Project Implementation

Photo: Will Menheere (Fairbanks Gold Mining Inc.)

A well prepared seedbed along the slope contour creates an ideal environment for seed germination, while the furrows limit down-slope water flow.

Section 2:

Planning

- *Goal Setting & Preparation*
- *Identify Site Conditions*
- *Seeding Methods*
- *Transplanting*
- *Planting Choices*
- *Planting Time*
- *Selection of Species*
- *Mulch & Erosion Matting*

Techniques

- *Charged Overburden Veneer*
- *Sod Clumps*
- *Vegetation Mats*
- *Natural Reinvasion*
- *Enhanced Natural Reinvasion*
- *Imprinting*
- *Scarification*
- *Dormant Seeding*

Wild Seed Collection

Potential Sources of Erosion

- *Wildfire*
- *Agriculture*
- *Transportation*
- *Riverbank Erosion*
- *Mining*

Conservation and Protection

- *Protecting Wetland Areas*
- *Invasive Plants*
- *Permafrost Conservation*

Planning


Photo: Gordy Schlosser (Great Northwest Inc.)

Emergent grass species are evident on this reclaimed landfill a few weeks after seeding.

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 & Preparation

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

- Gathering baseline data,
- Identifying site problems,
- Collecting reference plot information, and
- 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 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, topography and vegetation. Climate includes temperature, precipitation, and wind, as well as other factors. Climate records can be obtained online, through resources such as the National Oceanographic and Atmospheric Administration's National Climate Data Center, at 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 regional data 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. 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 or closely resemble the attributes of the reference site (SER, 2002).

Collecting information from a reference site can be costly, and is often limited by available funds.

Permitting

Permits may be required for some projects. Regulations are always changing, however, so consult appropriate agencies to make sure that you have any permits necessary. A list of agencies is included as Appendix B.

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 Permit (APDES). 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.state.ak.us/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. The regulations above were those in force at the time of printing. Please be aware of current regulations before beginning a project.

Identify Site Conditions

Potential limiting factors that will affect revegetation establishment are extensive, and a complete discussion is beyond the scope of this guide. This publication focuses on limiting factors that have been observed regularly on interior sites, 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

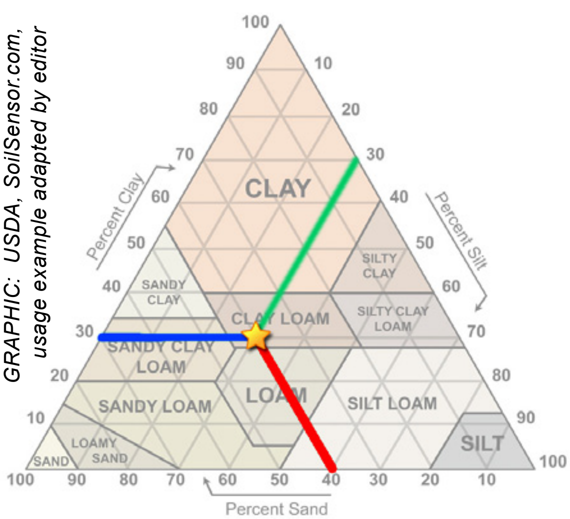
Soil is made up of mineral particles, organic matter, air, and water. Soil texture is determined by the composition of soil expressed as % sand, % silt, and % clay in which the total composition equals 100%. Seven classes of particle size are acknowledged with sands being the largest (2.0-.05 mm), silts (.05-.002 mm) intermediate in size, and clays (<.002 mm) being the smallest.

The Agronomic Soil Textural Triangle 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". 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.

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 limited absorptive capability for substances in solution.

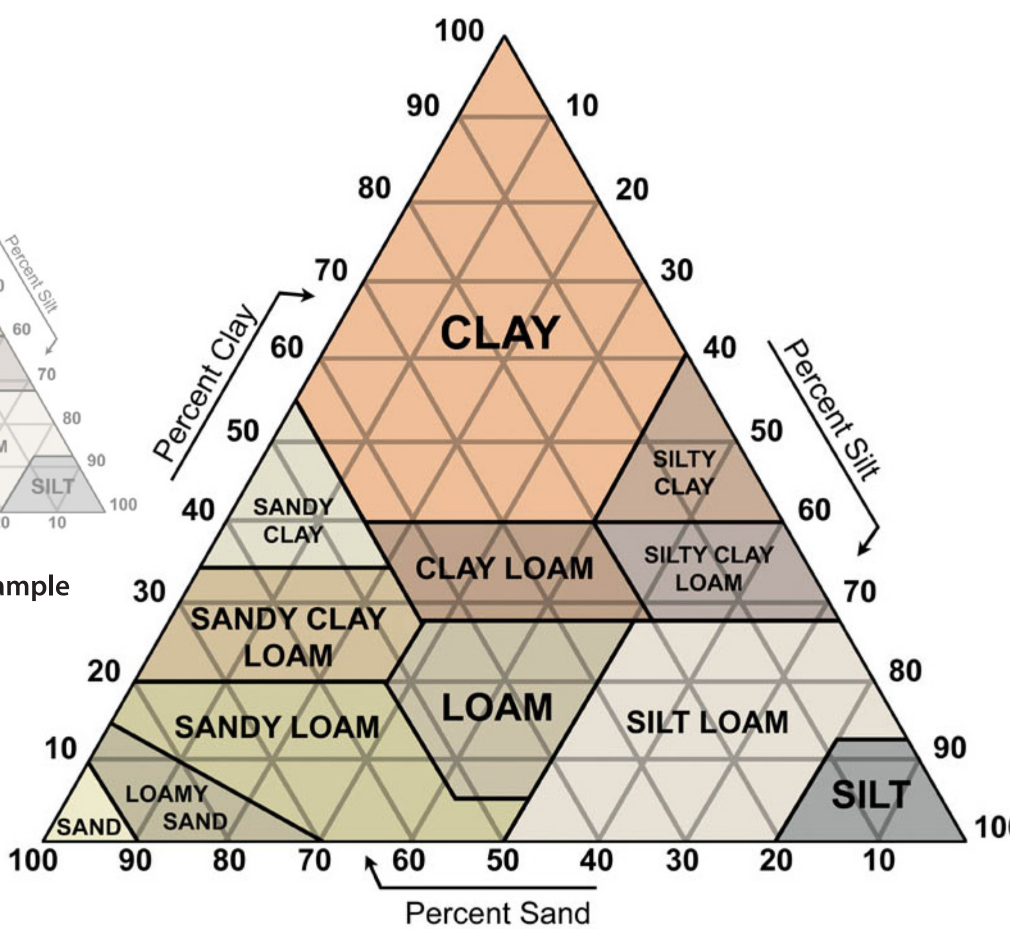
The remainder of this section refers to conservation activities on agricultural soils or undisturbed native soils. Details on construction site considerations are presented later in this chapter.

GRAPHIC: USDA, SoilSensor.com, usage example adapted by editor



Soil Textural Triangle usage example

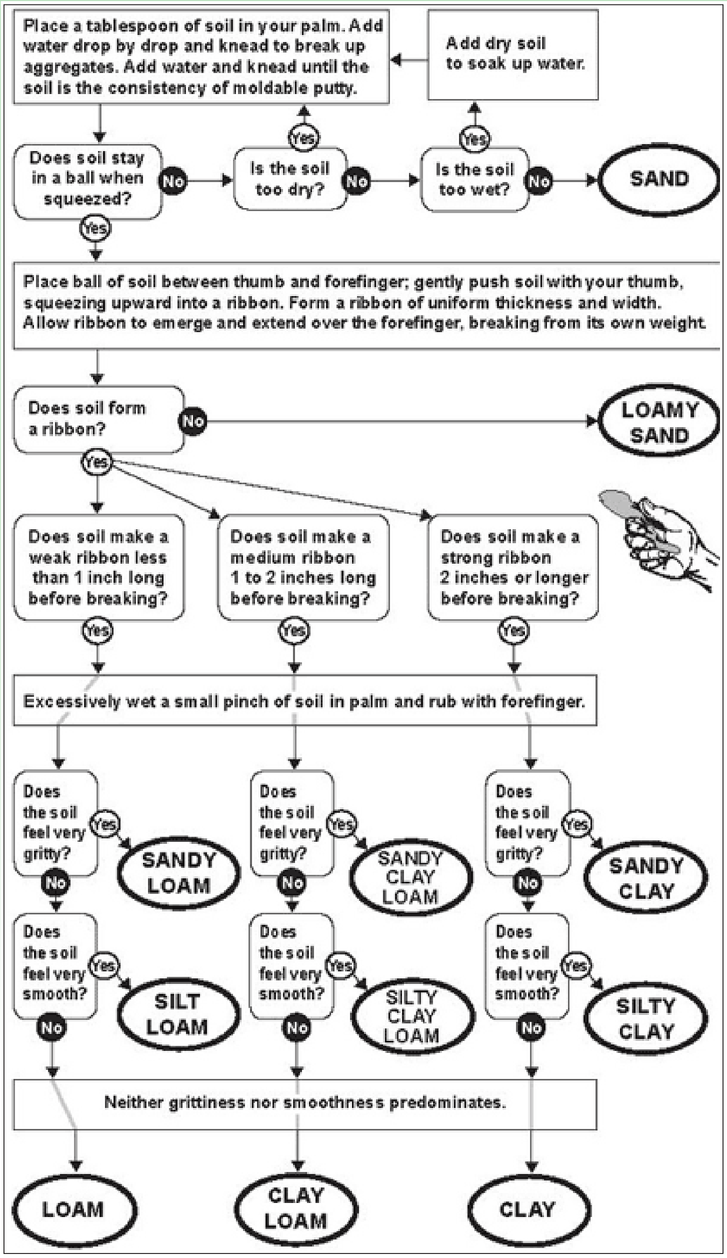
In the example above, the soil consisted of 40% Sand (red line), 30% Clay (blue line), and 30% Silt (green line). Thus, the soil can be classified as clay loam (indicated by the intersection of the three lines).



USDA Agronomic Soil Textural Triangle

GRAPHIC: USDA, adapted by SoilSensor.com, 2008

GRAPHIC: NRCS Irrigation Guide, USDA 1997



'By Feel' method of Soil Texture Analysis

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. Soil compaction refers to the reduction in the pore space of the soil by pressure applied to the soil surface. Compaction destroys the soil structure (compresses micropores and macropores), affects uptake and movement of water and inhibits plant and microbial growth.

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

Topography - Slope and Aspect

Slope angle and aspect can vary significantly at a site. Both of these factors influence the plant communities present. Slope angles are usually expressed as the ratio of the difference in height (*Vertical rise*) over the difference in length (*Horizontal run*). As an example: a 3:1 slope indicates three units of rise per unit of horizontal distance. Steep slopes are most prone to erosion and may require some form of surface stabilization, such as matting or mulch.

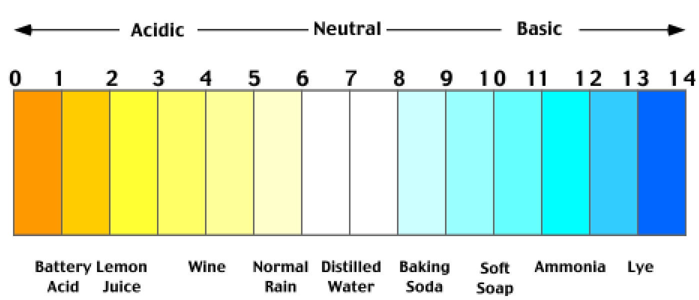
When a wetland is being restored, elevation gradients along the slope are very important. Many wetland species can only tolerate a certain level of water inundation. Plant loss can occur when planting in areas that receive too much or too little water; the result is an unsuccessful outcome from plant loss. Also, as one moves up in elevation the growing season declines because of lower air and soil temperatures.

Aspect is the direction a slope faces. North facing generally receives less sun and has wetter soils. Higher solar radiation, warmer air and soil temperatures, and drier soils are characteristic of south-facing slopes.

Soil pH - Acidity and Alkalinity

Soil pH is a measurement of soil acidity and/or alkalinity and has a major effect on nutrient availability. It is based on a logarithmic scale from 0 to 14. A number less than 7 represents an acidic soil, with the acidity increasing as the pH value gets closer to 0. Basic or alkaline are characterized by pH values greater than 7. A pH value of 7 indicates a neutral soil.

Basic soils contain high amounts of bases (calcium, magnesium, potassium, sodium, phosphates) and have generally developed in arid and



semi-arid climates. Acidic soils are formed in wetter climates where the bases have been leached through the soil profile. Having an idea of the pH value of the soil will help with plant selection, as some species prefer more acid soils and others prefer more alkaline soils. To correct acidic (low pH) soils a limestone application is used, and to mitigate overly basic (high pH) soils, sulfur is applied.

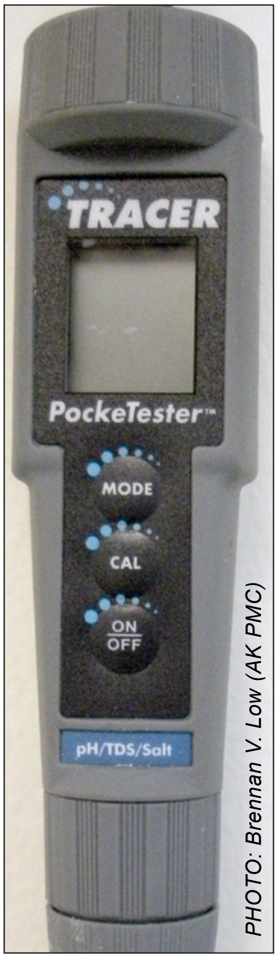


PHOTO: Brennan V. Low (AK PMC)

A portable pH / Electrical Conductivity meter is used to identify site conditions in the field

Electrical Conductivity

The electrical conductivity of a soil is determined by the amount of soluble salts in the soil. Plants grow best when the electrical conductivity (amount of salt) of a soil is low. Almost all plant species are endangered by high salt levels, particularly young seedlings. High salt concentrations can be found in arid climates where there is not enough rainfall to leach salts out of the plant root zone. Incorporating Gypsum into the soil may help to correct this.

Organic Matter

Organic matter consists of partially decayed and decomposed plant and animal matter, such as roots, branches, needles, bark and insects. In general, organic material makes up from 1 to 6% of the soil and is very important for water and nutrient retention. Revegetation potential is higher in soils with more organic matter.

Nutrients

In most forms of revegetation, 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 should be selected based on soil tests and the needs of the vegetation to be planted. Fertilizer is described using the percentages of three macro-nutrient elements: nitrogen (N), phosphorus (P), and potassium (K). For example, 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. This is to avoid compaction and unnecessary disturbance of the seed bed.

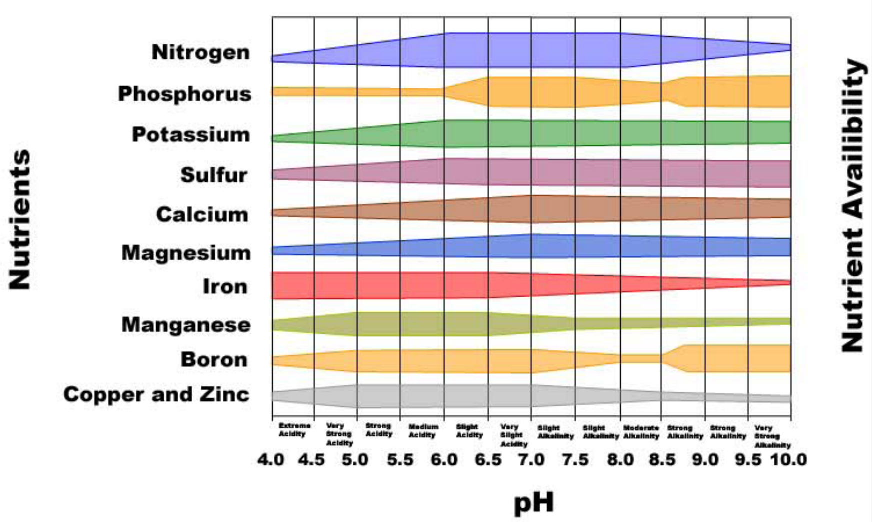
Topsoil

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.

Topsoils tend to have lower salt content than subsoils. When topsoil is removed during construction, the remaining soils can be very high in salts and pH (Steinfeld et al., 2007). Topsoil is a valuable resource in revegetation, and should be 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.

Influence of pH on Availability of Plant Nutrients



GRAPHIC: S.S.S.A.P, 1946 11:305, Redrawn by K. Williams; extension.org

Construction Site Considerations

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.

The **Unified Soil Classification System** (chart included below) 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).

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, equipment availability and site characteristics 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. This seeder has been successfully used on most soil types, except very gravelly soils.

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 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

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% passes No.200 sieve	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

Unified Soil Classification System (USCS)

An Ideal Seedbed Should :

1. Be free of construction debris;
2. Have relatively few large rocks or objects;
3. Be free of ruts and gullies;
4. Have the top two inches in a thoroughly tilled, friable, non-compacted condition (allowing a 170 pound person heel print to make a ¼ to ½ inch impression);
5. Be scarified to a depth of 6 to 8 inches, if soil is heavily compacted;
6. Devoid of non-native established weeds. Competition from weeds is can be a cause of seeding failure; and
7. Without a significant seed-bank of weedy species. Seed stored in the soil as hard or dormant seed may be viable and will germinate if the conditions are right. The presence of a nearby seed-bank often accounts for the surprise of a weedy species showing up on a site.

predation, and potential reduction in seed establishment and germination.

Broadcasting includes aerial seeding, hydroseeding, and hand-held methods. Hand-held and hand-operated spreaders are used due to their portability, increased speed, lower costs, and suitability to 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 vigorous plant growth. Grass growth can be inhibited, however, if too much mulch is applied.

Hydroseeding has also been portrayed as the most effective means for revegetating an area, though this claim is debated. The primary disadvantage of hydroseeding is the requirement for large quantities of water, which can result in numerous passes across the land that is being revegetated. The equipment is also complex, and mechanical problems can cause costly delays.

Hydroseeders are also useful as supplemental watering trucks once seed has been applied. Additional water applications increase project costs and are not always necessary to produce

Photo: Casey Dinkel (AK PMC)

A drill seeder, in this case a Brillion ©, is often used for planting revegetation species. The large drum in the background is an imprinter, used to firm the seedbed as well as create furrows into which the seed will settle.

Photo: Brennan V. Low (AK PMC)

A drill seeder drops seed into a row prepared by the spinning discs.

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.

Aerial Seeding

Aerial seeding uses an aircraft to place seed and fertilizer onto a site. This method is used to:

1. Broadcast seed over very large areas (50+ acres),
2. Apply seed rapidly to an area,
3. Apply seed in remote locations inaccessible to other seeding equipment.

Aerial seeding is used often after wildfires to stabilize slopes quickly and prevent erosion.

Seeding Rates

The revegetation suggestion chart on page 52 lists broadcast seeding rates for revegetation species. In this publication, hydroseeding is considered broadcast seeding with regard to seeding rates. Note that the rates provided should be halved when drill seeding.

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 several safe sites or micro-environments that provide favorable conditions 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.

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.

Photo: Gary Antoni (AK PMC)

Hydroseeding is used to revegetate slopes that are not easily accessed by traditional seeding equipment

Photo: Glenn Air / Northern Reclamation Services

Aerial seeding can be used for revegetating large, linear or remote sites.

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 Choices

After a species or species mixture has been selected, a decision needs to be made about which form of plant to use. Cost, revegetation objectives and availability of equipment are a few of the factors that influence this decision (Whisenant, 2005).

Seed

Seed is commonly used for revegetating disturbed areas. Seed is easy to collect, clean, store, transport, mix and apply to a site by drill or broadcast methods. Grass and forb species are usually directly seeded onto disturbed sites.

Seed Specifications

Quality seed is a critical component to success. Specifying "certified" seed assures quality 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 A*).

The true cost of seed can be determined by the Pure Live Seed calculation. To calculate Pure Live Seed (PLS), use the following 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 below:

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

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

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

Seed stored on site should be kept cool, dry, and in rodent-free areas. Remember seed is a living commodity; always buy seed based on the PLS calculation.

Certified Seed

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

The official use of the term Certified seed (with a capital C) is to describe seed grown under the rules of the Seed Certification Program. Its ancestry can be traced back to Registered Class or Foundation Class seed. In addition, the Certified seed must meet 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.

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.

Alaska Certified seed tags

Pre-certified Class seed tags

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. Certified seed should be used when available, although common seed is a usable product and may also 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. Avoid lower purities of seed.

Other Certification Classes

Many new native seed sources are being developed in Alaska. For the most part, these will not be sold as Certified seed. They may carry the following designations: **Source Identified**, **Tested Class**, or **Selected Class**. These classes will be in keeping with the standards of germination and purity of the Certification system, but the term Certified seed will not apply. These classes are referred to as being Pre-certified Class.

Transplants

Transplants are plants that were/are growing in their native habitat and are transplanted directly into a restoration site or nursery to be cultured for future use. Large transplants provide visual prominence to a site and have the ability to establish and spread quickly (Hoag, 2003).

Transplanting shock is a problematic and common occurrence, whereby the transplanted species fails to become established. Care should be exercised and appropriate horticultural practices used 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. 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 become established faster than seeded grass.

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 acclimate the seedlings to their new environment.

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, 2007). Containers come in a variety of sizes and shapes. Container-grown plants are able to tolerate harsher conditions more easily than bare-root transplants (Eliason & Allen, 1997).

Cuttings

The use of willow cuttings is the most common 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, a guide published by the Alaska Department of Fish & Game. This publication can be found online, at www.adfg.alaska.gov/index.cfm?adfg=streambankprotection.main.

Photo: Andy Nolen (AK PMC)

Willow stakes, planted while dormant, will grow again in the spring.

Planting Time

Timing is crucial to revegetation success. The optimum planting season is just before the longest period of favorable conditions. Spring planting is ideal where the primary growing season occurs in the late spring and/or summer. The end of the planting season for Interior Alaska generally falls between August 15th and 31st.

If you are planning a revegetation project after the end of the planting season, refer to the dormant seeding section of the Techniques chapter for further information.

Selection of Species

After receiving a project contract, assess the availability of potential species. If seed and plant materials are available at the correct time and an acceptable cost, the purchase should be made immediately. Buying seed early ensures that the product will be available as needed. Care needs to be taken to assure the seed and plant materials are properly stored in a dry, cool environment to prevent loss of viability.

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, 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. Therefore, it is imperative that species chosen 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 in Alaska, although in-state production is increasing, due in part to state and federal mandates requiring the use of these species.

A list of commercially available native plant species is available in the Native Plant Directory,

Photo: Brennan Low (AK PMC)

Seeding should be accomplished using high quality seed that has been properly stored and is free of weeds.

which can be found at the Alaska Plant Materials Center website, at plants.alaska.gov/native. A discussion of non-native and invasive plants can be found in the Conservation and Protection chapter, on page 43.

Mulch and Erosion Matting

If soil has a high erosion potential, consideration should be given to using a soil cover such as mulch or erosion matting. Using a soil cover can conserve soil moisture, moderate soil surface temperature and increase germination. 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 first and 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. An additional consideration 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.

Photo: Phil Czapla (AK PMC)

Geotextile fabric is a popular and effective type of erosion control matting. It is both inexpensive and resistant to weather extremes.

Photo: Sam Lamont (AK DOT&PF)

Seeded grasses become established through jute erosion control matting

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:

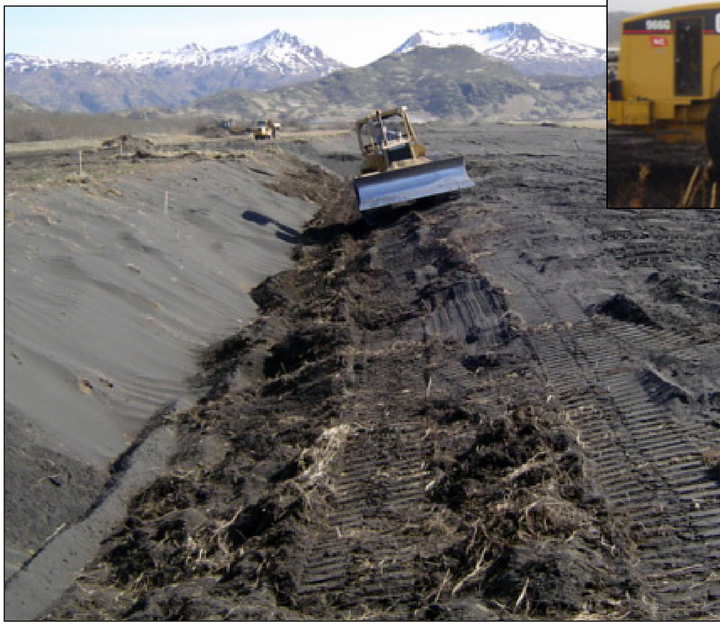
This technique promotes growth by spreading overburden (usually topsoil taken from a nearby work site) over an area to be revegetated. Seed, roots, nutrients, and microorganisms already present in the soil constitute the 'charge', and are relied upon to establish vegetation. The drawback to this revegetation technique is that it may involve placing an erodible material on the site.

An additional step to this revegetation approach consists of pushing the vegetative cover aside into debris piles, and then removing the topsoil layer and setting it aside as well. Upon completion of excavation, the site is re-contoured and the topsoil and vegetative debris is spread back over the area. The vegetative debris and 'charged' topsoil promote the growth of vegetation and increase the likelihood of a successful revegetation outcome.

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 www.dot.alaska.gov/stwddes/dcspubs/manuals.shtml.

Vegetative debris was spread over a re-contoured waste rock dump at the Illinois Creek Gold Mine.

Topsoil being gathered onsite - November, 2005



Spreading charged overburden - May, 2006

Heavy equipment used to spread topsoil - May, 2006

Photos: James Bowers (AK DOT&PF)

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).

Transplanted tundra plugs

Photos: AK DEC, Spill Prevention and Response

Placement of sod clumps

Harvesting sod clumps using a Bobcat

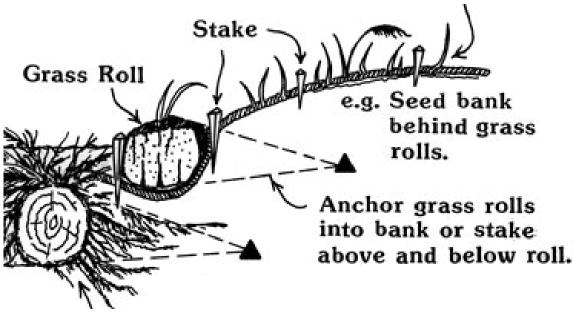


Photo: Nancy Moore (AK PMC)

A prepared grass roll, consisting of sod clumps wrapped in a 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: '<u>Streambank Vegetation and Protection, a Guide for Alaska</u>', or visit www.adfg.alaska.gov/index.cfm?adfg=streambankprotection.main.

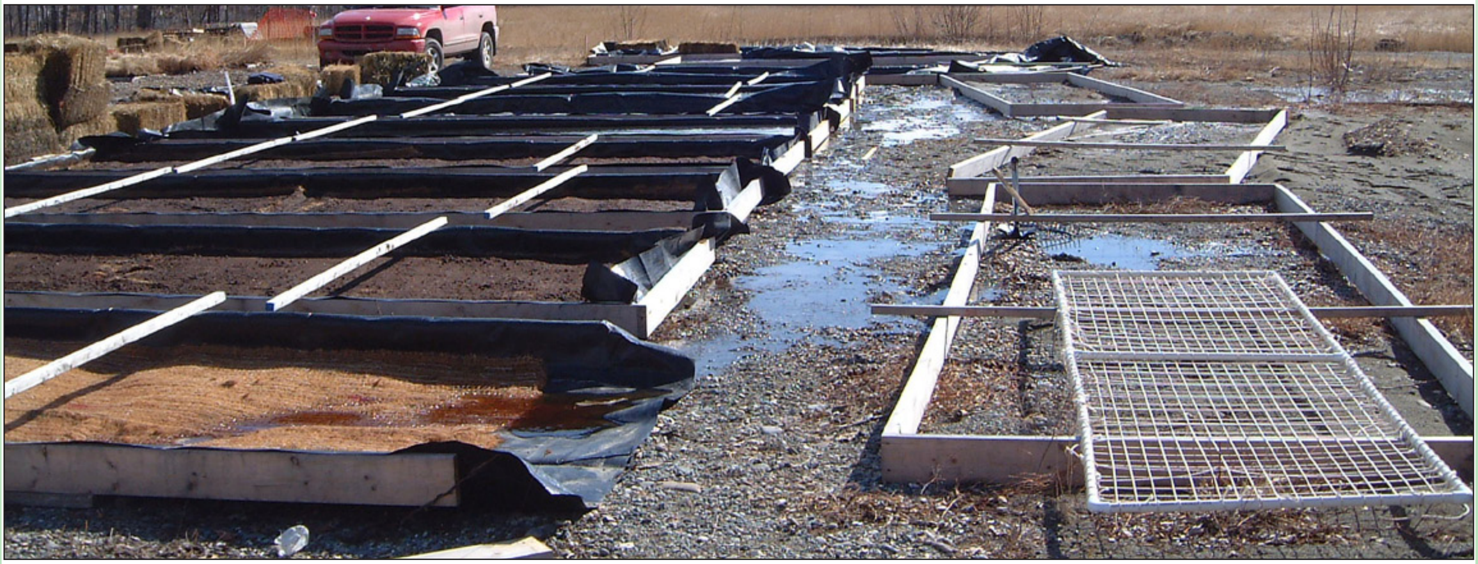
Vegetation Mats:

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 established.

Vegetation mats provide many of the same benefits of a sod clump, however 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: Peggy Hunt (AK PMC)

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

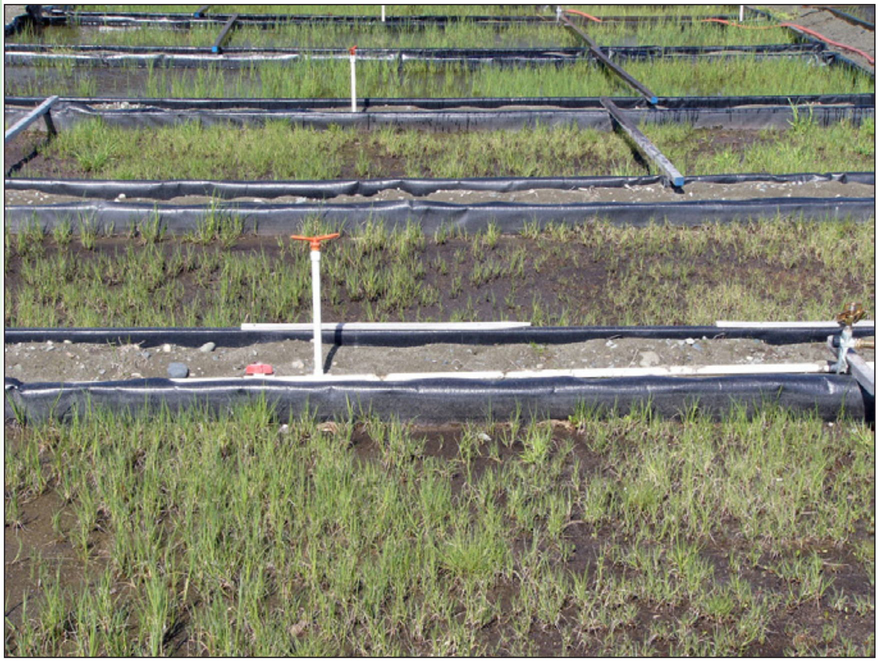


10' x 3' constructed mats framed with dimensional lumber, with thick plastic and erosion control matting used for the base. Only the biodegradable erosion control matting will remain once the mat is deployed.

Photo: Peggy Hunt (AK PMC)

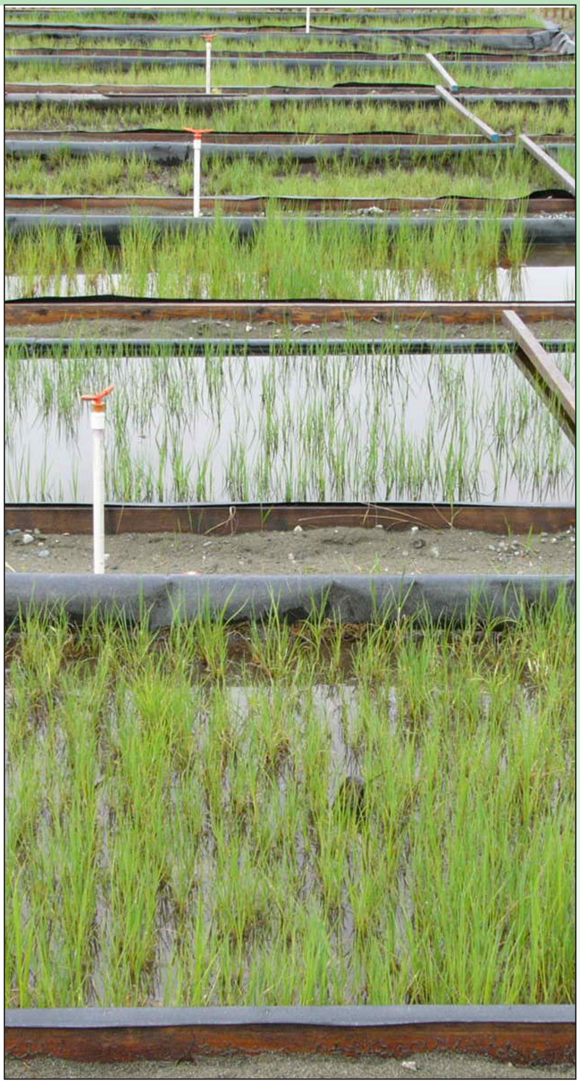
Stratified seeds are sown on a vegetation mat, using hand seeders and a constructed grid to seed at a rate of 1 seed per 2 inch square.

Photo: Peggy Hunt (AK PMC)



Germinated seeds take root in the constructed vegetation mats

Photo: Peggy Hunt (AK PMC)

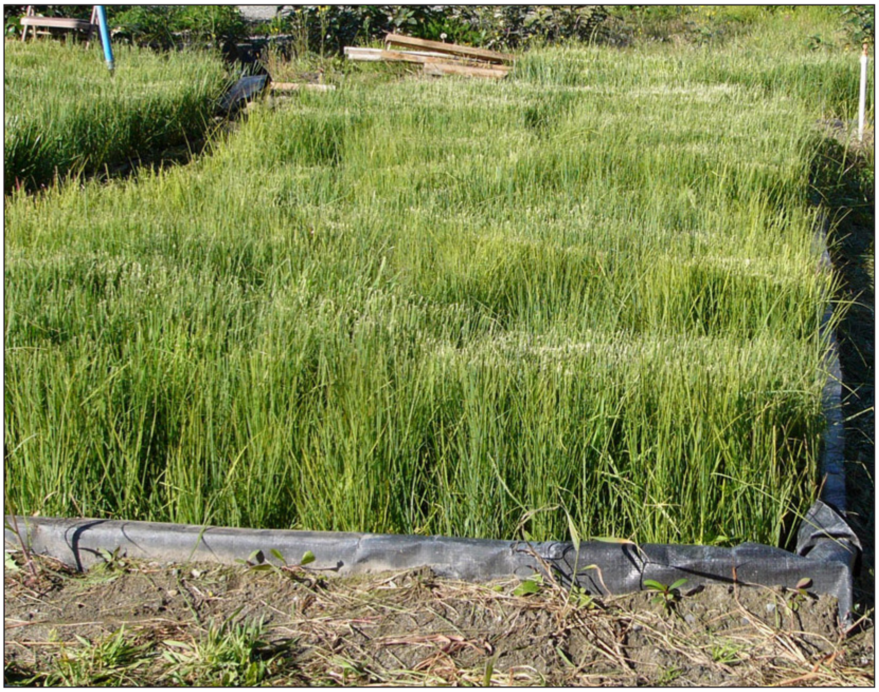


In situ irrigation allows wetland species to thrive in the constructed vegetation mat.

Photo: Don Ross

Underside of vegetation mat, showing developed roots inter-twined with erosion control fabric

Photo: Don Ross



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

Photos: Don Ross

Vegetation mats being installed along the waters edge

Vegetation mats, one year after transplanting

Natural Reinvasion:

This technique relies on natural processes to revegetate a site. It is a slow process with unpredictable results. Management is not required because neither seedbed preparation nor planting is done. Species from the surrounding areas arrive through natural processes, usually by wind dispersal. Though it may take many years for a plant community to become established, this method can be highly effective and is often used at sites that are out of view. When communities are concerned with initial aesthetic and visual appeal, or a regulatory timeline applies, this technique should be avoided.

Photo: Steve McGroarty (AK DOT&PF)

Natural invasion is evident at this materials borrow site, four years after the closure of the Illinois Creek Gold Mine. The borrow site is being colonized nicely by species from the surrounding area.

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 to arrive 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 the process does not perform well or other problems emerge.

Photo: Phil Czapla (AK PMC)

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

Photo: Stoney Wright (AK PMC)

Fertilizer should be applied to edge of existing vegetation.

Photo: Stoney Wright (AK PMC)

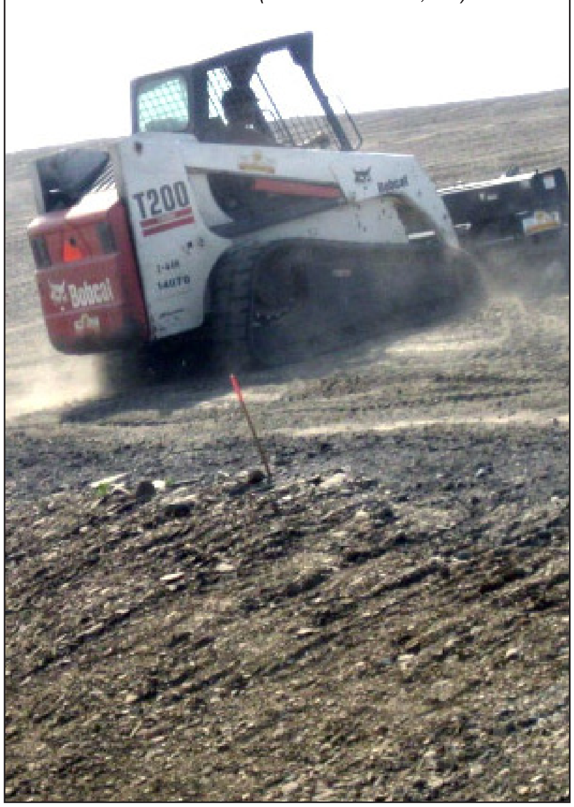
The effect of surface scarification on plant establishment and growth after two growing seasons. No seed was applied to the site, but it was fertilized with 20N-20P-10K at a rate of 500 pounds per acre.

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 captures runoff (Dixon, 1990). Imprinting can be accomplished with heavy equipment such as a compactor with a 'sheepsfoot' 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 tracked vehicle leave depressions on a soil surface. This technique is commonly used on sloping sites, before seeding. The equipment should be operated so as to leave depressions that will intercept runnoff as it flows downslope. When using the track-walking technique, the surface area of the treated site is increased by approximately 20%; application rates of materials should be adjusted accordingly.

Photo: Gordon Scholsser (Great Northwest, Inc)



If operating on a slope, tracked vehicles should be driven up and down to the slope such that the cleat marks left after track-walking are roughly perpendicular to the slope

Photo: Stoney Wright (AK PMC)

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

Photo: Stoney Wright (AK PMC)

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

Photo: Phil Czapla (AK PMC)

Surface imprinting accomplished using the 'track-walking' technique.

Photo: Stoney Wright (AK PMC)

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

Photo: Stoney Wright (AK PMC)

***Puccinellia nutkaensis* 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', may 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 scarifcation.

Photos: Stoney Wright (AK PMC)

Deep scarification of the soil surface can be accomplished using 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 .

Dormant Seeding:

Dormant seeding is the process of planting seed during late fall or early winter when soil temperatures are too cold for seed germination to occur; so that seed germination occurs the following spring.

Facts to consider when choosing Dormant Seeding:

Choosing dormant seeding as a revegetation approach will allow for an extended planting season. The planting window for revegetation projects can be extended by several months when the dormant seeding method is part of a revegetation plan.

Photo: Don Ross

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.

Planting seed later in the season can naturally overcome seed dormancy mechanisms. Some native species require exposure to cold and moisture (overwintering) to break internal and external dormancy. In these species, the winter season allows for stratification and scarification processes to take place. Breaking seed dormancy in a spring/summer planting schedule may require that these winter conditions be artificially recreated in a controlled environment. Most grasses used for revegetation in Alaska do not require this treatment. Forbs are more likely to require stratification.

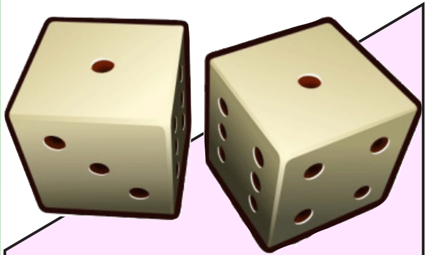
Another benefit of dormant seeding is the head-start it provides against weeds. Seed present in the soil at the start of the growing season will face less competition from weeds for resources like oxygen and water.

Dormant seeding can also result in significant and unanticipated problems. Unseasonably warm temperatures after seed placement can trigger germination, and the possible failure of the seeding effort due to seedling mortality. Also, seed predation by rodents or birds can become a concern if seed was not adequately protected. Seed can also be transported away from the intended site by wind during the winter, or by water erosion during spring break-up.

Remember that dormant seeding cannot be counted as an active measure on the Storm Water Pollution Prevention Plan (SWPPP) without some other physical measure that protects the soil surface overtop of the seed bed. Dormant seeding is not an immediately effective Best Management Practice (BMP).

Site Preparation & Planting

Seeding methods become more limited with dormant seeding. The ground should be frozen with a soil temperature below 40 degrees so that the seed will not germinate. Seeds must remain un-germinated and in place until after the next growing season starts.



Dormant seeding is a roll of the dice and requires a high degree of confidence. The user is essentially becoming a farmer.

Late season planting restricts the type of site preparation equipment that can be used, as well as the method used to apply the seed mix. Frozen soil on a project site is harder to manipulate, and this can affect the viability of the seedbed. A mechanical implement such as a drill seeder is not as adaptable to frozen soil. Broadcasting and hydroseeding are effective methods for distributing seed on frozen ground. If hydroseeding, a dark colored mulch should not be used in the slurry. Dark mulches may raise the soil temperature promoting early germination.

Planting Time & Rate

As a general rule dormant seeding should only be undertaken after the first hard killing frost, but not after four inches of snow. This will prevent premature germination and allow good seed-to-soil contact. Dormant seeding should never be attempted on crested snow.

Mulch application may necessary for unprotected and windy sites, to protect the seed and prevent it from blowing offsite. The type of mulch used and application rates will be determined by the project engineer or Storm Water Pollution Prevention Plan (SWPPP) for the project site. Application rates are usually in accordance with manufacturer specifications.

Higher application rates are recommended for dormant seeding because seed mortality rate is higher. A 15-25% increase is appropriate. Dormant seeding is not temporary seeding and should include both annual and perennial species.

Seeding schedules tend to be location specific. As rule of thumb, seed as soon as you can in the spring (i.e. when no crusty snow remains on the ground). Temperature in the spring has no effect on seed dormancy.

Wild Seed Collection

Photo: Andy Nolen (AK PMC)

A pull-type seed stripper is an effective means of harvesting wild seed without damage to the surrounding environment.

An alternative to obtaining seed commercially is to collect seed in the wild. Wild seed can be harvested from native grass, forbs, shrubs, and trees found at or near the project site (Steinfeld,Riley,Wilkinson, Landis, Riley, 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.

Collection of wildland seed is a lengthy process that benefits from prior planning. Seed collection, processing and increase are all steps that must be followed to make plant materials available. 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 **Appendix B: Partner Agencies**.

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.

Recognizing seed maturity depends upon several factors, and differs for grasses, trees, and shrubs. Color, taste, and hardness should be considered when determining if a seed is mature. Plants with fruits start green and change to red, blue, white, or varying colors with maturity. The sour, bitter taste in plant fruits indicates an immature plant. With time, higher sugar content in the fruit signals maturity, giving it a sweet taste when eaten. The hardness of the fruit will also change when mature. When fruit becomes soft and pulpy, it is usually mature.

Photo: USDA Forest Service

Cut stem just below the seed-head when harvesting seed by hand.

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 good species to hear and see those traits.

Grass seed maturity can be determined by how the seed responds when pressed between the fingers. The stages of grass seed maturity are summarized below (Steinfeld, et al, 2007):

- **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 make collecting difficult and blow the seed off site.

Seed collection methods are dependent upon the species being collected, 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. 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, necessitating alternate means of collection. For large, flat sites a combine or Woodward Flail-Vac © type seed stripper can be used. A pull type seed stripper can be mounted to an all terrain vehicle (ATV), facilitating collection on less flat ground.

Project scale is another consideration when collecting. 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.

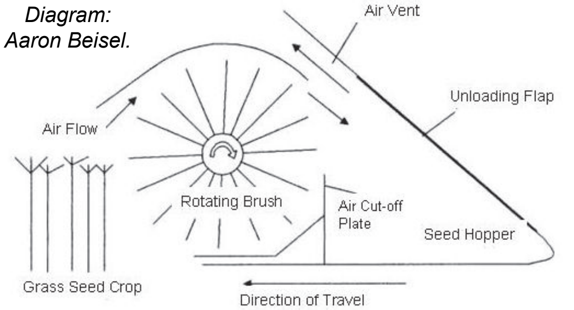
Photo: Stoney Wright (AK PMC)

Combine harvesting wild Bluejoint reedgrass (*Calamagrostis canadensis*)

Photo: Stoney Wright (AK PMC)

Collected fireweed stays in the seed stripper until removed for processing.

Diagram: Aaron Beisel.



Schematic of Woodward Flail-Vac © seed stripper

Photo: Prarie Habitats Inc.

A hand-held seed stripper is a solution for medium volume collections in inaccessible sites.

For inaccessible sites that are too large for hand harvesting, consider using a portable seed collector, such as a hand-held seed stripper or a commercial leaf vacuum. A push-type chipper shredder can also be used to collect seed, 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.

Seed processing involves separating weeds, chaff, dirt, stems, and other inert matter from the seed. This is generally done by 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, amongst other treatments. When sufficient quantities of seed are available, the increased seed must be collected and processed, as previously described, before planting can begin.

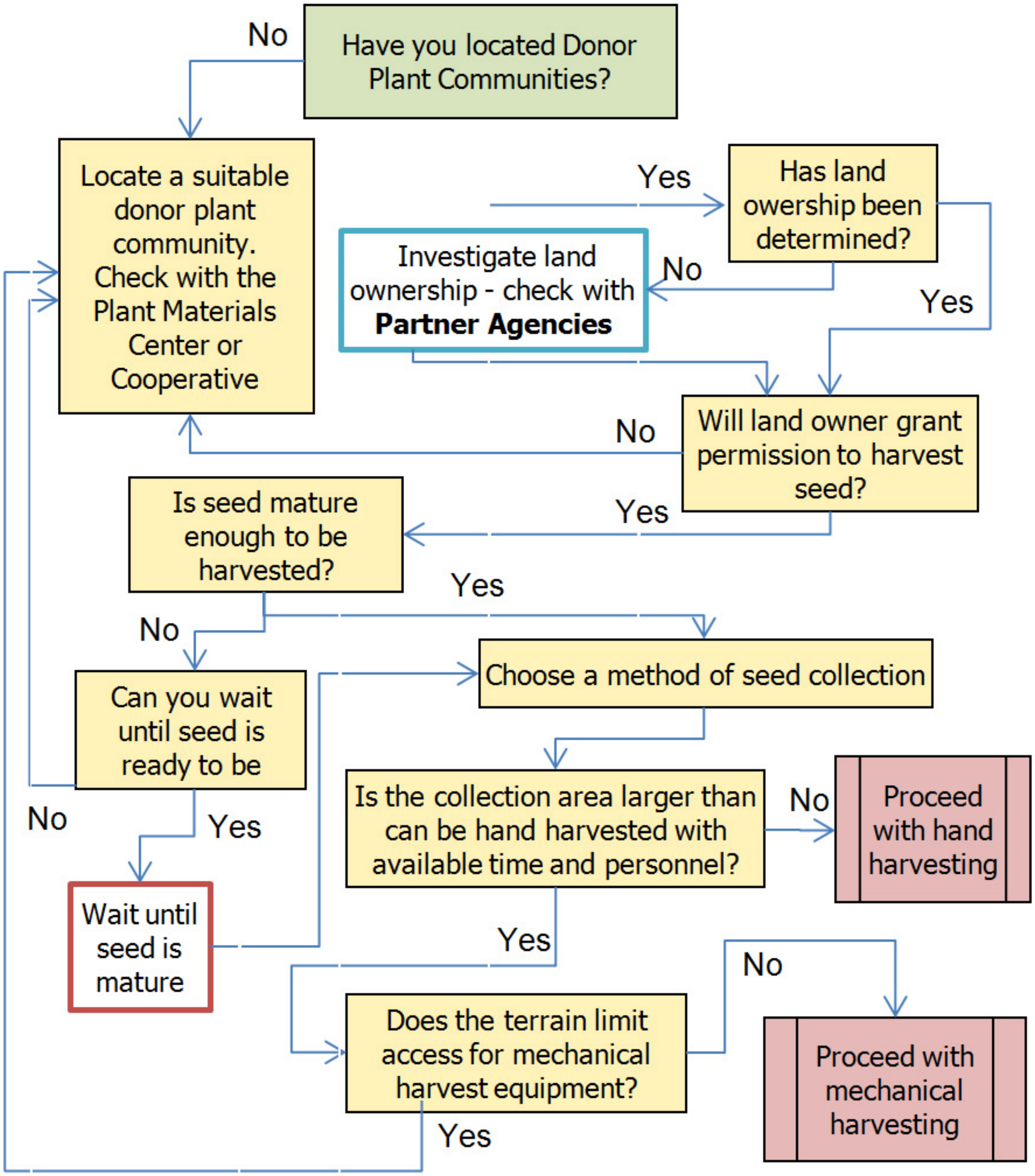
Harvested seeds from tree and shrub species are often started at a nursery and grown in nursery beds (bare-root stock) or containers (container-grown stock) in a greenhouse. Seedlings are then transplanted to the site when ready.

Photo: Troy-Bilt USA

A leaf blower with a vacuum function can be used to collect seeds in the wild.

Photo: Andy Nolen (AK PMC)

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



Wild seed harvest decision chart

Potential Sources of Erosion

The 2005 Highpower Creek fire burned 115,000 acres of Denali National Park

There are many industries and activities that affect the soils and vegetation of Interior Alaska. Erosion or sedimentation from wildfire, agriculture, transportation, and resource development industries needs to be monitored. This chapter will address notable and typical impacts to Interior Alaska.

Following best management practices from the beginning of a project is an effective way to ensure a successful outcome and minimize the potential for erosion. If questions arise in the development of a revegetation / restoration plan, contact the Alaska Plant Materials Center for assistance.

Wildfire

Natural events, such as wildfire, can have a large effect on the landscape. Wildfires originating from lightning strikes, up to 4000 in a single day, are common throughout the summer months. In 2004 and 2005, Alaska recorded its worst burn years to date. Over six and half million acres were burned in 2004, and another four million acres in 2005.

Fire is a natural part of the landscape, resulting in uneven age distribution of trees in the forest, increased wildlife habitat and improved forest health. Hot burns down to mineral soil are essential for the regeneration of Black Spruce forests. Land managers identify lands that will benefit from natural fire. Fires in these areas are monitored, but left to burn until ended by weather, lack of fuel, topography or until threats to other resources justify suppression action.

The process of succession takes place after wildfire. Here, cottongrass grows in the nutrient rich soil left after a burn.

Fire can be a major threat to life and property. It can potentially melt permafrost and be a source of erosion problems. Fire can result in the need for revegetation, slope stability and mitigation measures.

Wildfire can greatly affect species composition and age distribution of trees. Burned landscapes must go through transitional stages (succession) over time, as different tree species become established earlier and are replaced by other species over time. A diverse age and species distribution benefits not only forest health, flora and fauna, but creates natural barriers to wildland fire spread.

Natural reforestation and regeneration are successful in abating erosion in many areas, but with steep terrain, permafrost, or during certain seasonal weather conditions, the effects of fire can require remediation. Timing between fire occurrence and weather factors, such as thunderstorms, flooding or the onset of winter, can greatly influence the role of erosion.

Spruce bark beetle damage evident on White Spruce, *Picea glauca*

Spruce Bark Beetles and Other Dangers

Another factor that can play a role in the intensity and frequency of wildfire is the Spruce bark beetle. In the 1990's, southcentral Alaska experienced a beetle outbreak that killed millions of acres of spruce trees (Ross, Daterman, Boughton & Quigley, 2001). Although most devastating in Southcentral and the Copper River Valley, other natural, extensive insect infestations have created more localized problems in Interior Alaska. Tree mortality caused by the spruce bark beetle has increased the potential for large, intense wildfires, changing vast areas to grassland made impenetrable with wind-thrown dead trees.

This beetle attacks spruce trees by boring through the bark and laying eggs directly into the phloem tissue, the transport mechanism that distributes food throughout the tree. When this layer is destroyed, the tree will die. When spruce beetle populations increase, they will begin to shift from dead, dying, and stressed trees into healthy trees nearby (USFWS).

A method to reduce the fire hazard caused by bark beetles is the removal of trees killed by beetles and wildfire. This management strategy removes host trees or logs suitable for beetle colonization (Reynolds & Holsten. 1994; Schmid, 1981). Salvaging burned material also reduces surface fuel loads on the forest floor. Large woody debris on the forest floor after spruce beetle outbreaks is prime "fuel" for wildfires. Wildfires that occur in affected forests could be intense and difficult to control (Ross et al., 2001).

Agency policies concerning the removal of trees differ. The Alaska Department of Natural Resources, Division of Forestry and U.S. Forest Service remove diseased, dead, and dying trees in areas that are accessible, while the U.S. Fish and Wildlife Service encourages trees to be left in place to serve as nesting habitat and cover for wildlife. The U.S. Bureau of Land Management encourages harvest of diseased, dead, and dying trees on most lands under their oversight (USFWS).

Agriculture

Agriculture can be a source of erosion. Land clearing and grading (tillage) disturbs native vegetation and wildlife habitat. Application of chemical fertilizers and pesticides can affect soil nutrient cycles and groundwater. Soil erosion can lead to declining agricultural productivity and loss of topsoil. Understanding these dangers can help producers to avoid damage to the ecosystem.

The biggest dangers associated with agriculture are:

- Damage to soil, including erosion; and
- Contamination of water and soil from fertilizers & pesticides.

Ten times as much soil erodes on average from American agricultural fields as is replaced by natural soil formation processes. Since the formation of just one inch of agricultural topsoil can take up to 300 years, soil that is lost is essentially irreplaceable (Troutmann, Porter & Wagenet, 2008). Surface soils have the greatest water holding capacity and the highest density of plant nutrients. Cover crops, windbreaks and terracing are methods of limiting erosive threats to a soil.

Surface runoff carries manure, fertilizers, and pesticides into streams, lakes, and wetlands. Groundwater can also become contaminated by percolation of water and dissolved chemicals downward through the soil. Nitrogen from fertilizer is also a concern because of its high solubility in the nitrate form. Leaching from agricultural fields can elevate nitrate concentrations in underlying groundwater to levels unacceptable for drinking water (Troutmann et al., 2008). The use of conservation buffers and cover crops can minimize potential soil erosion and the leeching of harmful chemicals into surface and groundwater.

In the last 50 years, the State of Alaska has transferred over 80,000 acres of land into private ownership for agricultural development. The majority of this land is in the Delta area, approximately 100 miles southeast of Fairbanks.

In August 1978, the State of Alaska started the Delta Barley Project, a large scale commercial agriculture initiative, with the lottery sale of 22 parcels of land with an average size of over 2,700 acres (Davies, 2007). An additional land release of 15 parcels totaling 25,000 acres took place in early 1982, and the state has continued to release land for agricultural development. The State of Alaska occasionally makes agricultural parcels available for sale. For further information, check with the Alaska DNR, Division of Agriculture.

Photo: Casey Dinkel (AK PMC)

Fertilizer used in agricultural production may increase nitrate concentrations in ground and surface waters

Transportation

Alaskans depend on roads and railways for travel and transport of goods and services. These transportation corridors are common places for erosion to occur. Repeated activity may remove or limit vegetation growth while also increasing surface compaction. An established vegetative cover helps to bind the soil together, limiting erosion and sediment losses. It is prudent to make erosional observations on an ongoing basis, and take corrective actions when necessary. Rilling, sloughing, gullies, and sediment deposition are signs of erosion and may indicate a need for mitigation.

Another major project affecting the natural environment was the creation of the Alaska Highway, which starts in Dawson Creek, BC and terminates at Delta Junction. Today the Alaska Highway is fully paved, although frost-heaving and seasonal wear and tear ensures it is constantly under maintenance. Disturbances associated with the road require frequent revegetation to restore natural conditions. This helps with erosion, improves aesthetics and insulates the permafrost layer from warmer temperatures associated with bare ground.

Photo: Sid Richards (AK DOT&PF)

Riverbank erosion exposes a culvert along the Taylor Highway

The Dalton Highway (also called the "*haul road*"), was constructed in 1974. This 414 mile highway traverses an undulating landscape, creating a large, linear disturbance. The Dalton highway starts at the Elliot Highway and ends at Deadhorse, on the Arctic Coastal Plain. Truckers drive this route daily to supply the oil facilities in Prudhoe Bay. Continual road use requires ongoing maintenance to ensure that roads are passable.

Best Management Practices (BMPs) exist to address erosion hazards, and should be considered during construction. Selected BMPs can be found at the Alaska Department of Transportation & Public Facilities's website, at dot.state.ak.us/stwddes/desenviron/pop_swppp.shtml.

Riverbank Erosion

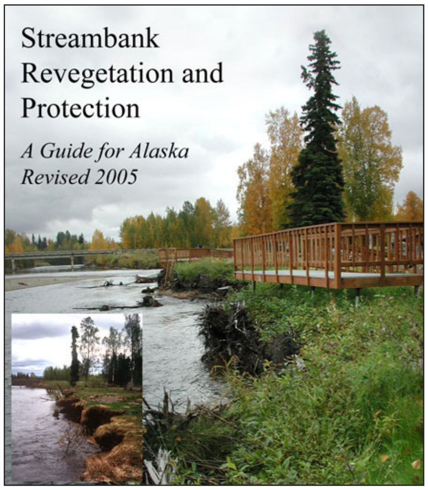
For communities and projects located along rivers, erosion is a predictable occurrence. Riverbank erosion is a natural process whereby high-flow events degrade embankments and can change the course of the river system. This threat is greatest during the spring break up, when water levels are high and flow is rapid. Ice jams that occur during spring melt are a major concern of many communities along rivers.

River systems are natural transportation corridors, and development along their banks is common. Roadways are sometimes located along rivers, presenting unique challenges for erosion and sediment control. The shoulders of

Photo: Alaska DOT&PF

The town of Eagle, Alaska was hit with a major flood event in the summer of 2009

roads can become waterlogged and unstable during high-flow events. The Chistochina River Wetland Restoration project, in the case studies section, dealt with some of these issues.



Rivers are important for subsistence and cultural reasons, even though the erosion potential is high. Flooding happens very quickly along rivers, and can cause a great deal of damage. This occurred in May, 2009 in the town of Eagle, on the Yukon River. About 30 houses were destroyed by flooding, and a major cleanup effort followed.

An ambitious project to control river flooding and limit potential damage was developed 40 miles upriver of Fairbanks. The Chena River Lakes Flood Control Project (CRLFCP) was put in motion after an August, 1967 flood left a swath of water in downtown Fairbanks, along with $180 million in damages. The 20,000 acre flood control complex consists of four 30-ton floodgates, Moose Creek dam and the Tanana River levee.

The CRLFCP takes water from the Chena River during periods of high flow and sends it toward the Tanana River. The complex can hold a volume of water equivalent to 224,000 football fields, each covered with one foot of water. Very rarely does water have to be released into the Tanana River.

Streambank Revegetation and Protection, a guide published by the Alaska Department of Fish & Game is a comprehensive resource which details the use of erosion control mats, coir logs, and willow revetments, among other technologies. This publication can be found online, at www.adfg.alaska.gov/index.cfm?adfg=streambankprotection.main.

Additionally, case studies of some significant projects affecting river and streambanks can be found in the Alaska Coastal Revegetation & Erosion Control Guide, also by the Alaska Plant Materials Center. You can find this publication at plants.alaska.gov/reveg.


Photo: J.K. Brooks

Wreckage is cleared from the Beaver Creek floodgate after a 2008 flood event in the Tanana valley

Mining

Mining operations disturb the natural landscape and are potentially a major source of erosion. Consequently, the mining industry is heavily involved in reclamation and revegetation. Extracting natural resources from the earth has an environmental cost. In Alaska, industrial processes are managed to minimize the damage caused by resource development. Laws and regulations exist to promote responsible resource development.

A federal law, the Surface Mining Control and Reclamation Act (SMCRA) of 1977, regulates surface coal mining and reclamation nationwide. Enforcement of this law was taken over by Alaska in 1983, with the passage of the Alaska Surface Coal Mining Control & Reclamation Act. Alaska law now provides for the oversight of mining operations, from exploration through to final reclamation activities.

An additional program created through this legislation is the Abandoned Mine Lands Program. This program provides for the reclamation of eligible lands that were mined and abandoned, or inadequately restored. Funding for this program comes from a fee assessed on each ton of coal, presently 31.5 cents/ton for surface mines and 13.5 cents/ton for underground mines. The Alaska DNR, Division of Mining, Land, & Water (DMLW) has jurisdiction over abandoned mines in Alaska. Lasting disturbances to the landscape are minimized through reclamation.

Interior Alaska Mining Operations		
Producing Mines	**Land Status**	**Mineral Deposits**
Usibelli Coal	State	Coal
Fort Knox	State/Mental Health Trust	Gold
Pogo	State	Gold
Advanced Exploration Project	**Land Status**	**Mineral Deposits**
Donlin Creek Project	Private	Gold
Livengood	State/Mental Health Trust	Gold
Ambler	State	Copper, lead, zinc, silver, gold
Nixon Fork	Federal	Gold

Mining Presence in the Interior

The mining industry is very important to Alaska's economy and provides thousands of job opportunities for people living in rural and urban areas. Additionally, mining brings in millions of dollars for local and state government through taxes. Mineral deposits are heavily concentrated in the Interior, and as a result most exploration, mine development and mineral production occurs in this part of Alaska. The Interior has three active producing mines, one development project and numerous advanced exploration projects. Driving exploration is the global demand for minerals, notably from countries such as Canada, China, India, South Korea and Japan.

Well in advance of mining operations, many qualitative and quantitative studies are conducted. These studies assess the economic feasibility and environmental impact of a project, and identify potential problems, such as threats to human health, critical habitat, and toxic materials. Information collected and analyzed may include climate, historical, archeological, hydrologic, geologic, and soil data. It should be noted that exploration projects do not always culminate in operating mines.

DMLW hosted a Northern Latitudes Mine Reclamation Workshop in May of 2011 which addressed several topics relating to revegetation. Abstracts and presentations can be downloaded from dnr.alaska.gov/mlw/mining/aml/nlmrws2011/.

Photo: Erin McKittrick, Ground Truth Trekking

The Usibelli coal mine is the only operating coal mine in Alaska. The active Two Bull Ridge mine is in the foreground, with the partially reclaimed and inactive Poker flats development in the background.

Conservation & Preservation

Photo: F. Golet (US FWS)

A wetland is an area innundated with water with emergent vegetation, such as this area in the Yukon Kuskokwim delta.

Protecting Wetland Areas

Wetlands are an important resource as they provide a number of functions such as wildlife habitat, passive and active recreational opportunities like photography and hunting, subsistence hunting, fishing, trapping, and aesthetic appreciation. Wetlands are defined as those lands: "inundated or saturated by water at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions" (Alaska Department of Environmental Conservation, n.d.).

Wetlands are transitional lands, between terrestrial and deepwater habitats, where the water table usually is at or near the surface or the land is covered by shallow water (Cowardin, Carter, Golet & LaRoc, 1979). Vegetation observed in wetlands is hydrophytic, meaning it grows in water or is found growing in a substrate that is periodically deficient in oxygen.

Alaska has an abundance of wetlands, more so than any other region of the United States. According to the National Wetland Inventory, wetlands account for more than 174 million acres and comprise more than 43 percent of Alaska's surface area (Hall, Frayer & Wilen, 1994). Interior Alaska consists of 41 percent wetlands - approximately 71 million acres. The largest wetlands in the region are the Kanuti flats and Tanana-Kuskokwim lowlands. North-facing slopes are common wetland areas, where shallow permafrost is conducive for trapping water. Vegetation in the Interior consists of millions of acres of Black Spruce muskeg and floodplain wetlands, dominated by deciduous shrubs and emergents (Hall et al., 1994).

Wetlands are ideal habitat for many waterfowl species.

Wetlands may be subject to regulation, under section 404 of the Clean Water Act (33 U.S.C. 1344) or Section 10 of the Rivers and Harbors Act (33 U.S.C 403). These laws are designed to slow the loss of wetland areas. The Clean Water Act is the law most often used to protect wetlands. The Rivers and Harbors Act requires a permit for work in navigable waters. Regulated activities include diking, deepening, filling, excavating, and the placing of structures. The Army Corps of Engineers regulates the discharge of dredged or filled material into wetlands. Corps staff issue permits relating to wetlands, and will assist applicants with the process of obtaining a permit.

Farming, ranching, and silviculture activities do not fall under section 404 regulations. The U.S. Department of Agriculture (USDA) has jurisdiction for areas that produce or could produce an agricultural commodity, including wetlands. Under the Food Security Act of 1985, the Natural Resource Conservation Service (NRCS) has the sole responsibility for wetland determinations and delineations affecting these USDA programs.

The Food Security Act of 1985 contains wetland conservation (also called "Swampbuster") provisions designed to discourage the conversion of wetlands into non-wetland areas and deny federal farm program benefits to producers who converted wetlands after December 23, 1985. A person who has produced an agricultural commodity on newly converted wetland is ineligible for certain benefits provided by the USDA, including commodity price support or production adjustment payments, farm storage facility loans, disaster payments and federal crop insurance.

Invasive Species

Invasive species are typically recognized as non-native species that, once introduced, spread beyond control to affect natural and agricultural resource or human health. Not all non-native species are invasive, and many are highly beneficial for agricultural or ornamental purposes.

Invasive plants and agricultural pests cause significant economic losses to agriculture and wild lands across North America. In Alaska, many notorious invasive agriculture and wildland weeds are not present, have a very limited distribution or have yet to invade natural areas. Some invasive weeds have become established in Alaska, however, and are impacting agricultural and wildlands.

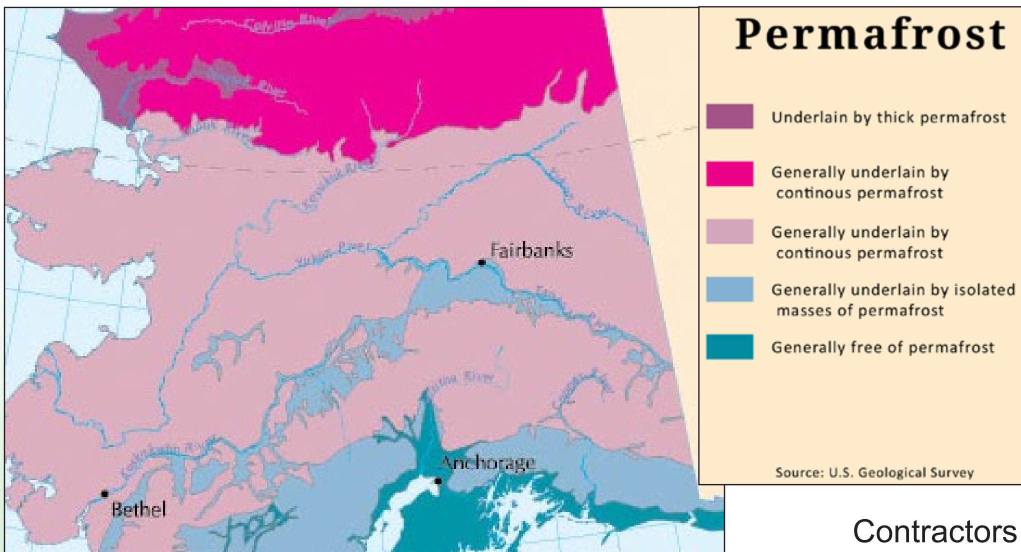
It is important to be aware of the presence of invasive weeds in your project area, and the vectors through which invasives can be transported to new areas. Invasive Plants of Alaska is a guide for identification, management and risk assessment posed by each species. This guide can be found at www.fs.fed.us/r10/spf/fhp/invasiveplants.htm.

The University of Alaska's Alaska Natural Heritage Program maintains an information clearinghouse for data on non-native species in the state. Location and management information is collected each year from agencies and organizations and is available in a database and mapping application at aknhp.uaa.alaska.edu/botany/akepic/.

The Alaska DNR, Division of Agriculture (DOA) has responsibilities pertaining to the prevention and regulation of invasive plants, including the authority to declare pests, inspect infested areas, enforce quarantines and eradicate pests. The State of Alaska's Plant Health and Quarantine laws (11 AAC 34) include a list of prohibited and restricted noxious weeds, as well as labeling and transportation requirements for seed sold in Alaska. DOA maintains a Strategic Plan for Invasive Weed and Agricultural Pest Management, used by the DOA and partners to prioritize and manage invasive plant infestations in Alaska. Detailed information about prohibited & restricted noxious weeds is available on the Alaska Plant Materials Center Website, at plants.alaska.gov/invasives/

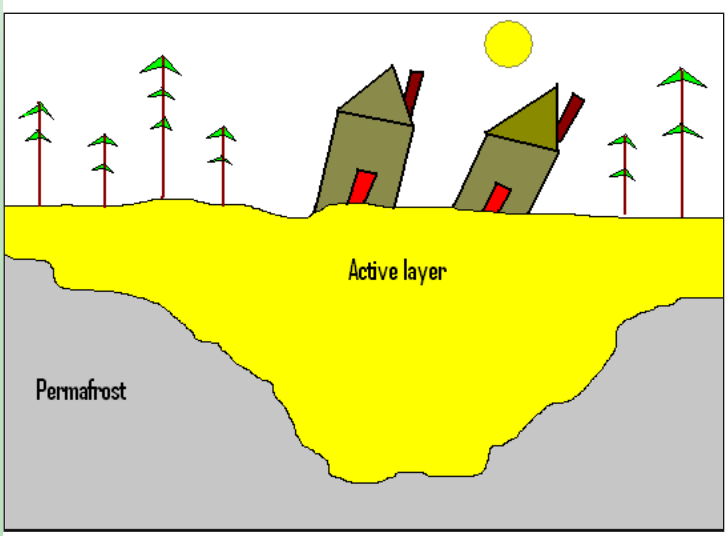
Permafrost Conservation

Permafrost, ground that remains frozen for two or more years, is common in interior regions of Alaska. The minimum of two years is meant to exclude the overlying surface layer that thaws every summer and freezes again every winter (Alyeska Pipeline Service Company, 2008) Two zones of permafrost are *continuous* and *discontinuous*. In the far north, the continuous zone is underlain by thick permafrost everywhere except for large bodies of water that do not freeze completely.



Permafrost distribution in Alaska

Graphics: Phil Czapla (AK PMC), Adapted from U.S. FWS Illustration



Thawing permafrost has expanded the active layer underneath these buildings. The removal of vegetative cover during construction allowed the soils to warm.

Discontinuous permafrost is commonly found on northerly aspects, where the average air temperature is only slightly below freezing (32 °F) and the annual soil surface temperature is between 23 and 32 °F.

Scattered pockets of unfrozen ground are found intermittently throughout the landscape in the Interior. The active layer of soil is limited to the depth that roots can penetrate. The permafrost zone is found beneath the active soil layer. The arctic and subarctic conditions of the Interior cause the ground to remain frozen for much of the year. The sun does not provide enough warmth to thaw the surface layer. In summer, vegetation growing on the surface acts as insulation, protecting the permafrost from melting under the sun's warmth.

Construction on permafrost

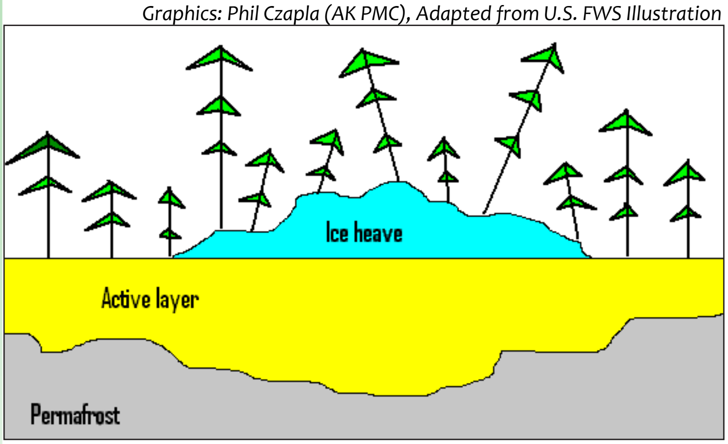
There are several variables to consider when building on permafrost. The distinct conditions associated with "frozen ground" must be considered when buildings, roadways, and other facilities are built. Understanding permafrost as a dynamic system necessitates that proactive measures be taken to minimize potential for damage.

Contractors developing buildings and roads should be conscious of the amount of vegetation removed. Removal of a vegetative layer on the surface will allow the sun to penetrate deeper into the soil, and may cause the permafrost to thaw. The heat of a building and associated utility lines may cause thawing.

Infrastructure developed in the presence of thawing permafrost sometimes requires engineered responses in place of or in addition to revegetation. One such response involves placing a thick layer of gravel under a roadbed or building structure. This gravel substrate acts as an insulation barrier between the surface layer and permafrost. An additional procedure is to construct foundations on pilings, limiting their heat transfer to the ground.

An additional area of concern for Interior Alaska is frost heaving. Seasonal melting of snow and rain water cannot infiltrate beyond the permafrost zone creating a saturated surface condition conducive to marsh, tundra, and wetland ecosystems. When cold weather traps the water between the soil and permafrost layer, it freezes and expands upwards creating a Pingo.

Graphics: Phil Czapla (AK PMC), Adapted from U.S. FWS Illustration



A "pingo" is created when water pooled in the active layer freezes, creating an ice heave above ground.

Trans Alaska Pipeline System

The construction of the Trans Alaska Pipeline System (TAPS) required the use of several distinct design methods to protect the permafrost. Approximately 75% of the pipeline traverses through permafrost soils (alyeska-pipe.com). Some problems resulting from permafrost include frost-heaving (pushing the ground upwards), frost-jacking (the structure on the ground pushed upwards along with the ground surface), and thaw settlement (structures settling into the ground caused by heat from structures) (alyeska-pipe.com). In light of these issues, three design solutions were developed and applied based on the soil conditions encountered.

- **Thaw-unstable permafrost conditions:**

In warm areas and where oil in the pipeline might cause thawing, the pipeline was placed above ground on special support structures called Vertical Support Members (VSMs). Each support leg has two, 2 inch pipes called "heat pipes," containing anhydrous ammonia. A heat pipe is a heat transfer mechanism. Anhydrous ammonia, a compound formed by two gases, nitrogen and hydrogen, is a refrigerant put in the VSMs to reduce the soil temperatures underground.

- **Unfrozen or thaw-stable permafrost:**

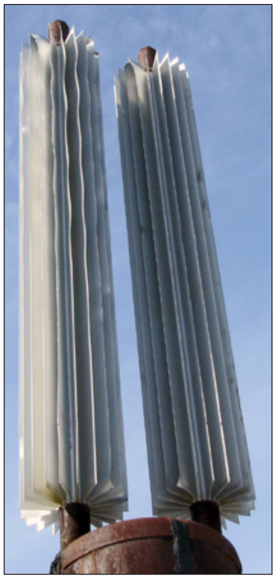
The pipeline was buried beneath ground using conventional methods. A ditch 8 ft. to 16 ft. deep was dug with the pipe underlain with a fine bedding material and covered with gravel padding and fill.

- **Thaw unstable permafrost & buried pipe:**

Certain portions of the pipeline had to be buried to account for animal crossings, rockslides, and avalanche areas. Permafrost protection from the heat of oil flowing through the pipeline was provided by insulation wrappings. In some areas the pipe was insulated and buried in a refrigerated ditch lined with 6 inch diameter pipe. Chilled brine is circulated through the pipe to maintain the soil in a frozen state.

The Trans-Alaska Pipeline system uses ammonia driven "heat pipes" to ensure that permafrost underground remains frozen.

Photos: Phil Czapla (AK PMC)



Thawing Permafrost

Freezing and thawing of the active layer in permafrost soil may cause erosion and impact vegetation. The frozen soil limits the amount of ground water accessible to the plants, and the depth of roots. Species growing on permafrost are only able to access the top few inches of the soil. Thawing soil also creates thermokarst; uneven surface topography recognized by pits, mounds, and depressions. These unstable soil formations are susceptible to wind and water erosion carrying sediment away from its origination point. If sediment moves into river systems a slew of additional concerns arise. A major objective of most revegetation projects is to include a vegetative cover that will protect and stabilize the soil surface. This protective layer keeps the suns rays from warming the frozen subsurface.

Photo: Stoney Wright (AK PMC)

Thermal degradation, resulting from thawed permafrost

In areas underlain by permafrost, travel is often restricted to the winter months - when snow cover insulates the ground and prevents damage to the tundra. Construction activity in permafrost areas is sometimes unavoidable. In these instances, following accepted practices to minimize the negative effects of thawing is advisable. The Alaska DOT&PF has a research paper entitled Documenting Best Management Practices for Cutslopes in Ice-rich Permafrost, which is available at dot.state.ak.us/stwddes/research/assets/pdf/fhwa_ak_rd_09_01.pdf.

Photo: S. Lamont & J. Russell (AK DOT&PF)

Advanced thawing on a cutslope causing silty runoff to flow into a ditch created using a gravel berm at the edge of the roadway. For further detail on this technique, refer to Alaska DOT Publication No. FHWA-AK-RD-09-11.