species are more effective in controlling erosion. These tend to be native species.
- Many native grass and forb species are good at preventing erosion as they are suitable for our unique climate.
- When selecting species suitable for erosion control, plant tolerances and preferences must be taken into consideration. For example, a xeric (e.g., very dry) prairie species should not be used to control erosion along a river bank. In the opposite situation, a riparian species should not be used to control erosion along a steep dry roadway escarpment.
- A tackifier (e.g., Hydromulch, Pennmulch, etc.) can be lightly applied to seed after it is put down versus hydroseeding which can cause handling issues with native seed and diverse seed mixes.
- Many types of geotextile fabric and material are available to prevent seed from migrating down slope. Unfortunately, some of these geotextiles are too thick to allow for enough light penetration and/or moisture penetration to trigger germination. Geotextiles should be thoroughly researched prior to use.
- Many geotextile fabrics and material will not allow for seedlings, especially more tender native seedlings, to penetrate the fabric if they do in fact germinate. Again, ensure that the type of geotextile is thoroughly researched before use.

- If seed is stabilized in some other way, heavier geotextiles can be buried while the seed mix is seeded on top of loam. This technique is applicable to areas that also require soil stabilization.
- Biodegradable bags containing seed and soil can be used and are available commercially. Bags are commonly made of burlap. The bags can be secured with stakes and placed directly on an eroding hillside or slope. The manufacturer will have specifications for the best placement and securing method based on the individual product type. It should be noted that only the very aggressive native species will be able to penetrate the geotextile. An appropriate mix for this application is discussed in Appendix 1. If the restoration is meant to increase biodiversity, another strategy that can be implemented is to hand broadcast a more diverse seed mix directly onto the bags during the next appropriate time window once they have broken down enough to ensure seed to soil contact. Due to the change in the surface, seed migration down slope is reduced. Seeding rates must be very heavy in order for this application to work as a lot of the seed is essentially buried in the soil and will not have a chance to come to the surface until the bag biodegrades. For an average sized bag, 400 g of seed or above has been successful in the Calgary region. Another important factor that needs to be considered in this application is moisture. In some instances, watering the seed bags during times of extreme drought may be utilized in order to mimic snowmelt and spring rains. This application may not be suitable for areas that are very dry such as south facing slopes and where watering is impossible due to access constraints.

Habitat Types and Seed Mixes

There are many different types of vegetation communities/habitat types. Broad terrestrial habitat types are outlined in *the Rangeland Health Assessment for Grassland, Forest and Tame Pasture* (Adams *et al.* 2016). At the most detailed level, these habitats are divided into plant community types based on soil information and dominant plant species by the various Range Plant Community Guides compiled by Alberta Sustainable Resource Development Public Lands. Together these documents interpret current land conditions and ecosystem health and guide the management of these lands in regards to grazing activities.

Detailed forest plant communities have been captured by documents developed through the Canadian Forest Service. For example, guides to various ecosites in the forested areas of Alberta classify ecosystems based on plant community, soils, age and numerous other factors such as in Beckingham *et al*. (1996). Together, this provides information on forest types which can be managed by prescriptive recommendations.

Although The City of Calgary Parks has a recent Global Information System (GIS) habitat layer, natural area habitats are generally characterized by growth form (e.g., grassland, riparian tall shrub, upland low shrub, etc.). Non-natural green space areas that are managed by Parks are identified through maintenance regime classifications such as Turf Class B (e.g., medium frequency of mowing).

As land type classifications are quite broad within Calgary Parks and are not based on the dominant plant species, recommending seed mixes based on these broad standardized classifications would not provide enough detail to ensure that these suggestions are useful. In addition, reference vegetation communities as identified in Adams *et al.* (2016) are often absent due to the effects of development and other urban pressures.

Instead, seed mixes are recommended based on the broad habitat type but may include a more detailed description of the plant community, urban pressures that affect the project site and/or the desired outcome of the seeding (e.g,. slope stabilization, pollinator corridor, etc.).

In addition, seed mixes that are indicated may have been developed for other portfolios or business units within The City of Calgary as they use the landscape specifications indicated in The City of Calgary Parks (current edition). The descriptions above the seed mixes will indicate the intent of the seed mix and how it is to be used. Also, it is important to note that for bioretention areas, the seed mixes may contain more species than referenced in *Low Impact Development Guidelines: Module 2-Bioretention and Bioswales Final Report* (The City of Calgary 2016). These additional species will be reflected in the preparation of the second version of this document which is set to commence in fall 2017.

Seed mixes are outlined in Appendix 1.

Section IV: Procurement

Introduction

Procurement is often the last thing that is thought about during the various stages of project management; however, it is very important. Firstly, it will save a lot of time and unnecessary work if the project manager has an understanding of what species are available as seed. The Alberta Native Plant Council website hosts a list of vendors that supply native seed. It can be found here: http://anpc.ab.ca/?page_id=785

Secondly, becoming familiar with the species selection they offer is beneficial when working on a project that requires restoration to a native plant community. Unfortunately, some plant seed may be difficult, if not impossible, to source and as such, recommending these species in a mix limits project progress. Also, trying to source seed that is difficult to procure may limit progress and may be counterproductive to the project due to the reasons that the seed is not available.

Factors that may contribute to a lack of seed availability of a particular species include:

- Species only grows in forested environments and therefore, collection access and ease is limited;

- Species prefers indirect light and/or shade and as such, grows sporadically in areas with woody vegetation making access difficult. Since the plants are widely spaced apart due to their habitat preferences, this makes collection very labourious;
- Species is a warm season plant and seed matures on the stem into the fall and winter. This makes collection difficult as frigid temperatures and dry vegetation cause significant seed loss during collection. Also, seed is often dropped at unpredictable times and as such, the majority of the seed is on the ground and not available for collection;
- Plants set seed at different times and seed maturity is non-uniform;
- Plant species does not propagate well from seed (e.g., poor germination and propagates more effectively from root fragments, etc.);
- Seed commonly suffers from disease (e.g., ergot);
- Species occupies a unique habitat type;
- Plant species does not flower yearly;
- Not a lot of available information on the plant's biology, habitat preference and range;
- Plant species is generally outcompeted and replaced by other more aggressive species in areas that contain development;
- Species is a decreaser; and,
- The plant's biology make collection difficult (e.g., short stature, seed pods/capsules present, seed flies away easily, etc.).

When a particular species of plant seed is difficult to procure, this may indicate that using the seed of this species in restoration may not be effective; however, there are many reasons why seed may not be available. The reasons listed above can assist with determining how much effort should be put into procuring seed from a particular plant species. If it will not increase the success of the restoration, then it is not worth the effort. If a species is unavailable, ask seed growers why it is not available. Their reasons will help with the seed mix design as certain species that occur in the reference vegetation community may not be help the restoration if included in the seed mix.

Sourcing Considerations

Besides becoming familiar with what species are available, there are things that should be asked prior to ordering seed. This will help with better project planning and allow for realistic expectations for the outcome of the project. Below is a list of questions and inquiries that should be asked prior to seed purchase. Rationale for the question is also provided.

Information to obtain from seed vendors and the rationale is listed below:

- What is the source of the seed? For example, seed should originate from as close to the project area as possible. Conservation of local genetics is key in order to have the seed germinate and grow to maturity as the genetics control the responses to the environment and as such, seed that is local in origin will have a better success rate regarding germination and growth.

- Has the seed been propagated from a wild collection or is it directly from a wild collection? If it has been propagated from a wild collection, how many subsequent harvests have occurred after it was put in the ground? This information will indicate how close the genetics are to the local population as seed that has been grown out multiple times from wild collections tends to be more aggressive. This is how native seed cultivars have been developed.
- How has the seed been grown if it has been grown out? This will provide information on what the hardiness is like of the resulting plants. For example, seed grown into plants in a non-irrigated field will likely be more tolerant to drought, winds, direct sun, etc. Generally, plants and the resulting seed from a growing operation that is located outside will be more tolerant of harsh conditions than plants and the resulting seed that have been grown in greenhouses or that have been in irrigated fields and/or areas that have been more maintained to increase production. There are exceptions when greenhouses intentionally stress plants.
- With reference to native seed, it should be determined whether the seed is a cultivar of a native species (see point above).
- Recent Seed Certificates of Analysis per species and seed lot should be available as per the recommendations in the *Development Guidelines and Standard Specifications: Landscape Construction* (The City of Calgary Parks current edition) and the *Habitat Restoration Project Framework* (The City of Calgary Parks 2014). Some exceptions may be warranted in situations where very little seed is available and testing would impact the project due to losing that amount of seed. Also, hand collected seed is usually quite pure and as such, certificates of analysis may not be required. This exception is up to the project manager.
- What is the age of the seed? Using older seed may be advantageous in the case of legumes (see Seed Storage) but would be detrimental to the project in the case of species that lose germination ability with time.
- How has the seed been stored? Storage methods can greatly influence germination or lack thereof.
- Ensure that species that may be confused with other species are taxonomically confirmed. For example, confirm that Rocky Mountain fescue is not sheep's fescue. If in doubt, ask for the genetic confirmation on the seed lot.

Section V: Conclusions

There are many aspects that can make seeding effective or ineffective. A small misstep in timing, handling, seed mix design or storage may make an otherwise successful restoration project plan not perform as intended. There is a large skill set that is required in order to know how to design seed mixes and get them germinating effectively within the project area. To complicate matters, these skills are constantly being refined as knowledge in the industry increases. It is paramount to listen to the experts, perform research and monitor the result of seeding activities. Far too often, recommendations are made without a good knowledge of what those outcomes are and how the

manipulation of certain variables affect those outcomes. This is why it is very important for industry, government and academia to work together and share results and as such, this is why this document was created. Although there are studies of restoration in private industry and academia, there are few information sources and studies regarding restoration and seeding work in the urban environment. This document attempts to fill that void and provide information on seeding specific to the urban environment of the city of Calgary.

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Section VII

Appendix 1 – Seed Mixes Based on Habitat Type and Intent

Introduction

Appendix 1 indicates seed mixes that have been used in successful restoration projects in Calgary. The seed mixes are based on a detailed habitat type and desired outcome.

The calculations below regarding percentage by weight assume that the seed has been cleaned and that it is not coated.

Detailed notes on possible species substitutions in mixes will be provided under the respective seed mix. General notes on substitutions include:

- Sheep's fescue can be substituted for Rocky Mountain fescue if the desire is to have a more aggressive non-native species;
- Awned wheatgrass can be substituted for slender wheatgrass to make the seed mix less aggressive;
- Forb species can be substituted for other forb species suited to the same habitat type;
- Forb species availability will often cause substitutions to be required; and,
- Generally, a legume has been included in the mix, except for when the use of a legume may not benefit the site at the current state.

The current botanical name corresponds to ACIMS (2016) while the previous botanical name is an older synonym that is commonly still used in many field guides, by growers and seed suppliers and other reference materials. If the previous botanical name is indicated as 'NA', this means it is not applicable as there have been no changes in taxonomy and the name of the species. The most prevalently used common name variations are listed in brackets.

Although the seed mixes contain species designed to be appropriate for each habitat type that they are designed for, the mixes are by no means are all inclusive. Availability through City of Calgary growing operations and ease of procurement are factors that strongly influence the seed mix design. The listed seed mixes have been shown to be effective in restoration projects within the Calgary area and are taken from actual restoration plans. Other seed mixes and species compositions may be just as effective; however, these are provided as examples.

It should be noted that species, especially forb species, may not be available in as large of quantity as desired. Due to this, some forb mixes may not indicate percentages or may indicate percentages based on availability only. All attempts should be made to build a seed mix based on the principles discussed in this document; however, in some cases this is not possible due to supply. The addition of biodiversity through forb species is beneficial, in any quantity.

Open Riparian Forest

This mix contains all native species and is suitable for an open riparian forest similar to what is found along the flood plains of the Bow River and Elbow River. This mix is compatible with balsam poplar riparian forest types and would not be appropriate for coniferous/mixed conifer-deciduous moist shaded forest types with a moss understory.

Various appropriate forb species can be substituted into the mix (e.g., Canada milk vetch, smooth aster, etc.) based on current supply. The species below were chosen as they are inexpensive and colourful in addition to one species being a legume/nitrogen fixer. Depending on the various wildflowers in the area, the forb species and amounts can be adjusted to introduce new forb occurrences or to complement the existing occurrences. The same logic applies to determining forb species percent by weight as outlined in this document.

Current botanical name	Previous botanical name	Common name	% by weight
Pascopyrum smithii	*Agropyron smithii*	western wheatgrass	25
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	15
Festuca idahoensis	*NA*	bluebunch (Idaho) fescue	15
Festuca saximontana	*NA*	Rocky Mountain fescue	10
Nassella viridula	*Stipa viridula*	green needle grass	10
Deschampsia cespitosa	*NA*	tufted hair grass	10
Koeleria macrantha	*NA*	June grass	10
Poa palustris	*NA*	fowl bluegrass	10
Agrostis scabra	*NA*	rough hair grass	5
Linum lewisii	*NA*	blue flax	3.75
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	3.75

Open Forest Mix

This mix contains all native species and is for an open forest which is generally drier than a forest with a denser canopy. The forest may be riparian but this mix is more aggressive than the riparian open forest mix as generally, open forest habitats are closer to anthropogenic disturbances such as picnic benches, trails, etc. This mix would be appropriate for restoration in a highly used natural area.

Species which are put as ‘trace’ are put in the mix at less than 1% due to cost and lack of supply. These species can be left out entirely if preferred.

Current botanical name	Previous botanical name	Common name	% by weight
Bromus marginatus	*NA*	mountain brome	20

Elymus canadensis	*NA*	Canada wild rye	18
Calamovilfa longifolia	*NA*	sand grass	10
Festuca saximontana	*NA*	Rocky Mountain fescue	10
Nassella viridula	*Stipa viridula*	green needle grass	10
Deschampsia cespitosa	*NA*	tufted hair grass	8
Elymus trachycaulus ssp. subsecundus	*Agropyron trachycaulum var. unilaterale*	awned wheatgrass	8
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	8
Koeleria macrantha	*NA*	June grass	8
Astragalus canadensis	*NA*	Canada milkvetch	3
Linum lewisii	*NA*	blue flax	2
Solidago altissima/Solidago lepida	*Solidago canadensis*	Canada goldenrod	2
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	1
Erigeron philadelphicus	*NA*	Philadelphia fleabane	trace
Lathyrus ochroleucus	*NA*	cream-coloured vetchling	trace

Forest Edge Mix for Sites Containing Remnant Fescue Stands

This mix contains all native species and was designed to mimic the plant community in a natural area located in the far south portion of Calgary. This area is a mix of deciduous forest stands and grasslands that contain remnant patches of fescue.

Current botanical name	Previous botanical name	Common name	% by weight
Pascopyrum smithii	*Agropyron smithii*	western wheatgrass	36
Nassella viridula	*Stipa viridula*	green needle grass	20
Festuca campestris	*NA*	mountain (foothills) rough fescue	13
Linum lewisii	*NA*	blue flax	13
Artemisia ludoviciana	*NA*	prairie sagewort (sage)	9
Elymus lanceolatus	*Agropyron dasystachyum*	northern wheatgrass	5
Festuca idahoensis	*NA*	bluebunch (Idaho) fescue	4

Upland Open Forest

This seed mix is intended for upland open dry forests which tend to be dominated by deciduous species. This mix contains all native species and assumes that no non-native species are to be introduced intentionally. This mix is similar to the other forest mixes within this document;

however, it is intended for areas that are on the upper escarpments of riparian forests and as such, are slightly drier and contain less silt than within the flood plain area.

Current botanical name	Previous botanical name	Common name	% by weight
Bromus marginatus	*NA*	mountain brome	16
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	16
Elymus trachycaulus ssp. subsecundus	*Agropyron trachycaulum var. unilaterale*	awned wheatgrass	15
Elymus canadensis	*NA*	Canada wild rye	10
Festuca saximontana	*NA*	Rocky Mountain fescue	10
Nassella viridula	*Stipa viridula*	green needle grass	8
Deschampsia cespitosa	*NA*	tufted hair grass	5
Koeleria macrantha	*NA*	June grass	5
Astragalus canadensis	*NA*	Canada milkvetch	3
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	3
Solidago spp.	*NA*	Canada goldenrod/low goldenrod (mixed)	2
Erigeron philadelphicus	*NA*	Philadelphia fleabane	1
Linum lewisii	*NA*	blue flax	1

Open Forest Grass Mix-High Usage Areas

This seed mix is intended for an open forest habitat type in a natural area that experiences high usage and is surrounded by non-native plant communities. Species in this mix are native grasses so that grass establishment can occur alongside broad-leaved weed treatment.

Current botanical name	Previous botanical name	Common name	% by weight
Elymus canadensis	*NA*	Canada wild rye	20
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	20
Bromus ciliatus	*NA*	fringed brome	15
Festuca idahoensis	*NA*	bluebunch (Idaho) fescue	15
Festuca saximontana	*NA*	Rocky Mountain fescue	15
Deschampsia cespitosa	*NA*	tufted hair grass	10
Koeleria macrantha	*NA*	June grass	5

Open Forest Forb Mix-High Usage Areas

This mix is intended to introduce forbs into an open forest habitat in a natural area that experiences high usage and is surrounded by non-native plant communities. Many other species of forbs would be appropriate for usage in a similar ecosystem; however, the mix was designed to mirror what was common in the area prior to disturbance and what species would compete with weedy non-native species. In addition, the mix was based on availability and as such, percentage by weight can be modified as required.

Current botanical name	Previous botanical name	Common name	% by weight
Astragalus canadensis	*NA*	Canada milkvetch	40
Linum lewisii	*NA*	blue flax	15
Solidago canadensis	*NA*	Canada goldenrod	10
Symphyotrichum ericoides	*Aster ericoides*	tufted white prairie aster	10
Symphyotrichum laeve	*Aster laevis*	smooth aster	10
Vicia americana	*NA*	American vetch	8
Solidago missouriensis	*NA*	low (Missouri) goldenrod	7

Wetland Peripheral Low Prairie Zone Mix

This seed mix is designed for the outer zone of a freshwater wetland and as such, the species in the mix are tolerant of fluctuating water levels, especially during spring runoff. Since the outermost portion of wetlands experiences the largest and most frequent changes in moisture, species selection must account for this. Since Calgary's soil tends to be more basic in nature, the seed selection accounted for the possibility that the wetland may be slightly alkaline, but not saline.

Current botanical name	Previous botanical name	Common name	% by weight
Elymus canadensis	*NA*	Canada wild rye	20
Elymus trachycaulus ssp. subsecundus	*Agropyron trachycaulum var. unilaterale*	awned wheatgrass	15
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	15
Festuca saximontana	*NA*	Rocky Mountain fescue	15
Deschampsia cespitosa	*NA*	tufted hair grass	10
Agrostis scabra	*NA*	rough hair grass	7
Glyceria striata	*NA*	fowl manna grass	5
Astragalus canadensis	*NA*	Canada milkvetch	3
Koeleria macrantha	*NA*	June grass	3
Solidago canadensis	*NA*	Canada goldenrod	2

Open Riparian Area Grass Mix

This seed mix contains only native grasses and was designed to be used to revegetate areas that had been treated for creeping (Canada) thistle (*Cirsium arvense*). Forbs are absent so that broadleaf weed control can continue.

The habitat type that this mix is suitable for would be a high use and/or disturbed natural area. Aggressive native species were chosen to compete with other non-native weedy species. The seed mix was created for an open area, containing few trees and shrubs under periodic influences of water. The various grasses were also chosen so that infrequent mowing may occur to encourage visitor usage.

Current botanical name	Previous botanical name	Common name	% by weight
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	20
Nassella viridula	*Stipa viridula*	green needle grass	20
Pascopyrum smithii	*Agropyron smithii*	western wheatgrass	20
Deschampsia cespitosa	*NA*	tufted hair grass	10
Festuca saximontana	*NA*	Rocky Mountain fescue	10
Poa palustris	*NA*	fowl bluegrass	10
Agrostis scabra	*NA*	rough hair grass	5
Koeleria macrantha	*NA*	June grass	5

Sandy/Gravelly River Bank Seed Mix

This seed mix contains native grasses and forbs. It has been designed to provide vegetation cover to an open river bank habitat type typical of areas that are normally dry but may become inundated during very high water events. The goal of this seed mix is to provide herbaceous erosion control as the species that were chosen can grow in silt, sand and gravels and generally tolerate poor soils. Although erosion control often employs the use of woody materials, in areas that are highly used, herbaceous cover may be a more viable option as human usage can still occur simultaneously along with revegetation.

Current botanical name	Previous botanical name	Common name	% by weight
Festuca saximontana	*NA*	Rocky Mountain fescue	40
Deschampsia cespitosa	*NA*	tufted hair grass	25
Calamovilfa longifolia	*NA*	sand grass	12
Koeleria macrantha	*NA*	June grass	8
Linum lewisii	*NA*	blue flax	5
Solidago missouriensis	*NA*	low (Missouri) goldenrod	5

Symphyotrichum ericoides	*Aster ericoides*	tufted white prairie aster	3
Symphyotrichum laeve	*Aster laevis*	smooth aster	2

Saline Wetland Peripheral Low Prairie Zone Mix-Natural

The species in this seed mix have been selected for their ability to tolerate high salinity, saturation and drought. Similar to the other seed mixes designed for areas adjacent to open water, these various plants have to withstand fluctuating water levels. In addition, the water in saline wetlands tends to fluctuate drastically as the majority of these wetlands are located in the prairie areas of east Calgary. The open landscape and lack of woody vegetation cover does not regulate moisture as much as the more forested landscapes do.

This seed mix utilizes native species that are adapted to this harsh environment; however, the collection and/or propagation of these species is very difficult. Access restrictions and government regulations related to Crown-owned water bodies hinder availability. Also, many wetland plants of the same species tend to set seed at different times making bulk collection almost impossible. Propagating these species in these types of habitats is another challenge which furthers complicates this type of seed production.

This seed mix is composed entirely of native grass species found in the Calgary area. Due to the issues with procuring this type of seed, often some of these species may be unavailable which, in that case, the other species in the mix can be increased proportionately. Also, the cost of this seed is very high and as such, project managers need to make a decision about the quality of the wetland, whether the wetland will be impacted in the future, if the wetland is naturally occurring, etc., among other things, to determine if using an entirely native seed mix is appropriate. As this seed mix mirrors what is naturally found in the outer wetland zones in saline prairie wetlands, the name indicates ‘Natural’ to differentiate between mixes designed to grow in these areas which contain non-native species. This mix would be most appropriate for ecologically healthy wetlands or wetlands that were healthy that are being restored to a more native state, wetlands that will remain healthy and/or wetlands that provide wildlife habitat.

Finally, a few modifications have been listed in the table to account for variations in site conditions. Wildflower species can be added if desired which is noted in the table.

Current botanical name	Previous botanical name	Common name	% by weight
Distichlis stricta	*NA*	salt grass	22
Festuca saximontana	*NA*	Rocky Mountain fescue	22
Poa palustris	*NA*	fowl bluegrass	15
Agrostis scabra	*NA*	rough hair grass	11
Deschampsia cespitosa	*NA*	tufted hair grass	10
Koeleria macrantha	*NA*	June grass	3

Wildflowers*	*NA*	smooth aster, tufted white prairie aster, shining arnica, low goldenrod, common yarrow, gaillardia, purple prairie clover, showy locoweed	(5)
*Puccinellia nuttalliana***	*NA*	Alkali grass	(10)
*Elymus trachycaulus ssp. Trachycaulus****	*Agropyron subsecundum*	slender wheatgrass	(X)

*In this mix, the wildflower can be any native salt tolerant plants that can withstand fluctuating moisture levels, including both drought and saturation. Generally, wildflowers are added into the mix at approximately 5%. They are not included in the total here but if the decision is to include them, the other percentages by weight would be reduced proportionately. A few examples of native plant species that would be appropriate for this habitat type have been provided in the common names column. Although the list shows a few examples, it is not exhaustive of what species could be used in this situation.

**As mentioned, many of the species in this mix, especially alkali grass, are difficult to procure. Alkali grass, the *Puccinellia* species native to the Calgary area, is the most difficult to find in appropriate quantities for restoration work and as such, it is not included in the mix; however, a recommended percentage of 10 has been indicated if it is available. As with the other modifications, if a species is added, the other species can be reduced proportionately.

***This species has been intentionally left out as slender wheatgrass is tall and has the ability to shade out other species; however, it is aggressive and suitable for the habitat type and as such, may be added in at a small percentage. Also, in habitats that are prone to weed invasion, slender wheatgrass may be put in at a higher percentage to help mitigate invasive species colonization.

Saline Wetland Peripheral Low Prairie Zone Mix-Anthropogenic

Similar to the species in the Saline Wetland Peripheral Low Prairie Zone Mix-Natural, these plants have been selected for their ability to tolerate high salinity, saturation and drought. Although this mix is very similar to the natural saline wetland mix, this mix contains non-native species. Various site characteristics may lead to including non-native species in the seed mix if the use of non-native species will not affect the ecological health of the site or negatively impact surrounding sites. As previously mentioned, many native species suited for these conditions are hard to find and come with a high price. Some of the characteristics that may lead to a decision to use non-native species in the seed mix could include that the site is:

- Isolated from other natural environment parks and the likelihood of the spread of non-native species into these natural sites would be extremely low;
- Not naturally formed;
- Highly modified from its once natural state;
- In poor ecological condition;
- Going to degrade over time regarding ecological health;
- Going to experience consistently high usage pressure; and,
- Requires restoration work to control legislated weeds.

Essentially, the species in this seed mix are going to overlap with the species in the bioretention features seed mix as the conditions are very similar; however, there are some general differences that should be noted. Most importantly, it is paramount to understand the features and functionality associated with the site. If the site has been constructed or modified, it is important to know how the engineering will affect the high and low water mark and at what frequency and extreme the water levels will fluctuate.

It should be noted that the seed mix for both the Saline Wetland Peripheral Low Prairie Zone Mix-Anthropogenic and the seed mix for the Bioretention Feature-Meadow Aesthetic are designed to provide a landscape cover that appears as a grassy meadow. Since the forb compositions can be modified, these mixes may be modified to be quite showy.

The differences between the seed mixes for the aforementioned Saline Wetland Peripheral Low Prairie Zone Mix-Natural and the Bioretention Feature-Meadow Aesthetic, occurring further in the document, are noted below. Again, the engineering specifications need to be understood to determine the plant species choices within these landscapes.

General Assumptions, including both similarities and differences, of the Saline Wetland Peripheral Low Prairie Zone Mix-Anthropogenic and the Bioretention Feature are that:

- Generally, non-native species present in both seed mixes are acceptable;
- Both situations need to deal with saline water input;
- The appearance of the Bioretention Feature-Meadow Aesthetic is more important than the Saline Wetland Peripheral Low Prairie Zone Mix-Anthropogenic due to the likelihood that the bioretention feature is in closer proximity to communities and residences and as such, this mix will generally use more colourful wildflowers;
- The water levels will fluctuate more frequently in a bioretention feature than in a modified saline wetland habitat due to the requirements of the soils to provide quick drainage. This is different in a saline wetland habitat that, for example, was natural in the past but has degraded due to the consistent input of storm water;
- A common situation is that stormwater input will cause fluctuations in a modified saline wetland but generally, during the summer, the open water mark gets higher as irrigation, overland drainage from impervious surfaces and lawn watering gradually increases the water levels throughout summer;

- The bioretention features will have larger inputs of water and quicker drainage times and as such, the bioretention features need to be more suited to experiencing flow, velocity and sediment loading;
- In order to be adapted to velocity, flow and sediment loading, generally, the plants in the bioretention features need to have thicker stems that will prevent lodging (e.g., the falling over of the plant) and tufted roots that bind soils; and;
- Both situations require aggressive species; however, due to aesthetics, very aggressive grasses should be used in lower percentages by weight in order to allow for sufficient forb coverage.

Both situations will have species that can also overlap with the seed mixes provided for boulevard coverage. This is because plants in both habitat types need to be adapted for saline soils and drought. During times of heavy precipitation, these species take advantage of additional moisture and because they are situated in a small soil containment area, that will lead to temporary soil saturation.

In the subsequent boulevard seed mixes, AC Saltlander green wheatgrass, is recommended. AC Saltlander green wheatgrass was developed by Dr. H. Steppuhn at the Semiarid Prairie Agricultural Research Centre (SPARC) (Barker 2014). AC Saltlander green wheatgrass was developed and put into production from the discovery of a naturally occurring wheatgrass hybrid that showed exceptional salt tolerance (Wall, Pers. Comm.). Besides the salinity tolerance of AC Saltlander, its biomass production in saline areas is very high. It is also very drought tolerant. Due to those characteristics, it started being used in boulevard applications in 2017. As it is a new species which has not been seeded in the Calgary area in urban applications, is high in stature and can be very competitive, it has not been used in other applications where it may take over the plant community. The records of past use are in rural applications such as in the reclamation of saline lands and oil and gas lease sites and pipelines.

In addition to access constraints and the associated difficulty it is to perform maintenance in bioretention features and peripheral low prairie zones of constructed/modified saline wetlands, the usage of AC Saltlander green wheatgrass has been limited. Once there is a general knowledge of how it performs in an urban context, its usage may be expanded to areas outside of boulevards but currently, since it would be difficult to eradicate in other situations once seeded, its use has only been on boulevards. Lastly, if it needed to be thinned or removed due to its competitive ability, this would cause compaction in bioretention features and wetland edges where soil is highly susceptible to compaction because of its moisture content. This would decrease the functionality of these features. For now, it is not recommended in anything other than Roads applications but in the future, it may be a species that will be included in various mixes for saline soils in non-natural environment parks.

Current botanical name	Previous botanical name	Common name	% by weight
Festuca saximontana	*NA*	Rocky Mountain fescue	25
*Elymus trachycaulus ssp. Trachycaulus**	*Agropyron subsecundum*	slender wheatgrass	15
Poa palustris	*NA*	fowl bluegrass	15
Agrostis scabra	*NA*	rough hair grass	10
Deschampsia cespitosa	*NA*	tufted hair grass	10
Distichlis stricta	*NA*	salt grass	10
*Puccinellia distans****	*NA*	Alkali grass (may be 'Fults' cultivar)	10
Koeleria macrantha	*NA*	June grass	5
Wildflowers**	*NA*	smooth aster, tufted white prairie aster, shining arnica, low goldenrod, common yarrow, gaillardia, purple prairie clover, showy locoweed	(5)

*Slender wheatgrass has been included in this mix as a non-natural saline peripheral low prairie zone likely has compromised ecological health. Although slender wheatgrass is very aggressive and may take over, it is not very long-lived (e.g., dies off after approximately 4 years). In this situation, coverage is more important than biodiversity and as such, there are no issues if slender wheatgrass dominates the site.

***Although the native *Puccinellia nuttalliana* can be used, *P. distans* is much easier to procure and is commercially available as the more aggressive 'Fults' cultivar (i.e., cultivars in production are more aggressive as they have the ability to be put into mass production).

**Wildflowers may be native and the same species from the Saline Wetland Peripheral Low Prairie Zone Mix-Natural may be used; however, other aggressive non-native species may be preferred in this situation. Generally, the non-native wildflowers are more aggressive and are less prohibitive cost wise. Approximately 5% is recommended and if the restriction of using native plants is absent, non-native legumes would be an effective choice due to their competitiveness and soil conditioning qualities. Species such as alfalfa and sweet clover have not been recommended as they are very common in the Calgary area as weeds and likely will come in on their own.

Colourful Mesic Grassland Mix

This seed mix is intended for open sunny area. This mix contains all native species and is for a grassland natural area typical of Calgary where aggressive species are required to compete with various introduced agronomics such as smooth brome (*Bromus inermis ssp. inermis*) and Kentucky bluegrass (*Poa pratensis*). The seed mix contains many forb species which can be

substituted with other forb species based on availability. The seed mix would be beneficial to an area that needs reintroduction of forbs or for an area where colour is desired.

Species which are put as 'trace' are put in the mix at less than 1% due to cost and lack of supply. These species can be left out entirely if preferred.

Current botanical name	Previous botanical name	Common name	% by weight
Deschampsia cespitosa	*NA*	tufted hair grass	14
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	14
Festuca idahoensis	*NA*	bluebunch (Idaho) fescue	14
Festuca saximontana	*NA*	Rocky Mountain fescue	14
Pascopyrum smithii	*Agropyron smithii*	western wheatgrass	14
Poa palustris	*NA*	fowl bluegrass	14
Agrostis scabra	*NA*	rough hair grass	8
Nassella viridula	*Stipa viridula*	green needle grass	8
Astragalus canadensis	*NA*	Canada milkvetch	3
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	3
Linum lewisii	*NA*	blue flax	3
Erigeron philadelphicus	*NA*	Philadelphia fleabane	1
Drymocallis arguta	*Potentilla arguta*	white cinquefoil	trace
Gaillardia aristata	*NA*	gaillardia	trace
Lithospermum ruderale	*NA*	woolly gromwell	trace
Monarda fistulosa	*NA*	wild bergamot	trace
Symphyotrichum laeve	*Aster laevis*	smooth aster	trace

Aggressive Native Grassland Mix

This mix was designed for seeding areas previously treated for creeping (Canada) thistle (*Cirsium arvense*). The species in this mix are all native but are aggressive and quick to establish. This mix is appropriate for grassland habitats where native species are desired but where other species will not be out-competed (e.g., mountain rough fescue). Blue flax is added into the mix as it provides quick cover, is aesthetically pleasing and readily self-seeds so that there is a continued supply of blooming plants.

Current botanical name	Previous botanical name	Common name	% by weight
Festuca saximontana	*NA*	Rocky Mountain fescue	25
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	20
Nassella viridula	*Stipa viridula*	green needle grass	20

Poa palustris	*NA*	fowl bluegrass	15
Koeleria macrantha	*NA*	June grass	10
Linum lewisii	*NA*	blue flax	10

Aggressive Soil Building Mix

This seed mix was designed to rehabilitate undesignated trails in a dry open grassland that were compacted and had little in the way left of topsoil and organic matter. This species contains hardy natives as well as the non-native species annual ryegrass. Annual ryegrass is used right in the mix as a cover and will break up the soil and produce organic matter with the intent that the hardy native species can utilize the soil after it has been improved. The native species in the mix also have the ability to grow in adverse conditions. Species used in this mix are inexpensive and no forbs have been incorporated as they can be incorporated at a later date. This is especially important if broadleaf weed control is planned for the site.

This mix is not meant for areas adjacent to healthy natural environment parks as the annual ryegrass will self-seed, potentially overwinter and spread into neighbouring areas.

Current botanical name	Previous botanical name	Common name	% by weight
Lolium multiflorum	*NA*	annual ryegrass	65
Deschampsia cespitosa	*NA*	tufted hair grass	12.5
Festuca saximontana	*NA*	Rocky Mountain fescue	12.5
Koeleria macrantha	*NA*	June grass	10

Aggressive Mix for Gravel and Subsoil-Soil Building

This seed mix is similar to the Aggressive Soil Building Mix but it is more aggressive due to the deletion of June grass and the increase of the other species. This mix should not be used in an area where the self-seeding of annual ryegrass and its spread may cause undesirable issues. This mix is specific for areas that lack organics and topsoil as all of these species can grow in very poor media, including gravel and mulch.

This mix is different than using annual ryegrass alone as it is intends to build organics with the annual ryegrass but then also provide future vegetation cover through the usage of the other two species.

Current botanical name	Previous botanical name	Common name	% by weight
Lolium multiflorum	*NA*	annual ryegrass	75
Deschampsia cespitosa	*NA*	tufted hair grass	12.5
Festuca saximontana	*NA*	Rocky Mountain fescue	12.5

Xeric Prairie Mix

This mix is meant for restoration of very dry open grassland (e.g., xeric prairie) and contains all native species. This species composition is commonly found on poor dry soils. Frequent places to find this type of prairie include open slopes and upper escarpments. This mix is not intended for the more mesic grassland areas that support rough fescue and a variety of shrubs, along with other vegetation species. This mix is intended for open areas that often have some exposed soil and do not contain a high percentage of shrubs.

A high percentage of forbs was used in this mix instead of more aggressive native species to maintain the integrity of the openness and xeric characteristics of the grassland. If grass completely covered the xeric prairie, the prairie would become more mesic and have an increased chance of weed invasion. The high percentage of forbs are also good for areas that are public facing due to aesthetic reasons.

Current botanical name	Previous botanical name	Common name	% by weight
Hesperostipa curtiseta	*Stipa curtiseta*	western porcupine grass	25
Elymus lanceolatus	*Agropyron dasystachyum*	northern wheatgrass	20
Nassella viridula	*Stipa viridula*	green needle grass	15
Bouteloua gracilis	*NA*	blue grama	10
Solidago missouriensis	*NA*	low (Missouri) goldenrod	6
Gaillardia aristata	*NA*	gaillardia (blanket flower)	5
Koeleria macrantha	*NA*	June grass	5
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	4
Antennaria parvifolia	*NA*	small-leaved everlasting (pussy toes)	3
Linum lewisii	*NA*	blue flax	3
Symphyotrichum falcatum var. falcatum	*Aster falcatus*	creeping white prairie aster	3
Symphyotrichum laeve	*Aster laevis*	smooth aster	1

Coverage Mix for Silt Deposition

This mix was designed to be quick growing and provide coverage in order to reduce the chances of weed invasion in riparian areas that contain silt depositions. This mix is not a complete riparian mix as it was intended for flood rehabilitation and for seeding native seed in non-optimal times. This mix contains all native species and can be seeded after high water events which usually take place in June. Seeding native seed in spring is optimal following ground thaw but since high water events take place after snow melt, this mix was intended to be used after high water events on areas without significant silt compaction but high human activity in adjacent areas.

Current botanical name	Previous botanical name	Common name	% by weight
Festuca saximontana	*NA*	Rocky Mountain fescue	53
Poa palustris	*NA*	fowl bluegrass	42
Linum lewisii	*NA*	blue flax	5

Boulevard Grass Cover

At times on roads with high traffic, boulevards need to be mowed to improve sight lines and for fire prevention. In this case, a grass cover alone may suffice. This grass mix needs to be very drought, salt and sediment tolerant due to the requirement to salt and sand heavily used roads. Also, the maintenance needs to be kept to a minimum to prevent required lane closures in order to mow, water and weed these areas and therefore, choosing shorter grasses that do not produce a lot of biomass is ideal.

The mix below is designed for heavily used roads which are regularly salted and sanded. The mix can be modified based on boulevard requirements which is why the notes column is added to this table.

Current botanical name	Previous botanical name	Common name	% by weight	Notes
Festuca saximontana	*NA*	Rocky Mountain fescue	40	Early germinating; low height with little leaf biomass
Deschampsia cespitosa	*NA*	tufted hair grass	20	Provides later coverage; tufted and as such, produces less biomass than other species as flower stalks are taller than leaves and leaves are mostly basal
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	15	Later germinating than *F. saximontana*; after germination, produces thick coverage; often reduces in canopy cover within 4 year's time; produces more biomass and as such, put in at a low % by weight; can reduce % by weight or leave out based on desired outcome
Lolium multiflorum	*NA*	annual ryegrass	15	Provides very early cover; often comes in from surrounding sites; has a tendency to die off with time in certain situations although it may persist on a site

				depending on the cultivar; can reduce % by weight or leave out based on desired outcome
Elymus hybrid	*NA*	AC Saltlander green wheatgrass	10	Very salt tolerant; has ability to take over; produces high biomass; put in at lower % by weight to ensure coverage but not monoculture; can reduce % by weight or leave out based on desired outcome and availability; limited availability

Early Successional Summer Mix for Boulevards

Unfortunately, it may be impossible to perform seeding on construction projects at the optimal times for germination and therefore, at times, seed mixes need to be designed using quick-germinating species. The challenge that can occur with this when mowing ability is restricted and/or the timing allows for cover crops to mature and self-seed, is that these areas may become more of an anesthetically-displeasing monocrop, lacking biodiversity and colour. This dictates that a mix needs to be designed that will provide early coverage, colour and not be aggressive enough to prevent the addition of more species and diversity later in the project timeline.

To achieve this, a mix was developed to provide coverage to boulevards that would be seeded in late July. The mix contains both native and non-native early successional species at rates that will allow for fall overseeding to add more biodiversity and colour. The mix needs to be both salt and drought tolerant and successful when seeded in a non-optimal time. It also cannot be aggressive enough to completely cover the site so other species can be introduced in the fall. Lastly, it has to tolerate poor soils and limited maintenance, due to project constraints such as access issues and limited maintenance regimes. The mix below has been designed to fulfill these challenges.

Current botanical name	Previous botanical name	Common name	% by weight
Festuca saximontana	*NA*	Rocky Mountain fescue	30
Linum lewisii		blue flax	30
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	10
Lotus corniculatus	*NA*	bird's-foot trefoil	10
Festuca ovina	*NA*	sheep's fescue	5
Koeleria macrantha	*NA*	June grass	5
Lolium multiflorum	*NA*	annual ryegrass	5
Puccinellia spp. (P. distans or P. nuttalliana)	*NA*	alkali grass	5

Boulevard Mix for Pollinators

This mix contains both native and non-native species that are tolerant of boulevard conditions; however, this seed mix is designed to be showy and colourful and contains many species that are beneficial to pollinators. The plants in this seed mix are not intended to be low growing with low biomass. The mix is intended to look like a colourful meadow and as such, if a highly manicured look is desired, this mix should not be used. In addition, a notes column is also present so that one can modify the mix based on site-specific characteristics and desired outcomes.

Current botanical name	Previous botanical name	Common name	Notes	% by weight
Deschampsia caespitosa	*NA*	tufted hair grass	Can thrive in moist and dry conditions; salt tolerant.	10
Elymus glauca	*NA*	blue wild rye-	Highly used in decorative sidewalk beds adjacent to the road in downtown core; attractive with coarse blue foliage; small percentage in mix so that forbs can thrive as well.	9
Astragalus canadensis	*NA*	Canada milk vetch	Readily available and inexpensive; salt tolerance unclear but early successional so likely will provide initial cover as top soil layer was replaced.	5
Elymus hybrid cultivar	*NA*	AC Saltlander green wheatgrass	Need small amount in mix so that it does not choke out other species but can provide cover in the most saline areas of the boulevards; Recommended	5

			rates of 5-10 lbs per acre for pasture; with a mix containing this large seed, 5% should account for enough seed dispersion and be adequate.	
Carthamus tinctorius	*NA*	safflower	Likely cannot find seed so not accounted for in mix; need samphire cultivar adapted for shortest growing season as it is an annual; cultivars developed for Canadian cultivation in salty dry soils but production never took off.	5-likely not available
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	Can thrive in moist and dry conditions; salt tolerant.	5
Festuca saximontana	*NA*	Rocky Mountain fescue	Was the only species in the seed mix that germinated this year on the Blackfoot/Glenmore boulevard although other species will likely germinate this growing season.	15
Helianthella quinquenervis	*NA*	aspen sunflower	Readily available, salt tolerant and inexpensive; attractive with yellow flowers specialized for pollinators	7

Koeleria macrantha	*NA*	June grass	May come in as a later succession species; can handle drought and some salinity.	4
Linum lewisii	*NA*	blue flax	Salt and drought tolerant. Tolerates a wide range of conditions as grows naturally in xeric prairie to mesic open forest.	10
Lotus corniculatus	*NA*	bird's-foot trefoil	Good salt tolerance; legume so N fixing capability and legumes specialized for pollinators.	6
Onobrychis viciifolia	*NA*	sainfoin	Readily available, salt tolerant and inexpensive; attractive with pink pea-like blooms.	8
Poa secunda	*Poa junctifolia* (alkali bluegrass)	Sandberg bluegrass	Will thrive when conditions are moister so likely will be green in spring and dormant in summer.	3
Puccinellia distans or Puccinellia nuttalliana	*NA*	'Fults' alkali grass is generally the commercially available cultivar of P. distans. Eastern species is slender salt-meadow grass Nuttall's salt-meadow grass is native Alberta species	Can handle very saline conditions; Native *Puccinellia nuttalliana* not usually available but *P. distans* has very similar properties; *P. distans* colonizing boulevards where creeping red fescue and tall fescue have died off near edges of road.	8

Symphyotrichum laeve	*Aster laevis*	smooth aster	Salt tolerant native Compositae; Attractive as tall with purple flowers; drought and saturation tolerant.	
Symphyotrichum ericoides	*Aster ericoides*	tufted white prairie aster	Salt tolerant native Compositae; thrives with neglect; very drought tolerant and withstands mowing.	
Solidago missouriensis	*NA*	low goldenrod	Loved by pollinators; salt, drought and saturation tolerant.	
Gaillardia aristata	*NA*	gaillardia	Attractive daisy-like flower that is red/yellow/orange; salt tolerant and can thrive in moist to dry soil.	
Sisyrinchium montanum	*NA*	common blue-eyed grass	Tough plant. Keep seed separate so can try and grow species where one can see it amongst the other plants when not in flower.	5 (percentage as part of the total to account for limited availability of some species)

Bioretention Feature-Meadow Aesthetic

This seed mix, with its variations, is intended to be used in non-mulched bioretention features where silt loading, water velocity, drought, saturation and salts put stress on many species (The City of Calgary 2016). It is assumed that drainage of these features will occur within 24 hours; however, certain variables not anticipated in project design may result in longer drainage periods and as such, additional saturation.

Native forbs and graminoids tend to be very effective in these applications as there are many species adapted to the peripheral low prairie zones of seasonal wetlands in the Calgary area. The dominant vegetation in these zones can withstand drought and anaerobic conditions as the wetlands increase in size during spring rains and runoff and, depending on the wetland class,

may dry up completely by the summer's end (Stewart and Kantrud 1971). As many saline wetlands occur in east Calgary and the pothole prairie wetland topography continues east of Calgary, a large number of plant species occupy these unique saline niches and as such, are very salt tolerant. This allows them to be useful in various applications where saline soils are problematic such as in bioretention features where salt from road de-icing continuously flows into these swales and ponds. In addition, as the plants in these natural wetland habitats experience flow, they are generally resilient to some velocity and sediment loading.

The notes section is intended to allow the user of this mix to work with a base of plant species that are hardy in this environment and modify the composition regarding height preferences, forb availability and site characteristics. These species are all native to the Calgary area, with the exception of aspen sunflower which occurs south of Alberta, but may not be commonly found throughout Calgary (e.g., curly cup gumweed tends to be found on the eastern edge).

Current botanical name	Previous botanical name	Common name	Notes	% by weight
Elymus glaucus	*NA*	smooth (blue) wild rye	Very salt and drought tolerant and often used in landscaping applications where other species would fail (e.g., boulevards, sidewalk features, etc.). The plant is very coarse, competitive and tall and may shade out and outcompete other shorter species.	15
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	This species is very tough and is tolerant of salt, velocity, sediment and drought; however, it is very competitive and may form a monoculture due to the fact it has been bred for seed harvest. Two registered cultivars are available in Canada with the first one dating back to 1970 (Canada Food Inspection Agency 2017).	10
Festuca saximontana	*NA*	Rocky Mountain fescue	Can withstand drought, saline conditions,	15

			saturation and overall harsh conditions. Performs well in boulevard applications and is a source of early plant cover.	
Nassella viridula	*Stipa viridula*	green needle grass	Salt tolerant and can withstand drought but will take advantage of extra moisture although it does not perform well in consistent wet soil. This species may be outcompeted on wet soils by weeds.	10
Deschampsia cespitosa	*NA*	tufted hair grass	Withstands salt, drought, saturation, velocity and sediment. Performs well at inlets and outlets of bioretention features. Tufted growth habit also makes it look more manicured in appearance. Often categorized as a low lying land species although it can grow in a variety of conditions.	10
Koeleria macrantha	*NA*	June grass	Withstands salt and drought but will take advantage of	5

			extra moisture. Short in stature so may get shaded out by other plants with time. This species will begin to provide cover after the early germinating species but prior to the later succession species.	
Poa palustris	*NA*	fowl bluegrass	Most reference literature indicates it prefers the outer zones of fresh water wetlands; however, it can tolerate saline conditions and is commonly observed in saline wetlands. In addition, when it is seeded as a restoration species, it tends to persist even in xeric grassland environments.	10
Agrostis scabra	*NA*	rough hair grass	Very tolerant of drought and saline conditions. Withstands salt and although short in stature with a weak stem, it is quite competitive.	5
Symphyotrichum ericoides	*Aster ericoides*	tufted white prairie aster	Drought, velocity, saturation and saline tolerant.	1

			This species can withstand mowing and is quite variable in height and may mature at a very short stature if repeatedly mowed/grazed. Aesthetically pleasing when in bloom but has a messy appearance when not in flower. Some report that the stems tend to break off when desiccated and form tumbleweeds (Leta Van Duin, Pers. Comm.).	
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	Salt and drought tolerant. Tolerates a wide range of conditions as grows naturally in xeric prairie to mesic open forest.	1
Arnica chamissonis	*NA*	leafy arnica	Tolerant of salt, velocity, drought and saturation and performs well in bioretention applications (Leta Van Duin, Pers. Comm.).	2
Arnica fulgens	*NA*	shining arnica	Withstands salt, velocity, drought and saturation. Dominates the	2

			vegetation community in outer the wetland zones in the Dry Mixed Grass area of southeast Alberta. Grows in various prairie habits elsewhere and works well in native planter applications.	
Linum lewisii	*NA*	blue flax	Provides early plant cover and withstands drought as well as some salinity. Currently being tested in more saline environments such as boulevards.	2
Helianthus maximilianii		narrow-leaved sunflower	Salt and drought tolerant although will take advantage of extra moisture as it becomes available. Seed is hard to procure. Non-native.	3
Helianthella quinquenervis	*NA*	aspen sunflower	Native to the western United States although it can be successfully used in perennial gardens in Alberta. Currently being tested in boulevard applications.	3

Achillea millefolium	*NA*	common yarrow	Very tolerant of salt, drought, saturation, sediment and velocity and one of the first native species to colonize bare soil. This species tends to bind soil with its rhizomatous growth. A variety of showy coloured cultivars are available	2
Grindelia squarrosa	*NA*	curly-cup gumweed	Very tolerant of salt, drought, saturation, sediment and velocity and one of the first native species to colonize bare saline soils. Can withstand very high salinity.	1
Solidago missouriensis	*NA*	low goldenrod	Salt and drought tolerant and can withstand very poor soils.	2
Solidago canadensis	*NA*	Canada goldenrod	Recent taxonomic changes have split *S. canadensis* into *S. altissima* and *S. lepida*. Tends to appreciate some extra moisture but can grow in fairly dry soils. Withstands some salinity and may naturalize along roadsides.	1

Native Bright Seed Mix

This seed mix is intended to provide guidance to appropriate wildflower species that can be introduced into a mesic grassland or forest edge environment. This mix is also appropriate for naturalization projects where a large quantity of native forbs are desired. This mix is by no means inclusive of what wildflowers may be appropriate, but instead is based on what has been produced through the seed propagation work of The City and/or what is also commercially available. The species that are easier to procure and less cost prohibitive are put in the mix at a very high percentage by weight in order to provide a mix that is available and reasonably priced.

It should be noted that this mix may allow for the forb vegetation strata layer to be introduced into a restoration project after the graminoid component has established. A restoration plan may introduce the forbs later in the project as there may be a period of broadleaf weed control using herbicide and as such, introducing forbs into the initial seed mix would be counterproductive as they would be negatively affected or killed by the herbicide application.

In addition, in certain cases, a graminoid strata layer may be present without a forb strata layer. In these cases, seeding a wildflower mix without a grass component would allow for the introduction of these plants. In an urban environment, aesthetics are often more important than in a rural environment and buy-in from adjacent residences may appreciate a non-mowed/manicured area if there is a colourful component to the landscape.

Finally, if project planning indicates that wildflower species should be introduced without a graminoid portion of the mix, then the wildflower species in a particular mix can always be introduced on their own.

Current botanical name	Previous botanical name	Common name	% by weight
Linum lewisii	*NA*	blue flax	25
Solidago missouriensis	*NA*	low (Missouri) goldenrod	25
Astragalus canadensis	*NA*	Canada milkvetch	16
Artemisia ludoviciana	*NA*	prairie sagewort (sage)	10
Solidago canadensis	*NA*	Canada goldenrod	5
Vicia americana	*NA*	American vetch	5
Anemone multifida	*NA*	cut-leaved anemone	2
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	2
Drymocallis arguta	*Potentilla arguta*	white cinquefoil	2
Erigeron philadelphicus	*NA*	Philadelphia fleabane	2
Gaillardia aristata	*NA*	gaillardia (blanket flower)	2
Monarda fistulosa	*NA*	wild bergamot	2
Symphyotrichum laeve	*Aster laevis*	smooth aster	2

Foothills (Mountain) Rough Fescue Grassland Mix

This seed mix is designed to be used in areas where one wants to restore foothills/mountain rough fescue grassland. This seed mix is only appropriate in areas that are surrounded by foothills rough fescue grassland as in any other situation, the grassland would not recover and valuable foothills rough fescue seed would be wasted. Foothills rough fescue does not set seed until after the first few years of growth and may only set seed every five years or so (Johnston and MacDonald 1967).

Within an urban environment, natural recovery in disturbed mountain rough fescue grassland is virtually impossible due to invasive species surrounding remnant fescue grasslands in the Calgary area. Seeding reclaimed sites in the Foothills Fescue Natural Subregion to a rough fescue monoculture resulted in success after two years (Sherritt 2012). Competition from native grasses commonly found in the same natural subregion also has shown to decrease the ability of rough fescue to establish when combined in the same seed mix (Sheley and Bates 2008).

In an urban environment, the likelihood of non-native invasive species colonizing disturbed rough fescue grassland is very high. Since mountain rough fescue seed takes years to establish a rough fescue stand, other native plants that grow alongside mountain rough fescue have been added at lower percentages. This at least introduces mountain rough fescue back to the seed bank but provides coverage so that the area is not invaded by weeds. This allows the landscape to have a chance to get on a succession trajectory back to mountain rough fescue grassland. Forbs have not been added to this mix as it is assumed that surrounding grasslands will provide the necessary introduction of wildflowers to the restored area. Regardless, blue flax could be added to this mix to make it more aggressive but not significantly outcompete the mountain rough fescue. In this case, all of the other species should be reduced except for the mountain rough fescue.

Current botanical name	Previous botanical name	Common name	% by weight
Festuca campestris	*NA*	mountain (foothills) rough fescue	40
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	25
Festuca idahoensis	*NA*	bluebunch (Idaho) fescue	15
Elymus lanceolatus	*Agropyron dasystachyum*	northern wheatgrass	10
Koeleria macrantha	*NA*	June grass	10
Linum lewisii	*NA*	blue flax	(X) (reduce all species except for mountain rough fescue)

Berm Stabilization Mix

This seed mix was designed to revegetate a soil berm void of vegetation that had become very weedy and dry due to the lack of shade. Since the adjacent locations were natural environment parks, only aggressive native species were used in order to prevent non-native plant encroachment into the neighbouring native plant communities. In addition, needle grasses were not used in this situation but they could be added where warranted. In a situation that requires a very aggressive grass, green needle grass would be most appropriate. Forbs were also not included due to the high likelihood of broad-leaved weed treatment continuing on the site.

Current botanical name	Previous botanical name	Common name	% by weight
Elymus canadensis	*NA*	Canada wild rye	30
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	30
Festuca saximontana	*NA*	Rocky Mountain fescue	25
Deschampsia cespitosa	*NA*	tufted hair grass	10
Koeleria macrantha	*NA*	June grass	5
Nassella viridula	*Stipa viridula*	green needle grass	(X)

Xeric Slope Mix-Graminoids Only

This mix is meant for restoration of dry open slopes that are surrounded by non-native plant communities. Remnant foothills rough fescue grassland is not present in the area. Habitat types are typical of escarpments and alternate between grassland and tall upland shrubland. Forbs are included in a separate mix to allow for easier seed handling and spread as well as to account for the likelihood of necessary broadleaf weed treatment during graminoid establishment.

Current botanical name	Previous botanical name	Common name	% by weight
Bromus ciliatus	*NA*	fringed brome	15
Elymus lanceolatus	*Agropyron dasystachyum*	northern wheatgrass	15
Festuca saximontana	*NA*	Rocky Mountain fescue	15
Nassella viridula	*Stipa viridula*	green needle grass	15
Festuca idahoensis	*NA*	bluebunch (Idaho) fescue	10
Hesperostipa curtiseta	*Stipa curtiseta*	western porcupine grass	10
Bouteloua gracilis	*NA*	blue grama	8
Calamovilfa longifolia	*NA*	sand grass	7
Koeleria macrantha	*NA*	June grass	5

Xeric Slope Mix-Forbs Only

This mix is meant for the introduction of forbs into a dry open slope habitat surrounded by non-native plant communities. This mix only contains forbs to allow for broad-leaf herbicide application during grass establishment and to allow for a more even cover of forbs when hand broadcast seeding. Habitat types are typical of escarpments and alternate between grassland and tall upland shrubland. Remnant fescue grassland is not present in the area.

The forbs listed here have been grown specifically for Calgary based restoration projects and as such, can be produced at a quantity that is appropriate for parks-scale work; however, in this case percentage by weight is not listed. Although enough seed was available for the project area, harvest quantities alone dictated which species were used in what quantities.

Current botanical name	Previous botanical name	Common name	% by weight
Antennaria parvifolia	*NA*	small-leaved everlasting (pussy toes)	NA
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	NA
Gaillardia aristata	*NA*	gaillardia (blanket flower)	NA
Galium boreale	*NA*	northern bedstraw	NA
Hedysarum boreale	*NA*	northern hedysarum	NA
Linum lewisii	*NA*	blue flax	NA
Linum lewisii	*NA*	blue flax	NA
Solidago missouriensis	*NA*	low (Missouri) goldenrod	NA
Symphyotrichum ericoides	*Aster ericoides*	tufted white prairie aster	NA
Symphyotrichum falcatum var. falcatum	*Aster falcatus*	creeping white prairie aster	NA
Symphyotrichum laeve	*Aster laevis*	smooth aster	NA
Vicia americana	*NA*	American vetch	NA

Dry Slope Mix-Graminoids Only

This mix is meant for restoration of dry open slopes that are surrounded by non-native plant communities. This mix contains native species that prefer slightly more moisture than those in the xeric slope mix. This mix is also more aggressive than the xeric slope mix and is meant for restoration of areas that have a high chance of tall weedy species invading the site. Remnant foothills rough fescue grassland is not present in the area although some patches of native xeric prairie are within the surrounding area. Forbs are included in a separate mix to allow for easier seed handling and spread as well as to account for the likelihood of necessary broadleaf weed treatment during graminoid establishment.

Current botanical name	Previous botanical name	Common name	% by weight
Pascopyrum smithii	*Agropyron smithii*	western wheatgrass	30
Elymus lanceolatus	*Agropyron dasystachyum*	northern wheatgrass	22
Nassella viridula	*Stipa viridula*	green needle grass	17
Bromus ciliatus	*NA*	fringed brome	11
Festuca idahoensis	*NA*	bluebunch (Idaho) fescue	6
Deschampsia cespitosa	*NA*	tufted hair grass	5
Koeleria macrantha	*NA*	June grass	4
Bouteloua gracilis	*NA*	blue grama	3
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	2

Dry Slope Mix-Forbs Only

This mix is meant for the reintroduction of native forbs into a dry slope environment. This area is invaded with taller weedy species, especially smooth brome, and requires aggressive native forbs to compete with various invasive species. Forbs can be introduced after grass establishment and broad-leaf weed control has occurred. This mix contains appropriate forbs based on the habitat type; however, it is not a complete list of every forb species that could be included in the mix.

Percentage by weight of the various forb species can be adjusted based on availability, as required. Blue flax is put in at a high percentage by weight as it produces early initial ground cover, is usually available and inexpensive to procure and is aesthetically pleasing. In addition, low goldenrod was put in at a high percentage by weight as it is also more easily procured. The other species add biodiversity while the former two species create the bulk of the mix so that plants for pollinators are dispersed throughout the project site.

Current botanical name	Previous botanical name	Common name	% by weight
Linum lewisii	*NA*	blue flax	30
Solidago missouriensis	*NA*	low (Missouri) goldenrod	25
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	7
Gaillardia aristata	*NA*	gaillardia (blanket flower)	7
Monarda fistulosa	*NA*	wild bergamot	7
Symphyotrichum laeve	*Aster laevis*	smooth aster	7
Vicia americana	*NA*	American vetch	7
Symphyotrichum ericoides	*Aster ericoides*	tufted white prairie aster	5
Symphyotrichum falcatum var. falcatum	*Aster falcatus*	creeping white prairie aster	5

Green Roof Forbs Mix-Thick Soil Profile

This seed contains all native forb species, with the exception of aspen sunflower, designed to add additional colour and texture to a green roof with a thick man-made soil profile of containing approximately 30 mm of topsoil. The species in the seed mix are hardy and can withstand extreme temperatures and wind speeds as the green roof experiences harsh prairie conditions being in the extreme southeast end of Calgary. All species are native except for aspen sunflower which is indigenous just south of Alberta in the United States of America. It was added as it was easy to grow and procure in addition to it being able to withstand extreme weather.

This species mix is by no means all inclusive; however, it is provided as a guideline based on what was used in this green roof restoration project.

It should be mentioned that sedums (*Sedum spp.*) are often used in green roof applications (Lawlor *et al*. 2006) as they are quite tolerant of extreme conditions; however, in a green roof application that has thick organic soil, they tend to do poorly as they prefer habitats with thinner, drier and less organic soils, like most succulents.

The percentage by weight can be varied based on availability. Blue flax and aspen sunflower were used in the highest amounts as they were readily available and provide a base seed mix in order to incorporate the other less-available species at lower rates. The addition of multiple wildflowers provides diversity and also allows for the smaller amounts of other species to be mixed in and hand broadcast seeded uniformly throughout the site.

Current botanical name	Previous botanical name	Common name	% by weight
Helianthella quinquenervis	*NA*	aspen sunflower	40
Linum lewisii	*NA*	blue flax	25
Solidago missouriensis	*NA*	low (Missouri) goldenrod	10
Anemone multifida	*NA*	cut leaved anemone	5
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	5
Gaillardia aristata	*NA*	gaillardia (blanket flower)	5
Oxytropis monticola	*NA*	late yellow locoweed	5
Symphyotrichum laeve	*Aster laevis*	smooth aster	5
Vicia americana	*NA*	American vetch	5
Symphyotrichum ericoides	*Aster ericoides*	tufted white prairie aster	2
Symphyotrichum falcatum var. falcatum	*Aster falcatus*	creeping white prairie aster	2
Artemisia ludoviciana	*NA*	prairie sagewort (sage)	1

Green Roof Forbs Mix-Thin Inorganic Medium

This seed contains all native forb species and is appropriate for the addition of forbs to a green roof that uses a thin, inorganic rocky growing medium. Various *Sedum* species and other “rock garden” plants are thriving on this roof. This seed mix was designed to introduce additional (native) forbs onto the green roof. The green roof specifically was designed to contain forbs only. In a few areas, prevalent winds seems to have prevented vegetation establishment and the handbroadcast seeding of hardy native forb species is being done to fill in areas void of vegetation.

The forbs in this mix are replicating what native forbs have naturally been introduced by bird activity. Also, other available forb species that can grow in thin inorganic soils are included. In addition, due to the adjacent honey bee hives, suitable showy native forbs that can be utilized by the bees are included.

Aspen sunflower was not used in this case as it is non-native to Alberta. Large expanses of high quality natural environment parks are in the vicinity and as such, spread of non-natives into these areas may cause environmental issues so this was prevented by using only native species.

Since this mix was ordered in a very small quantity, percentages have not been provided. Similar to other forb mixes, available quantities were utilized.

Current botanical name	Previous botanical name	Common name	% by weight
Anemone multifida	*NA*	cut leaved anemone	NA
Artemisia ludoviciana	*NA*	prairie sagewort (sage)	NA
Campanula rotundifolia	*NA*	harebell	NA
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	NA
Gaillardia aristata	*NA*	gaillardia (blanket flower)	NA
Linum lewisii	*NA*	blue flax	NA
Monarda fistulosa	*NA*	wild bergamot	NA
Oxytropis monticola	*NA*	late yellow locoweed	NA
Solidago missouriensis	*NA*	low (Missouri) goldenrod	NA
Symphyotrichum ericoides	*Aster ericoides*	tufted white prairie aster	NA
Symphyotrichum falcatum var. falcatum	*Aster falcatus*	creeping white prairie aster	NA
Symphyotrichum laeve	*Aster laevis*	smooth aster	NA
Vicia americana	*NA*	American vetch	NA

Green Roof Grass Mix-Thin Inorganic Medium

This seed mix contains all native grass species and is appropriate to use on a thin soil with little organics. The grasses that were chosen have the ability to thrive in poor soils and are highly drought tolerant. Grasses were not included initially on this green roof to ensure that they did not dominate the site; however, some areas of the roof have not filled in with vegetation and as such, a select few native grasses were chosen to fulfill this role. These tufted grasses will not form a thick rhizomatous matt and have leaves that are more localized at the base. Due to these characteristics, they are appropriate for this application and will not outcompete the forbs on the site.

Current botanical name	Previous botanical name	Common name	% by weight
Festuca saximontana	*NA*	Rocky Mountain fescue	50
Koeleria macrantha	*NA*	June grass	15
Deschampsia cespitosa	*NA*	tufted hair grass	35

Xeric Forbs Mix-Prairie Naturalization

This seed mix is composed of native forbs and was designed to introduce a wildflower component into a landscape in northeast Calgary that was naturally prairie but was converted into an irrigated manicured park many years ago. Presently, a new lower input landscaping design has been implemented with the idea to decrease mowing and eliminate irrigation while maintaining pleasing aesthetics. This is being done by utilizing native plants and adding forbs

into the turf grass which is dying off due to lack of water. Eventually, the site will look like a wildflower meadow.

A forb mix has been added to areas that will remain unmowed along the pathway and other dry open areas. In addition, wildflower species have been added individually. These are indicated in the table as well as labelled “monoculture.”

In cases like this where the areas that require diversity are very small, it was most feasible and cost efficient to add the forbs of limited supply and habitat tolerance first to ensure even coverage. This is opposite of what is done in some circumstances when small amounts of various species are added to a base mix that is in a much larger quantity. This technique allows the forbs that are less habitat-specific and cost prohibitive to be used more liberally and in other various applications while the forbs very specific to the certain small project areas and microclimates are used only in specific areas in even coverage amounts.

As with many of the forb seed mixes, availability has played a role in the percentage by weight of species in the mix.

Current botanical name	Previous botanical name	Common name	% by weight
Solidago missouriensis	*NA*	low (Missouri) goldenrod	58
Gaillardia aristata	*NA*	gaillardia (blanket flower)	22
Symphyotrichum falcatum var. falcatum	*Aster falcatus*	creeping white prairie aster	11
Symphyotrichum laeve	*Aster laevis*	smooth aster	9
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	monoculture
Linum lewisii	*NA*	blue flax	monoculture
Vicia americana	*NA*	American vetch	monoculture

Grass Mix-Prairie Naturalization for Meadow and Shrub Beds

This seed mix is composed of native graminoids and was designed to introduce native grasses into a landscape in northeast Calgary that is was naturally prairie but was converted into an irrigated manicured park. Presently, a new lower input landscaping design has been implemented with the idea to decrease mowing, eliminate irrigation and eliminate the usage of organic mulch while maintaining pleasing aesthetics.

Wood mulch is present in some of the shrub beds and in others, it is not present as the shrub beds are still being designed and installed. In areas where mulch is present, it will be removed as much as possible. Mulched shrub beds require the constant addition of mulch to maintain aesthetics and suppress undesirable vegetation growth. Due to the naturalization program designed for this park, the mulch has not been replaced and has broken down substantially so that its removal is much less labourious.

This seed mix is designed to look less “wild” and a little more manicured as it utilizes shorter tufted grasses and grasses of unique textures and colours.

Since the areas are quite small that are to be naturalized with these seed mixes, one mix was created to naturalize both the grassland areas and the shrub beds. Although this is not ideal, it was more cost effective to seed with one mix than to create more specific mixes for each habitat type. Most of the species are tolerant of sun and partial shade, with the exception of blue grama, and therefore, creating and procuring one mix was much more feasible than procuring two mixes.

Current botanical name	Previous botanical name	Common name	% by weight
Elymus lanceolatus	*Agropyron dasystachyum*	northern wheatgrass	15
Festuca idahoensis	*NA*	bluebunch (Idaho) fescue	15
Festuca saximontana	*NA*	Rocky Mountain fescue	15
Bouteloua gracilis	*NA*	blue grama	10
Elymus canadensis	*NA*	Canada wild rye	10
Elymus glaucus	*NA*	smooth (blue) wild rye	10
Nassella viridula	*Stipa viridula*	green needle grass	10
Koeleria macrantha	*NA*	June grass	8
Deschampsia cespitosa	*NA*	tufted hair grass	7

Mulched Shrub Bed Naturalization

This seed mix is composed of both native and non-native species designed provide ground cover for a wood mulched shrub bed so that the continuous addition of mulch for weed suppression and water retention is not required. Ideally, as much mulch as possible should be removed prior to hand broadcast seeding to increase seed to soil contact and optimize germination. As many shrub beds have had yearly mulch additions, the depth of organic mulch can be quite substantial. Removal of the top coarse layer of mulch is necessary and removal down to soil is preferred although that is unrealistic.

Plant species that have shown to tolerate a lack of seed to soil contact for germination and growth in other Calgary-based projects were chosen for this seed mix. In addition to mulch removal, treatment of a high nitrogen fertilizer prior to seeding is recommended to further break down mulch. This also assists in adding nitrogen back to the shrub bed that has been depleted by the decaying mulch.

In addition, as organic mulch continues to break down and more soil is formed, the aggressive native species that germinate in poor soils but not pure mulch begin to colonize the site, therefore putting the landscape on a proper successional trajectory. Legumes have been included that will start to thrive after additional soil is formed and provide bioavailable nitrogen

which will help with the mulch breakdown and the soil formation. Once mulch breakdown is complete, nitrogen will be released as it is not tied up in the decomposition process.

Common yarrow is recommended due to its ability to tolerate lack of soil. It can be seeded with the other species in the mix and when planted as a potted specimen, it further helps with soil building. The native common yarrow is white in colour but for an application that does not require all native plant material, many colourful cultivars could be utilized. A percentage of the seed mix is not provided for yarrow as it is more commonly available as a potted plant that is fairly inexpensive to purchase. Since it is successful in this type of application, it was included as a reminder and to allow for one to choose introducing it either by seed or as a live plant.

Current botanical name	Previous botanical name	Common name	% by weight
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	25
Linum lewisii	*NA*	blue flax	20
Lolium multiflorum	*NA*	Italian (annual) ryegrass	20
Astragalus canadensis	*NA*	Canadian milk vetch	10
Deschampsia cespitosa	*NA*	tufted hair grass	10
Festuca saximontana	*NA*	Rocky mountain fescue	10
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	5
Achillea millefolium	*NA*	common yarrow/yarrow cultivar	seed or potted material

Native Seed Mix for Erosion Control Textiles

Various types of textiles are used for erosion control in areas where the introduction of non-native species has caused a decrease in ecological health such as along river corridors, riparian areas and escarpments. The shift in the vegetation community from deep rooted native species to shallower rooted rhizomatous agronomic species decreases the soil binding ability. This leads to erosion issues which are drastically magnified during high water events as the non-native species do not provide soil stability and flood protection.

Unfortunately, native seed is generally slower to establish than many agronomic species and when it is placed under an erosion control fabric, either covered and staked into the soil or enclosed in a bag with soil, many of the native species get out competed. This is because invasive agronomic grasses colonize the surface once the fabric starts to break down. In addition, many of the tufted native grasses that are very effective at binding soils and preventing erosion have small seeds and when mixed into soil and covered with geotextile fabric (e.g., under fabric or in a biodegradable bag), they get buried too deep to germinate.

This seed mix contains aggressive native species that will break through the fabric as intended and cause light penetration. This will allow for the less aggressive smaller-seeded native

species to germinate next. This succession trajectory will bring about a mix of vegetation that will allow for soil binding and erosion control.

This seed mix is appropriate for the majority of slopes experiencing erosion issues. Generally, these slopes will be very dry for the majority of the year but may experience saturation during very high precipitation events or during spring runoff. If the site is very xeric or quite moist, this seed mix may be modified slightly to account for more extreme conditions. Regardless, the species listed here are effective at breaking through geotextile fabric so they should be included in the mix along with additional other species.

Generally, overseeding at the next appropriate time after the soil has been exposed through the germination of the species listed below can further bind soil and increase biodiversity. Overseeding may be a more viable option rather than including less aggressive native species in the original seed mix; however, if time and budget limitations do not allow this, introducing them into the seed mix will at least put them in the site's seed bank. This can possibly lead to their germination in the future after more soil exposure occurs.

Current botanical name	Previous botanical name	Common name	% by weight
Festuca saximontana	*NA*	Rocky mountain fescue	20
Elymus lanceolatus	*Agropyron dasystachyum*	northern wheatgrass	15
Elymus trachycaulus ssp. trachycaulus	*Agropyron subsecundum*	slender wheatgrass	15
Koeleria macrantha	*NA*	June grass	15
Pascopyrum smithii	*Agropyron smithii*	western wheatgrass	15
Linum lewisii	*NA*	blue flax	10
Nassella viridula	*Stipa viridula*	green needle grass	10

Fresh Water Riparian Graminoid Seed Mix at or Above 1:2 Flood Water Surface Elevation

This seed mix was developed to be used in areas that have become devoid of vegetation next to the open water mark along a watercourse or waterbody. This can be due to flooding/scouring or construction. In rural areas, natural recovery is often very successful; however, in urban areas the chance of weed colonization of bare soil increases drastically.

The species in this seed mix are all native graminoids. The project area that this is equivalent to is at or above the 1:2 flood water surface elevation. No forbs were included in the seed mix as the emergent vegetation zone forbs will come in naturally if the habitat is appropriate for them. In addition, emergent forb species are difficult to procure and measures to keep the seed in place will likely decrease the effectiveness of forb germination.

Since these areas are likely on sloping ground, some type of method needs to be implemented so that seed migration down slope does not occur.

It should be noted that this seed mix is less aggressive due to the addition of hydrophytic species (e.g., plants adapted for saturation and anaerobic conditions) such as the reed grasses and manna grasses. Species that tolerate both saturation and drought are more competitive and their percentages by weight may be increased if the project requires a more aggressive seed mix.

Possible substitutions and additions are noted in the table below.

Current botanical name	Previous botanical name	Common name	% by weight
*Elymus trachycaulus ssp. subsecundus**	*Agropyron trachycaulum var. unilaterale*	awned wheatgrass	15
Glyceria striata	*NA*	fowl manna grass	15
*Calamagrostis stricta ssp. inexpansa***	*Calamagrostis inexpansa*	northern reed grass	10
Festuca saximontana	*NA*	Rocky Mountain fescue	10
Juncus balticus	*NA*	wire (Baltic) rush	10
Nassella viridula	*Stipa viridula*	green needle grass	10
Pascopyrum smithii	*Agropyron smithii*	western wheatgrass	10
Poa palustris	*NA*	fowl bluegrass	10
Agrostis scabra	*NA*	rough hair grass	5
Deschampsia cespitosa	*NA*	tufted hair grass	5

*Slender wheatgrass can be substituted for awned wheatgrass to make the seed mix more aggressive. Adjustments should be made to ensure the taller slender wheatgrass does not out-compete the other species due to its competitive abilities and height.

**Narrow reed grass (*Calamagrostis stricta*) can be substituted for northern reed grass if northern reed grass is unavailable, although northern reed grass is more common in the Calgary area.

Fresh Water Riparian Seed Mix at or Above 1:5 Flood Water Surface Elevation

This seed mix was developed to be used in areas that have become devoid of vegetation upland from the 1:2 flood water surface elevation mark. This can be due to flooding/scouring or construction. In rural areas, natural recovery is often very successful; however, in urban areas the chance of weed colonization of bare soil increases drastically.

Both native graminoids and forbs are present in this seed mix. This area will be less frequently inundated with water than the area at the 1:2 flood water surface elevation and as such, may

become be inundated with water approximately every 5 years. Water presence will have an influence on this area but overall, the influence will be minimal.

It should be noted that this mix contains some species that tend to prefer colonizing areas of sandy and silty soils. If sand and silt deposition are minimal, other fresh water riparian seed mixes may be more appropriate.

Since these areas are likely on sloping ground, some type of method needs to be implemented so that seed does not migrate into the water.

Possible substitutions and additions are noted in the table below.

Current botanical name	Previous botanical name	Common name	% by weight
*Elymus trachycaulus ssp. subsecundus**	*Agropyron trachycaulum var. unilaterale*	awned wheatgrass	19
Festuca saximontana	*NA*	Rocky Mountain fescue	16
Pseudoroegneria spicata ssp. inermis	*Agropyron spicatum var. inerme*	(beardless) bluebunch wheatgrass	14
Festuca idahoensis	*NA*	bluebunch (Idaho) fescue	11
Nassella viridula	*Stipa viridula*	green needle grass	11
*Achnatherum hymenoides***	*Oryzopsis hymenoides*	Indian rice grass	9
Elymus lanceolatus	*Agropyron dasystachyum*	northern wheatgrass	9
Koeleria macrantha	*NA*	June grass	5
Pascopyrum smithii	*Agropyron smithii*	western wheatgrass	4
Dalea purpurea	*Petalostemon purpureum*	purple prairie clover	2

Sand grass can be added if desired and the area is sandy.

*Slender wheatgrass can be substituted for awned wheatgrass to make the seed mix more aggressive. Adjustments should be made to ensure the taller slender wheatgrass does not outcompete the other species due to its competitive abilities and taller height.

**Later successional due to hard seed coat so germination will take more than one year; difficult to handle; can be removed and other species increased proportionately; prefers colonizing sandy/silty areas; included to increase biodiversity.

Fresh Water Riparian Seed Mix at or Above 1:100 Flood Water Surface Elevation

Since this type of ecosystem is likely in a flood plain but above any regular influence of water inundation, a seed mix designed for restoring vegetation on the site would be more influenced by the existing surrounding habitat type (e.g., open forest, etc.) than by the presence of the waterbody or watercourse. Seed mixes based on habitat type instead of the likelihood of flooding are listed in this appendix. It should be noted that infrequent flooding is a very important natural disturbance regime; however, as aforementioned, no continuous influence of inundation is present in this type of habitat.