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Experimental Trials for Restoring Disturbed Sites in Permafrost Areas Using Bioengineering Techniques

By Laberge Environmental Services

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1.0 BACKGROUND

Placer mining has over a one hundred year history in the Yukon Territory. Placer mining has typically taken place in the Klondike Region near Dawson City, with smaller areas of activity in the Whitehorse, Livingstone, Carmacks and Kluane areas. The majority of placer mining has taken place in the zone of discontinuous permafrost. Within the discontinuous permafrost zone, vegetated valley flats and north-facing slopes generally are underlain with permafrost. The permafrost thickness is highly variable and may reach depths of 60 meters. The active layer covering the permafrost also varies greatly in thickness ranging from a few centimetres to several metres depending on the slope, aspect, etc.

To access gold bearing gravels, the removal of extensive quantities of overburden is usually required. Once this insulative cover is removed, the thermal equilibrium of the permafrost is disrupted and thawing occurs. This affects the stability of soils and vegetation and slope failure may occur. The extent that exposed permafrost melts depends partly on the amount and form of ice content. As melting progresses, the potential for mass movement of soil increases. Melting permafrost usually results in a wetter environment than was initially present, which further affects the natural revegetation process.

Bioengineering is the use of living plant materials to perform engineering functions such as erosion control and stabilization of steep slopes. Although bioengineering methods are now commonly used in the stabilization of steep problem slopes in more moderate climates (Polster, 1997), experimentation with these techniques in areas underlain with permafrost is still required. Advantages of using bioengineering systems are that they can be installed without machine access (which in permafrost areas would disturb the site even more), they strengthen with age, and they are less expensive than traditional hard engineering practices.

1.1 Project Objective

The objective of this project is to determine whether bioengineering techniques can effectively be used in stabilizing permafrost-rich slopes that have been disturbed by placer mining activity. It has been found that native vegetation will recover quite quickly on stabilized sites which have an adequate covering of soil fines. In this project, bioengineering techniques were employed on a site underlain with permafrost to gauge their success in hastening the slope stabilization and natural revegetation processes.

2.0 STUDY AREA

The study area is situated in the ecoregion known as the Yukon Plateau (Central) as determined by the Ecological Stratification Working Group (1995). This ecoregion consists of rolling hills separated by broad, deeply cut valleys. Much of this ecoregion is covered by a veneer of recent (1300 years BP) volcanic ash.

Spruce forests cover the region with white spruce growing in the drier areas and black spruce in the wetter ones. A unique vegetation feature in this ecoregion is the sagewort grasslands and aspen parklands that occur on south-facing slopes. These grasslands result from a semi-arid climate and the layer of volcanic ash, a situation that occurs nowhere else in the boreal forests of Canada.

Specifically, the study site is located on a northwest-facing slope along an un-named tributary to Big Creek, located west of Carmacks (Figure 1). Locally this tributary is referred to as Noname Creek. This site is underlain with permafrost and in the summers of 1999 and 2000 was disturbed by placer mining activity. The disturbance was mainly caused through improper road construction. Slope failure and gullying had been observed at this disturbed site following the high rainfall summer of 2000 (Rob Thomson, pers. comm.) Placer mining ceased in the fall of 2000, and most of the equipment was removed from the site by the summer of 2001.

3.0 METHODOLOGY

3.1 Reconnaissance Survey

A reconnaissance survey was undertaken on July 6th, 2001, by Bonnie Burns, Stu Withers (LES) and Rob Thomson (DIAND). The mining claims and surrounding area were traversed on foot and a site was chosen for the bioengineering experimental trials. This site is an incised gully that has recently been formed as a result of heavy tracked mining equipment moving up and down the slope. An estimated 2 litres/sec flow of water was observed in the lower end of the gully during the July site visit. This water is a result of melting permafrost. No stream existed at this site prior to disturbance.

This particular gully was selected because it represented a common (and one of the worst) land erosion problem on the site. In nearby undisturbed areas, the depth to permafrost was determined to be approximately 18 inches and overlain by a moss layer of approximately 6 inches. The gully is one to two meters deep and up to 8 meters wide.

Willows were chosen as the best shrub species to be used for the bioengineering trials, as they have been proven to be easily propagated from stem cuttings. Willows were also found to be common in the area. Only a limited amount of plant material was found in the immediate Noname Creek area (including *Salix alaxensis*, *S. glauca*, and *S. pulchra*). Larger amounts were located along Mechanic Creek and Big Creek (primarily *Salix arbusculoides*) and these areas were selected as plant donor sites for the restoration project.

3.2 Field Trials

The bioengineering field trials were conducted on September 12th to 15th, 2001. The dormant willow cuttings (*Salix arbusculoides*) were collected daily from the Big Creek valley and riparian zone. The cuttings used in the construction of the live gully breaks and the live pole drains were generally about one inch in diameter. The cuttings for live staking were approximately one quarter to one half inch in diameter and approximately 40 cm in length. Willow cuttings were collected using pruning shears. The upper new growth from each cutting was removed, leaving a leaf bud near the upper cut line.

The bioengineering techniques used in this restoration project are largely adapted from those described by Polster (1997). They include live gully breaks, live staking and live pole drains. A photographic record of the Noname Creek project is depicted in Appendix A.

3.2.1 Live Gully Breaks

A total of 12 live gully breaks were constructed across the upper reaches of the gully, spanning a linear distance of approximately 100 metres.These gully breaks consist of wattle fences constructed across the gully at intervals averaging about 9 meters. They are designed to control the initiation of torrenting and slow down the water velocity, thereby reducing further erosion. Sediment is trapped behind the breaks, forming terraces that allow vegetation to re-establish. As the live willow cuttings take root, the gully breaks strengthen.

At each gully break, a shallow trench was first excavated across the channel, and stakes (dead black spruce collected from the nearby slope) were driven into the gully bed along the trench at intervals of about 0.5 meters. Dormant willow cuttings, 3-4 meters long, were then laid in an overlapping lattice against the upstream side of the stakes and butted into the sidewalls of the gully. The gully breaks were then backfilled with local material to hold them in place (see Plates 1 to 4).

3.2.2 Live Willow Staking

Live willows were staked in the zone alongside the incised trench between gully break #1 and gully break #6 (see Plate 5). Live staking is particularly useful in stabilizing the flow of silty material on slopes.

Dormant willow cuttings, approximately 40 cm long, were inserted into the soil in the gully bottoms and sidewalls so that about three-quarters of the length of the cuttings were underground with the distal ends up. They were randomly spaced at about 0.5 m.

3.2.3 Live Pole Drains

Live pole drains were constructed in two locations, one upstream from the first gully break (see Plates 7 and 8), and one between gully break #7 and gully break #8 (see Plates 9 and 10). Live pole drains are bundles of live cuttings used to provide stability to sites with excess soil moisture. The bundles are placed in shallow trenches in such a manner as to collect and drain off the water. A cover of woody vegetation is provided as the willows sprout and grow while the excess water continues to drain from the lower end.

At the site of each live pole drain, a shallow trench was first excavated along the drainage channel of the gully. Bundles of dormant willows were constructed from cuttings, 3-5 meters long, with tips and butts alternating. Bundles were tied tightly with binder twine at 0.2-0.3 meters in diameter (see Plate 6). The bundle at the upstream site was about 25 meters long and the one at the downstream site was about 8 meters long. At each site the bundle was placed in the trench and lightly backfilled with local materials.

Figures 2 and 3 show the placement of the large pole drain and the 12 gully breaks at scales of 1:3000 and 1:1000 respectively. The gully breaks are depicted as numbered squares and have been plotted according to their GPS position.

4.0 DISCUSSION AND RECOMMENDATIONS

As noted earlier, a major advantage of bioengineering work is that the use of heavy equipment is usually not required. It is, however, quite labour-intensive. The collection, storage, transport and placement of live plant materials can be very time-consuming. This type of land restoration work is therefore ideally suited to projects with a community volunteer component or a student training program.

To determine any degree of success of this project, follow up surveys will need to be conducted. The willows will remain dormant throughout the winter months and may start producing new growth in the spring. However, this may not be initially apparent, as generally the plant will concentrate its energy on producing roots. A return visit to the site should be conducted in mid summer of 2002. The gully fences will be inspected to determine if they survived freshet. If they haven't washed out, they should have created sediment traps and commenced the creation of terraces. These in turn will eventually provide medium for the growth of invading vegetation.

The live willow staking and the live pole drains will be inspected to check for sprouting and growth. Meticulous field records were kept, including GPS readings of each bioengineering placement, to ensure all experimental plots can be relocated on site during future visits.

To accurately assess the success of the bioengineering techniques employed in the current study, monitoring should be conducted annually for a minimum of five years.

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