Project Implementation

Erosion control fabric supporting willow stakes and seeded plants, along the banks of the Matanuska River

Section 2:

Planning

A constructed berm at Fishing Hole Inlet on the Homer Spit awaits revegetation in this 1999 photograph. The establishment of vegetation is a practical and effective means of maintaining a constructed grade.

Planning should be the first step for any project. The revegetation/restoration process requires careful planning and management, as the designer is working with biological processes that have specific timing and environmental requirements. When multiple stakeholders are involved in a restoration project, design decisions should be coordinated. This allows restoration goals to be implemented effectively.

Goal-Setting and Preparation

The planning phase of a restoration project encompasses several steps. These include

- gathering baseline data
- identifying site problems
- collecting reference plot information
- setting goals

Goals tell managers about the desired state of the ecosystem, as compared to a reference ecosystem. Objectives are measures taken to attain the goals, and are evaluated on the basis of performance standards (SER, 2002). Without clear goals, objectives and performance standards, a restoration project should not move forward.

Performance standards come from an understanding of the reference ecosystem and the realization that the trajectory of the degraded site should progress towards the desired state of recovery comparative to the reference site.

If data collected and interpreted during monitoring shows that performance standards have been met, then project objectives have been reached. Revegetation goals may include erosion control, visual enhancement, weed control, or other desired outcomes. Often, in coastal areas, the goal is erosion control.

Baseline Environmental Data Collection

After determining the revegetation objectives, take note of factors influencing the site. These include climate, soils and vegetation. Climate includes temperature, precipitation, and wind, plus other factors. Climate records can be obtained online, through resources such as the National Oceanographic and Atmospheric Administration's National Climate Data Center, at www.ncdc.noaa.gov/.

A soils inventory involves identification of soil types and characterization of the soil types, as well as distribution. Soil surveys have been completed by the Natural Resource Conservation Service (NRCS) and are accessible online at soils.usda.gov/. If feasible, a sample of soil from the site should be sent to a soil testing lab. There, a lab analysis will check the physical (texture, density), chemical (pH, salts, organic matter) and biotic (activities of organisms) characteristics of the soil. All of this information aids in developing a seed and fertilizer mix.

Mapping of vegetation types and characterization of the vegetation types in regards to production, cover and density will be part of an in-depth vegetation analysis. Review available data for your region prior to creating a revegetation plan.

Reference Sites

A reference ecosystem serves as a model for planning a revegetation/restoration project, allowing for measurement of the progression of an ecosystem towards its desired end-state (SER, 2002). It's important to note that a restored ecosystem can never be identical to the reference site. A reference system is best assembled from multiple reference sites to account for the possibility that one particular site may be biased.

Many sources of information are useful in describing a reference site, such as lists of species present, maps of the site prior to damage, and aerial and ground-level photography (SER, 2002). Reference ecosystems should have high production and species composition in order for managers to evaluate the progress of the ecosystems towards its desired state of recovery. Eventually, the restored ecosystem should emulate the reference site (SER, 2002).

Collecting information from a reference site can quickly become expensive, and is often limited by available funds .

Permitting

Permits are required for some projects. Projects that disturb an acre or more, discharge storm water into a municipal separate storm sewer system (MS4), or into the surface waters of the United States require an Alaska Pollutant Discharge Elimination System (APDES) Permit. This permit is issued by the Alaska Department of Environmental Conservation (DEC), in accordance with the Federal Clean Water Act. APDES permits are issued as either a phase one or phase two permit depending on the size of the area disturbed and nearby population. More information about the APDES program can be found at the DEC website, at dec.alaska.gov/water/npdes/.

A dewatering permit is necessary if the total discharge volume is equal to or greater than 250,000 gallons and wastewater discharge is located less than one mile from a contaminated site. Other permits are necessary for projects that affect fish habitat, historic properties, endangered species, and other concerns.

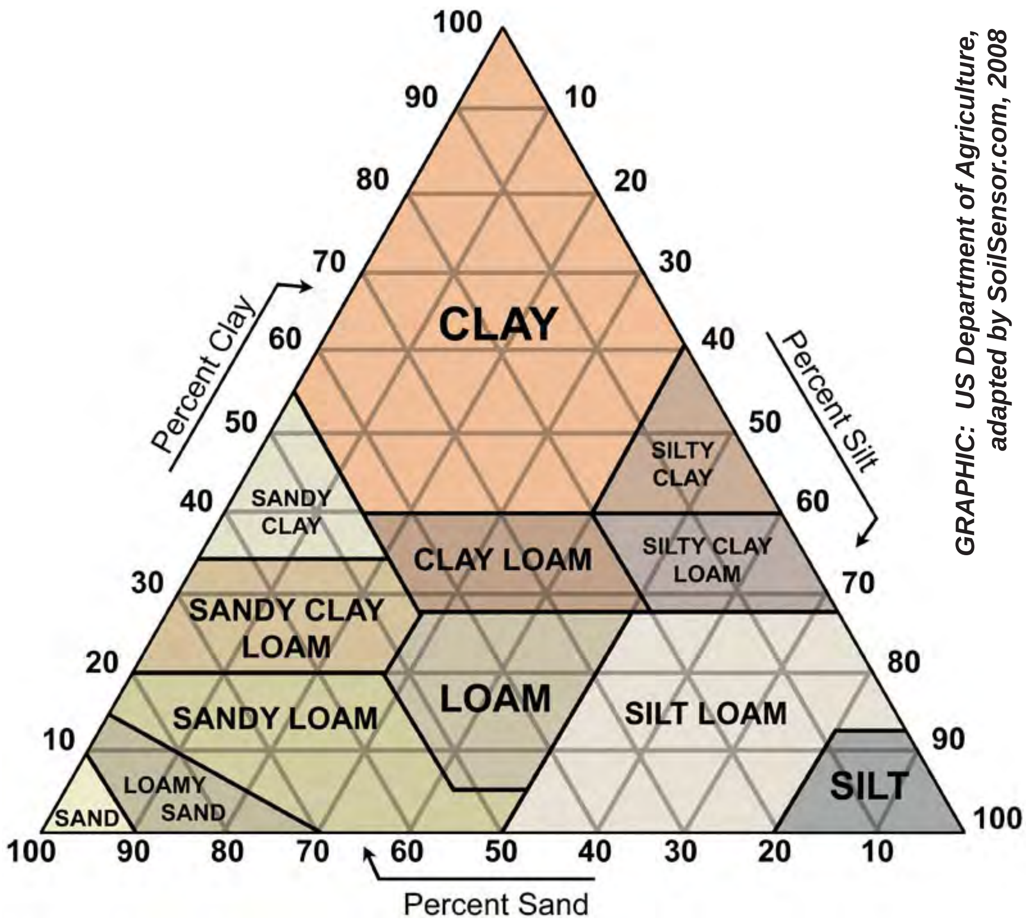
Identify Site Conditions and Develop Mitigation Measures

Potential limiting factors that will affect revegetation establishment are extensive, and a complete discussion is beyond the scope of this guide. This publication is focused is on the limiting factors that have been observed regularly on coastal sites in Alaska, and other parameters important for revegetation success.

Plant growth depends on water availability. The amount of water a type of soil can hold and how easily roots can penetrate the soil depend on the texture and structure of the soil.

Soil Texture

Soil is made up of mineral particles, organic matter, air, and water. Soil texture is determined by the composition of soil, expressed as % sand, % silt, and % clay. Seven classes of particle size are acknowledged with sands being the largest (2.0-.05 mm), silts (.05-.002 mm) intermediate in size, and clays (<.002 mm) being the smallest.



GRAPHIC: US Department of Agriculture, adapted by SoilSensor.com, 2008

Figure 3: USDA Agronomic Soil Textural Triangle

The Agronomic Soil Textural Triangle (Figure 3, Figure 4) is a tool used to determine the textural type of a soil. Field analysis of soil texture can also be done using the "By Feel Method" (Figure 5). This qualitative method is quick, easy, and fairly reliable. Testing procedure involves wetting a sample of the soil and working the soil between one's fingers. Water is often used to moisten the soil, but saliva is also suitable. Texture cannot be determined accurately when the soil is dry. Quantitative measures to determine soil texture are also available. Contact the Alaska Plant Materials Center for more information about testing and analysis of soils.

GRAPHIC: USDA, SoilSensor.com, adaptated by editor

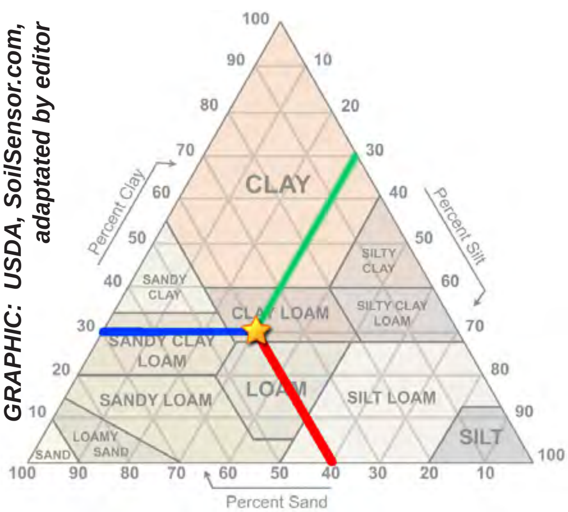


Figure 4: Soil Triangle usage example

In the example above, the soil consisted of 40% Sand (red line), 30% Clay (blue line), and 30% Silt (green line). Thus, the soil is classified as clay loam, as indicated by the intersection of the three lines.

Some characteristics of clay soils are that they restrict air and water flow, have high shrink-swell potential, and are highly absorptive.

Sand, in contrast, has a low water holding capacity, due to large pore spacing, and has limited absorptive capability for substances in solution.

Soil Structure

The aggregation of mineral soil particles (sand, silt, clay) is referred to as soil structure. The arrangement of soil particles create varying pore spaces allowing different quantities of moisture to be retained. This is referred to as the porosity of the soil, and will be noted on a soils test. A reduction in the pore space of the soil by pressure applied to the soil surface initiates soil compaction. Compaction compresses micropores and macropores, destroying the soil structure. This affects the uptake and movement of water and can inhibit plant and microbial growth.

Breaking up compacted layers can be accomplished by mechanical tillage. Equipment should be operated along the contour to reduce the potential of water entering furrows and creating soil erosion problems.

Nutrients

In most forms of revegetation, the application of fertilizer at the time of seeding is necessary. Most commercial fertilizers meet minimum standards for quality. When problems do arise, they can usually be traced to the product becoming wet during storage or shipment.

Fertilizer is described by a three number designator, referred to as N-P-K. These num-

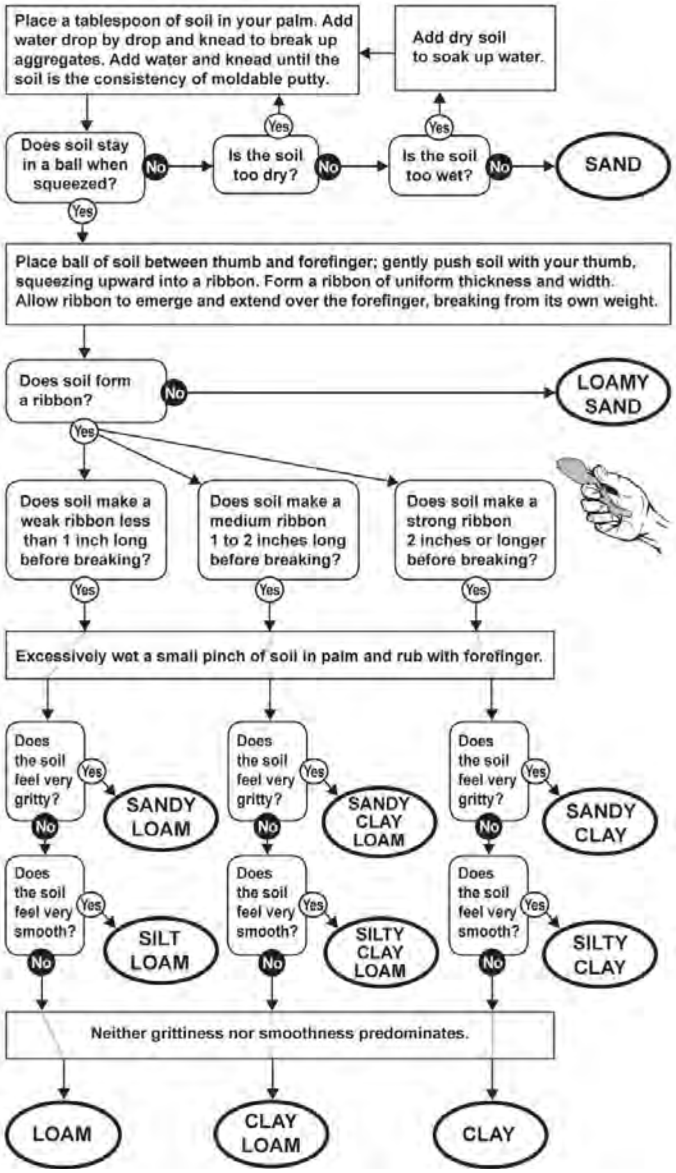


Chart: NRCS Irrigation Guide, USDA Natural Resources Conservation Service, 1997.

Figure 5: The 'By Feel' Texture Classification Method

Photo: Roadside Revegetation (Steinfeld et al., 2007)

Figure 6: Heavily compacted soil; Note platy structure. Water flow through this soil is poor.

bers refer to the percentages of three elements: **nitrogen**, **phosphorus**, and **potassium**, respectively. Therefore, 20-20-10 fertilizer contains 20% nitrogen, 20% phosphorus, and 10% potassium by weight.

If possible, fertilizer should be applied concurrent with or prior to seeding. Once the seed has been applied, no additional traffic should be allowed on the site, to avoid compaction and unnecessary disturbance of the seed bed.

Topsoil

The topsoil layer in undisturbed areas in Alaska is often very thin, and therefore expensive and impractical to salvage. However, this layer is a source of native seed, plant propagules, organic matter, and soil microbes which can enhance the quality of the substrate being revegetated. Top soil is a valuable resource in revegetation, and should be preserved or salvaged when possible.

Many construction sites in Alaska have exposed surfaces of gravel or gravely soils. Gravelly sites tend not to be highly erodible. If some fine particles are present in the gravelly soil, adapted species will grow without additional topsoil. In fact, the addition of a layer of topsoil on a gravel surface can increase erosion potential.

Photo: Stoney Wright (AK PMC)

Figure 7: Arctic Bluegrass, *Poa arctica*, established on a gravelly coastal spit near Port Clarance LORAN station

Construction Site Revegetation

Construction and mining sites rarely have intact soil horizons. The preceding discussion on soil profiles does not apply to most disturbed land. More basic measures of soil particle size, elasticity, and water holding capacity are usually applied to construction and mining sites. The uniform soil classification table is the best means of determining soil characteristics for revegetation purposes.

Major divisions			Group symbol	Group name
Coarse grained soils more than 50% retained on No. 200 (0.075 mm) sieve	gravel > 50% of coarse fraction retained on No. 4 (4.75 mm) sieve	clean gravel <5% smaller than #200 Sieve	**GW**	well graded gravel, fine to coarse gravel
			GP	poorly graded gravel
		gravel with >12% fines	**GM**	silty gravel
			GC	clayey gravel
	sand > 50% of coarse fraction passes No.4 sieve	clean sand	**SW**	well graded sand, fine to coarse sand
			SP	poorly-graded sand
		sand with >12% fines	**SM**	silty sand
			SC	clayey sand
Fine grained soils more than 50%	silt and clay liquid limit < 50	inorganic	**ML**	silt
			CL	clay
		organic	**OL**	organic silt, organic clay
	silt and clay liquid limit < 50	inorganic	**MH**	silt of high plasticity, elastic silt
			CH	clay of high plasticity, fat clay
		organic	**OH**	organic clay, organic silt
Highly organic soils			**Pt**	peat

Chart: American Society for Testing & Materials D 2487-83

Figure 8: Unified Soil Classification System (USCS)

The **Unified Soil Classification System** (USCS) describes both the texture and grain size of a soil. Symbols are composed of two letters; the first represents primary grain size division (>50% of soil). The second letter refers to the uniformity or plasticity of a soil, or to a second major soil type (>12% fines present). A complete symbol chart is included as Figure 8.

Revegetation Objectives

After receiving a project contract, immediately purchase seed and plant materials. This ensures that the revegetation portion of the project can be completed while equipment and personnel are available. Seed and plant materials must be properly stored in a dry, cool environment to prevent loss of viability.

Site Preparation

Seedbed preparation is the primary concern of most revegetation projects, since it is the most labor-intensive, energy consumptive, and often determines success or failure (Vallentine, 1989). The objectives of site preparation are to create environments that provide conditions favorable for seed germination and seedling growth.

The surface of the prepared seedbed should be relatively smooth for drilling and rough for broadcasting. Germination and survival increase with proper site preparation. An ideal seedbed should:

1. Be free of construction debris.
2. Have relatively few large rocks or objects.
3. Be free of ruts or gullies.
4. Have the top two inches in a friable, non-compacted condition (allowing a heel to make a ^{1}/4 inch depression).
5. Be scarified to a depth of 6 to 8 inches if heavily compacted.
6. Devoid of non-native weeds.
   (To determine which non-native weeds are of concern, refer to **Invasive Plants of Alaska**, produced by the USDA, in cooperation with the Alaska Soil and Water Conservation District, or refer to plants.alaska.gov/invasives/).

If traditional surface preparation equipment such as disks and/or chisel plows are available, the conditions required for adequate surface preparation are the same as previously noted.

Note: If hydroseeding is chosen as a method of seed application, surface preparation as described in this section may not be applicable.

Seeding Methods

The objective of seeding is to place the seed where it is needed and in proper contact with the soil. The method used depends upon the plant species being seeded and the characteristics of the site, such as soil type and topography.

Drill Seeding

Drill seeding is a method whereby the seed is placed in a soil furrow and covered with a relatively precise amount of soil. Drill seeders are used most often in agricultural settings. One type of drill seeder, the Brillion-style, is often used for revegetation of mine and construction sites (Figure 9). This seeder has been successfully used on most soil types, except very gravelly soils.

Figure 9: Brillion ® tow-behind drill seeder


Figure 10: Handheld broadcast seeder

Fertilizer cannot be applied with all drill seeders, however. The drill seeder delivers the seed into the soil, packs the seed in place, and applies seed with high accuracy. This method is considered by many to be the best method of distributing seed, however the need for specialized equipment may be impractical at many remote sites in Alaska.

Broadcast Seeding

The broadcast method scatters seed on the soil surface and relies on natural processes or harrowing to cover the seed. The recommended seeding rate for broadcasting is double that of drilling due to the lack of application control, seed predation, and the potential for reduced seed establishment and germination rates.

Figure 11: A truck-mounted hydroseeder applies a seed mixture

Broadcasting includes aerial seeding, hydroseeding, and hand-held methods. Hand-held and hand-operated spreaders (Figure 10) are commonly used on coastal sites due to their portability, speed, low cost and because they can be used for both seed and fertilizer application.

Hydroseeding

Hydroseeders are well suited for seeding steep slopes and rocky areas, as they apply mulch, seed, and fertilizer in a single step. Hydroseeders come in truck-mounted and trailer forms. Major contractors either have a hydroseeder or can easily subcontract one.

Hydroseeder manufacturers have claimed that hydroseeding promotes more vigorous plant growth, but that claim has not been proven. In fact, grass growth can be inhibited if too much mulch is applied.

The primary disadvantage of hydroseeding is the requirement for large quantities of water, which can result in numerous passes across land that is being revegetated. The equipment is complex, and potential mechanical problems can cause costly delays.

Hydroseeders are also useful as supplemental watering trucks once seed has been applied. Additional applications of water increase project costs, and are not always necessary to produce a good stand of vegetation. Even without additional water application, seed will remain dormant until rainfall provides sufficient moisture for germination.

A hydroseeding contract should state that seed will not remain in the hydroseeder for more than one hour. This will prevent seed from absorbing excess water and being damaged by the dissolved fertilizer.

Transplanting

Transplants, cuttings, and sprigs are all a form of planting where some portion of a live plant is placed directly into the soil. This is a labor intensive process, however there are times when it is the most appropriate revegetation method. Planting transplants, sprigs or cuttings is a way to jump-start vegetation growth, as the transplanted species has already reached a certain state of development.

Planting Time

Timing is crucial to revegetation success. The optimum planting season is just before the longest period of favorable conditions. In Alaska, spring planting is optimum where the primary growing season occurs in the late spring and/or summer. The following table approximates the end of planting season across several regions of Alaska. The earliest time to plant is when the snow melts and the site is accessible.

Latest Date to Seed:	
Arctic Coast	**July 15**
Western Alaska	**August 15**
Southcentral region	**August 31**
Southeast Alaska & Aleutian Islands	**Sept. 15**

Selection of Species

One of the most important criteria for successful revegetation is species selection. A restoration project seldom relies on a single species, however. A classic definition states:

> *"Species selection strategies that emphasize diversity assume species-rich ecosystems are more stable and less susceptible to damage from unusual climactic events, disease, or insects." (Whisenant, 2005)*

Several characteristics are important in choosing a seed mixture, including reliable establishment, the ability to survive changing conditions, and ease of propagation (Coppin & Stiles, 1995).

The Alaska Plant Materials Center recommends including at least three species in a planting mixture. Plant species should be chosen based on their adaptation to the project site and whether or not it is native to the area being revegetated.

Species is Adapted to site

The harsh environments of Alaska limit species growth and production potentials. It is imperative that chosen species are able to survive and thrive in the local environment. Climatic, topographic, and soil conditions all influence plant performance, and should all be taken into account when selecting species.

Species is Native to the area

Native species, already adapted to Alaska, generally perform better than introduced materials. However, prices may be higher for native plants or seed. Availability is currently the primary obstacle to using native species for revegetation in Alaska. In-state production of native plants is increasing, however, due in part to state and federal mandates requiring the use of these species.

A list of potential commercially available native species is listed in the Native Plant Directory, a publication of the Alaska Plant Materials Center, available online at plants.alaska.gov/native/.

Planting Methods

After a species or species mixture has been selected, a decision needs to be made about which form of plant to use. Revegetation objectives, cost, and the availability of equipment are a few of the factors that influence this decision (Whisenhant, 2005). Refer to Figure 15, on page 24, to determine which planting procedures are most appropriate for your site.

Seed

Seed is the most commonly used plant material for revegetating disturbed areas, because it is easy to collect, clean, store, transport, mix and apply to the site using drill or broadcast methods. Grass and forb species are usually directly seeded onto disturbed sites.

Seed Specifications

Quality seed is critical to success. Specifying "certified" seed assures quality because the seed must meet certain standards for germination and purity; certification also provides some assurance of genetic quality.

Some native seed species are not available as certified seed. Seed quality can still be ascertained by examining percent germination and percent purity; information that will be clearly labeled for any seed sold in Alaska. This labeling is required by 11 AAC, chapter 34: Seed Regulations (included as Appendix B).

The true cost of seed can be determined

by the Pure Live Seed calculation. To calculate Pure Live Seed (PLS), use the equation:

$$PLS = \left[\frac{\text{Germination \%} \quad x \quad \text{Purity \%}}{100} \right]$$

The true price of seed, then, can be determined using the equation:

$$Price_{PLS} = \left[\frac{\text{Bulk cost of seed / lb} \quad x \quad 100}{PLS} \right]$$

These calculations can increase the accuracy of bid comparisons. PLS price is a good method of comparing different seed lots at time of purchase.

All seed sold or used in the state of Alaska must also be free of noxious weeds, under 11 AAC 34.075. This is noted on seed tags, along with germination and purity.

The seed mixes presented in this manual have been carefully developed and are based on results from trials throughout the state. Give careful prior consideration to any deviation from the suggestions. If problems occur or questions arise regarding seed, call the Alaska Plant Materials Center at (907) 745-4469.

Seed stored on site should be kept cool, dry, and in rodent-free areas. Remember seed is a living commodity. A bag may contain seed; however some percentage may be dead husks - the equivalent of cadavers. Always buy seed based on the PLS Calculation.

Certified Seed

The term "certified seed" can cause confusion because it is used to describe two different issues:

The official use of the term Certified seed (with a capital C) is to describe seed that has been grown under the rules of the Seed Certification Program. Certified seed is the usual commercial category of seed. Its ancestry can be traced back to Registered Class or Foundation Class seed. In addition, the Certified seed must meet variable standards of purity and germination. These standards are a means of verifying authenticity of a seed source. All the Alaska developed seed varieties or cultivars can be sold as either Certified or common.

Figure 12: Alaska Certified seed tags

Seed can also be certified (without a capital C) to be free of weeds or as meeting a minimum germination standard (11 AAC 34.075). This has nothing to do with variety identification - it simply indicates the quality of the seed. In other words, the buyer knows quality, but has no assurance of type (other than species).

Certified seed should be used when available. Seed produced in Alaska is easy to trace to its origin. It may be common (uncertified) 'Arctared', but it is still 'Arctared'. Minimum purities and germination should always be stated with orders. Common seed is a usable product and may be used to meet demands. Common seed should meet Certified standards with regard to germination and purity, although these standards may need to be relaxed to acquire sufficient material for a large job. Lower germination rates can be overcome by increasing the seeding rate. Lower purities, however, should be avoided, as weeds can become a problem.

Other Certification Classes

Many new native seed sources are being developed in Alaska. For the most part, these

Figure 13: Pre-certified class seed tags

will not be sold as Certified seed. They may carry the following designations: ‘Source Identified’, ‘Tested’, or ‘Selected’. These classes will be in keeping with the certification system and standards of germination and purity will be enforced, but the term ‘Certified seed’ will not apply. These classes are referred to as being ‘Pre-certified’ class.

Transplants

Transplants are plants growing in their native habitat that are transplanted directly into a restoration site, or into a nursery to be cultured for future use. Large transplants are able to establish and spread more quickly than other planting methods, and have a more immediate effect on visual aesthetics (Hoag, 2003).

Transplanting shock is a problematic and common occurrence, whereby the transplanted species fails to become established, for any number of reasons. These include lack of moisture or nutrients and stresses to the root system. Care should be taken to prevent transplant shock.

Sprigs

Sprigging is a method of transplanting whereby a plant clump is divided into individual sprigs, each of which is capable of growing into a new plant (Figure 14). On sites where coastal erosion is a concern, sprigging is an excellent means of reinforcement, as the roots of the transplanted species will create a rhizomatic web that ties together loose grained soils (Ffolliott *et al*., 1994).

Sprigs can be harvested from wild stands of vegetation, and planted without special equipment. A sprig does not need to have well-developed roots at planting time, only a portion of the below ground crown. The above ground portion of a sprig may die back after transplanting, however this is not cause for concern. New growth will start from the below ground portion. Sprigs

Planting Procedure Selection Chart

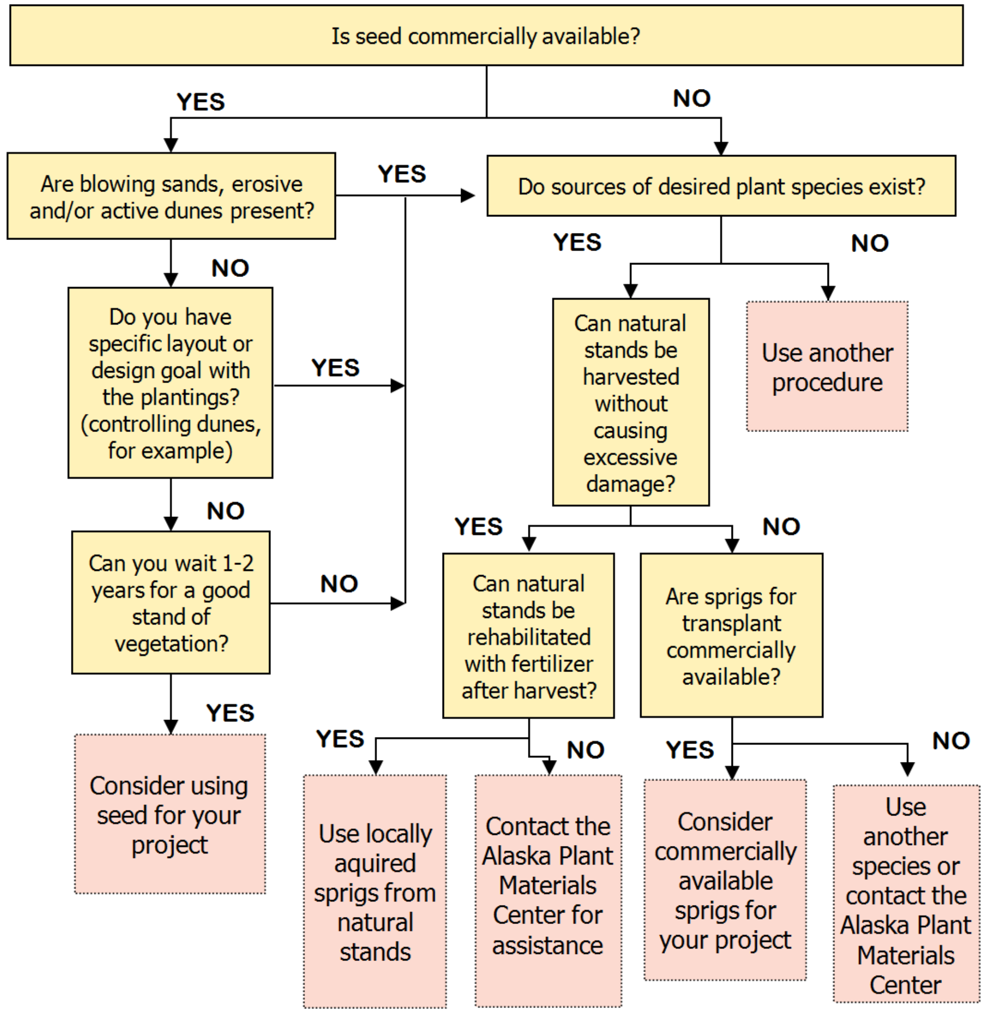


Figure 15: Planting procedure selection chart seeds vs. sprigs

Figure 14: A clump of Beach Wildrye suitable for division into sprigs. This plant could create three or four viable transplants.

The use of Beach Wildrye on sandy and gravelly coastal areas is a proven practice. To learn more about Beach Wildrye transplants and erosion control, refer to Appendix A: Beach Wildrye Planting Guide.

become established faster than seeded grass.

The planting procedure selection chart (Figure 15) may be used to decide which planting methods to use in a given situation.

Bare-root stock

Bare–root stock is commonly used to establish woody plants. Seedlings are grown in outdoor nurseries, lifted from the soil when dormant, and then stored in a cool and moist environment until transplanted (Munshower, 1994). Hardening, which induces dormancy, is often done in a 6-8 week period prior to transplanting, in order to expose the seedlings to conditions similar to the planting site.

Figure 16: A clam-gun is an effective means of harvesting sprigs of sedge

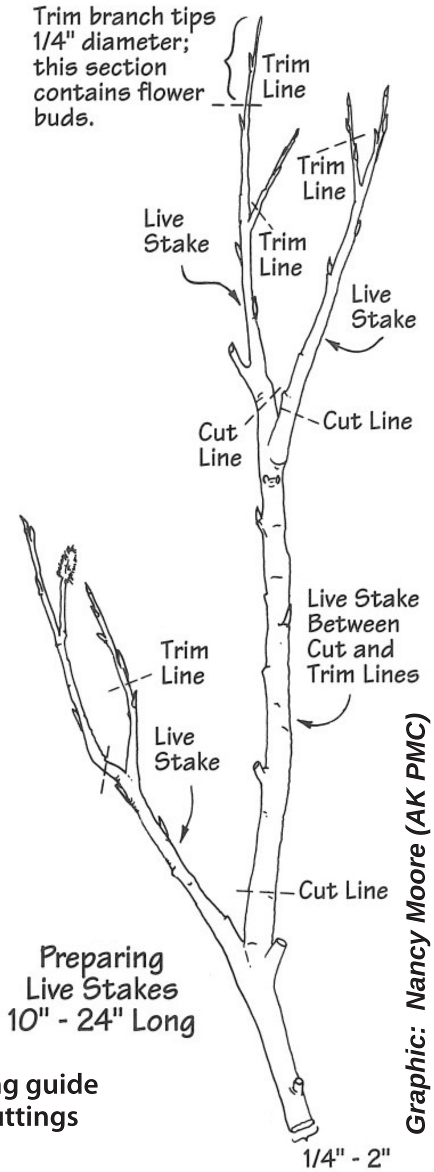


Figure 17: Trimming guide for vegetative cuttings

Container – grown stock

Container stock is grown in artificial growing media in a controlled environment, usually a greenhouse. When harvested, the root system forms a cohesive plug (Steinfeld, *et al*., 2007). Containers come in a variety of sizes and shapes. Container grown plants are able to tolerate harsh conditions more easily than bare-root transplants (Eliason & Allen, 1997).

Cuttings

The use of willow cuttings is the most commonly used method of vegetative planting in Alaska, both historically and today. The use of willow cuttings has proven successful in all areas of Alaska where willow occurs naturally. Because timing is critical to both collection and planting, prior planning is an absolute necessity.

For detailed instructions on the use of willow cuttings, please refer to Streambank Revegetation and Protection, published by the Alaska Department of Fish & Game. This publication is online, at www.sf.adfg.state.ak.us/sarr/restoration/techniques/techniques.cfm.

Figure 18: Willow cuttings were used to re-establish vegetative cover on the banks of the Kenai River

Mulch & Erosion Matting

When deciding a soil cover method to use (i.e. mulch or erosion matting), several factors should be considered. Erosion potential due to wind or water is the primary consideration. If the soil does not have a high erosion potential, then mulch and/or matting may be skipped. The second consideration is cost. Application of mulch and matting add significant costs to a project; not only in materials, but also in labor. The third consideration is safety. Sections of netting may come loose and cause hazards to wildlife and property. A final concern is that straw may introduce unwanted weeds.

The above concerns do not apply to wood and paper fiber or similar products used in hydroseeders. When hydroseeders are used, mulch is obligatory. The mulch fiber forms a slurry that acts as a carrier for the seed and fertilizer. Without mulch, seed and fertilizer would not suspend properly or efficiently in solution, and uniform distribution would be impossible. Mulch also serves as a visual indicator of areas that have been treated.

Figure 19: Erosion Control matting can stabilize a cut slope while seed or transplants become established

Wild Seed Collection

A pull-type seed stripper is an effective means of harvesting collections of wild seed

An alternative to obtaining seed commercially is to collect seed from the wild. Wild seed can be harvested from native grass, forbs, shrubs, and trees found at or near the project site (Steinfeld, et al, 2007). If seed collection occurs at a considerable distance from the project site, make sure the species is adapted to the site conditions before using it in a revegetation project. For an example of wildland seed collection, review the Girdwood Sedge Restoration case study in this manual.

Collection of wildland seed is a lengthy process that benefits from prior planning. The steps in this process are seed collection, processing, and increase. Seed collection includes locating donor plant communities, collecting seed, and choosing a method of harvest. When determining where to harvest, remember that there is no un-owned land in Alaska; collecting seed from any property, unless it is your own, requires the permission of the owner. If the potential seed collection site is state, federal, or tribally owned land, permits may be required. For a list of agencies and large land holders in Alaska, refer to the **Partner Agencies** section.

Figure 20: A tractor mounted potato harvester being used to harvest Beach Wildrye

Proper timing in the season is critical for successful seed collection. A number of field visits may be required in order to collect seed that is ripe and mature. Seeds go through different stages of maturity; being able to recognize these stages allows one to collect seed in the proper ripening window. This collection window may vary from a few days to several weeks. Additional collection trips in the following year may be required if this window is missed. Also, some species may not produce enough seed in a single year, requiring multiple collection trips before planting can commence.

Methods of recognizing seed maturity differ for grasses, trees, and shrubs. Color, taste, and hardness are factors to consider when determining if a seed is mature. Plants with fruits start green and change to red, blue, white, or other colors with maturity. A sour or bitter taste in fruits indicates a immature plant. With time, higher sugar content in the fruit signals maturity, giving it a sweet taste when eaten. Also, the hardness of the fruit will change when mature. When the fruit becomes soft and pulpy, it is usually mature.

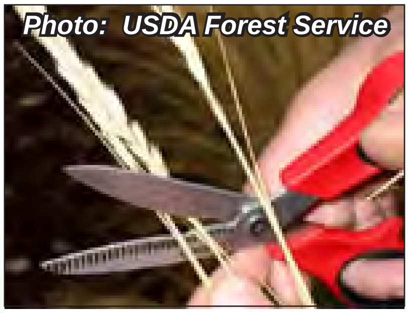


Figure 21: When harvesting by hand, cut the stem just below the seed-head

Seed pods are another indication of maturity. If rattling can be heard when the pod is shaken, then the seeds are ready to collect. Cracks or breakage of the seed pod is another indicator of readiness. Lupine is a species that displays these traits.

Grass seed maturity can be determined by how the seed responds when it is pressed between the fingers. The stages of grass seed maturity are best expressed by *Steinfeld, et al.*

> “• **Milk stage**: A milky substance is secreted when pressure is applied, indicating an immature seed lacking viability.
>
> • **Soft-dough stage**: Seed has a doughy texture, indicating it will have low germination and viability if collected.
>
> • **Hard-dough stage:** No excretion of dough or milky substance when squeezed. Seeds are collected at this stage. Seeds can be collected at the transition between soft-dough and hard-dough stages. If collection occurs between these stages, seed should not be stripped from the plant. Instead, seed heads should be cut and placed in collection bags where seeds will continue to mature.
>
> • **Mature:** Seed in this stage are usually too hard to bite. Collection should begin immediately, because the seeds can dislodge from the stem at any time.”

Weather conditions at the collection site are another variable to consider. Seed collection should commence during dry weather with little wind. High wind can blow the seed off site and make collection difficult.

Seed collection methods are dependent upon the species being collected,

Figure 22: A Woodward Flail-Vac © seed stripper attachment is used to collect large amounts of wild seed, such as fireweed

where collection occurs, and the scale of the project. Grass seed is often harvested by hand, usually by shaking it off the stem or cutting off the seed head with a knife or scissors (Figure 21). Shrub seed can be picked by hand or lightly shaken into a tarp or bucket for collection. Large-scale harvesting is usually accomplished by mechanical means. Collection bags should allow airflow; cloth bags are often used.

Terrain is another factor that determines how the seed is collected. Steep slopes may limit access by mechanical equipment, requiring alternate means of collection. For large, flat sites a combine (Figure 30) or Flail-Vac © type seed stripper (Figures 22 - 25) can be used. A pull type seed stripper can be mounted to an All Terrain Vehicle, facilitating collection on less flat ground.

Figure 23: Collected fireweed stays in the seed stripper until removed for processing

Project scale is another consideration when collecting seed. The quantity of seed needed will often determine how seed is collected. Small quantities can be collected by hand, but large-scale projects requiring large amounts of seed will benefit from using mechanical implements.

For inaccessible sites that are too large for hand harvesting, a portable seed collector, such as a hand-held seed stripper (Figure 27) or a commercial leaf vacuum (Figure 28) can be utilized. A push-type chipper/shredder can also be used to collect seed (Figure 26), however some damage to the seed may occur, due to the nature of the equipment. Regardless of the method of collection, processing is required before the seed can be used for revegetation.

Diagram courtesy of Aaron Beisel.

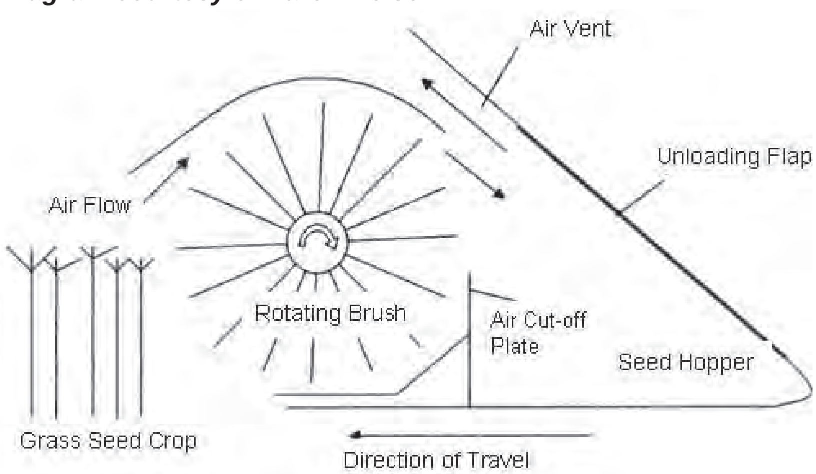


Figure 24: Schematic of a Woodward Flail-Vac © seed stripper

Seed processing involves separating weeds, chaff, dirt, stems, and other inert matter from the seed. This is generally done using specialized equipment, but seeds can also be processed by hand for smaller field collections. After cleaning, the seed is tested at a seed lab for purity and germination.

Seed increase involves taking cleaned wild seed and planting it in a nursery field. The field is then cultured for heavy seed production, which involves weeding and fertilization,

Figure 25: Using a seed stripper leaves the inflorescence (seed-head) intact, allowing for multiple equipment passes

amongst other treatments. When sufficient quantities of seed are available, the increased seed must then be collected and processed, as previously described, before planting can begin.

Harvested seeds from tree and shrubs species are often started at a nursery and grown in nursery beds (bare-root stock) or containers (container-grown stock) in a green-house. Seedlings are then transplanted to the site when ready.

Figure 26: A chipper shredder with a vacuum used to harvest seeds

Figure 27: A Hand-held seed stripper is an effective solution for medium volume collections in inaccessible sites

Figure 28: A leaf blower with a vacuum function can be used to collect seeds

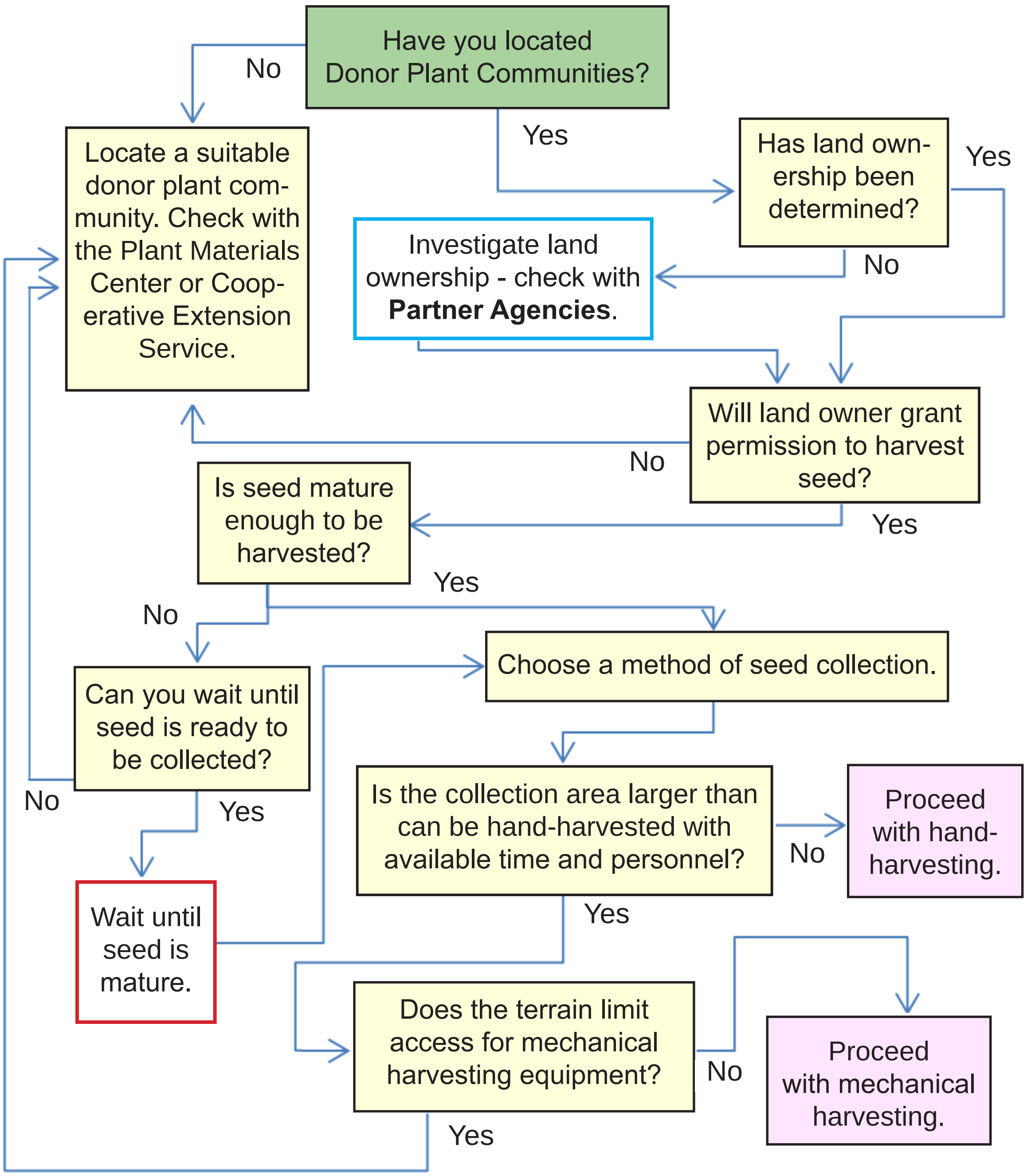


Figure 29: Wild seed harvest decision chart

Figure 30: Combine harvesting a wild Bluejoint Reedgrass (*Calamagrostis canadensis*) stand

Techniques

Many techniques exist for revegetation, including pre-prepared vegetation mats

In a number of situations, revegetation through seeding is not practical. There are several alternative methods that can be used to revegetate an area, in place of seeding. The different approaches highlighted in this chapter provide for greater flexibility to various site conditions and available materials.

Charged Overburden Veneer:

The charged overburden veneer technique promotes growth by spreading overburden (usually topsoil taken from a nearby work site) over the area to be revegetated. Seed and roots already present in the soil constitute the 'charge', and are relied upon to establish vegetation. The term "charged overburden veneer" was coined during the Shemya Island road close-out project included in the case study section. The drawback to this revegetation technique is that it may involve placing an erodible material on the site.

Special measures must be taken if the overburden material has the potential to be transported into storm sewer systems and / or surface waters. Numerous Best Management Practices (BMPs) exist to limit soil sediment transport. For more information, view appendix F of the Alaska Storm Water Pollution Prevention Plan Guide, available at dot.alaska.gov/stwddes/desenviron/resources/stormwater.shtml

Photos: James Bowers (AK DOT)

Topsoil being gathered onsite - November, 2005


Spreading charged overburden - May, 2006

Heavy equipment used to spread topsoil - May, 2006


Vegetation growth after 2 seasons - August, 2008


Vegetation cover fully established, using charged overburden technique - August, 2008

Sod Clumps:

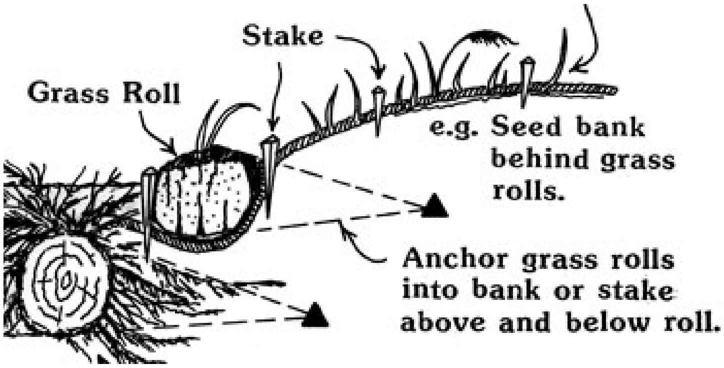
The use of sod clumps is a form of transplanting whereby natural vegetation stands are harvested in block form. Dimensions of these blocks vary from one to several feet square (Muhlberg & Moore, 1998). Using sod clumps provides immediate vegetative cover on a site, and species are able to establish on a large area more quickly than with other forms of transplanting (i.e., using sprigs or individual plants).

Photo: Pentec Environmental / Hart Crowser Inc.

Clumps of sod deposited near an estuary to promote quick vegetation establishment

Photo: Nancy Moore (AK PMC)

A prepared grass roll, consisting of sod clumps wrapped in an biodegradable fabric, with slits cut in the top for the shoots



Sod clumps are also used in the restoration of erodible stream banks. Grass rolls use sod clumps wrapped in biodegradable fabric to stabilize river banks and quickly establish vegetation cover.

For further explanation of this technique, refer to the ADF&G publication: 'Streambank Revegetation and Protection, a Guide for Alaska', available at www.adfg.alaska.gov/index.cfm?adfg=streambankprotection.

Vegetation Mats:

If clumps of sod are not readily available, a vegetative mat can be prepared in a nursery or greenhouse, and later transported to the site. In this technique, plantings are grown in a controlled environment until roots and rhizomes have become established.

Vegetation mats provide many of the same benefits of a sod clump, though at a greater cost in time, materials and labor. Prior planning is necessary when using vegetation mats, as the preparation of a mat will take at least one growing season. Some seeds may require stratification, while others may require scarification. All of these factors should be taken into account if you are using this technique.

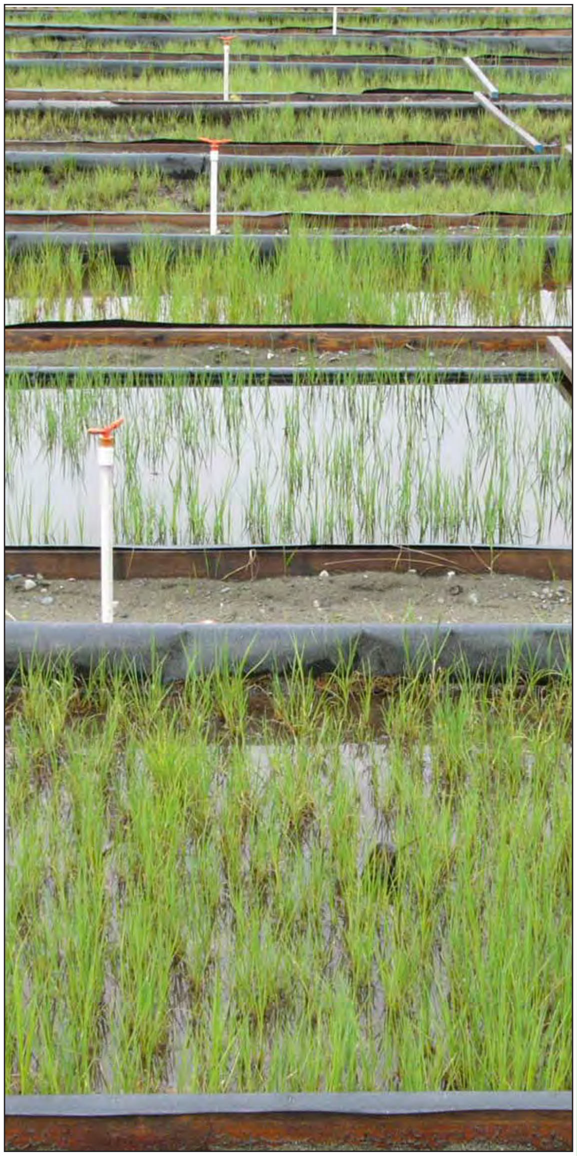
Photos: Nancy Moore (AK PMC)

Seeds in flats for cold / moist stratification over the winter. During the stratification process, seeds are placed in cloth bags, with a layer of peat beneath and above them. The cloth around the seeds provide a steady source of moisture.

Soil spread on erosion control fabric provides a binding medium for roots

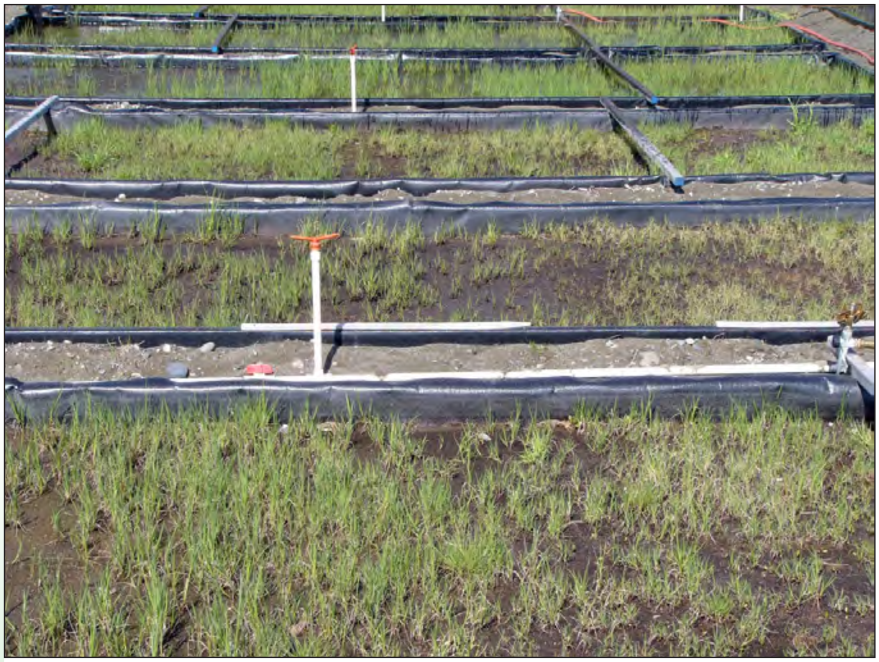
10' x 3' constructed mats framed with dimensional lumber, with thick plastic and erosion control matting used for the base. Only the biodegradable erosion control matting will remain once the mat is deployed.

Stratified seeds are sown on a vegetation mat, using hand seeders and a constructed grid to seed at a rate of 1 seed per 2 inch square



In situ irrigation allows wetland species to thrive in the constructed vegetation mat

Photos: Nancy Moore (AK PMC)



Germinated seeds take root in the constructed vegetation mats

Underside of vegetation mat, showing developed roots intertwined with erosion control fabric

Established water sedge mats ready for transport to site


Vegetation mats should be sized to fit available methods of transportation


Heavy plastic sheeting facilitates on-site transport of the vegetation mats


A line of vegetation mats, ready for placement


Vegetation mats being installed along the waters edge


Vegetation mats, one year after transplanting

Photos: Nancy Moore (AK PMC)

Enhanced Natural Reinvasion:

Natural reinvasion can be assisted or enhanced with any combination of surface preparation or modification techniques, fertilizers, and soil amendments. This technique is infrequently used in the field, as few sites offer ideal conditions. Additionally, the regulatory process precludes methods that cannot give specifics of final vegetative cover and/or composition.

The enhanced natural reinvasion method of revegetation is dependent upon seed arriving at the site by natural processes. This method is faster than natural reinvasion, but still has a relatively low success rate. Anyone wishing to apply this technique must understand the potential for failure, and be willing to move to an active form of revegetation if problems emerge.

Using a tow-behind broadcast seeder to apply fertilizer can ensure uniform distribution

Fertilizer should be applied to edge of existing vegetation

The effect of surface scarification on plant establishment and growth after two growing seasons. No seed was applied to the site, but it was fertilized with 20N-20P-10K fertilizer at a rate of 500 pounds per acre.

Imprinting:

Land imprinting is a method of seedbed preparation that uses heavy rollers to make a depression in the soil surface, creating basins in the soil that reduce erosion, increase water infiltration and capture runoff (Dixon, 1990). Imprinting can be accomplished with heavy equipment such as a compactor with a 'sheeps-foot' attachment. A broadcast seeder is often attached to the back of an imprinter to apply seed.

When the soil has been imprinted, uncovered seeds in the basin areas will tend to be covered by natural processes such as wind and rain. Imprinting creates micro-climates suitable for plant germination and growth. 'Track-walking' is a method of imprinting whereby the cleats on a track leave depressions on a soil surface. This technique is commonly used on sloping sites, before seeding.

Photo: Stoney Wright (AK PMC)

The wheels of this landfill compactor imprint the surface area, creating basins of micro relief in the seedbed

Aerial Photo: Bill Quirk

A striated pattern is still visible one year after the above site was imprinted. Vegetative cover is a result of natural reinvasion; no seeding or fertilization occurred.

Photo: Stoney Wright (AK PMC)

Imprinting creates pockets in the soil, each with a favorable micro-climate for vegetation growth

Imprinting:

Surface imprinting accomplished using the 'track-walking' technique

Vegetation grows in the depressions created by the cleats of a tracked vehicle

Alkaligrass grows in the depressions created by bulldozer tracks

Scarification:

Soil is scarified on almost all sites in preparation for seeding and fertilizer.

A harrow is a tool used to roughen the soil surface and kill shallow-rooted weeds. This process, called harrowing, can also break the compaction layer within the first few inches of the surface. When used after broadcast seeding, a harrow will help to cover the seed with soil.

Heavy equipment, such as graders and front-end loaders, are frequently used for scarification on highly compacted rocky soils. A dozer blade can be modified with 'tiger teeth' at regular intervals and used for scarification.

Photos: Stoney Wright (AK PMC)

Deep scarification of the soil surface can be accomplished with a grader with a 'ripper shanks' tool bar

A bulldozer, modified with 'tiger-teeth' attached to the blade, is an effective means of surface modification that promotes root growth by reducing soil compaction

Conservation & Protection

Eelgrass beds near Craig, Alaska

Coastal landforms and vegetation communities are especially vulnerable to damage, and care should be exercised to minimize impacts to these areas. Areas that need particular attention are coastal dunes, eelgrass beds, and estuarine habitats. This chapter will address protection methods and regulations that affect these resources.

Preventing Damage to Dunes:

Coastal dunes are a dynamic landform consisting of fine-grained material, such as sand, bound together with vegetation. The rhizomes and roots of dune adapted species hold the loose soil together. A unique coastal feature, dunes are susceptible to erosion caused by natural and human sources. Wind is the main transport mechanism for sand. Vegetation serves to protect sand dunes, preventing movement and stabilize soil. (Maia, et al., 2007). If erosion processes are allowed to continue, a loss of plants and animal habitat, and / or, damage to scenic beauty could occur. Restoration and conservation of dunes will ensure continued protection from damage arising from natural and human forces.

For the purposes of this guide, dune restoration will focus on the "soft" (vegetative) approach, as an alternative to engineered structures. The soft approach relies on biodegradable erosion control blankets, native plant materials and / or seed for dune stabilization. Engineered structures such as stone and concrete walls are often not an acceptable approach, because of public opposition. Dune restoration activities should be undertaken for the purpose of reestablishment of dunes and vegetative cover, as well as controlling human impacts that can destabilize dunes (Rooney, 2007).

Coastal dunes can be damaged by foot and vehicle traffic, wave action, and extreme winds. Limiting traffic to a threatened area is a very effective way to preserve dune formations. This may be achieved by walkways through the dune area, access barriers (fencing), laws (fines), and informative signage. Dune degradation from wind and wave action can be mitigated with vegetation that provides the structural integrity for soil fixation and retention. A revegetation plant species with this characteristic is Beach Wildrye. More information about this species can be found in Appendix A: *Beach Wildrye Planting Guide*.

There are presently no regulations in Alaska prohibiting activities that may damage dunes. The city of Kenai has adopted an ordinance limiting access to dune environments and establishing fines. A physical barrier has also been constructed to protect threatened dunes. Previously, coastal dunes at the mouth of the Kenai River were routinely being damaged by camping and fishing traffic. The success of this approach is evident; dune formation is widespread and vegetation is well established.

Photos: Brennan V. Low (AK PMC)

Dune protection measures in place near the mouth of the Kenai River

Protection of Eelgrass:

Eelgrass is a sea grass primary found in shallow nearshore waters along coastlines. Its

Eelgrass is a sea grass that is a protected fish habitat; impacts to eelgrass beds must be mitigated in Alaska

preferred habitat is 3 to 12 feet below the surface of the water, a zone with abundant light. Eelgrass beds provide habitat for invertebrates and are utilized by a variety of fish species for spawning, rearing, and feeding. Eelgrass is also valuable in protecting the shoreline from erosion and wave action. The species has a narrow tolerance for turbidity, sediment disturbance, and eutrophication (McCracken, 2007). Eutrophication refers to high nutrient levels in the water depleting oxygen available for marine species, a process associated with algal blooms. The vulnerability of eelgrass to shoreline development warrants the protection of this coastal habitat.

There are numerous regulations and permits concerning habitat restoration projects. Some federal regulations of note are the Clean Water Act and the Magnuson-Stevens Fishery Conservation and Management Act. Section 404 of the Clean Water Act requires prior approval for any discharge of dredge or fill material, and prohibits discharge or filling if a practicable alternative exists. Dredging and filling activities represent a known threat to eelgrass habitat in Alaska. Good water quality and circulation are necessary for healthy eelgrass populations.

The Magnuson-Stevens Act requires the development of fishery management plans (FMPs) which include descriptions of Essential Fish Habitat (EFH) for documented species, and measures that can be taken to conserve and enhance these habitats. Eelgrass beds are protected because of the importance of this type of habitat for fish rearing. The National Marine Fisheries Service (NMFS), part of National Oceanic and Atmospheric Administration (NOAA), is tasked with implementing the Magnuson-Stevens Act.

NOAA's Office of Habitat Conservation conducts environmental reviews of non-fishing activities, and supports habitat restoration efforts through the Habitat Restoration Center. The goal of the Office of Habitat Conservation is to minimize impacts to marine resources; including eelgrass beds and estuaries.

Eelgrass beds are threatened by excessive sediment deposition, which can be a result of soil erosion. Strategies for erosion control include revegetation (detailed in this guide) and streambank restoration. The latter topic is covered in detail in 'Streambank Revegetation and Protection', published by the Alaska Department of Fish & Game. This document is available at www.adfg.alaska.gov/index.cfm?adfg=streambankprotection.main. NOAA fisheries will have additional recommendations for the conservation of sea grasses.

Within Alaska, the 'special aquatic site' designation affords additional protection and consideration to sensitive habitats, including eelgrass beds (Harris, 2008). Proposed development projects that may have an impact on these sites are reviewed by permitting agencies.

Protection of Estuarine Habitats:

An estuary is a body of water that is found along the coast and is formed when freshwater from a river flows into the salt water of the ocean. The mixing of nutrients from fresh and salt water supports an environment teeming with life. These areas provides food and shelter for wildlife and plant species. Estuaries also provide recreational opportunities, fishing and tourism jobs, aesthetic value, and food. Estuarine habitats include mudflats, salt marshes, wetlands, and eel-grass beds.

Years of disregard for estuaries has resulted in habitat loss, diminished economic opportunities for fishing and tourism, and negatively impacted the quality of life for coastal communities.

Estuaries throughout Alaska are quite healthy, and have seen with minimal development (Nature Conservancy, 2010). Potential threats include oil spills, sedimentation from erosion, dredging and filling activities, as well as pollution.

Laws and regulations exist for the protection of estuaries and the habitats they provide. One such law is the Estuary Restoration Act (ERA) of 2000. This act enhanced federal monitoring and research capabilities, provided funds for financial and technical assistance in estuarine habitat restoration, and established an Estuary Habitat Restoration Council, charged with coordinated federal restoration efforts. This Council is comprised of the National Oceanic and Atmospheric Administration (NOAA), Environmental Protection Agency (EPA), Department of the Interior (U.S. Fish and Wildlife Service), Department of Agriculture (Natural Resources Conservation Service), and the Department of Army.

An estuary in the Copper River delta

Amendments were made to the ERA in 2007. One notable amendment was the delegation of small projects (less than $1,000,000) to NOAA, USFWS, EPA, and NRCS by the Secretary of Army. Also, NOAA, USFWS, EPA, and NRCS receive $2.5 million per fiscal year through 2012 to carry out restoration projects. Section 320 of the Estuary Restoration Act directs the Environmental Protection Agency to administer a National Estuary Program, and assist states in developing a 'Comprehensive Conservation and Management Plan' (CCMP). As of 2011, there is no CCMP for Alaska.