Revegetating Composite/ Consolidated Tailings Wetlands using Donor Wetland Soils, in the Oil Sands Mining Region of Fort McMurray Alberta.

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Abstract

Creating functional and self-sustaining wetlands and wildlife habitat in the bitumen mining areas of northeastern Alberta brings tremendous challenges. By the year 2023, mined areas are expected to exceed 1406 km^2. Much of the pre-mining area is occupied by wetlands, and research related to wetland reclamation and revegetation is extremely limited. This study investigates the potential of wetland sediments to serve as suitable seed and substrate sources for wetland vegetation colonization and growth on consolidated/ composite-tails (CT) wetlands. A completely randomized block, reciprocal (or switchback) experiment was designed, wherein experimental plots were exchanged between natural and constructed wetlands and paired with identically treated control plots. Species composition, percent cover, plant height and net percent infestation data were collected in mid-July and August of 2002 along with monthly water and soil samples. Preliminary results show differences in species colonization rates between treatment wetlands. Study findings will help determine the potential for recreating self-sustaining, functional wetlands and direct future wetland revegetation research.

AN APPROACH TO RECLAMATION IN HIGHLY ALTERED LANDSCAPES

Creating functional and self-sustaining wetlands and wildlife habitat in the bitumen mining areas of northeastern Alberta brings tremendous challenges. Wetland habitats exist along a transitional zone from terrestrial to deepwater aquatic habitats. Simple changes in hydrology can shift wetland conditions to support different life forms. Such is the case with wet post-mining sites. The initial alteration of the boreal terrain by surficial oil sands mining is profound and of a magnitude (locally) comparable to volcanism or glaciation. Prior to the commencement of mining, vegetation is removed, and soil (referred to as muskeg) is either is mixed with overburden and stockpiled for later use as a reclamation amendment, or directly placed onto a new reclamation site. Unlike natural processes, mining alterations to habitats are planned and within this planning are designs for establishing specific replacement habitats after mining.

In 1999, Suncor Inc. Oilsands (Suncor) constructed a series of wetlands for treating wastewater discharged from its tailings ponds (Golder Associates Ltd., 2000). Constructed wetlands were built on a layer of composite/ consolidated tailings (CT) capped with a layer of fine tails. The CT is a wet, gypsum enriched slurry of mature fine tails produced as a by-product of processed oil sands. Both the wastewater and CT are slightly to moderately saline, high in total dissolved solids, and contain elevated concentrations of sulfur, chlorides, naphthenic acids and metals.

As leaseholders from the Province of Alberta, Suncor and Syncrude Canada Ltd. (Syncrude) are required to reclaim disturbed sites to an end land-use that has equivalent or better land capability compared with pre-disturbance conditions. End land-uses must also be continuous with surrounding leases (Alberta Environment, 1999). The highly altered environment of the CT landscape and the stringent environmental legislation requirements pose many challenges to revegetation.

Wetlands existing in the planned mining area are mostly bogs. Unfortunately, bog vegetation and its creation processes (organic

accumulation, weak internal drainage, acidification) are not feasible to replace in a sub-century time frame. However, wetland reclamation may be viewed as an opportunity for increasing the occurrence of regionally rare habitats (bogs are not rare in this region) and offering enhanced functions for a different set of wildlife species. Wildlife assemblages of common species are somewhat substitutable except where human dependencies or regional/ national threats to species occur. There are no known endemic specialists or endangered species that are wetland obligates associated with the mining area. However, at the microscopic level, it is likely that the microbial fauna represent a highly selected subset

INCREASING RECLAMATION RATE WITH INTRODUCTIONS OF NATIVE BIOTA

I. Plant Community Establishment

The goal of this reclamation project, like many others, is to accelerate plant community development through active and adaptive management. Establishment of suitable hydrology and substrate (soil, detritus and plants) is expected to be an essential basis for a functional food web and for ameliorating the deficiencies of recently mined or processed wetland soils. Therefore, simple and effective wetland plant community establishment is one portion of this study. Capping overburden materials with donor wetland soils is proposed as a cost-efficient mechanism for accelerating native species colonization. While muskeg might provide some seed sources, it would most likely serve as a substrate, providing nutrients to planted or seeded species, whereas wetland sediments provide sources of propagules, seeds and nutrients (van der valk and Pederson, 1989). Species richness in created wetlands receiving donor soils can be higher than the donor wetlands themselves (McKnight, 1992), because of existing seedbanks at created wetland sites and/ or physical disturbance of the donor soil, exposing seeds and facilitating germination (Smith and Kadlec, 1989). Vivian-smith and Handel (1996) found that donor wetland soil in a freshwater reclamation project enhanced species richness and plant density, proving the potential for using imported seed and bud banks to enhance revegetation success.

Oil sands mining areas represent a unique opportunity to study near-primary successional sequences of vegetation and invertebrate communities. Additionally, because invertebrates represent one of the most basic links in the biotic food web, restoration activities that speed their successful colonization may help restore wetland functions of sediment aeration, waterfowl production and soil remediation. Of particular interest is the ability to introduce wetland plants and invertebrates into newly created wetlands from natural or reclaimed wetlands and affect the outcome of wetland conditions.

This project examined the feasibility of speeding wetland succession by introducing wetland plants and invertebrates earlier than they would have colonized naturally or by the replacement of excavated peaty surface layers versus wetland sediments. .

II. Soil and Water Monitoring

Successful plant community establishment on CT deposits is contingent upon developing an understanding of the interactions occurring among the water, soil and plants. CT and CT water characteristics may pose significant constraints to plant recruitment, growth and survival. Bulk density and porosity may influence emergence and rooting potential of newly recruited seedlings and transplanted sod. Soil texture will influence the movement of nutrients and water through the soil. Elevated electrical conductivity at the soil surface may inhibit germination, because salts increase osmotic potentials, thus making it difficult for seedlings to draw water. Consolidated tailings have limited ability to exchange gases, thus it is likely that redox potential (Eh) will be problematic. In one study, *Spartina patens* showed limited gas exchange functioning and nitrogen uptake when salinity was 6 ppt and Eh was lowered to -115 mV (Bandyopadhyay et al., 1993). Plants exposed to metals and naphthenic acids in soil and water may show signs of phytotoxicity in the form of chlorosis or

necrosis, hence species survivability and recruitment might be lowered.

Soil and water monitoring was used to help explain observed differences in plant recruitment, growth and survival between treatments. Our objectives were to:

1. determine whether chemical and physical and chemical characteristics of CT will limit plant recruitment, growth and survival
2. predict whether CT can be used as a medium to support a viable, productive, self-sustaining ecosystem over the long-term.
3. determine whether sediment exchanges are a suitable revegetation technique for establishing plant communities in CT wetlands [I'm not sure whether Lee meant use this instead of your #2 or as well as]

METHODS

This study takes the form of a reciprocal or switchback experiment (MarAnon and Bartolome, 1993), wherein experimental plots were laid out in two natural wetlands (emergent marshes) and randomly paired with identical plots in the CT wetland. Each site also has an adjacent, onsite control plot to compare plant establishment performance.

Three 20 m transects were spaced across both donor wetlands to mimic boardwalk transects that had been constructed in the CT wetland. Plots were then set up as six randomized blocks across the wetlands. A total of 210 plots were established (60 plots in each of the natural wetlands and 90 plots in the CT wetland); sediments were not switched between donor sites.

Prior to sediment removal, vegetation in each plot was characterized and stems were cut down to the soil surface. To prevent soil washing into other plots or out of the experimental wetlands, all samples were placed in five gallon buckets. Each bucket was filled with the corresponding substrate (eg. CT in the CT wetland) and then the donor soil was placed, surface-oriented, in the top 20 cm of the buckets. Holes were drilled into the buckets to allow for movement of water and ions into the soils. Holes were then covered with a commercial landscape fabric to prevent loss of soil material from the buckets. Surface soils from the CT wetland were likewise placed on the excavation location in the natural marsh. Transplanting occurred during June and early July 2002, after the upper 20 cm of soil thawed.

Vegetation Sampling and Analyses

Vegetation sampling was conducted twice over the course of the summer: in mid July and August. Each plot was visually assessed for species richness, average height of the tallest three species, and percent cover by species.

Freidman's nonparametric 2-way ANOVA was used to examine whether differences in percent cover and species richness were significant between treatments (Zar, 1999). The Nemenyi test was used to determine which treatments were statistically significant (Zar, 1999).

Water and Soil Chemistry Sampling and Analyses

Surficial water samples were collected in each of the three treatment wetlands monthly (May – September 2002) and analysed at the Syncrude Research Centre for total dissolved solids, chlorophyll a, chlorides, sulphates, total nitrogen, total dissolved phosphorous, metals, total extractable hydrocarbons and naphthenic acids. Conductivity, pH, temperature and dissolved oxygen levels were measured using a portable YSI multi-meter at the time of water sampling. At the June and August sampling period, sediment samples were also taken at two depths (0-10 and 10-20 cm) both within and outside the buckets. Results were then summarized and ordination techniques will be used to link site-specific physical conditions and associated vegetation communities.

PRELIMINARY FINDINGS

Preliminary findings from 2002 suggest that there is differential species recruitment from the donor soil among treatments (donor soil 1, donor soil 2 and control) for both natural wetlands and the CT wetland. These differences

could be attributed to the age of the CT material. Since the CT material has only been placed on the landscape for three years in the CT wetland and three months in the natural wetland, it is likely that this is an insufficient time to build up a seedbank reserve. It is also possible that the chemical and physical characteristics of CT may result in a differential recruitment or colonization of species. Conditions may favour or inhibit some species over others. It is unknown whether wetland plant species richness and abundance will differ between CT treatments and donor soil treatments in the natural and CT wetlands over time.

Results from 2002 also show differences in species richness and percent cover for sods switched into the CT wetland, compared to corresponding control plots in the natural wetlands. Factors that maybe contributing to these differences include: water depths, water and soil chemistry (differences in concentrations of available nutrients, metals, salts, hydrocarbon concentrations).

FUTURE RESEARCH

Vegetation, water and soil sampling will continue in May- September of 2003, as was done in 2002. Data will be compiled for the two years and tested for differences between years and treatments. Additionally, at the end of the field season, plant tissue samples will be collected and then analysed for metal, nutrient and elemental concentrations. Plant rooting depths and soil bulk density will also be measured at this time. This data will then be used to help explain differences in species recruitment, growth and survival between treatments. From these findings, we can draw prescriptive management plans to identify bottlenecks to wetland revegetation and precribe management techniques to maximise plant colonisation rates.

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