ADAPTIVE MANAGEMENT OF FORESTRY PRACTICES IN PINE-LICHEN WOODLANDS IN NORTH-CENTRAL BRITISH COLUMBIA

Site 1 (98-Mile, Mackenzie) and Site 2
(Malaput – Vanderhoof) Pretreatment Assessments

March 2002

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Introduction

The management of pine-lichen woodlands receives a high level of scrutiny throughout British Columbia. These forest types provide an important source of forage for northern caribou throughout portions of the winter months (Johnson et al., 2000). Projects evaluating the development of terrestrial lichens after disturbance have been a centre of focus in several regions of the province. There are many projects currently underway. Miège et al. (Miège et al., 2001) have been conducting operational silviculture system trials within the range of the Itcha-Ilgatchuz herd in the Chilcotin region. Williston and Chichowski (P. Williston personal communication) are assessing the effects of mountain pine beetle infestations on lichen community development in the range of the Tweedsmuir-Entiako herd. Coxson and Marsh (2001), Sulyma and Coxson (2001), and Sulyma (2001) have recently conducted work in the Omineca region focusing on the development of an understanding towards the ecology of terrestrial lichens in areas used by the Wolverine herd.

This project is similar in nature to that of Miège et al. (2001) in that forestry practices are being assessed to determine their impacts on the development of terrestrial lichen communities. The objectives associated with lichen development between the projects are, however, varied as work conducted by Miège et al. (2001) focuses on using alternative silviculture systems to create a "sheltered" environment and protect terrestrial lichens from disturbance. In the Omineca lichen re-growth after harvesting appears to recover within 20 to 30 years after the disturbance (Sulyma, 2001). In the Laidman Lake area of the Vanderhoof Forest District lichen ecology is similar to that of the Omineca (Sulyma, 2002). Thus, the focus for this project is to determine which forestry practices, within currently used silviculture systems, provide the most suitable conditions for terrestrial lichen re-growth.

Common forestry practices on sites under this study incorporate ground based harvesting systems to remove trees from the setting. These systems include the use of machines such as feller bunchers, skidder or forwarders, and processors to prepare trees for loading onto logging trucks. When skidders are used the system is referred to as whole tree harvesting because the entire tree - stem, crown and all, are dragged to a landing where they are processed (prepared for delivery to the mill). Correspondingly, when a forwarder is utilised the system is called cut-to-length because trees are processed at the stump (in the setting where they are felled) and only the finished log is taken to the landing to be loaded onto the truck. Site preparation practices utilised on these dry sites varies from no treatment to light impact slash re-alignment, which aids in planting and promotes natural regeneration (referred to as scarification).

In this study we have focused on assessing treatment effects, towards lichen community development, of the conventional forestry practices typically used in the study area. Nine different treatment regimes were established to test a combination of harvesting, site preparation and regeneration methods (Table 1) (Sulyma and Wawryszyn, 2001). Due to the broad geographic extent of this project and the range of involvement from different forestry partners, variations in the combination of regimes implemented will occur at each site.

Within the 2001 project year the objective was to establish two sites and have them ready for harvesting treatments to be conducted in 2002. This report outlines the pre-treatment data

Table 1. Summary of the project treatment regimes.

Treatment Regime	Predicted Conditions for Lichen[1]	Harvesting Method	Harvesting Season	Site Preparation	Regen Method	Results of the Treatment
1	Best	Whole tree	Winter	None	Natural	Create small amounts of debris with little disturbance to the lichen mats and providing a more open canopy cover during regeneration.
2	Good	Cut to length	Winter	None	Natural	Create large amounts of debris with little disturbance to the lichen mats and providing a more open canopy cover during regeneration.
3	Moderate	Cut to length	Summer	None	Natural	Create large amounts of debris with moderate disturbance to the lichen mats and providing a more open canopy cover during regeneration.
4	Moderate	Cut to length	Summer	None	Plant	Create large amounts of debris with moderate disturbance to the lichen mats and providing a more closed canopy cover during regeneration.
5	Worst	Cut to length	Summer	Drag scarify	Natural	Create large amounts of debris with very heavy disturbance to the lichen mats and providing a more open canopy cover during regeneration.
6	Good	Whole tree	Summer	None	Natural	Create small amounts of debris with heavy disturbance to the lichen mats and providing a more open canopy cover during regeneration.
7	Moderate	Whole tree	Summer	None	Plant	Create small amounts of debris with heavy disturbance to the lichen mats and providing a more closed canopy cover during regeneration.
8	Worst	Whole tree	Summer	Drag scarify	Natural	Create small amounts of debris with very heavy disturbance to the lichen mats and providing a more open canopy cover during regeneration.
9	Worst	Whole tree	Summer	Drag scarify	Plant	Create small amounts of debris with very heavy disturbance to the lichen mats and providing a more closed canopy cover during regeneration.

[1]This designation is based on the premise that no disturbance provides optimal conditions for lichen growth and regeneration.

collection process at the study sites. The two sites in this report are referred to as the "98-Mile" site (Site 1 - in the Mackenzie Forest District), and the "Malaput" site (Site 2 - in the Vanderhoof Forest District). At the 98-Mile site, six treatment regimes and a control area were established. At the Malaput site, five treatment regimes and a control were established. Site comparisons were made to identify consistency within and between both study areas. Detailed treatment regime maps are also presented (Appendix 1 and 2) to help ensure accurate re-establishment of permanent sample plots after the completion of forestry activities.

Study Area Location

Site 1: 98-Mile

The 98-Mile site is located approximately 70 km northwest of the town of Mackenzie in the Mackenzie Forest District of the Prince George Forest Region (Figure 1, and see Appendix 1). It is situated near 98 km on the Finlay Main, which is also at the junction of the Manson Forest Service Road (FSR) with the Finlay. Six treatment regimes and a control area were established at this site (Table 1, Figure 2[1]). The site falls within UTM Zone 10, and has a general coordinates of, northing: 6168365 and easting: 447151. The site falls entirely within the Williston moist cool sub-zone of the Sub-Boreal Spruce biogeoclimatic zone (SBS mk2) (MacKinnon et al., 1990).

Site 2: Malaput

The Malaput site is located approximately 150-km southwest of the town of Vanderhoof in the Vanderhoof Forest Districts of the Prince George Forest Region (Figure 1, and see

[1] Treatment regime numbers have been designed to correspond between all tables and figures within the project documentation.

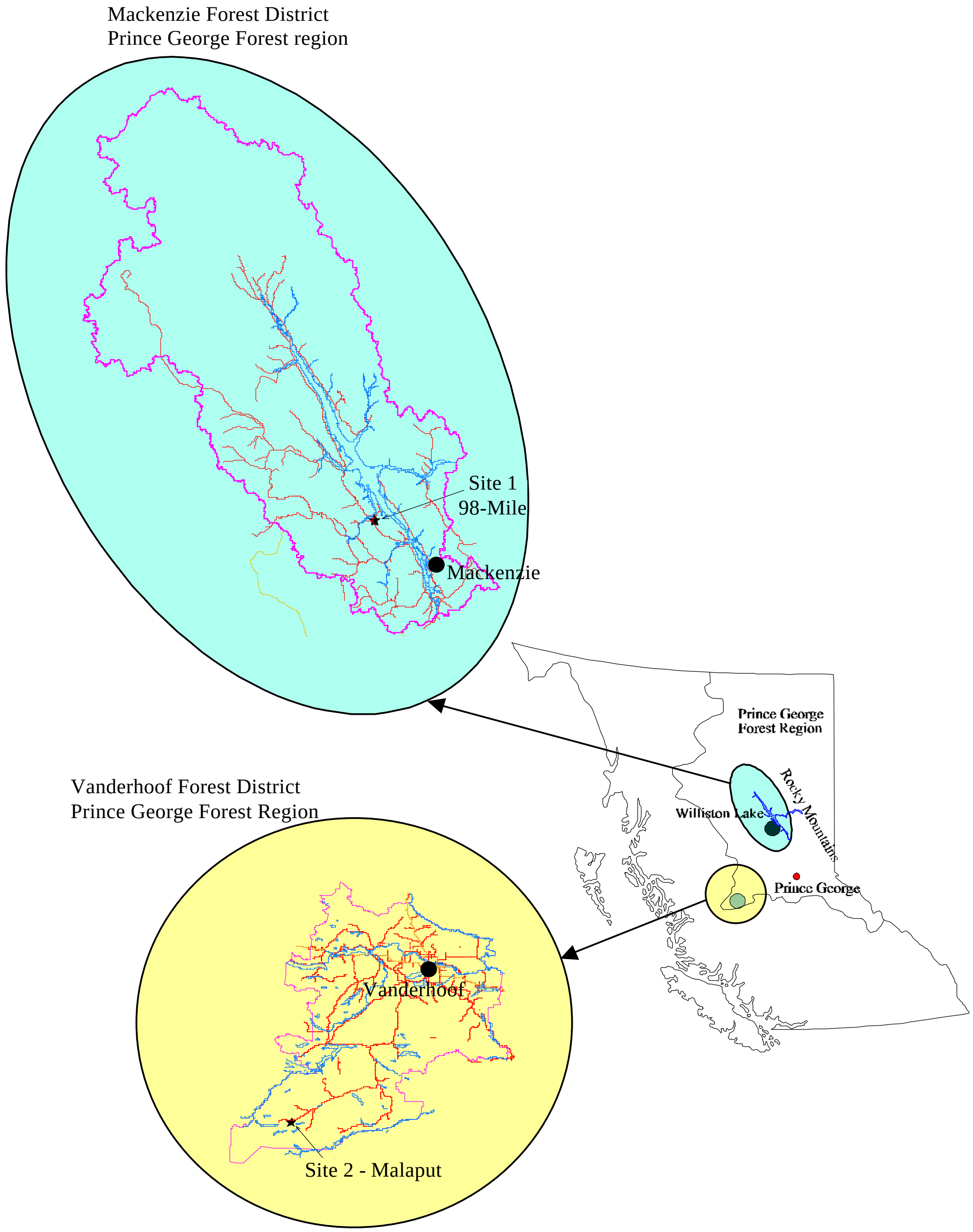

Figure 1. Location Map

Figure 2. Site 1: 98-Mile overview map

Appendix 2). It is situated at 2 km on the Malaput 8000, which is just south of ±17 km on the Malaput FSR. Five treatment regimes and a control area were established at this site (Table 1, Figure 3). The site is in UTM Zone 10 and has general coordinates of, northing: 5890175 and easting: 349475. The site is in the moist cold subzone of the Sub-Boreal Pine Spruce biogeoclimatic zone (SBPS mc) (DeLong et al., 1993).

Methods

Site Survey:

For each treatment regime a 300 m strip-line transect running in a general east/west direction was established (Appendix 1 and 2). A tight chain was used to establish a tie-line to the point of commencement of each strip-line transect. At the 98-Mile site, the tie-lines were fixed from the closest intersection of the proposed on-block roads at angles of 45, 135 or 315 degrees. At the Malaput site, past small-scale salvage activities constrained the location of the strip-lines. In turn, the strip-lines were placed to maintain a maximum distance from harvested patches. Tie lines were established from the existing built roads within the study area and generally ran in a north/south direction.

Strip-line transects were tight chained from the point of termination (POT) of the tie-lines with marker pins placed every 50 m. A second tie line was established at the POT of each strip-line. This was extended on a bearing and distance that would permit the marking of the point with a permanent stake beyond the boundary of the treatment area. Plot centres were established at 50 m intervals along the strip-lines and used for forest stand evaluations and course woody

Figure 3. Site 2: Malaput overview map

debris surveys. Throughout the process, care was taken to avoid stepping on the south side of the strip-lines over a one-metre strip where vegetation plots were established.

All marker pins used for this project were 30 cm spikes with a washer and 1 m of pink winter ribbon attached to aid in their location after logging. The two closest trees to each pin were painted pink below 20 cm. The trees were marked with metal tags stating the distance to the marker pin and the relevant plot location information (Appendix 1 and 2). All of the marker pins were placed as flush as possible into the ground to prevent removal during logging. The locations of the marker pins were also recorded using a global positioning satellite (GPS) unit and data was differentially corrected using Pathfinder Office V2.11 (Trimble Navagation Ltd., Sunnyvale CA). Appendixes 1 and 2 contain detailed maps with explicit spatial information for each of the treatment regimes.

Forest Stand Evaluation:

Fixed area plots of either 100 m^2 or 200 m^2 were set up at each of the six marker pins to assess forest attributes. Plot size was selected based on the uniformity of the stem distribution of the stand being assessed and on achieving an objective of having a minimum of 10 combined co-dominant and dominant trees to measure (Husch et al., 1982). The plots were centred 30 cm to the north of the marker pins to avoid disturbing the permanent placement of them. Each tree in the plot was marked with a ribbon and given a number. The height, diameter at breast height (DBH), counted age and tree species were recorded for each tree. The height and diameter values were used to calculate basal area, tree volume (Watts, 1983) and tree biomass (Standish et al., 1985) for the stand. Total stand age was derived by adding seven years to the counted age. This resulted in a slight underestimate as the correction factor of 7 years is for stump height in pine-lichen woodlands (Sulyma and Coxson, 2001). For stems with a DBH less than 4 cm, a simple tally was kept, separating the trees according to species and whether they were ≥ 1.3 m or <1.3 m in height. Vegetation and soil overviews were also conducted at each stand plot to allow a biogeoclimatic ecosystem classification assessment (DeLong et al., 1993).

Understorey Vegetation Evaluation:

Understorey vegetation cover was evaluated using both ocular estimates and photo imaging of 0.71 m X 0.71 m quadrats. To ensure broad coverage of the study area, each transect was divided into three 100 m sections with 14 randomly selected quadrats established in each section. The quadrats were established along the south edge of each strip-line. Marker pins were placed on two corners at each of the quadrat location. For each quadrat, ocular estimates of percent cover were made of the vegetation to the species level before they were photographed.

Photographs were taken using a 28-mm lens on a manual single-lens-reflex camera mounted on a tripod with a horizontal boom. Digital copies of the photographs were assessed using SigmaScan Pro 5.0 (1999, SPS Science Inc., Chicago). All shrub lichens (*Cladina mitis, C. Rangiferina, C. Stellaris, Cladonia uncialis* and *Stereocaulon alpinum*) were digitized and a cover estimate was calculated for each quadrat.

Coarse Woody Debris (CWD) Evaluation:

Course woody debris was evaluated using the procedure from the “Field Manual for Describing Terrestrial Ecosystems” (Anonymous, 1998). All single pieces and piles were tallied on each CWD sub-transect. Piles were rarely encountered during the pre-treatment surveys; however, they are expected to be common after harvesting.

Soil and Forest Floor Cover Disturbance Evaluation:

A walk through assessment of the sites indicated that very little soil disturbance existed. It was, therefore, determined that only post harvest soil and forest floor cover disturbance will be measured. Disturbance will be measured using the survey methods detailed in the "Soil Conservation Surveys Guidebook" (Anonymous, 1997) with the following modification applied. An additional category of disturbance termed mixing will be added for this study. This category is intended to provide a way of noting if any of the treatment regimes result in mixing of organic and mineral soil layers. The mixing of these layers is expected to provide a habitat that is favourable for herb growth that will effectively reduce lichen development.

Data Analysis:

Stand and site factors were assessed using ANOVA to help identify if variation existed in the data sets both within and between the sites. Assessments of average site values were supported using paired T-Test. All values in the text are presented as the mean plus or minus one standard deviation ($\bar{x} \pm 1SD$).

Results

Both sites have typical soil, terrain and plant community characteristics of pine-lichen woodlands. These include well-drained soils with a poor nutrient regime and a forest overstorey dominated by lodgepole pine (Johnson, 1981; Rowe, 1984; Stevenson, 1991). Both sites also had forest floor vegetation communities expressing conditions associated with the latter sages of succession (Coxson and Marsh, 2001). An assessment of the estimates of lichen cover between the two sites indicated there was a greater cover of lichens at the Malaput site than the 98-Mile site (Table 2). The reciprocal trend was evident with the cover of feather moss where the 98-Mile site had a greater cover than the Malaput site (Table 2). This trend, however, was not statistically significant.

The stand characteristics that were noted to be different between the two sites were associated with tree age and coarse woody debris. Trees at the Malaput site (112.2±10.9 years) were slightly younger than trees at the 98-Mile site (152.6±11.4 years) ($T(74)=15.63, P<0.0001$). Regarding coarse woody debris, variations in volumes existed between treatment regimes at the 98-Mile site ($F6, 34)=5.52, P<0.0001$). Comparing the two sites, there were differences between the piece size diameters ($T(77)=4.67$, $P< 0.0001$) and with the percent of the ground the coarse woody debris covered ($T(77)=3.2$, $P=0.0022$). No other significant trends were noted with the stand structure and vegetation community structure, either between the two sites or within each of the individual sites. Some variation, however, was noted in the site features. Soil texture was finer and general topography slightly more sloped at the Malaput site.

Site 1: 98-Mile

The soils at the 98-Mile site were very uniform. All treatment regimes had sand texture soils with < 5% coarse fragment content. Coarse fragments were gravel sized. The terrain of the site was flat to gently rolling. Most slopes encountered were <5% gradient; though, few scattered pitches of up to 12% were recorded. Soils were deep (>1.0 m) and "rapidly drained" (Anonymous, 1998). Based on soil conditions, the site was evaluated to be subxeric and nutrient poor (DeLong et al., 1993; MacKinnon et al., 1990). This combination of edatopic

Table 2. Mean % cover ($\bar{x} \pm$ 1SD) of lichen assessment groups and a comparison of the values between the two study sites.

Assessment Group	Site 1: 98-Mile	Site 2: Malaput	t-value
n=	291	230	
Cladina Species[1, 3]	1.1 ± 2.8	2.2 ± 5.6	T(520)=2.11, P=0.0085
Cladina and Cladonia Species[2, 3]	1.2 ± 3.2	3.4 ± 7.2	T(520)=4.20, P<0.0001
Photo cover assessment[1, 4]	0.4 ± 1.3	0.9 ± 3.4	T(520)=2.11, P=0.036
Feather moss[5]	69.0 ± 24.01	64.7 ± 31.0	T(520)=1.73, P=0.084

[1] Group includes: *Cladina mitis, C. rangiferina, C. Stellaris, Cladonia uncialis* and *Stereocaulon alpinum.*
[2] Includes Cladina Species group plus: *Cladonia ecmocyna, C. gracilis,* and *C. cornuta.*
[3] Values are based on ocular estimates of .
[4] Values based on digitized photos of 0.71 m X 0.71 m quadrats.
[5] Group includes: *Pleurozium schreberi, Ptilium crista-castrensis, Hylocomium splendens.*

grid position places the site within the 02 site-series (Feather moss – Cladina plant association) of the SBS mk2 biogeoclimatic zone. Assessments of the vegetation correspond with the 02 site series designation, however, the plant community composition does also overlap with that of the 03 site series (Huckleberry – Soopolallie plant association).

The forest overstorey was dominated by a lodgepole pine stand with a density of 1226±405 stems/ha that was 152.6±11.4 years old. Tree height was 17.3±4.5 m and the diameter at breast height was 18.5±2.7 cm. Basal area, volume and biomass figures for this site are summarized in Table 3. The ground vegetation composition and cover was also consistent across the site (Table 4). Feather mosses (dominated by *Pleruozium schreberi*) were the most prevalent species in the forest floor vegetation community. Lichen patches, however, were present throughout the entire study area. Table 4 presents a species list and the % cover for all treatment regimes.

The piece size of the coarse woody debris, based on diameters, did not vary between the treatment regimes (Table 5). The volume, however, did $(F6, 34)=5.52, P<0.0001$). The control area (TR 1-99) had lower volumes than treatment regimes 1-3, 1-4 and 1-6 . Likewise, treatment regime 5 had lower volumes than treatment regime 3. An assessment of the percent ground covered by coarse woody debris was consistent with the volume findings except a difference was not noted between treatment regimes 1-3 and 1-5.

<u>Site 2: Malaput</u>

All treatment regimes at the Malaput site had sand to sandy-loam texture soils. The coarse fragment content of the soils was approximately 25%. Coarse fragments were gravel sized. The soils were deep (> 0.5 m) and rapid to well-drained. The site has gently sloping

Table 3. Mean values ($\bar{x} \pm$ 1SD) for stand characterization variables.

Variable	**Site 1: 98-Mile**	**Site 2: Malaput**
n=	42	33
Tree Species Composition (%)		
Lodgepole pine (*Pinus contorta*)	98.0	97.4
White spruce (*Picea glauca*)	1.5	2.1
Subalpine fir (*Abies lasiocarpa*)	0.5	0.0
Trembling aspen (*Populus tremuloides*)	0.0	0.5
Stand Age (years)	152.6 ± 11.4	112.2 ± 10.87
Tree Height (m)	17.3 ± 2.5	17.2 ± 2.4
Density (stems/ha)	1226 ± 405	1138 ± 85.6
Basal Area (m^2/ha)	35.7 ± 8.0	35.5 ± 9.2
Volume (m^3/ha)	330.6 ± 85.6	322.4 ± 99.0
Biomass (ton/ha)	194.4 ± 44.0	191.0 ± 52.9

Table 4. Species list and mean percent cover ($\bar{x} \pm$ 1SD) of forest floor vegetation presented by treatment regime. A "t" (trace) denotes <0.1% cover and a blank cell denotes 0.0% cover for the indicated species. The n=42 for all treatment regimes except 1-5 where n=39 and 2-99 where n=20.

Assessment Group/	**Site-Treatment Regime**												
Species	**1-1**	**1-2**	**1-3**	**1-4**	**1-5**	**1-6**	**1-99**	**2-1**	**2-6**	**2-7**	**2-8**	**2-9**	**2-99**
Exposed Soil									0.1 ± 0.6			0.3 ± 1.6	
Coarse Woody Debris	2.4 ± 5.6	2.5 ± 5.7	4.2 ± 8.0	3.5 ± 7.1	3.4 ± 6.5	4.0 ± 7.2	1.3 ± 4.1	1.2 ± 5.5	1.9 ± 4.2	2.8 ± 6.8	2.5 ± 8.4	1.0 ± 4.3	2.4 ± 5.0
Litter Cover	16.2 ± 9.2	19.3 ± 1.1	22.9 ± 7.3	18.8 ± 15.9	14.9 ± 13.0	19.6 ± 12.3	22.8 ± 21.5	25.2 ± 21.9	24.0 ± 21.0	21.3 ± 16.1	22.1 ± 21.8	31.8 ± 24.1	19.1 ± 15.8
Achillea millefolium								t	0.1 ± 0.3	0.1 ± 0.4	0.1 ± 0.2		
Amelanchier alnifolia	t	0.6 ± 3.9	0.1 ± 0.5										
Aralia nudicaulis				t									
Arctostaphylos uva-ursi	1.2 ± 4.0	0.9 ± 2.5	1.0 ± 2.3	0.9 ± 1.9	1.6 ± 2.7	5.2 ± 6.5	1.7 ± 3.4	5.7 ± 8.1	5.3 ± 6.0	3.3 ± 5.1	4.5 ± 6.0	7.4 ± 10.4	1.7 ± 3.3
Barbilophozia spp.	0.4 ± 1.3	0.2 ± 1.1	0.9 ± 4.7	0.3 ± 1.0	0.6 ± 2.1	0.4 ± 1.7	0.3 ± 1.5	0.2 ± 1.5	0.2 ± 0.9	0.8 ± 3.3	t	t	
Calamagrostis canadensis						t		t	t				
Cetraria ericetorum			t	t	t	t		0.1 ± 0.2	t	0.3 ± 0.9	0.2 ± 0.6	0.2 ± 0.4	
Chimaphila umbellata				0.2 ± 0.8	t						t	0.1 ± 0.6	
Cladina mitis	0.6 ± 1.5	0.1 ± 0.5	0.6 ± 0.5	0.1 ± 0.5	1.2 ± 2.7	0.6 ± 1.7	0.5 ± 1.2	0.8 ± 2.5	1.1 ± 4.7	1.5 ± 6.2	0.5 ± 1.0	0.8 ± 1.5	0.6 ± 0.9
Cladina rangiferina	0.4 ± 1.2	0.3 ± 1.0		0.2 ± 0.7	1.1 ± 2.3	0.8 ± 2.1	1.1 ± 2.2	1.7 ± 5.2	1.2 ± 3.9	0.5 ± 1.2	0.6 ± 2.0	1.6 ± 3.9	0.6 ± 1.0
Cladina stellaris	t	t			t								
Cladonia carneola	t	t		t			t	t	t		t	t	t
Cladonia cenotea							t						
Cladonia cervicornis-verticillata								t	t			t	
Cladonia chlorophaea		t				t			t			t	
Cladonia coccifera												t	
Cladonia cornuta	0.1 ± 0.3	t		t	t	t	t	0.2 ± 0.6	0.1 ± 0.3	0.1 ± 0.4	0.1 ± 0.4	0.2 ± 0.4	0.1 ± 0.2
Cladonia crispata						t		t	0.1 ± 0.5	t	0.2 ± 0.8	0.2 ± 0.5	
Cladonia deformis									0.1 ± 0.2	t	t	t	t
Cladonia ecmocyna	0.1 ± 0.6	0.1 ± 0.5	t	t	0.3 ± 0.7	0.2 ± 0.6	0.1 ± 0.6	0.8 ± 1.6	1.3 ± 3.9	0.5 ± 1.3	0.4 ± 1.2	2.7 ± 6.0	0.4 ± 1.0
Cladonia fimbriata			t					t	t	t		t	t
Cladonia gracilis							t	t			t		
Cladonia multiformis									t				
Cladonia phyllophora								0.2 ± 0.5	0.1 ± 0.2		0.2 ± 0.5	0.1 ± 0.3	t
Cladonia pleurota						t		t	t		t	t	
Cladonia pyxidata								t	t			t	
Cladonia subulata								t					
Cladonia sulphurina	t	t	t		0.1 ± 0.5	t		t	0.1 ± 0.2	0.1 ± 0.2		0.1 ± 0.2	t
Cladonia unicalis						t	0.1 ± 0.2	t	t		t	0.1 ± 0.5	
Cornus canadensis	6.3 ± 4.5	3.5 ± 3.0	3.7 ± 3.5	3.8 ± 3.5	0.6 ± 2.0	9.3 ± 10.5	3.4 ± 3.3	5.2 ± 3.6	3.2 ± 2.6	3.9 ± 3.0	4.3 ± 3.7	3.1 ± 3.0	3.0 ± 2.8

Table 3. Cont.

Assessment Group/	Site-Treatment Regime												
Species	**1-1**	**1-2**	**1-3**	**1-4**	**1-5**	**1-6**	**1-99**	**2-1**	**2-6**	**2-7**	**2-8**	**2-9**	**2-99**
Dicranum polysetum	4.7 ± 9.5	4.9 ± 7.7	2.0 ± 3.7	1.5 ± 2.2	4.0 ± 4.7	6.6 ± 8.3	2.1 ± 3.0	0.3 ± 1.0	0.2 ± 0.7	0.3 ± 1.2	0.4 ± 1.6	0.3 ± 1.1	0.4 ± 1.2
Dicranum spp.							0.2 ± 1.1	0.7 ± 1.6	0.5 ± 1.3	0.6 ± 3.1	0.2 ± 0.9	0.7 ± 2.2	0.6 ± 1.4
Empetrum nigrum									1.0 ± 3.9				
Epilobium angustifolium	0.2 ± 0.7		0.1 ± 0.5	0.1 ± 0.4				0.2 ± 0.5	0.1 ± 0.4	0.1 ± 0.4	0.3 ± 0.6	0.1 ± 0.4	0.2 ± 0.5
Fragaria virginiana					t				t		0.1± 0.4	t	
Geocaulon lividum	1.6 ± 1.9	1.7 ± 2.2	1.6 ± 2.2	1.2 ± 1.6	0.9 ± 1.5	1.2 ± 1.6	1.7 ± 1.7	t		t			
Goodyera oblongifolia			t	t			t						
Hylocomium splendens	4.6 ± 13.4	3.5 ± 12.2	1.4 ± 3.7	6.7 ± 16.3		1.1 ± 4.9	0.2 ± 0.8				0.4 ± 1.7	1.0 ± 6.1	
Juniperus communis	0.2 ± 0.8	0.5 ± 2.4		0.2 ± 1.5	0.3 ± 1.6			0.1± 0.8			t		
Linnaea borealis	1.2 ± 2.1	1.3 ± 2.0	0.7 ± 1.4	1.0 ± 2.0	1.6 ± 2.6	3.9 ± 7.2	3.6 ± 5.9	3.2 ± 2.7	6.0 ± 6.3	5.5 ± 7.2	6.1 ± 7.2	4.5 ± 4.9	2.9 ± 4.8
Lycopodium complanatum	0.5 ± 2.0	1.7 ± 6.9	3.2 ± 6.8	1.0 ± 2.8	2.0 ± 4.2	1.5 ± 5.0	4.5 ± 8.9		0.2 ± 0.8		0.1 ± 0.8	0.4 ± 1.9	
Maianthemum cnadense	0.8 ± 1.2	0.2 ± 0.5	0.2 ± 0.5	0.1 ± 0.3	0.2 ± 1.1	0.5 ± 1.1	0.4 ± 0.8						
Lelampurum lineare		0.1 ± 0.5	0.2 ± 0.9	0.1 ± 0.5			0.1 ± 0.3			t			
Oryzopsis asperfolia	0.3 ± 0.8	0.2 ± 0.5	0.1 ± 0.2	0.1 ± 0.3	t	0.1 ± 0.3	0.2 ± 0.5	t	t	t	t	t	
Oryzopsis pungens	0.1 ± 0.2	t	0.1 ± 0.2	0.2 ± 0.5	0.1 ± 0.3	0.1 ± 0.3	t	0.3 ± 0.8	0.1 ± 0.4	0.1 ± 0.3	0.3 ± 0.6	0.1 ± 0.2	0.1 ± 0.2
Peltigera apthosa	0.8 ± 2.7	0.7 ± 2.5	0.1 ± 0.6	0.3 ± 1.0	0.5 ± 2.4	0.5 ± 2.4	2.5 ± 6.3	0.6 ± 1.5	2.4 ± 4.6	2.9 ± 6.7	1.2 ± 3.1	1.6 ± 4.0	2.4 ± 4.1
Peltigera malacea	0.8 ± 2.6	0.8 ± 2.6	0.8 ± 1.8	0.2 ± 1.2	1.9 ± 3.1	2.6 ± 4.1	0.2 ± 1.1	2.3 ± 3.8	2.1 ± 5.6	0.6 ± 1.9	2.2 ± 5.5	2.1 ± 3.5	0.8 ± 1.8
Pleurozium schreberi	69.6± 24.6	66.0 ± 23.8	66.8 ± 19.9	64.8 ± 27.4	74.9 ± 19.6	56.5 ± 29.1	61.8 ± 30.2	62.2 ± 31.2	61.5 ± 30.7	71.6 ± 26.4	67.5 ± 29.8	53.3 ± 36.1	73.2 ± 26.0
Polia spp.					t								
Polytrichum juniperinum			0.1 ± 0.5			t	0.2 ± 0.8	t	0.3 ± 0.9	0.1 ± 0.3	t	0.1 ± 0.4	
Ptilium crista-castrensis	0.3 ± 1.6	0.3 ± 1.6	1.1 ± 2.8	1.7 ± 10.8	t	0.3 ± 1.6	1.9 ± 5.7	0.6 ± 2.5	0.3 ± 1.1	0.1 ± 0.5	0.1 ± 0.5	1.0 ± 6.2	0.6 ± 2.2
Pyrolia asarifolia	0.1 ± 0.3	t		0.1 ± 0.3	0.1 ± 0.5	t	t	t	0.4 ± 0.7	0.2 ± 0.6	0.2 ± 0.4	t	
Pyrolia secunda	0.1 ± 0.2	0.1 ± 0.5	0.2 ± 0.7	t	t	t	0.1 ± 0.5					0.1 ± 0.2	
Rosa acicularis	0.3 ± 0.7	0.4 ± 0.8	0.4 ± 0.7	0.3 ± 0.7	0.4 ± 0.8	0.5 ± 1.1	0.7 ± 1.3	0.8 ± 1.1	0.1 ± 0.4	0.1 ± 0.5	1.5 ± 2.2	0.5 ± 1.0	0.4 ± 0.8
Salix spp.						0.6 ± 3.9	t				t		0.2 ± 0.7
Shepherdia canadensis	4.7 ± 6.7	7.7 ± 9.5	4.1 ± 6.2	4.0 ± 4.6	2.5 ± 4.9	4.4 ± 7.5	2.6 ± 3.5	2.0 ± 4.0	3.8 ± 6.9	2.7 ± 4.3	2.1 ± 3.7	2.9 ± 3.8	2.3 ± 3.3
Solidago multiradiata					0.1 ± 0.3	t		t			0.2 ± 0.7		0.1 ± 0.2
Spirea betulifolia	0.4 ± 1.0	1.0 ± 2.3	0.3 ± 0.8	0.9 ± 1.8	0.1 ± 0.5	0.4 ± 1.1	0.8 ± 1.6		0.5 ± 1.2	0.2 ± 0.7	0.2 ± 0.4	0.4 ± 1.2	
Stereocaulon alpinum			0.1 ± 0.6		0.1 ± 0.8			0.3 ± 0.8	0.1 ± 0.3	t	0.1 ± 0.4	0.2 ± 0.8	
Vaccinium caespitosum	0.8 ± 1.8	0.3 ± 0.8	0.6 ± 1.0	0.2 ± 0.6	0.4 ± 1.5	1.4 ± 2.8	0.5 ± 0.9	1.8 ± 2.1	0.8 ± 1.3	2.1 ± 2.5	2.3 ± 2.3	2.1 ± 2.2	1.9 ± 3.1
Vaccinium membranaceum								0.7 ± 1.3	2.4 ± 4.8	t	1.0 ± 2.0	0.7 ± 1.3	
Vaccinium myrtilloides	1.3 ± 3.3	3.1 ± 6.6	1.8 ± 3.3	4.5 ± 6.3	5.9 ± 5.4	0.5 ± 3.1	3.5 ± 4.3						
Vaccinium vitis-idaea	2.1 ± 2.7	0.7 ± 1.8	0.7 ± 1.7	1.0 ± 3.5		0.5 ± 2.0	0.2 ± 0.4						
Viburnum edule	t	t	t	0.3 ± 1.6		0.3 ± 1.6	t						
Shrub Lichens from Photos	0.5 ± 1.4	0.2 ± 0.6	0.1 ± 0.4	0.1 ± 0.3	0.7 ± 1.6	0.7 ± 2.1	0.5 ± 1.3	0.9 ± 2.5	1.3 ± 5.9	0.7 ± 2.6	0.4 ± 0.8	1.4 ± 4.1	0.2 ± 0.4

Table 5. Mean values ($\bar{x} \pm$ 1SD) for coarse woody debris variables at each site.

Variable		Site 1: 98-Mile	Site 2: Malaput
	n=	42	35
Piece Size Diameter (cm)		10.9 $\pm$ 3.0	15.4 $\pm$ 5.0
Volume (m^3/ha)		60.2 $\pm$ 48.2	63.2 $\pm$ 59.0
Cover (%)		6.7 $\pm$ 5.5	3.6 $\pm$ 2.5

terrain and a southwest aspect. Slopes ranged between 0% and 12%, with the majority of the site having slopes <7%. Both soil and vegetation factors identify the site as subxeric and nutrient poor (DeLong et al., 1993). With this combination of edatopic conditions this site falls within the 02 site series (Kinnickinnick – Cladonia plant association) of the SBPS mc biogeoclimatic zone.

The forest overstorey was dominated by a lodgepole pine stand with a density of 1138±661 stems/ha that was 112.2±10.9 years old. Tree height was 17.2±2.4 m and the diameter at breast height was 19.4±3.8 cm. Basal area, volume and biomass figures for this site are summarized in Table 3. Like the 98-Mile site, the ground vegetation composition and cover was also consistent across this site (Table 4). Feather mosses (dominated by *Pleruozium schreberi*) were the most prevalent species in the forest floor vegetation community with patches of terrestrial lichens being regularly distributed throughout the study area. Coarse woody debris characteristics were uniform at this site. No variations in volume, size or percent cover were tallied (Table 5).

Discussion

Project activities for 2001 focused on establishing two field sites, and evaluating the uniformity of various characteristics both within and between them. For the most part, the two sites showed little variation. They both had similar forest floor vegetation and forest overstoreys characteristics. A slight variation in the mean lichen cover (Table 2) was noted between the two sites. This contrast, though statistically significant, was considered negligible because of the small difference between them. The statistical significance was over emphasised due to a large sample population, which corresponded with a small effect size (Kirk, 1996).

The trend associated with lichen cover between the two sites corresponds with succession trends found in the Omineca (Coxson and Marsh, 2001). The 98-Mile site, which was older, had slightly lower cover of lichens and higher cover of feather mosses compared to the Malaput site. The total cover of terrestrial lichens at the Malaput site, however, was lower than Coxson and Marsh (2001) found for similar aged stands around Germansen Lake (in the Omineca region). This trend is likely a function of the forest stand structure at this site (Sulyma 2001). Both of the stands assessed under this study had estimated stand volumes greater than 325 m^3/ha and individual trees that were sufficiently large to create a microclimate at the forest floor suitable for feather mosses to flourish. In the absence of the microclimate moderation provided by the trees, it is anticipated that the environmental conditions, which will be created from harvesting, would be detrimental to the feather moss community and advantageous for terrestrial lichens.

Expected changes in the lichen community will likely be very subtle. To assist in providing more precise data, a photo plot procedure was employed to collect information on lichen cover. The intent of this procedure was to serve as an objective approach towards cover assessments. Conducting ocular estimates gives a general means to assess changes, however, if the lichens are somewhat slow to respond, the subtle changes expected in the early years of the trials may not be picked up. By digitizing the shrub lichens on photographs that are re-established on an annual basis, very fine changes in lichen cover should be detected.

The photo plot procedure was focused on the shrub lichen component of the vegetation community (see footnote 1 of Table 2). The shrub lichens were chosen as the assessment group for two primary reasons. First, they are easily digitised and second, they are an important component of the “reindeer lichen” functional group deemed as forge for northern caribou (Johnson 2001). Regarding digitising, the shrub lichens have definable edges that can be followed in digital copies of the photographs. Conversely, many of the *Cladonia* species, or club lichen, are intermingled with other vegetation and litter matter and are not easily discernible on the photographs.

The removal of the forest overstorey is expected to have a positive effect on microclimate conditions and a coresponding favourable effect on the presence of shrub lichens (Sulyma, 2001). Harvesting activities, however, do have to potential to negate any positive microclimate influence through creating ground disturbance and slash accumulations. The existing coarse woody debris characteristics did show variation in the pre-treatment data set were encountered. At the 98-Mile site, variations were experienced between treatment regimes. Regarding the volume of debris, the control (TR 1-99) was significantly lower than three other treatment regimes at this site. This, however, should have little influence on the impacts future assessments. Excluding the control, no significant variation was recognized between the six treatment regimes that were established. This should permit comparable results in future years between the treatment regimes (i.e. those with activities); yet, the control will still provide a relative reference regarding what changes may have occurred at the site under undisturbed conditions.

Though some variation was encountered at the 98-Mile site, the mean volume of debris is consistent between it and the Malaput site. There were, on the other hand, differences between the percent of the ground covered by coarse woody debris and the piece size diameter between the two sites. The percent of the ground covered by coarse woody debris (and finer slash) can have a negative influence on lichen success (Miège et al., 2001; Webb, 1998). Lichens need alternating periods of wetting and drying. Smothering them with debris prohibits adequate drying, thus, they begin to die off and decompose.

The existing tally for coarse woody debris is intended to focuses on large diameter pieces. This is partly a function of measuring potential habitat for smaller wildlife species. For this study, a minimum diameter of 7.5 cm was used to determine if a piece of debris was to be tallied (Anonymous, 1998). Because of the influence the debris has on the lichen community, a modification for subsequent years would be to measure the cover of smaller diameter pieces (down to 4.0 cm). The important functional attribute of debris, for this project, is the effect it has on the smothering and subsequent survival of terrestrial lichens, it is not necessarily a measure of habitat quality for small mammals.

There was one critical difference between the two sites that was not assessed within the existing data set. At the Malaput site a major bark beetle epidemic exists. Though the beetles are not expected to have an impact on the outcome of the study, some modifications/variations were required in the layout of the treatment regimes. Transects at the Malaput site were established to avoid infringing on areas that were previously disturbed by small-scale salvage activities. In some instances (e.g. TR 2-6) tie-lines were inserted into the strip-line to extend the strip-line out of the range of existing disturbance. All existing small-scale salvage activities at the Malaput site are current (i.e. they are less than 2 years old). In turn, there should be no impact to the results of treatment regime areas of this project resulting from the past activities.

This will not be the case with the control area TR 2-99. Whilst current attack in the control area is low, bark beetles will attack it. This forecast is based on personal observations of the rate of beetle spread identified at the site in 2001. The beetle attack will reduce the effectiveness of the control area; however, it will provide some insight towards the impacts of beetles on the lichen community development.

The project objectives of identifying and preparing two sites for forestry activities were achieved. Both sites are ready for the implementation of harvesting treatments. Relatively little variation was noted between the two locations. This uniformity will be favourable when conducting comparisons of all the treatment regimes. To provide further strength to relationship expressed at these sites, the project goal is to install further site replicates in each of the geographic regions in the 2002 field season.

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Appendix 1: 98-Mile Map Set

- Key Map
- Site Map
- Treatment Regime Maps

Appendix 2: Malaput Map Set

- Key Map
- Site Map
- Treatment Regime Maps