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Long Term Gravel Pad Reclamation on Alaska's North Slope

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Overview

Alaska's arctic North Slope is and has been a heavily debated place, especially when degradation from oil drilling occurs and the land needs to be restored. When oil companies drill for oil in the permafrost they must create stable surfaces for equipment. The surfaces created are used for oil drilling pads, roads, and pipeline routes. A majority of the stable surfaces are made of gravel from local deposits (Jorgenson and Joyce 1994), and the gravel pads are usually three to six feet (one to two meters) in depth (Streever 2001). Once the oil is depleted from the drill site, the equipment is removed, the oil-well is capped, and the gravel pads are abandoned, leaving areas that need to be reclaimed. Alaska's arctic coastal plain is approximately 20 million acres (8.1 million ha), of which 16.6 million acres (6.7 million ha) are considered permafrost wetlands (Fanter and Herlugson 1995). Since the late 1970's, the United States Department of Army has issued permits to allow for more than 21,000 acres (8,500 ha) of wetlands to be filled with gravel (Fanter and Herlugson 1995). Of all the land in the Alaskan Arctic degraded from oil drilling 74% is gravel–filled pads (Jorgenson and Joyce 1994). With federal and state environmental policies now in place for North Slope oil development, companies working there must eventually return the land to a condition as close to the surrounding tundra as possible (Herlugson et al. 1995). In compliance with governmental policies, oil companies have implemented strategies for reclaiming damaged tundra. The main reasons for revegetating the North Slope are to aid in control of soil erosion and degradation, restore wildlife habitat, and improve aesthetics (McKendrick 1999).

Reclamation Strategies

The ultimate goals of most reclamation projects have been to establish plants as quickly as possible and allow for natural succession to occur. Eventually natural succession will lead to similar vegetation of the surrounding tundra (McKendrick et al. 1997). On gravel pads there are two main strategies that have been used to reclaim damaged areas including revegetation of gravel to compensate for lost wildlife habitat, and secondly reclamation of contaminated soils from oil spills (Jorgenson and Joyce 1994).

The first steps taken for reclamation are identifying native plants, experimenting with seeding practices, and manipulating ground fill for better plant establishment (McKendrick et al. 1992). Some of the dominant plant species which have been identified and used in reclamation projects are graminoids – including *Carex aquatilis*, *Eriphorum angustifolium*, *Dupontia fisheri*, *Poa glauca*, and *Festuca rubra*; willows – *Salix ovalifolia*, and *S. reticulata*; and mosses – *Sphagnum* sp. (Shirazi et al. 1998). The establishment of native plants is also important for creating forage and cover for a number of native animals (McKendrick 1999).

There are also strategies for reclamation of oil spills on and near gravel pad sites. One approach to remove the oil is tilling the contaminated soil and applying fertilizers to increase volatilization (McKendrick and Mitchell 1978, Mitchell et al. 1979). The best results occurred when the oil contaminant was left for a period of time before tilling, which allowed for more volatilization. Tilling immediately after a spill incorporated more toxins deeper into the soil structure, which decreased contaminant breakdown (McKendrick and Mitchell 1978a). Burning spilled oil was also used (McKendrick and Mitchell 1978a). The best results occurred when the oil spill was immediately burned; if the oil was allowed even two days to absorb into the soil, burning became difficult, if not impossible (McKendrick and Mitchell 1978a). One negative effect of burning oil was the sterilization of the soil as well as the decrease in organic matter levels, especially during the growing season. Burning during the winter months allowed more plant survival (McKendrick and Mitchell 1978a).

Slow Recovery Potential due to North Slope Climate

Alaska's North Slope is an environment of extreme cold, winds and a very short growing season, all of which make reclamation difficult. The North Slope is all permafrost soil or rock which has remained below 32°F (0°C) for a minimum of two years (Alyeska pipeline website 2000). Permafrost can range from a few inches (several cm) to over 2230 feet (680m) in depth (Alyeska pipeline website 2000). Temperatures along the North Slope can reach a low of -60°F (-51°C) in the winter and have an average annual temperature of 10°F to 21°F (-12°C to -6°C) (Arctic tundra province 1995). The low temperatures result in short growing seasons ranging from seven to ten weeks (Jorgenson and Joyce 1994). Along with the low temperatures and short growing seasons, the North Slope receives two to ten inches (5 to 25 cm) of precipitation per year; approximately one-third falls during the growing season (Jorgenson and Joyce 1994). The yearly snowfall accumulation will melt in three to ten days. Virtually all of the snowmelt is surface flow since the ground only thaws a few centimeters deep (Jorgenson and Joyce 1994).

Revegetation Practices

Revegetation of gravel pads is important for reducing thermokarst reactions. Thermokarst is the collapse of surface from melting of massive ice; in essence the ground sinks and pools form (Walker and Walker 1991). When thermokarst occurs the soil hydrology is drastically affected and can make restoration extremely difficult and even impossible (Walker and Walker 1991). In undisturbed tundra the organic layers of the soil act as an insulator, which reduce thermokarst reactions (Walker and Walker 1991).

A major objective for revegetation is to create a barrier to prevent seed from blowing away and to collect snow to act as thermal protection during the harsh winter months. On undisturbed sites plant litter accumulates snow, but on open gravel sites there is nothing to hold the snow. To compensate for the lack of a windbreak, snow fence has been used as a snow trap (McKendrick et al. 1992). Along with the artificial windbreak hydro-mulch has been used to hold the seed in place (McKendrick et al. 1992). The two to six feet of overburden, which is removed for gravel pad construction, has also been used and shown to aide in moisture retention and increase aeration for seed establishment (McKendrick et al. 1992).

Problems occurred during early revegetation attempts, which either prevented or reduced the establishment of desired communities. Initially when revegetation efforts began in the 1970's erosion was thought to be a major risk for open exposed soils; so fast, dense growing plant species were used as cover crops – *Arctagrostis latifolia*, *Festuca rubra* and *Poa glauca* (McKendrick 1997). These grasses were expected to be short lived and allow for colonization of other tundra species. After 25 years the areas are still dense grass stands, and have not allowed for natural colonization to occur. On the other hand, seedings performed at the same time with other grasses like *Puccinellia arctica* allowed other tundra species to recolonize (McKendrick 1997).

One of the most important things learned in reclamation experiments is the tundra soils are considerably nutrient poor, specifically in nitrogen and phosphorous (Shaver and Chapin 1980, McKendrick 1991, Truett and Kertell 1992). It was also noted that seeded areas failed initially where no fertilizer was used (McKendrick 1997). Nitrogen and phosphorous are naturally occurring in tundra soils, but they are in an organic form. Low temperatures and the frost depth of the soil prevent the decomposition of organic nutrients. Thus very little mineralized nitrogen and phosphorous are available for plant uptake (Truett and Kertell 1992). To compensate for the lack of available nutrients several trials have involved the additions of fertilizers to aid in revegetation (McKendrick 1991, Jorgenson and Joyce 1994). They also learned with large doses of phosphorous and potassium the gravel pads revegetated rapidly with grasses, but succession was decreased because the grasses had increased in longevity (McKendrick 1991).

Some areas had problems with drilling mud (used as a lubricant and waste products of oil drilling), which had seeped from the oil drilling pits into the surrounding tundra (McKendrick 1991). Originally poor plant establishment in the mud was thought to be from heavy metal contamination. Once pH tests were performed it was found to be high, which rendered the heavy metals unavailable. More tests concluded high concentrations of sodium chloride were found to be the cause of the poor plant survival (McKendrick 1991). On one test site seeding failed in 1991 and 1992 due to sodium chloride contamination (Reiley et al. 1995). To attempt a decrease in sodium chloride levels in the soil a calcium nitrate solution was added to the contaminated soil. After the application of calcium nitrate in 1993 and 1994 levels of sodium chloride declined and vegetation was established again (Reiley et al. 1995).

Success of Reclamation Practices

Most reclamation projects include the use of fast growing native vegetation which is important to reduce thermokarst reactions as well as allow for natural succession of plant species (Helm 1997). Estimations made of species diversity and concentrations to reach those of the surrounding tundra range from one hundred to two hundred years (Streever 2001). After completing several long-term projects McKendrick (1997) concluded there is little risk of erosion in the North Slope area. Erosion is reduced for two reasons: one the ground is frozen when snowmelt occurs and secondly the overall slope of the land is relatively flat resulting in very little silt carry. Hence the rapid revegetation which is currently being used may not be the best tactic for establishing communities of flora. As noted earlier from previous reclamation practices some of the revegetative crops used tend to get too dense to allow fast paced natural succession.

Observations of long term success of several projects have been made. Revegetation plots with grasses in the early 1970's, which were heavily fertilized, are still flourishing (McKendrick 1997). Plots seeded at the same time which were not fertilized and the grasses did not fair well have been colonized by native tundra species (McKendrick 1997), which was unexpected to occur in the short period of time. Seedings dominated by *Puccinellia langeana*(alkaligrass) were expected to remain a monoculture, but instead declined and allowed for native tundra to recolonize the site (McKendrick 1999). Areas where oil had been spilled and/or burned in 1973, to test tundra response to oil contamination, had been colonized by native vegetation by 1997 (McKendrick 1999a); although areas of heavier oil spill tests had fewer colonizers compared to light spill sites (McKendrick 1999a). McKendrick (1997) developed a list of priorities for establishing a target community of vegetation. They included the selection of naturally occurring plant species (not just rapidly establishing vegetation), the selection of sexually and vegetatively reproductive plants, three to four years of organic matter build up, standing dead vegetation for wind breaks (to catch snow drift), and creating a moss layer to insulate the ground to prevent thermokarst.

Wildlife habitat has also improved. Caribou have been observed feeding on reclaimed areas; arctic ground squirrels and nesting birds have also moved into the revegetated areas (McKendrick 1999). These observations indicate there is now enough forage and cover to attract and sustain them. The observation of birds indicates there is an adequate amount of plant debris and moss in the revegetated stands to allow nesting. Unexpected wildlife observations occurred indicating they may even prefer the disturbed sites to undisturbed tundra (McKendrick 1991). This is especially evident with the caribou, which have created trails along old gravel roads (McKendrick 1991). Over long term observation McKendrick (1999) found significant improvements had occurred over the span of twenty plus years to allow for native tundra communities to persist.

Technological Advances to Accelerate Restoration

With the increased environmental awareness and public opinion, the oil industry is looking to minimize inputs and maximize output while reducing ecological impacts by using newer concepts to obtain oil. One newer technology being used is a machine called a Rolligon; Rolligon's are designed with large balloon tires to reduce surface pressure, thus they leave minimal ruts in the tundra surface. Along with minimizing pressure of vehicles, some gravel roads are being substituted with ice roads to the drill sites. When these melt in the spring the evidence of traffic soon fades (McKendrick 1991, Hazen 1997). In conjunction with ice roads, ice pads are being experimented with in place of gravel drill pads with the idea when the drill is abandoned virtually no restoration will need to be done (BP website 2000). Another advancement is the gravel pad size. Twenty years ago a twenty-well pad took up 25 plus acres (10 ha) of land, now the same volume drill operation only uses about 12 acres (5 ha) of gravel pad, since the equipment size has decreased (McKendrick 1991). Also, where salt pollution from the drilling process was a problem, newly engineered systems are being used to seal the contaminants in the well itself in hopes to prevent outside contamination (McKendrick 1991). Pipelines are also being installed higher to allow for caribou and other wildlife to roam unhindered (BP website 2000). The pipelines are also being installed the same time the ice roads are being built in order to minimize the amount of stress from vehicles on the tundra surface.

Alaskan North Slope Reclamation

A unique aspect of restoration in Alaska's North Slope is the multifaceted approach to refine revegetation strategies. Their attention to optimizing recovery is critically important in this harsh environment which has very problematic growing conditions. Conditions of low temperatures, extreme wind, and a short growing season make vegetation establishment extremely difficult. The key advancements they've made are identifying the importance of fertilization to maximimize establishment of newly seeded lots and eliminating the use of cover crops, because of their unexpected impacts to their target community. As a result of the reclamation done on the North Slope, successfully revegetated areas and increased use by wildlife have been observed. They have also made strides to reduce environmental impacts (and so minimizing what needs to be restored) by improving construction practices so the area needed for operation is minimized and by implementing new and cleaner technologies such as ice road and pad construction along with low impact vehicles. The use of multi-approach reclamation strategies is especially important since Alaska's North Slope oil will continue to be an important energy resource.

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