ENSC 495 Independent Research Report

Determining the viability of salvaged organic peat soil using peat-mineral mixes and surrogate growth species *Poa pratensis* and *Lolium multiflorum*.

By Kyle Tieulie

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Prepared For Dr. Chen

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ENSC 495 Concordia University College of Alberta

Abstract

Peat-mineral mixes (PMM) have been shown and recommended as a suitable reclamation material when upland boreal forest soil (LFH) is not available or cost-prohibitive (Alberta Environment 2012, Mackenzie 2013). During the construction of some wellsites an engineered pad is constructed above the original peat soils. During the reclamation process activities often allow for a potential cost efficient opportunity to salvage these buried soils. The following experiment used two selected species of grass *Poa pratensis* and *Lolium multiflorum* and five different PMM's (20:100, 40:60, 60:40, 80:20 and 100:0). Peat soil was collected from an undisclosed location in which peat soil was buried under an engineered pad. Mineral soil was collected from a vegetated natural area within Parkland County, AB. The experiment was ran for 30 days, upon decommission, data for shoot length, shoot biomass, root bounding and nutrient deficiency. Data was then analyzed using descriptive statistics, t –test, correlational analysis and single factor anova. Results show positive correlation and significant effect for *P. pratensis* and *L. multiflorum*, respectively. From this experiment we have identified the possible viability of buried organic peat, and areas of improvement for further study.

Keywords: peat, mineral, soil, peat-mineral soil, reclamation, *Poa pratensis, P.pratensis,* Kentucky bluegrass, *Lolium multiflorum, L. multiflorum*, annual ryegrass

Table of Contents

List of Figures

List of Tables

Appendixes

Introduction

The purpose of this project was to help expand the area of environmental science as it relates to reclamation and remediation and the management of reclamation materials associated with oil and gas industry. The practice of burying of organic peat soil during the construction of oil and gas production sites was at one point common place with numerous sites with buried organic soils. Oil and gas operators are required to reclaim any specified land as described by the Alberta Environment Protection and Enhancement Act (EPEA) in order to do so the operators must obtain a reclamation certificate (Alberta Government 2014). The goal of reclamation is to reclaim land to an equivalent capacity to support land use similar to pre-disturbance conditions (ESRD 2013). For the many of Alberta reclamation projects this means upland boreal forest is the reclamation goal which can defined by Aspen, jack and lodgepole pine white spruce (Natural Regions Committee 2006). Prior to reclamation the site must be assessed and remediated to the Alberta Tier 1 Guidelines or the site specific Tier 2 Guidelines (ESRD 2014A, ESRD 2014B). The Athabasca Oil Sands area has long accepted the use of organic peat soil as a reclamation material and the best management practices outline the use peat-mineral mix (PMM) as a substitute for the placement of LFH soil (Alberta Environment and Water 2012); however only when it is not available because the LFH soil has been demonstrated to be a better reclamation material for the reclamation of upland boreal forest (Mackenzie 2013). Recently the Alberta Energy Regulator has approved the salvage of PPM for shallow organic soils for in-situ oil sands processing plants and oil production sites (Baily 2014). This change will increase the amount of PMM being used in future reclamation and justify its use at other production sites. With no current plans to recover buried organic soils it may present a cost efficient opportunity to salvage this material during the remediation process.

Organic peat soils are an important reclamation materials for its ability to alter the landscape capabilities increasing organic carbon, decreasing bulk density, increasing field capacity, assisting reclamation and increasing water-holding capacity (Moskal et al. 2001). Peat-mineral mixes can serve as reclamation of upland boreal forest when available LFH has already been exhausted or is not financially feasible for reclamation projects (Alberta Environment and Water 2012).

Mineral soil is a critical component for all reclamation projects as a substrate for the capping of unsuitable overburden as is the case in the Athabasca Oil Sands Area with the reclamation of both overburden and tailings (Alberta Environment 2012). When developing reclamation plans it is important to consider that with as much applicable science the resulting soils will be anthropsoils (Naeth et al. 2012). Theoretically the components of anthropsoils could be fined tune to meet environmental conditions, however is cost prohibitive to actual reclamation projects. While these anthropsoils may mimic the contemporary soil that was once a part of the surrounding ecosystem and may eventually form similar soils; this is uncertain face of climate change which is a major contributor to the factors of soil formation (Birkeland 1999, Boule et al. 2001). The selection of *Poa pratensis* (Kentucky bluegrass) and *Lolium Multiflorum* (Annual ryegrass) was because of their documented success in northern climates and their ability to tolerate a variety of conditions including, salinity, drought and acidic soils (Chintala et al. 2012, Dong et al. 2014, Perlikowski et al. 2014).

This experiment had two objectives one is to identify the viability of using salvaged organic peat from under a decommissioned oil and gas production site; second was to identify the most effective PMM ratio as a reclamation material. In order to characterize the efficacy of PMM's two surrogate species were used *P. pratensis* and *L. multiflorum*. Using both selected species and a selected PMM ratios the experiment ran for 30 days. On decommissioning data was collected and analyzed statistically.

Methods and Materials

Experimental treatments were set up using mineral soil collected from a natural upland with well-established vegetation and no screening was performed, prior to collection vegetation and LFH was removed. Buried organic peat soil was collected from an undisclosed location during a Phase II ESA using a 6" solid stem augur at approximately 1.0 – 2. 0 mbgs. The collected buried organic peat soil was screened in the field using a RKI™ Eagle, Field Scout™ EC probe to ensure that the soil was free of contamination and suitable for reclamation. The seed for *P. pratensis* and *L. multiflorum* seed was acquired from Apache Seed of Edmonton, Alberta.

The mineral soil was mechanically cleaned using soil sieves and the sieve shaker to break up large portions, remove vegetative biomass and ensure proper admixing with the peat soil. The peat soil was prepared by hand breaking large masses and removing any mineral soil that was collected with the peat soil. Three replicates of each treatment were prepared at the same time to ensure that the treatment mixture was homogenous. The treatment mixtures were PMM ratios of 100:0, 80:20, 60:40, 40:60 and 20:80 and were constructed in 10 x 10 x 8 cm soil planter boxes. This treatment was set up was used for both *P. pratensis* and *L. multiflorum.* To ensure consistent amount of seed was placed in each treatment a pinch calibration was performed with an average 0.29 and 0.75 g of seed being placed for *P. pratensis* and *L. multiflorum*, respectively. The seed of both P. *pratensis* and *L. multiflorum* were spread across the top of the treatment and given sufficient water and covered with plastic to retain moisture and assist germination. Once germination had occurred and significant sprouting was established the plastic was removed. The treatments were randomly placed in trays contained in a Biotronette Mark III® Environmental Chamber which was set to natural diurnal cycle of 16:8 light and dark. The treatments were monitored and watered on a consistent basis (3-4 days a week) and the experiment was conducted for 30 days. On the final day the entire mass of each treatment was recorded and labeled and placed containers which were than frozen so that they could be processed at a later time. The following other parameters were measured and recorded soil moisture using a PASCO scientific Xplorer GLX™ and PASPORT™ Soil Moisture Sensor, soil pH using a Field Scout® SoilStik™ pH Meter, Shoot biomass was cut at the soil shoot interface dried and weighed and the amount of root bounding (with photos) one set of the *P. pratensis* treatments was not recorded for this as it was not salvageable after attempting to separate the soil from the treatment.

Descriptive statistics were performed on the experimental data also including a simple t-Test to ensure equal variance of shoot biomass and average soil moisture, assumptions were proven. Correlational analysis was used to define any possible correlations on the raw data. Linear regression was used to confirm correlations and provide graphical interpretation. Single factor Anova was performed to analyze the correlation between peat percentages and shoot biomass for significance. For theses these analyses we have two statistical hypothesis

Ho = There is no significant difference among the treatment and shoot biomass

Ha = There is significant difference among the treatment and shoot biomass.

Results

Both the descriptive statistics and t-tests met assumptions of variance within treatments and between groups. Correlation analysis showed a positive correlation between shoot biomass and average soil moisture and average shoot biomass and peat percentage for both *P. pratensis* and *L. multiflorum*.

There was also a positive correlation for average soil moisture and average soil pH for *P. pratensis.* The root binding and average soil moisture was positively correlated for *L. multiflorum*, the soil moisture was also much lower in the *L. multiflorum* when compared to the *P. pratensis.* All correlational results are in Table 1.

Table 1. Correlational Analysis of Raw Data

P. pratensis Correlation

	RB	*SBM*	*ASM*	*ApH*	*Peat %*
RB	1				
SBM	-0.02377	1			
ASM	-0.32076	0.29445	1		
ApH	-0.53957	-0.01034	0.169108	1	
Peat %	-0.10721	0.20868	0.226436	-0.37543	1

L. multiflorum Correlation

	RB	*SBM*	*ASM*	*ApH*	*Peat%*
RB	1				
SBM	-0.03139	1			
ASM	0.134595	0.284282	1		
ApH	-0.27963	-0.35285	-0.6039	1	
Peat%	0	0.338513	0.315912	-0.55844	1

RB - Root binding

SBM - Shoot biomass

ASM - Average Soil Moisture

ApH - Average pH

Liner regression confirmed and graphically describes the positive correlation between peat percentages and shoot biomass for both *P. pratensis* and *L. multiflorum*. This relationship can be seen in Figure 1 and 2.

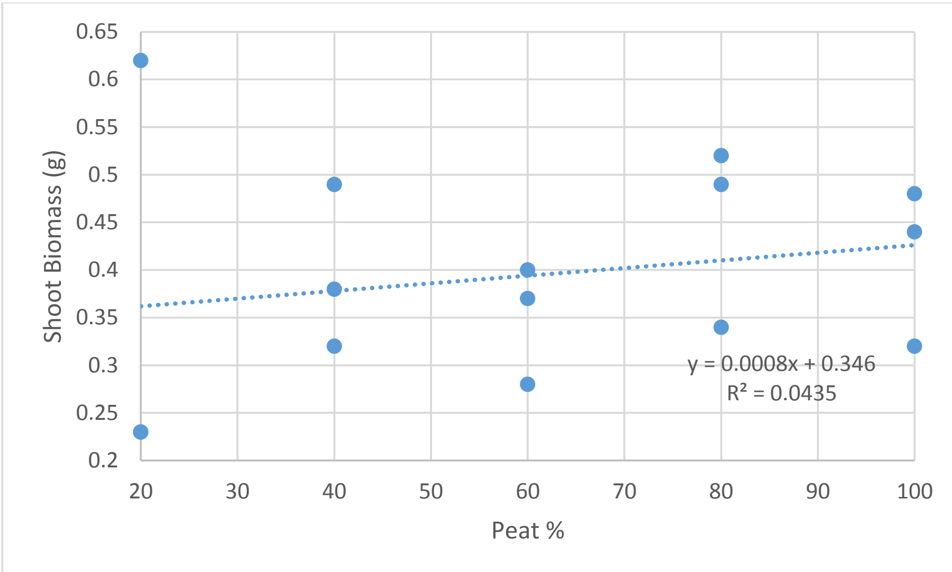

Figure 1. Linear regression of shoot biomass of *P. pratensis* as compared to treatment percentage of peat $R^2 = 0.0435$ showing a positive correlation between the two variables.

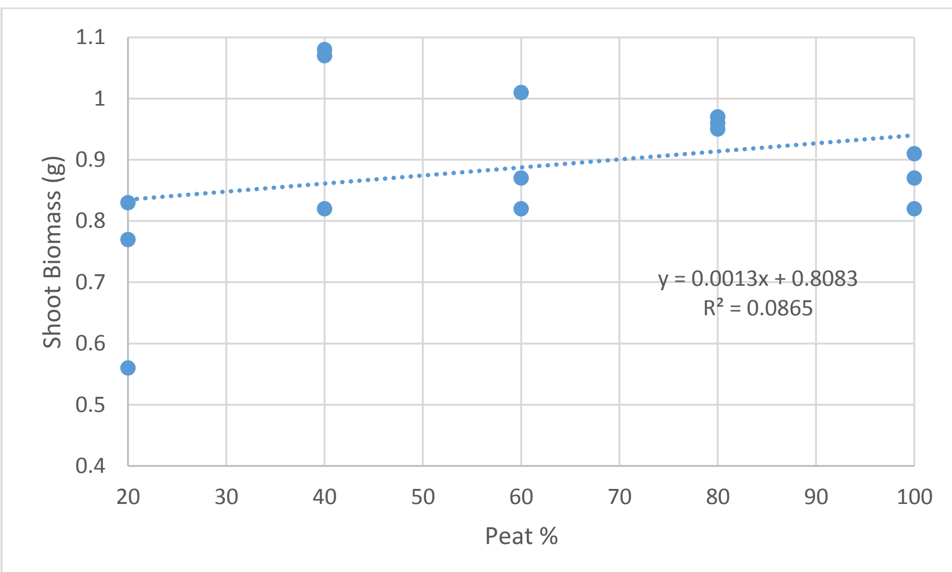

Figure 2. Linear regression of shoot biomass of *L. multiflorum* as compared to treatment percentage of peat $R^2 = 0.0865$ showing a positive correlation between the two variables.

Single factor Anova was used to compare the effect of experimental treatment on shoot biomass on *P. pratensis* and *L. multiflorum*. For *P. pratensis* at $P \leq 0.07$ [$F(4,14) = 0.316652$, $p = 0.860488$]. The F value was less than Fcrit and $p > 0.07$, therefore we accept the Ho. For *L. multiflorum* at $P \leq 0.07$ [$F(4,14) = 3.105034$, $p = 0.066548$]. The F value was less than Fcrit and $p < 0.07$, therefore we may reject the Ho.

Symptoms of nutrient deficiency such as chlorosis (yellowing) and necrosis at the tips of the grass blades were noted *L. multiflorum*. Symptoms were not observed in the *P. pratensis.*

Discussion/Conclusion

From the correlation analysis we can draw several conclusions that the correlation between average soil moisture and peat percentage is a result from the increased water holding capacity of peat soil (Moskal et al. 2001). The difference in correlation of average soil moisture and root binding between *P. pratensis* and *L. multiflorum* while not analyzed further is likely do the difference in average moisture and shoot biomass between the two trials. The *L. multiflorum* being an annual grass germinated and grew faster than the *P. pratensis* which increased the water uptake for those treatments. The final conclusion we drew from the correlation was the positive correlation between shoot biomass and peat percentage of each treatment for both *P. pratensis* and *L. multiflorum.*

Single factor Anova showed that the positive correlation between shoot biomass and peat percentage for was not significant for *P. pratensis* ($P \leq 0.07$ [$F(4,14) = 0.316652$, $p = 0.860488$]) and we accepted the null hypothesis that the percentage of peat did not affect the shoot biomass for *P. pratensis.* The lack of significance is thought to be the lack of complete growth development this conclusion is drawn from the lack of nutrient deficiency symptoms, indicating that all treatments were still getting adequate nutrients from each treatment.

Single factor Anova showed that the positive correlation between shoot biomass and peat percentage for was significant L. multiflorum ($P \leq 0.07$ [$F(4,14) = 3.105034$, $p = 0.066548$]) and therefore we may reject the Ho. This significance is confirmed from the appearance of nutrient deficiency symptoms, indicating that treatments were not getting adequate nutrients.

While these results are indicative of possible correlations they should be considered introductory and further work should be done in small scale models before moving onto a larger models or real scale application. During the experiment several issues were identified, the ratio of soil to grass growing limiting nutrient availability and interfered with data collection. The experimental treatments had no water retention bottom and reducing the soil moisture of treatments.

In summary this experiment provided preliminary results showing the viability of buried peat as a reclamation material. The results showed a positive correlation showing increased growth rate as the peat to mineral soil ratio increased this should be repeated in longer and larger scale studies. Salvaged buried peat should be considered as a suitable potential reclamation material.

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Conflict of Interest

No outside funding was acquired for the conduction of this experiment all equipment was supplied by the Concordia University College of Alberta, with the exception of the soil pH meter. The donation of the pH meter by Navus Environmental was done so on good faith, with no expectation of benefit, credit or remuneration from the outcome of this study.

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