



Restoration and Revegetation Planning for Disturbed Sites in the Exit Glacier Area, Kenai Fjords National Park

Natural Resource Report NPS/KEFJ/NRR—2014/791



ON THE COVER

Clockwise from top left: Western columbine (*Aquilegia formosa*) growing along the trails at Exit Glacier; Revegetation sign on the Harding Icefield Trail in Kenai Fjords National Park; Goat's beard (*Aruncus dioicus*) growing along the trails at Exit Glacier; Park staff checking the ripeness of Lupine (*Lupinus nookkatensis*) seeds.

Photograph by: Kenai Fjords National Park

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Christina L. Kriedeman

National Park Service
Kenai Fjords National Park
411 Washington St./ PO Box 1727
Seward, AK 99664

April 2014

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Kriedeman, C. 2014. Restoration and revegetation planning for disturbed sites in the Exit Glacier area, Kenai Fjords National Park. Natural Resource Report NPS/KEFJ/NRR—2014/791. National Park Service, Fort Collins, Colorado.

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Abstract

A need for a restoration planning document was identified due to impacts from maintenance projects and visitor use in the Exit Glacier Area. Without active restoration, degraded areas will remain without native vegetation for an extended amount of time, and may become dominated with invasive plant species. The purpose of this document is to provide guidance and information for planning and implementing restoration projects in the Exit Glacier Area of Kenai Fjords National Park. This document includes information about project planning, revegetation techniques, compliance, permitting, site monitoring, and a preliminary list of plant species suitable for seed collection.

Acknowledgments

Funding for this project was provided by the National Park Service, Alaska Regional Office, and Kenai Fjords National Park. We'd like to thank the people who assisted in making this project a success, especially Alaska Department of Agriculture, Plant Material Center staff P. Czapla, L. Mahlev, and C. Dinkel; NPS staff F. Klasner, W. Mahovlic, T. Federal, T. Fulton and S. Torigoe.

Introduction

Kenai Fjords National Park is located in southcentral Alaska, including more than 669,000 acres on the southeastern coast of the Kenai Peninsula. The Exit Glacier area in the northeastern part of the park is the only area accessible by road so is the most heavily developed and visited area within Kenai Fjords National Park. Development and visitor impacts in the Exit Glacier area have disturbed natural vegetation, leaving them susceptible to invasive plant species, erosion, and reduced ecological and aesthetic value. National Park Service policy emphasizes minimum interference with natural ecosystem processes and the resulting plant communities.

The construction of the Exit Glacier Nature Center, the removal of the fee collection building, maintenance projects, and visitor impacts along trails have left areas without vegetative cover. Allowing disturbed areas to revegetate on their own can be a slow process, especially on sites without topsoil (Densmore, et al., 2000).

Without active restoration, degraded areas will remain devoid of vegetation for an extended amount of time, or may become dominated by invasive non-native plant species. This could easily lead to the spread of invasive plants to disturbed areas associated with Exit Glacier's recently deglaciated landscape and the effects of climate change. A comprehensive restoration program is needed to repair impacted areas as they occur due to development and user impacts as has been identified in the Exit Glacier Plan and General Management Plan Amendment to be "... revegetated with native plant species and restored to duplicate natural conditions," and to "... prevent the spread of known exotic species populations. . ." (USDI 2004).



Figure 1. Location Map of KEFJ in Alaska.

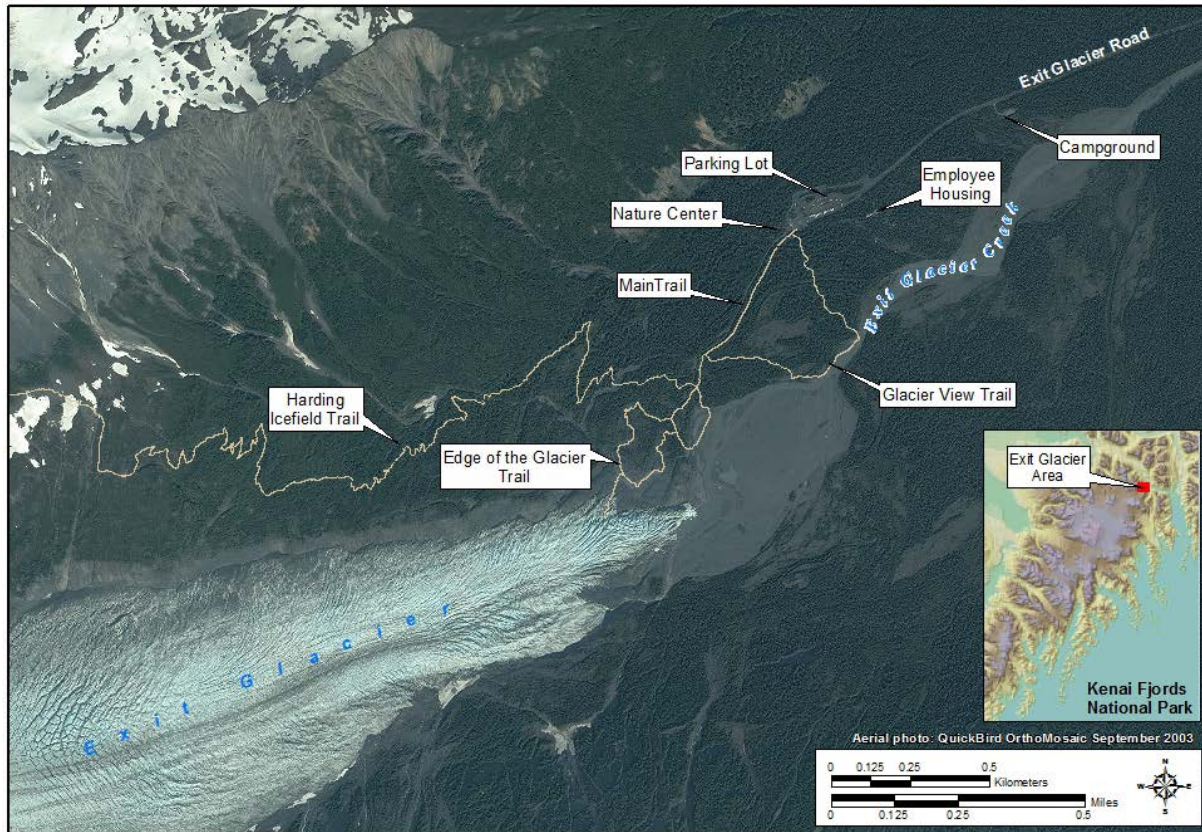


Figure 2. Development in the Exit Glacier Area (Kurtz 2010).

The purpose of this document is to provide guidance and information to meet current and future revegetation needs in the Exit Glacier Area of Kenai Fjords National Park. This report attempts to compile information about project planning, revegetation techniques, recommended plants and seeds, plant and seed collection protocol, monitoring, compliance, and other agencies and organizations that can provide assistance.

Project Planning

Planning is crucial to any successful revegetation project. It can begin before a disturbance occurs, such as a planned construction project, or after a disturbance, such as social trail development, has occurred. A revegetation strategy should be developed based on a site analysis including: the size of the disturbed area; types and forms of available plant species; available soil; elevation and grade; and the desired management outcome. A realistic timeframe for completion of the project is another important consideration; it can take years to collect seed and grow plants before work begins on the ground.

Revegetation Goal

Identifying a revegetation objective is crucial to having a successful project. Park Managers need to decide what goals they want to accomplish when planning a revegetation project.

Revegetation goals can include soil stabilization, reestablishment of pre-existing plant communities and spatial patterns, improved aesthetics, restored ecosystem function (Densmore et al. 2000), number of species, species mixes and groupings, barriers to visitor access, or a combination of these objectives. All restoration goals should include preserving genetic diversity and integrity, controlling invasive plant species, and creating a project that is sustainable.

Site Analysis

The restoration area needs to be analyzed for environmental factors that will affect plant establishment and growth. During site analysis, both abiotic (nonliving) and biotic (living) factors should be considered (Densmore et al. 2000). Abiotic factors effect what plant species can grow in a site. These include: slope and aspect, which influence temperature and moisture levels on the ground; elevation, which can influence the length of the growing season and temperature; and soil characteristics, which can affect stability, compaction, texture, and moisture. Important biotic factors to consider during site analysis include: plant communities that are established in and around the restoration site; pattern and densities of plant populations; and what plant species established in the area can be easily propagated (Densmore et al. 2000).

Species Selection

Plant species for seeding and planting should be selected based on the site analysis, project goals, and plant species that have been used successfully in past revegetation projects. Plants will have a better chance of survival if species that are appropriate for the site based on site conditions like light, water and nutrient availability are selected. Sites with similar characteristics can be used as a reference site to select appropriate species. If there is historical knowledge about what plant community was on the site before it was disturbed, that information can be used to select plant species that are most likely to survive on the site. Select plant species that are typically found together in plant communities because they will usually be suited to the same type of conditions. Plants that are found growing together may have symbiotic associations or may be dependent on the presence of specific species to survive. (Dorner 2002).

Project goals are also an important factor in deciding what plant species to use in a project. If a project goal is to prevent visitors from accessing a closed trail, woody species may be more desirable choice than herbaceous ones. The use of trees and shrubs in a project will produce a much different outcome than if herbaceous species are used or even a mix of the two. The desired goal and outcome of the project will be an important factor in plant selection.

The ability to propagate plants from seed or the availability of plants for transplant is one of the primary limiting factors when it comes to species selection. Not all species easily grow from seed and plants may not be available to transplant to a site if the disturbance was not planned and plants could not be salvaged.

In some cases, disturbed sites will be left to revegetate on their own or only salvaged soil will be reapplied to a site. In this situation, plant species that have propagules left in the soil and that spread from the surrounding plant communities will populate the area. Allowing a site to revegetate on its own is a decision that will be made in the planning process depending on the project goals.

Severity of Disturbance

Densmore, Vander Meer and Dunkle (2000) suggest assessing the severity of the disturbance as a guide to selecting what type of revegetation technique is necessary. They identify three levels of disturbance: light, moderate, and severe. In lightly disturbed areas the vegetation is damaged or destroyed, but the organic layer of soil is still intact. This type of disturbance may only require soil scarification of compacted soil or merely eliminating the source of disturbance so that the site may recover on its own. Moderately disturbed areas have had the vegetative cover and organic soil layer removed so that the top layer of mineral soil is exposed. This level of disturbance will require seeding or transplants from other areas since the remaining soil is likely devoid of most propagules. Severely disturbed areas have all soil removed, exposing only subsurface material that have little nutrients or ability to hold moisture. These areas more generally are difficult to restore, but because the Exit Glacier area is in a newly exposed glacial valley, there are plants adapted to these types of conditions. A project at this level of disturbance may take more time and effort depending on restoration goals.

Establishing a Timeframe

Advanced planning is essential when developing a restoration project. It can take a few years to collect enough seeds or grow enough plants for a project. It is usually not practical to start planning a project in the fall and expect to start work on the ground in the spring if plants and seeds are not already available. In the short Alaska growing season, timing is important for collecting and planting seed and plants. It may take more than one year to complete a project even when plants and seeds are available. Mortality of plants over the winter needs to be considered and more plants may be needed to replace those that died to meet established goals for the project. It is worth the effort to thoroughly evaluate a site and develop a plan that is going to achieve desired goals, as well as work within a realistic time period (Dorner 2003).

Revegetation Techniques

There are many different methods used to restore vegetation to a disturbed site, depending on the situation. Some of these revegetation techniques are appropriate for restoration of planned construction projects and some are more appropriate for restoring areas that have been disturbed past land use practices. One or a mix of these different types of revegetation techniques can be used to meet project objectives.

Site Preparation

Before starting any planting or other revegetation, it is essential to ensure that site conditions are suitable for plants or seeds to grow and survive (Dorner 2002). Slope and soil compaction need to be considered. Sloped landscapes are prone to soil sliding and erosion and should be stabilized before any planting. Waterbars, terraces, and reinforced waterways should be installed if needed (Densmore et al. 2000). Instead of smoothing out the soil surface before planting, it is more desirable to create a rough surface where soil, moisture and seeds can collect. This can be done by running over a site with equipment with tracks or by creating uneven surfaces with the bucket of a backhoe or with handtools.

Soil scarification

Soil scarification is a technique used to loosen or break up soil that has been compacted to increase moisture absorption and create soil conditions that improve the ability of plants and seeds to grow and germinate. For smaller projects, soil scarification can be done by hand raking the soil surface. In large areas, ripping can be done with a tractor with ripper tines, or with a backhoe or loader with a toothed bucket. Ripping should be done to a depth of 25-50 cm (Densmore et al. 2000). When working on slopes, raking or ripping should be done parallel to the slope before planting seeds to provide pockets of soil to hold seed and prevent them from falling or washing down the incline.

Soil Salvage

Top soil is generally very poorly developed in much of the Exit Glacier area and is generally made up of a thin organic layer on top of a layer of mineral soil or gravel. Salvaged top soil is a good medium for planting as well as a source of seeds. Soil is alive and contains microbes, invertebrates, nutrients and living plant material. If there is top soil available on a site before disturbance occurs, it should be scraped off and stored for reapplication to the site after a construction project is completed. Soil can be removed with hand tools on a small site, and with a bucket or bulldozer on larger sites. Soil is full of living plant propagules and top soil alone can be used to revegetate a disturbed area much more quickly than if it is left to revegetate on its own. Soil can be reapplied by sprinkling it back over the area after site preparation with shovels or a bucket on heavy equipment.

If there is only gravel exposed at a site, there are plant species in the Exit Glacier area that are adapted to growing in gravel soil; the biggest concern is that gravel does not hold moisture for very long. If top soil is available, it should be saved as it not only provides a source of plant propagules, but it holds moisture so plants and seeds do not dry out as quickly.

Storing soil

When salvaging topsoil the main concerns should be keeping the soil alive, free of invasive plant infestations, and protecting it from damage such as compaction while it is being stored (Colorado Department of Natural Resources 1998). Soil should be used in the same season that it was stockpiled if possible. Living microorganisms are sensitive to anaerobic conditions and compaction. Plant propagules may decompose and no longer remain viable if stored over time. This does not mean that soil stored over a number of years should not be used; there are some plant species whose seeds can survive many years and top soil holds moisture and provides germination sites for seeds coming from outside the revegetation site. Soil should be stored where it is not exposed to invasive plants that could be spread to restoration sites. Stored soil can be covered with a tarp to protect it from erosion and disturbance, but it should allow air and moisture to penetrate. It is better to store many smaller piles of soil than to have one big pile because large piles can create anaerobic conditions, which can kill microorganisms living in the soil (Colorado Department of Natural Resources 1998).

Natural Revegetation

Disturbed sites with a low level of impact to soils and plants are good candidates for natural revegetation. Natural revegetation is relatively inexpensive, but can be a slower process than planting native plants and may leave the site open and more susceptible to invasion by non-native plants. There must be native plant propagules in the soil or a source of native reproductive material close enough to the site that can repopulate the disturbed area (Dorner 2002).

These types of sites may only need compacted soil to be scarified and protected from further disturbance until native vegetation reestablishes. The use of salvaged top soil containing propagules is another effective way to promote natural revegetation (Densmore et al. 2000).

Natural revegetation is appropriate for small higher elevation disturbed sites in the Exit Glacier area, which are dominated by Alaska bellheather (*Harrimanella stelleriana*), partridgefoot (*Luetkea pectinata*), and Aleutian mountainheather (*Phyllodoce aluetica*). These species can be encouraged to spread back into linear disturbed areas, such as social trails along the Harding Icefield Trail, by scarifying the soil to reduce compaction and adding a light application of 20-20-20 fertilizer (Czapla 2011).

Planting

Native plants can be reestablished in a restoration site by seeding, using salvaged plants from a construction site, and using dormant cuttings or container-grown plants depending on what may be available and the timing of the project. Preserving the genetic makeup of the site is important and includes using native plants that are genetically similar to the surrounding undisturbed communities (Densmore et al. 2000). To maintain genetic integrity, Densmore, Vander Meer, and Dunkle suggest using plant and seed sources from within a six kilometer radius of the disturbed area. They also suggest that collections should be made within the same broad vegetation type and in areas that have not been infested with non-native plant species.

The visual appearance of the final restored site must also be taken in account during the planning process. Plants should not be spaced evenly or in distinct rows. Use the undisturbed surrounding areas or a similar plant community as a model on how to space plants in a site and to decide what the final density of plants should be when the project is complete.

Seeds

Seeds can be a viable option when native plants are not available for salvage or transplant. During planning, identify the plant species that occur in conditions similar to the restoration site so species that are best suited for the site can be selected for seed collection. At least one year should be allowed for collecting the amount of seed needed for a project and larger restoration sites may require more.

Seed Collection

Locate and carefully document plant communities that will be used for seed collection so plants can be easily relocated by staff when the plants are in seed. Sites that have similar elevation, aspect, and slope to the restoration site should produce seeds of plants best suited to the site.

Not all plant species are easy to grow from seed. As part of this project, the Alaska Plant Material Center assisted the park in identifying plant species growing in the Exit Glacier area that they have had success growing from seed. Appendix A provides a list of seeds collected in the park for use in revegetation projects that are known to easily germinate from seed. This list provides a place to start for selecting species to grow from seed, but park staff should experiment with growing different species of native seeds and continue to expand this list.

Areas that are infested with invasive plant species should be avoided when considering sites for seed collection. Invasive plant seeds could easily be spread to the restoration site if they are mixed with other plant species where seeds are being collected.

Seed collection bags should be labeled with the species name, date, aspect and percent slope, and location where the seeds were collected. Each species should be collected into a separate bag to make it possible to differentiate them during processing make them easier to clean. Seeds of the same species, but collected from different sites should be bagged and labeled separately (St. John et al. 2003). Tools for seed collection that are useful in the field include: plastic and paper bags, pen/pencil for labeling bags, scissors or pruning shears, GPS unit and camera.



Figure 3. Biological Science Technician harvesting seeds in Denali National Park and Preserve (NPS Photo).

Collection methods that do not damage the plant include hand picking or stripping, cutting seed clusters or seed heads off the plant. Do not remove all the seeds from an individual plant; overharvesting can impact the ability of a plant to survive and reproduce. A general guideline is to only harvest one third of the seed in a population and leave two thirds. Seeds should be collected from many individual plants in a community with different characteristics to maintain

genetic diversity. This includes harvesting seeds from tall, short, robust, and scrawny plants (Dorner 2002).

Collection Timing

It is important to locate plants for seed collection early in the growing season and monitor seeds for ripeness throughout the summer. If seeds are harvested too early they will not be viable, and if they are collected too late seeds may have already dispersed or shattered. Different plant species ripen at different times so monitoring plant phenology throughout the summer is the best way of tracking ripeness over the growing season (Luna and Wilkinson 2009).

Seeds will not mature at the same time every year depending on plant phenology. Winter snowfall, temperature, elevation, and precipitation are some of the factors that can affect the timing of plant development. Plant populations at lower elevations generally mature earlier than at higher elevations, so collections can start at low elevations and move up in elevation as plants mature and seeds are ready to harvest (Luna and Wilkinson 2009). Revisit plants identified for seed collection a number of times over the summer looking at the phenology of flowers and seeds so the window for seed collection is not missed.

Drying seeds

After seeds are collected they should be allowed to dry before cleaning or storing to prevent mold or decay. Freshly collected seeds generally have high moisture content even if they seem dry at the time of collection. If seeds are collected in the rain they may need extra time for drying. Seeds can be spread out thinly on screens for drying. After drying, non-fleshy seeds should be stored in paper or cloth bags to prevent spoilage. Fleshy fruits will need to be cleaned quickly so they don't spoil. They need to be kept in plastic bags and kept cooled before shipping to be cleaned (St. John et al. 2003).

Cleaning and Storing

After seeds are dry they are shipped to the Alaska Plant Material Center in Palmer for cleaning. The park does not have the equipment and facilities to clean seed at this time. Cleaned seeds should be stored in cool, dark, dry conditions. They do not need to be kept frozen. Seed should be used within a couple of years of harvest because seeds lose their viability over time (St. John et al. 2003).

Overcoming Seed Dormancy

Seed dormancy is a way for seeds to wait to germinate until conditions are suitable for growth. Some seeds require specific conditions to break this dormancy and will need specific steps to be taken before the seed is planted so the seed will germinate. Some seeds do not require special steps to assist with germination, so some research will be required to identify which species will need special treatment before planting and which will not.

Seed Scarification

Some seeds will need to be scarified before they are planted to improve the rate of germination. Scarifying is done by physically breaking open or scratching the seed coat to let in moisture and to allow gas exchange (Densmore et al. 2000). This can be done mechanically by actively scratching the seed coat between a sandpaper blocks.

Seed Stratification

Some types of seeds require exposure to dry and freezing temperatures or moist and cool temperatures for a period of time to break dormancy. This is called seed stratification and this breaks seed dormancy regulated by the inner seed tissue (Rose et al. 2008).

When to Plant Seeds

For plants to germinate during the summer season, plant the seeds as soon as the snow melts and the ground is no longer frozen, generally in early June depending on the snow pack. Seeds planted in July and August are more likely to produce seedlings that are not well established and may not survive the winter. Seeds can also be planted in the fall and will not germinate until the following spring (Densmore et al. 2000). Fall seeding should occur by early September before the ground freezes.

Seeding Rate

The desired plant density identified during planning will govern the seeding rate and the total amount of seeds that will need to be collected in advance. If the area is large or the density is high, seed collection may take more than one season.

Seeding

Broadcast seeding

Broadcast seeding scatters seed on the ground by hand, or using a handheld or hand operated broadcast seeder. This type of seeding is appropriate for small projects that have been typical in the Exit Glacier area. The seeding rate should be increased to get the desired plant density when broadcast seeding due to the inaccuracy of application (Wright and Czapla 2010). If seeds are small or very light, sand may need to be mixed with seeds to get more even coverage or to get the plant density desired on the site. The advantage of this technique is that equipment is cheap and easy to use, and seeds are scattered randomly. After seeds have been broadcast they will need to be raked or harrowed to cover the seeds with soil.

Drill Seeding

Drill seeding is a method of seeding where equipment is used that places the seed below the surface of the soil and covers it. This technique is typically used with larger seeds and requires specialized agricultural equipment. This seeding method is not recommended for use in the gravelly soils typically found in the Exit Glacier area, but is mentioned in this document so planners know what other techniques are available. This method is expensive. It plants seeds in straight rows and requires equipment that is difficult to get to more remote sites (Dorner J. 2002).

Hydroseeding

Hydroseeding uses a slurry containing water, seeds, and wood fiber, along with other additives such as fertilizer, soil stabilizers, and dye for ease of application. If seed and mulch are applied together there is a good chance that seeds will be prevented from making contact with the soil. If seeds germinate in the mulch and do not make soil contact, they will dry out and die (Colorado Natural Areas Program 1998). Hydroseeding is often used on large projects or on projects that are difficult to access due to steep slopes (Colorado Natural Area Program 1998). There are many things to consider when deciding whether to hydroseed. Large amount of water are used in the process, so there must be plenty of water available near the restoration site. The equipment is

complex and if mechanical problems occur, there can be significant delays (Wright and Czapla 2010).

Raking

After seeds have been spread out on the site they should be raked to increase seed contact with soil. Raking increases the germination rate of seeds by covering them in soil and protecting seeds from the wind, runoff and herbivory (Densmore et al. 2000). Raking can be done by hand if it is a smaller size site or by harrowing or chaining on large sites (Dorner 2002).

Dormant Cuttings

Cuttings are collected from dormant plant species that are able to easily root. This includes woody species like willow and cottonwood. These species are adapted to easily root after flooding when stems are buried. Not all species of willow root easily from cuttings. Table 1 below provides a list of willow species that are found in the park, that root from cuttings, and what habitat type they are found in. To improve the chances that a willow species will do well at a site, use cuttings from the same willow species that are growing in the area under similar conditions (soil type, available moisture, sunlight, etc.). If possible locate willows species for use in a project during the summer when plants still have leaves and are easier to identify. Mark plants that have been selected to harvest cuttings with flagging or collect GPS coordinates so that they will be identifiable in the spring when harvesting of cuttings will take place. Black cottonwood (*Populus balsamifera ssp. trichocarpa*) is another woody species that is appropriate for use as a dormant cutting. Black cottonwood is easy to identify when it is dormant, but selecting plants to collect cuttings from ahead of time will save time in the spring when there can be copious amounts of snow on the ground. Limit the amount of cuttings taken from one plant. Spread out the impact of cutting branches over a larger number of willows or cottonwood (Densmore et al. 2000).

Table 1. Willow and cottonwood species found in the Exit Glacier area that root readily from cuttings and their habitat.

Taxon	Common Name	Habitat¹	Wetland Indicator Status
<i>Salix alaxensis</i> (Anderson) Coville	Felt-leaf willow	Gravel bars of rivers with in association with other alpine meadows, and young forests.	Facultative
<i>Salix stichensis</i> Sanson ex Bong	Sitka willow	Very common in coastal areas in wetlands, disturbed sites, and on sandbars of fast-flowing creeks.	Facultative
<i>Salix pulchra</i> Cham.	Diamond-leaf willow	Wetlands bordering lakes and on sandbars of fast-flowing creeks, occupying the wetter zone of a habitat.	Facultative Wetland

Taxon	Common Name	Habitat¹	Wetland Indicator Status
<i>Salix barclayi</i> Andersson	Barclay's willow	Dominant species in subalpine willow thickets and in moist disturbed sites at lower elevations, very common along road right-of-ways.	Facultative
<i>Populus balsamifera</i> P. <i>trichocarpa</i>	Black cottonwood	Grows on recently disturbed alluvium, riparian habitats, and moist woods on mountain slopes: very flood tolerant.	Facultative

¹(Collette 2004)

Collecting Cuttings

Cuttings should be collected in early spring before leaves and catkins appear. Cut branches that are ¼ inch to 2 inches in diameter and 3 to 4 feet long. Dormant cuttings can be collected and rooted in sterile soil before planting, or stored for a short time, and placed in the ground as soon as the soil has thawed (Muhlberg and Moore 1998, Walter and Hughes 2005).

Storing Cuttings

Cuttings can be stored by burying them in the snow in a shady location to help keep them viable if the ground is still frozen and they cannot be planted immediately. Keep branches long while cuttings are stored to reduce drying. If cuttings are stored, only remove branches that will be planted in a day and place them in a bucket of water to reduce drying while at the revegetation site. Soaking cuttings up to 48 hours before planting can help to increase survivability (Muhlberg and Moore 1998, Walter and Hughes 2005).

Planting Cuttings

Dormant cuttings can be planted as soon as the soil thaws. It is ideal to plant cuttings before July so there is time for roots to become established before the end of the growing season. Dormant cuttings can be planted directly in the ground, called live staking, or they can be placed in pots of soil and allowed to form roots before planting in the ground (Muhlberg and Moore 1998, Walter and Hughes 2005). Several live stakes can be cut from one dormant cutting. Cut live stakes that are 10 to 18 inches long and approximately ½ to 3 inches in diameter. One or two leaf buds must be left at the top of the stake so that it will eventually grow leaves. Remove the upper part of the branch where flower buds, or catkins, are located (Muhlberg and Moore 1998, Walter and Hughes 2005). If soil is soft, a long narrow shovel can be used to open up a hole to plant the live stake. If soils are hard, a short piece of ¾ inch or less rebar can be used to make a hole by hammering it into the ground. The live stake can then be placed in the hole leaving no more than 2 buds above ground. Soil must make contact with the live stakes once they are placed in the hole to allow rooting and to retain moisture. Putting water in the hole around the stake reduces air pockets around the stem and increases soil contact. Leave a small well around the stem of the live stake to collect and hold water. The live stake will need to be kept moist for at least 4 to 6 weeks while roots are becoming established. Live stakes will have much higher survivability if they are planted in moist soils. If plants are placed in gravel soils, stakes will need regular

watering to keep stems and newly forming roots from drying out. Topsoil is not necessary (Muhlberg and Moore 1998, Walter and Hughes 2005).

Transplants

Transplants can be salvaged from the project or from a nearby area if appropriate. Transplants provide an immediate visual improvement (Wright and Czapla 2010). They should be replanted as soon as possible so the root system can become established before winter. If transplants need to be stored, they should be put on plastic tarps with as much soil attached to the roots as possible. They should be kept in shaded areas to keep them from drying out, and they will need to be watered if there is not enough rainfall to keep soil moist before they are planted in the ground.

Careful planting will improve the likelihood that a transplant will survive. Dig a hole that has plenty of room for the transplant's roots to spread out. Make sure that the crown of the plant is level with the surface of the soil at the revegetation site. Cover plant roots completely with soil. Water the plant to increase soil contact with roots and to prevent drying. Leave a small well in the soil around the plant to collect and hold water (Muhlberg and Moore 1998, Walter and Hughes 2005).

Vegetation Mats

Vegetation mats will most likely be utilized in the alpine zone of the Exit Glacier area which is dominated by mat-forming species like mountain heather (*Phyllodoce spp.*) and partridgefoot (*Luetkea pectinata*). Vegetation mats are good for filling in impacted areas and providing immediate vegetative cover if they become available during a trail construction project.

A useful strategy for removing vegetative mats is by cutting around the edge of the vegetation to the desired size using a tool with a sharp edge. Use a shovel or other sharp tool to undercut the mat so it can be peeled away by hand. Cut the mat into sizes that can be carried by hand or that are the desired size for a project (Densmore et al. 2000). For alpine plants, vegetation mats should be cut into pieces no smaller than ten inches square if possible to decrease desiccation and increase the likelihood that enough of the root system remains for the plants to survive. For vegetation mats that contain larger size plants, cut pieces large enough so that plants have enough root system to survive. If small pieces of vegetation mat remain after larger mats are removed, plant them in between larger mats to protect them from drying out.

If vegetation mats are not planted immediately, keep them moist and protected from the sun and drying winds. Tarps can be used to cover them for short amounts of time to decrease desiccation. If conditions are dry and water is available it is a good idea to water mats if they are stored for more than a few days before they are planted in the ground.

When planting a vegetation mat, dig a depression in the soil deep enough so the top of the mat is at ground level. Make sure soil beneath the mat has been scarified if it has been compacted. Place the vegetation mat into the depression and make sure soil is covering roots and the area around the exposed edges of the mat. Water vegetation mats after they are transplanted to increase soil contact with roots and to reduce shock (Densmore et al. 2000).

Sprigs

Sprigs are made by splitting a transplant into smaller units made up of shoots with roots attached. Grasses are ideal for splitting up into sprigs. The advantage of using sprigs is that there will be many more individual plants to use in a restoration site. This is useful if limited supplies of transplants are available and there is a large area to revegetate. Only harvest the number of transplants that can be separated into shoots and planted in a day because shoots can easily become dried out. If shoots are not being harvested on-site and need to be transported, place them in water until they are planted and protect them from wind and direct sunlight. Sprigs can be planted by inserting a shovel in the soil and pushing it forward to create an opening. Place the sprig in the opening, remove the shovel, and pat the soil down around the spring (Muhlberg and Moore 1998, Walter and Hughes 2005).

Container-grown plants

Planning for the use of container grown plants will have to begin years in advance. The park does not have the facilities or resources to grow plants, so a contractor or an outside agency like the Alaska Plant Material Center will be needed to grow plants. The Alaska Plant Material Center can also provide technical assistance with specific revegetation questions. The planting of container-grown plants will be more costly than seeding, but will provide larger and more established plants to a site, and can provide immediate visual appeal. Seeds or cuttings will need to be collected from the park and sent to the grower for propagation.

Container-grown plants need to be hardened off before they are planted in the ground to acclimate the plants to their new environment. Bring container grown plants to the planting area about a week ahead of time. Make sure they are kept watered and protected from extreme winds and sun while they are adjusting to new environmental conditions. When planting container grown plants in the ground, make sure the hole is large enough for the entire root system to be covered. Roots should have plenty of room to spread out within the hole. If the roots at the bottom of the pot have grown long and twisted in the pot, it may be necessary to break up or cut the roots before planting so they hang down more vertically (Densmore et al. 2000).

Fertilizer

Fertilizer may be useful in some revegetation projects, but in the Exit Glacier area many species are adapted to growing in nutrient-poor soils. There are also plant species that have a symbiotic association with mycorrhizal fungus which naturally enhances nitrogen in the soil.

The Alaska Plant Material Center staff suggests using fertilizer on narrow social trails and linear sites where native plants are already moving back into these impacted areas. Revegetation can be assisted by breaking up compacted soil and applying a light layer of fertilizer. This will promote the growth of native species already trying to recolonize disturbed areas. The recommend application rate is 12 pounds per 1000 square feet of area of 20-20-10 NPK (percentages of nitrogen, phosphorous, and potassium) fertilizer (Czapla, 2011).

Planting Timing

It is important to consider planting timing when planning a revegetation project, especially since the growing season in Alaska is so short. Seeds and plants need to be in the ground long enough during the growing season to become established so they can survive the winter. Planting should

be completed as soon as the snow melts and the ground thaws. All planting should be completed by August 31 at the latest (Wright and Czapla 2010).

Maintaining/Watering Plants

During the planning process, establish what type of maintenance is needed after planting is complete. Who will be responsible for site maintenance needs until plants are established should be determined during planning.

Revegetation projects may require watering until plants are established. The water system is limited in the Exit Glacier area, so the plan must address what source of water can be used and how it will be transported to the site. A water tank on a trailer can be used for sites in the parking lot or along the road system. Backpack water tanks with sprayers can be used on more remote sites that are only accessible on foot and where proximal water is limited.

Water applications rates and timing will depend on the amount of precipitation after planting, but water will be needed for plants that are transplanted when they are first put in the ground and during dry times during the growing season.

Assume there will be some plant mortality in a revegetation project due to conditions on the site, climate, planting methods and plant maintenance. Plan ahead and have plants available to replace any lost over the year. Monitor revegetation sites to determine how many plants need to be replaced to get desired species densities.

Contracting and Agreements

If outside partners, agencies or business are going to be involved in a project, a contract or agreement will be necessary. It can take from three to six months to complete a contract or agreement, so start the process as early as possible. The park Contracting Officer will be able to help decide what process is most appropriate for a project.

Contracts

A contract can be completed by a business or an organization and is used to procure property or services to get work completed independently of the Park Service. The contract will spell out the work that needs to be completed and the Park Service pays for the work to be done. Work with a Contracting Officer to decide if the contract can be sole-source or will have to go out to bid.

Agreements

There are three types of agreements; a grant, a cooperative agreement and an interagency agreement. Agreements involve working with one or many partners that are typically from a university, another government agency, or non-profit organization. With all agreements, there must be justification that the agreement benefits the public or the receiving organization, and that the park is significantly involved in the project.

Identify Compliance Needs

During the planning process, compliance needs should be identified and completed well before the actual project begins on the ground.

NEPA

All National Environmental Policy Act (NEPA) compliance must be completed before the project begins. NEPA compliance should be included in any preplanned project that will cause ground disturbance, and any restoration work should be included.

Wilderness

If a project area is inside the proposed wilderness boundary of the park, a Minimum Requirement Analysis (MRA) is required to be completed. The park's Wilderness Coordinator will be involved if this is the case.

Cultural Compliance

Cultural compliance must be completed for all projects to determine compliance with Section 106 of the National Historic Preservation Act. Contact the parks Cultural Resource Manager for guidance on how to initiate this process.

Plant Material Held Temporarily Outside the Park

Because Kenai Fjords National Park does not have the facilities to clean and store seed or to grow plants, other agencies or contractors will be performing this service. Seeds and plants that are held outside the park will require a signed DI-105 Receipt for Property. This will allow the park to track where and how much plant material is being held outside the park and when it is returned.

Other Permits

Seeds and plants may be collected from outside park boundaries on lands belonging to other agencies if appropriate. Check with each individual agency for permitting and any other requirements.

Invasive Plant Mitigation

Ground disturbance creates open spaces for invasive plants to easily colonize. Restoring a site with native plants as soon as possible decreases the chances that invasive plants will invade the area. Vehicles, tools and humans can spread invasive plants if they do not take precautions when working in areas that have been disturbed.

Site and Material Inspection

The area around a disturbed site may be infested with invasive plants and they can be spread to a disturbed site by those working in and around the area. Invasive plants can also be spread to a disturbed site from other areas. Make sure that vehicles and individuals do not access the disturbed area through an area infested with invasive plants. Materials used for fill, such as sand and gravel, can be infested with invasive plants. Inspect fill sources for invasive plant infestations before it is brought on site.

Equipment Inspection

Invasive plants can be spread from other areas on equipment. Vehicles and tools should be cleaned and inspected before they are used within the park. Avoid traveling through sites infested with invasive plants to get to the restoration area to work. Individuals working in the site should make sure clothing and shoes are free of soil and plant propagules from outside the site.

Plant and Seed Sources

If container-grown plants are used in a project, they could be a source of invasive plants. Container-grown plants will be grown outside the park by another agency or a contractor and may be exposed to invasive plants. Inspect the site for invasive plant infestations where native plants will be grown. If invasive plants are found, make sure they are removed before plants for use in park restoration projects are grown. Check the soil in pots for invasive plant species before placing plants in the ground.

Avoid collecting seeds from areas that are infested with invasive plants to prevent spreading them to revegetation sites. Non-native plant seeds could easily get mixed in with native seeds during collection.



Figure 4. *Taraxacum officinale* growing in KEFJ (NPS Photo).

Protecting the Project Area

After planting is complete, it is important to install some type of barrier to protect the project from foot or vehicle traffic. There should be a balance between providing protection to the project and making it as visually unobtrusive as possible (Densmore et al. 2000). Check sites regularly so if barriers are not working, a new strategy can be implemented before the revegetation project is ruined.

Signs

Signs can be a simple way to give the public a message about why they should stay off a recently restored site. Make sure to use the latest NPS sign standards and consult with appropriate park staff when developing new signs. The message should be clear and concise. The size of the sign should be appropriate for the location. Use the smallest size needed to keep impacts to the view shed to a minimal level.

Interpretive signs can be used as an opportunity to educate the public. Longer and more descriptive text can be used to discuss what impacts occurred at the site and what the goals are for restoring it. A restoration project can be a great way to educate the public about impacts and the importance of maintaining intact ecosystems.

Fencing

Fencing can provide a higher level of protection for restoration projects. It puts an obstacle in front of or around a revegetation project. Fences can be made of many different materials including: wood, rope, metal, or plastic. Signs are often used in association with fencing to inform the public why there is a fence and why they should not go into the fenced area. Fencing should be checked and maintained regularly to monitor whether the fence is still protecting the restoration area and to check for any problems it may be causing to wildlife or the environment (Muhlberg and Moore 1998, Walter and Hughes 2005).

Rock barriers

Rocks can create a barrier to restoration projects in some circumstances. Large rocks can be used in landscaping around revegetation projects to deter vehicles from parking in or driving through the project area. Rocks can be used to deter visitors from walking through an area by making the surface of the ground uneven and difficult to walk on. Partially burying rocks make them more stable, and looks more natural (Densmore et al. 2000).

Jute Mesh

Jute mesh can be used to deter visitors from walking onto revegetation sites and to prevent erosion on slopes. Jute mesh provides protected areas for seeds to settle and grow, and spaces for plants to grow between the wide mesh. It is biodegradable in warmer climates, but can be



Figure 5. Revegetation sign used along the Harding Icefield Trail (NPS Photo).

persistent in Alaska's cold climate. It is important to use signs in association with the jute mesh so visitors understand that they should not walk on the mesh. When trails are muddy, jute mesh can look like an inviting dry path to walk on.

Monitoring

Monitoring provides feedback on how well a restoration project is meeting project goals and objectives. It is also an important tool that can be used to identify problems early while they are still small or inexpensive to address. Monitoring provides information about what is working and what is not (Elizinga et al.1998). It is an organized way to keep an eye on a project so changes can be made to make the project successful. Monitoring with an identified objective allows project planners to use an adaptive management approach where management actions are altered as information is gathered about what techniques work and what do not to meet identified goals. Monitoring may be one of the most important steps in a revegetation project but is the component most often left out or forgotten (Dorner 2002).

The monitoring technique selected often reflects the complexity of restoration goals, and the available resources and staff skills. Alaska Plant Material staff recommends monitoring projects for at least 5 years. Formal site monitoring should begin before site work begins and completed at least once a year typically in August when the growing season is mostly complete.

To keep monitoring fairly simple, presence/absence and photo points can be used together to monitor a species of interest (Czapla, P. personal communication, March 3, 2013). Presence/absence techniques simply document whether the species occurs at the site or not. A single species or multiple species can be documented at a site. Photopoints are photographs taken from the same point and includes the same photographic extent so the changes in vegetation can be compared over the years. A global positioning system (GPS) unit and compass should be used to document the exact location and bearing the photo was taken from. Photos taken in previous years can also be used as a guide to recapturing the same area of landscape or features in the frame (Elizinga et al.1998).

If a more quantitative measure is needed to reflect project goals, then measuring cover will provide a more detailed look at changes in vegetation. The point intercept technique measures cover based on the number of times a target species is intersected by a point along a line. (Elizinga et al.1998).

There are other methods for monitoring the progress of revegetation projects including monitoring species density, frequency, and other techniques for measuring cover that can be utilized depending on what specific monitoring goals are identified for a project. Only a few techniques have been discussed in this document.

Discussion

This document was developed to provide guidance during planning and implementation of revegetation and restoration projects. It does not include every possibility and should be considered a starting point for developing a project. The plant species lists in this project includes an initial list of species that have been recommended for use in the Exit Glacier area, but new species should be added to the list as we experiment with using different types of plants and seeds on projects in the future. It is hoped that the content of this document will be considered during planning when park projects will cause ground disturbance that will need to be restored.

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Appendix A: Plant Species Identified for Seed Collection

This list is the first years attempt at collecting native seeds for revegetation projects in the park. This list is not meant to be a comprehensive list of plants for seed collection. This list should expand, change and evolve over the years as park staff experiment with using different species of plants as a source of seeds in restoration projects.

Plant Species List for Seed Collection in the Exit Glacier Area in 2012

Taxon	Common Name	Seed Collection Timing
<i>Aquilegia formosa</i>	Western columbine	Late August
<i>Aruncus dioicus</i>	Goat's beard	Late September
<i>Calamagrostis Candadensis</i>	Blue-joint Reedgrass	Late September
<i>Carex mertensii</i>	Merten's sedge	September
<i>Festuca rubra</i>	Red fescue	Early September
<i>Hordeum brachyantherum</i>	Meadow barley	Early September
<i>Lupinum nootkatensis</i>	Lupine	Late August
<i>Phleum alpinum</i>	Alpine Timothy	Early September
<i>Poa alpina</i>	Alpine Bluegrass	Early September
<i>Trisetum spicatum</i>	Spiked trisetum	Early September
<i>Valeriana sitchensis</i>	Sitka valerian	Early September

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NPS 186/124302, April 2014

National Park Service
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Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

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