

ADAPTIVE MANAGEMENT PROJECT PLAN

ADAPTIVE MANAGEMENT OF FORESTRY PRACTICES IN PINE-LICHEN WINTER RANGE FOR NORTHERN CARIBOU IN NORTH CENTRAL BRITISH COLUMBIA

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SECTION 1: INTRODUCTION

This adaptive management plan (AMP) outlines a process for integrating the management of winter range for northern caribou (*Rangifer tarandus*) with forestry practices. The integration of these two resources in strategic level plans (i.e. the Mackenzie LRMP and the Vanderhoof LRMP) has resulted in the establishment of caribou strategies and technical/public advisory groups that have recognised the social, economic and ecological importance of both resources and the interactions between them. Regarding interactions, limited information and uncertainties related to decision making have resulted in a conflict situation that demands research be conducted to resolve issues.

The geographic area proposed for this project is west of the Rocky Mountains in the Prince George Forest Region. Specifically, project installations will be established in the Laidman Resource Management Zone (RMZ) in the Vanderhoof Forest District and the Blackwater, Klawli, Misinchinka and Buffalohead RMZ's in the Mackenzie Forest District. Due to the large geographic extent of this project, study sites are within the annual ranges of four different caribou herds (Heard & Vagt, 1998). Sites in the Laidman RMZ are utilised by the Tweedsmuir-Entiako herd. Sites in the Klawli and Blackwater RMZ's fall within the range of the Wolverine herd, the Chase herd uses areas in the Buffalohead RMZ and sites in the Misinchinka RMZ are used by caribou from the Kennedy Siding herd.

The component of caribou winter range that this study will evaluate is lichen woodlands. These are generally located on lower elevation alluvial terraces that have a dominant overstorey of lodgepole pine and have very coarse textured soils. Terrestrial lichens, or reindeer lichens, which provide caribou foraging opportunities for portions of the winter months (Cichowski, 1993; Terry & Wood, 1999; Wood & Terry, 1999) are naturally predominant in 70 to 140-year-old stands (Coxson et al., 1999; Maikawa & Kershaw, 1976). The dominance of these lichens is a function of severe growing conditions at a site, which impedes the growth of vascular plants and bryophytes (Rowe, 1984). There is limited information available regarding the impacts of forestry on pine-lichen winter ranges. Thus, the focus of this project is to improve the understanding of management paradigms regarding the implementation of forestry activities on the associated forest types.

Within the Mackenzie Forest District a 'caribou model' is being developed under the Omineca Northern Caribou project. The model (Netica V1.37, 2000) incorporates Bayesian belief networks and a geographic information system (ArcView V3.2, 1999) to determine the value of a caribou herd range considering different landscape disturbance regimes. One component of this model is a pine-lichen winter range (PLWR) sub-model. This sub-model evaluates four key elements to determine the value of terrestrial lichen sites for caribou use. These elements are lichen habitat capability, stand overstorey characteristics, forest floor characteristics and the utility of the stand for caribou use. A detailed description of this sub-model is included in Appendix 1.

This project focuses on collecting and evaluating information on two elements of the sub-model, the stand overstorey characteristics and the forest floor characteristic nodes. These are used to express the condition of the microclimate and the growing medium at a site, both of which are modified through forestry practices. Improving our understanding of the factors influencing the distributional ecology of terrestrial lichens result in a more reliable sub-model that can be used to manage for caribou and forestry resources.

The preparation of this plan is a collaboration of private and government interests. The main proponents are Slocan Forest Products (Plateau and Mackenzie Operations), Abitibi Consolidated, L&M Lumber, British Columbia Ministry of Forests, Forest Renewal British Columbia, and the Vanderhoof Innovative Forest Practices Agreement (IFPA).

There are three main sections within this document.

- Section 1: Contains the project background and project design.
- Section 2: Refers to the problem definition, problem statement, scope, objectives (management and learning), and areas of uncertainty within the AMP. This section also contains the project design parameters, and the implementation and monitoring procedures.
- Section 3: Entails the logistics of the project and the budget, and highlights the project participants and their responsibilities.

BACKGROUND

PURPOSE OF USING AN ADAPTIVE MANAGEMENT PLAN (AMP)

The purposes of using an AMP on this project compared to traditional research methods are:

- To provide opportunities for resource managers to play the lead role in the decision making process associated with new information collected on caribou and forest resources.
- To provide an avenue of implementing policies on an operational basis. This process allows managers to focus on resource management issues while proceeding with development and application of programs, even through situations that are erratic. Results from an adaptive management project generate information from management actions. This creates a database that can be integrated back into the model for continually improving management paradigms.
- To utilise a process that has been demonstrated to be an acceptable tool for improving resource management. As such, it can be incorporated into forest management certification processes.

OVERVIEW

Terrestrial lichens provide an important forage source for northern caribou throughout their range. The sustainable availability of this forage requires a landscape mosaic containing a range of age classes, particularly in areas where lichens are replaced in late successional stages of stand development by feather mosses. In pre-industrialised landscapes fire was the primary agent for stand initiation events. However, in modern landscapes forest management practices and the associated fire suppression techniques have greatly changed the seral stage distribution and the pattern of forest stands on the landscape.

Pine-lichen woodlands are also important for forestry activities. They are used for balancing employment and fibre supply because they provide ground for early and late summer harvesting. Forest harvesting however, is often seen as being incompatible with caribou range management. Removing the forest canopy can potentially destroy both arboreal and terrestrial lichen communities which caribou require to survive (Kranrod, 1996; Rowe, 1984).

TERRESTRIAL LICHENS

Lichens are the expression of a symbiotic relationship generally between two separate organisms, algae and fungus. The algae contain chlorophyll that manufactures carbohydrates through photosynthesis, while the fungi are made up of spongy threads that support the algae and protect them from drying out (McCune & Geiser, 1997). Lichens are commonly divided into three categories: crustose, foliose, and fruticose. For this particular adaptive management project we are interested in the fruticose lichens *Cladonia mitis*, *C. arbuscula*, *C. rangiferina* and *Cladonia uncialis*, which are commonly referred to as reindeer lichens.

Lichens have a variety of reproductive strategies and physical features to promote successful colonisation of a site. The most common strategy for reindeer lichens is to reproduce via vegetative means. This occurs when a disturbance process results in the distribution of all the components of lichen that are necessary for it to grow in a new location.

Forest stands suitable for lichen development (pine-lichen woodland) are characterised by a flat or south aspect, dry coarse textured soils and a poor nutrient regime (Johnson, 1981; Rowe, 1984; Cichowski, 1993). This combination of features creates harsh growing conditions resulting in small trees that have short, rounded crowns and understory plant communities that are sparse. Lichens do well on these sites because they can tolerate the harsh growing conditions and do not have to endure competition from other vegetation.

Developing management approaches for lichens involves consideration of ecological factors that influence both the growing medium and the microclimate of the site. In a retrospective study conducted in the Omineca region in the summer of 2000, we found some of the lichen species were damaged by overexposure to solar radiation resulting from the removal of the crown. This relationship is an expression of change in the microclimate that will be assessed under this study.

Two other factors that influence the suitability of a site for lichens are directly related to the ability of the growing medium to support higher plants. The first is a function of mixing organic material into mineral soil horizons and enriching the nutrient regime and moisture holding capacity. The second is the accumulation of organic material on a site which can both modify the microclimate and create a future source of organic input into the mineral soil.

SUCCESSION AND WILDFIRE:

Succession involves the replacement of one plant community by another in a progressive development through time. The succession of terrestrial lichen communities in lichen dominated woodlands is variable throughout their range. General patterns that have been documented contain three of four interim phases of succession (Brulisauer et al., 1996; Carroll & Bliss, 1982; Johnson, 1981; Maikawa & Kershaw, 1976; Morneau & Payette, 1988; Payette et al., 2000; Rowe, 1984). Common late seral plant are dominated by one of either *Stereocaulon spp.*, *Cladina spp.* or feather moss such as, *Pleurozium schreberi*. In the Omineca, Coxson et al.(1999) identify a climax for pine-lichen woodlands dominated by feather moss communities.

Reindeer lichens are slow growing and are associated with mid- to late-succession stages of a pine-lichen woodland (Carroll & Bliss, 1982; Coxson et al., 1999; Maikawa & Kershaw, 1976; Payette et al., 2000). Under a natural disturbance regime, terrestrial lichens re-establish after a wildfire but do not constitute suitable caribou forage attributes until a site is approximately 70 years old (Johnson, 1981). This relationship between lichens and wildfire is well documented (Johnson, 1981; Klein, 1982; Morneau & Payette, 1988; Rowe, 1984). Wildfire initiates the succession process, destroying the existing plant community for the short term. It creates microsite conditions that are unsuitable for forb species to flourish. Over time however, the forest overstorey and forest floor characteristics change to a state where mosses, forbs and shrubs can dominate.

When wildfire is replaced by harvesting, lichen regeneration is different from that found under a natural regime. There is limited information available regarding this comparison, however, work by Webb (1998) in Ontario, Woodard (1995) in Alberta and our retrospective study in the Omineca indicate lichen sites that have been harvested developed terrestrial lichen communities much sooner than those disturbed by wildfire. In the Omineca we found terrestrial lichen communities after 17 years on harvested sites

that were indicative of communities found in 70 to 100-year old naturally disturbed stands (Sulyma, 2000).

FOREST MANAGEMENT:

Forest harvesting in pine-lichen woodlands has a relatively short history. These stands provide easy harvesting opportunities, however, they contain low volume which has deterred licensees from aggressively cutting them. As a combination of the need for early and late summer ground and changes in harvesting technology, pine-lichen sites are becoming more desirable for forestry activities.

The primary silviculture system for lodgepole pine forests in BC is clearcutting. Stand re-establishment activities generally consist of raw planting or some form of scarifying to promote natural regeneration. The type of regeneration method is believed to impact the spacing of trees which can be an important factor relating to the succession of terrestrial lichen communities. Planting can result in uniform rows of trees that develop relatively large crowns. The shaded conditions found in the planted stands could favour the establishment of mosses and forbs that would then out-compete lichens.

The disturbance created by forestry activities is another issue that must be addressed. The current general trend for forestry activities is to conduct harvesting on a snow pack to minimise the disturbance to lichen. This reduces licensee's flexibility in timing activities for these sites and takes away one of the primary benefits associated with harvesting them.

Two harvesting systems are used within the study area. Whole tree harvesting systems are used in both Mackenzie and Vanderhoof, and cut-to-length systems are used only in Mackenzie. Differences between these systems that are relevant to this study are:

1. Whole tree systems process trees at a landing or roadside. Cut-to-length systems process trees in the harvest setting at the stump where the tree was cut. Processing in the setting results in higher accumulations of organic debris spread over the site, which can potentially impact lichen communities.
2. Cut-to-length systems use a forwarder to move logs off of the harvesting setting. Whole tree systems utilise a skidder. Skidding trees (without a snow pack) has the potential to create a greater level of disturbance to the lichen mat than the cut-to-length system.

Within the Vanderhoof portion of this study mountain pine bark beetle (*Dendroctonus ponderosae*) pose a serious concern towards the status of all pine stands in the Laidman Lake RMZ. Management of the beetle epidemic currently takes precedent over the management of all other resources. Beetle management activities employed within caribou areas have an emphasis on brood removal only. The Vanderhoof District Beetle Management Strategy is attached as Appendix 2 and provides greater detail on direction of forest management activities as they pertain to the beetle epidemic.

INTEGRATING FORESTRY AND LICHEN MANAGEMENT

The integration of forestry and lichen management paradigms can result several management approaches. Two contrasting approaches are *maintenance* and *recruitment*. Maintenance is the process where pre-harvest lichen communities are kept intact through harvesting and site preparation treatments so that they provide a consistent, or increasing source of forage for caribou in young (<20 years old) stands. Recruitment, on the other hand, aims to create disturbance results that are the same as a wildfire, in effect mimicking the natural succession process.

Activities conducted under this project will focus on applying the maintenance approach. Information from retrospective studies identifies lichen communities that have developed as soon as 15 years after harvesting contain a similar abundance and composition of species found naturally 70-years after a wildfire. Implementing the recruitment approach requires that fire be used as a tool to create the desired conditions. The liability associated with fire is high, thus, it would not likely be considered a regular tool for managing pine-lichen woodlands. As a result, it has been excluded from the proposed treatment regimes identified for this project.

PROJECT DEVELOPMENT

The development of this project has occurred from multiple planning initiatives converging on a common goal. Within both the Mackenzie and Vanderhoof Forest Districts the associated Land and Resource Management Plans (LRMP) have identified concerns around managing caribou resources. The LRMP's were useful for recognising the social concerns with this issue, as well as identifying information gaps in the biological and technical information required for decision making.

Extending from the LRMP process, subsequent initiatives have undertaken the task of addressing northern caribou issues. In Mackenzie the establishment of the Biologist's Technical Committee for Caribou Management has proceeded with initiatives to collect information on caribou resources. Likewise, in Vanderhoof the Innovative Forestry Practices Agreement technical and strategic committees and the public advisory group have all recognised the necessity to proceed with the synthesis of a caribou strategy and the resultant requirement for more information.

In 2000 the development of a caribou model proceeded under the Omineca Northern Caribou Project. This model is an adaptive management process that incorporates information on the habitat and population dynamics of caribou herds in the Mackenzie Forest District. As a component of the habitat evaluation, it determines the relative value, for caribou, of forest polygons that support terrestrial lichen communities. The model is made with the best available information. However, it is recognised that ongoing evaluations of the successes and failures of it be fed back into the process to continually update decision parameters. This project provides an avenue to test the mechanisms identified within the model.

In January 2000, a workshop was held in Prince George to get input on project parameters for the portion of this project in the Mackenzie Forest District. In March of 2000 a second workshop was held for project participants in the Vanderhoof Forest District. Information from both of these workshops forms the foundation for this AMP.

SECTION 2: PROJECT OUTLINE

PROBLEM STATEMENT

The goal of this project is to produce a tool to assist in the management of forestry and caribou resources. The tool will incorporate information from a variety of different silviculture treatments and their effects on lichen development. There are few examples available that provide guidance for the integration of these resources. This project will serve as a benchmark for future management endeavours.

SCOPE

Activities of this project will focus exclusively within ecosystems that are suitable for supporting terrestrial lichen communities. In general this means the 02, and in some instances the 03 site series within the biogeoclimatic zones encountered by the broad geographic extent that is being assessed.

The geographic extent of the project is the portion of the Prince George Forest Region that is west of the Rocky Mountains. Project activities will specifically target the southern two-thirds of the Mackenzie Forest District and the southwest quarter of the Vanderhoof Forest District.

The time scale of this project is categorised into short-term and long-term events. The short-term component involves monitoring indicators for the first 30-year period after harvesting. Some of these indicators, such as, changes in the forest floor vegetation community and costs associated with treatments will be evident within the first five years of the project start. The long-term time frame involves changes of the vegetation community, or specifically lichens response to changes in the forest overstorey and the growing medium. Long-term changes are evident from 30 years after harvesting to 140 years.

OBJECTIVES

MANAGEMENT OBJECTIVES

- To create conditions suitable for promoting reindeer lichen earlier than what is found on sites that have been disturbed by wildfire.

- To harvest using silviculture systems that create conditions suitable to perpetuate reindeer lichens so they are usable for foraging opportunities by caribou.
- To validate parameters and test the robustness of the PLWR sub-model of the Mackenzie Caribou model.
- To create managed stands for the purpose of demonstrating how forestry activities can be integrated with caribou resource values.

LEARNING OBJECTIVES

- To improve the understanding of lichen ecology and the associated interactions with different levels of artificial disturbance.
- To create a knowledge base for future reference and management decisions.
- To collect information that can be used as a feedback mechanism for the PLWR sub-model of the Mackenzie caribou model.

KEY UNCERTAINTIES

Uncertainties are issues that are recognised, but that fall outside the scope of the study, or are factors that can not be controlled. The main uncertainties associated with this project are:

- There are many possible treatment regimes that can be explored. Within a workshop held to collect information and ideas for this project, the working group established a matrix with over 400 possible options to test for. Time and cost restrictions result in the selection of a small subset of regimes to test, thus, we have focused on a matrix that evaluates what are considered to be the best and the worst treatment regimes for terrestrial lichens.
- The response of vegetation communities can be slow. Our initial focus is to quantify short-term responses. We recognise the importance of assessments over a longer time frame, however, multi-year funding has not been guaranteed for this project.
- Mature forests are susceptible to many damaging agents. Bark beetle and wildfire are two agents that are relatively common and can impact project installations. Risk factors will be assessed prior to establishing sites.
- Licensees involved with this project have standard operating procedures and commitments to local contractors. These items can be coupled to result in further constraints. For example requirements for milling activities set standards for harvesting and processing of logs. In turn, contractors have the equipment to meet the defined needs. This results in limitations of treatments that can be applied on an operational basis. In turn, treatment regimes have been designed to be sympathetic of operational constraints.
- The pine stands in the Laidman Lake RMZ are currently threatened by a mountain pine bark beetle outbreak. The design of this project is sensitive to treatments that must be undertaken to control this epidemic. Areas being harvested to address beetle populations will be assessed to determine if they have suitable characteristics to be incorporated into this study.

- This project is focusing on techniques that promote the maintenance of reindeer lichens (as opposed to a recruitment strategy). There is no body of literature that identifies a long-term forecast on the development of lichen communities that have not been established from a wildfire event. The assumption applied to this project is that reindeer lichen communities established after harvesting will provide suitable levels of forage for much of the rotation of a stand.

PROJECT DESIGN

STUDY AREA

The geographic area proposed for this project is west of the Rocky Mountains in the Prince George Forest Region. Specifically, project installations will be established in the Laidman Resource Management Zone (RMZ) in the Vanderhoof Forest District and the Blackwater, Klawli, Misinchinka and Buffalohead RMZ's in the Mackenzie Forest District (Figure 1). Site information for each study area is presented in Table 1.

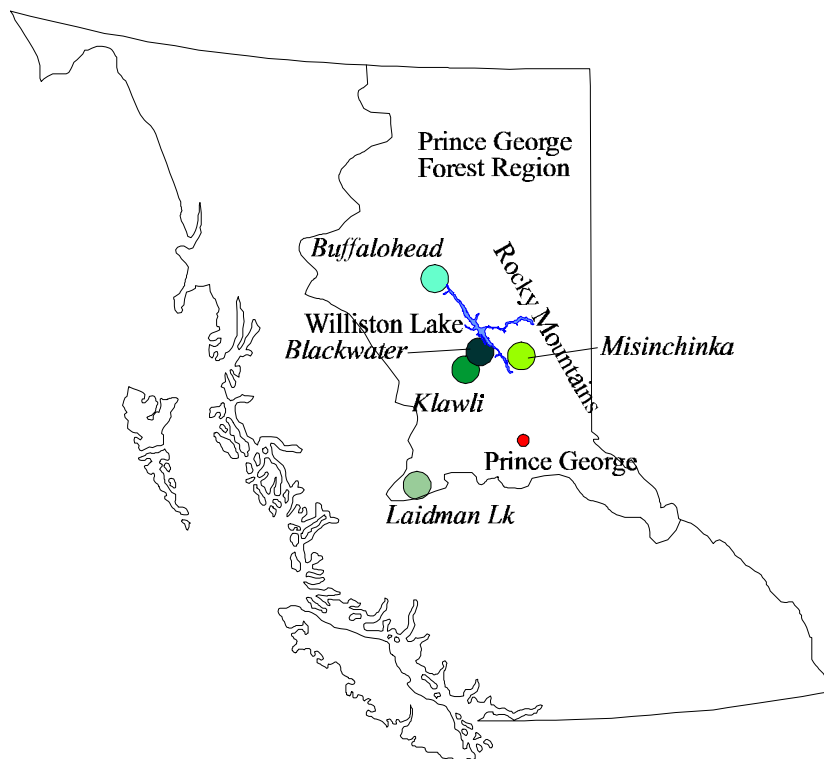


Figure 1. Overview map of the project area.

Table 1: Detailed site information

RMZ	Forest District	Site	UTM (Zone 10)		BEC Zone
			Northing	Easting	
Blackwater	Mackenzie	98-Mile	6150200	473270	SBS mk2
Klawli	Mackenzie	Klawli	6149000	396400	ESSF mv3
Buffalohead	Mackenzie	Tsay Keh			SBS mk2
??	Mackenzie	Mac 4			SBS
Laidman	Vanderhoof	Vhoof 1			
Laidman	Vanderhoof	Vhoof 2			
Laidman	Vanderhoof	Vhoof 3			

The study will utilise a randomised incomplete block sampling design, which will involve establishing four sites in the Mackenzie Forest District and three in the Vanderhoof District. In Mackenzie, three sites will be treated by Slocan – Mackenzie Operations and one by Abitibi Consolidated. At each of the sites treated by Slocan – Mackenzie Operations six treatment regimes will be established. A summary of the treatment regimes is listed in Table 2. The site treated by Abitibi Consolidated will be tested for eight treatment regimes. Within the Vanderhoof Forest District, Slocan – Plateau Operations will treat three sites. On each of these sites, five treatment regimes will be established. A matrix expressing relationship of treatments both within and between the Mackenzie and Vanderhoof study areas is presented in Table 3.

The sampling design has been developed to collect key information on terrestrial lichen ecology. Mechanisms assessed include the relevance of different levels of soil disturbance to lichen development, the significance of organic biomass accumulation, and the importance of light penetration through young developing stands. Plot combinations that will be used to assess the three mechanisms are summarised in Table 4.

SUMMARY OF THE ECOLOGICAL ZONATIONS ENCOUNTERED THROUGH THE STUDY AREA.

Mackenzie Forest District: This portion of the study falls within the Sub-Boreal Interior (Sbi) ecoprovince. The ecosections encountered in this portion of the study are the Babine Uplands, Manson Plateau, McGregor Plateau, Nechako Uplands and the Parsnip Trench. Five biogeoclimatic zones are encountered through the Mackenzie portion of the study. These are the Williston moist, cool subzone (mk2) the Mossvail moist cool subzone (mk1), the Willow wet cool subzone (wk1) and the Finlay-Peace wet cool subzone (wk2) of the Sub-Boreal Spruce zone (SBS xx) and the Omineca moist, very cold sub-zone of the Englemann Spruce Sub-Alpine Fir zone (ESSF mv3).

Vanderhoof Forest District: This portion of the study falls within the Nazko Upland ecosection of the Central Interior (Cei) ecoprovince. The four biogeoclimatic zones encountered through this portion of the study area are: the moist cold subzone of the Sub-Boreal Pine-Spruce zone (SBPSmc), the Babine moist cold and Kluskus moist cold

subzones of the Sub-Boreal Spruce zone (SBSmc2 and SBSmc3), and the Nechako moist very cold subzone of the Engelmann Spruce-Subalpine Fir zone (ESSFmv1).

Table 2. Treatment regimes to be applied at each site

Treatment Regime	Predicted Conditions for Lichen ¹	Harvesting Method	Harvesting Season	Site Preparation	Regen Method	Netica Trends ²		
						H ³	M	L
1	Best	Whole tree	Winter	None	Natural	26.5	30.0	43.5
2	Good	Cut to Length	Winter	None	Natural	22.4	27.3	50.3
3	Moderate	Cut to Length	Summer	None	Natural	19.1	26.2	50.3
4	Moderate	Cut to Length	Summer	None	Plant	18.7	26.2	54.7
5	Worst	Cut to Length	Summer	Drag Scarify	Natural	9.02	23.1	67.9
6	Good	Whole Tree	Summer	None	Natural	21.2	27.9	50.9
7	Moderate	Whole Tree	Summer	None	Plant	20.8	27.7	51.5
8	Worst	Whole Tree	Summer	Drag Scarify	Natural	12.2	23.8	64.0
9	Worst	Whole Tree	Summer	Drag Scarify	Plant	12.5	24.3	63.2

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

² These values (taken from Box D: terrestrial Lichen abundance of the model in Appendix 1) are interim and will be revised as the Netica Model is updated

³ H=high, M=medium, L=low

Table 3. Treatments to be undertaken at each site.

Treatment Regime	Slocan – Mackenzie Operations			Abitibi	Slocan – Plateau Operations		
	98 Mile	Klawli	Tsay Keh	Mac 4	Vhoof 1	Vhoof 2	Vhoof 3
1	X	X	X	X	X	X	X
2	X	X	X	X			
3	X	X	X	X			
4	X	X	X	X			
5	X	X	X	X			
6	X	X	X	X	X	X	X
7				X	X	X	X
8				X	X	X	X
9					X	X	X

Table 4. Pairwise comparisons developed to assess the three chosen disturbance mechanisms.

Mechanism	Pairwise comparison listed by treatment
Mineral soil and forest floor disturbance	1 vs. 2, 3 vs. 6, 4 vs. 7, 5 vs. 8
Build-up of organic biomass	1 vs. 6, 2 vs. 3, 3 vs. 5, 6 vs. 8
Alterations of light intensity at the forest floor	3 vs. 4, 6 vs. 7, 8 vs. 9

INDICATORS AND STANDARDS

Forest harvesting modifies the environment and microclimate at the forest floor. These changes influence which species are dominant in the vegetation community. To determine the influence of harvesting practices, changes in the composition and the abundance of species in the vegetation community and the level of disturbance to the forest floor will be monitored. Particular attention will be given to the terrestrial lichen and feather moss communities.

Forecasts of expected trends have been modelled with Netica (Table 3). These trends, in conjunction with information from the retrospective study are used to provide the potential scenario results for each treatment regime, and are presented in the following sections. A detailed forecast for the 98-Mile site is also provided. As more thorough information is collected for each of the study areas, detailed forecasts will be derived and attached to this document.

The difficulty with applying information from the retrospective study to create defined forecasts of lichen abundance lies in the uncertainties associated with that study. Two specific uncertainties are not knowing the stand condition prior to harvesting and working with unreliable history information on the older blocks. Not knowing the preharvest stand condition creates difficulties in extrapolating trends that should be evident in the early years of this study. For example the 98-Mile site proposed for treatment has a poor abundance of terrestrial lichens at present. Following the trends of the retrospective study, this cover should increase. If however, the preharvest conditions of sites we are modelling had very dense lichen at the time they were harvested, the proposed trend may be misleading. Accordingly, this uncertainty is an impetus for the establishment of this project.

Costs associated with implementing alternative forestry strategies are also important and will be assessed throughout the project. Costing assessments will focus on three main areas. These are administration, harvesting/engineering, and silviculture.

TREATMENTS/MANAGEMENT ACTIONS

The management actions or forestry practices to be applied under this AMP will create conditions that provide the most desirable, and the least desirable environments for maintaining and promoting reindeer lichen growth. We hypothesise that the most desirable conditions are created by minimising both the amount of debris that is accumulated on the forest floor and the amount of disturbance that occurs to it, and by maintaining an open or poorly developed forest overstorey. Mixing organic debris into the surface mineral soil horizons, and creating a dense closed canopy by contrast, will create the worst conditions.

FORECASTED OUTCOMES

On areas where the *best* conditions for lichens are created, we expect there will be little decline of reindeer lichen cover in the short term. As the stand reaches 15-years after harvesting, lichen cover will increase to 20 - 40 percent cover. Moss that is present will suffer from overexposure, thus, a reduction of feather moss cover within the first years after the harvesting treatment should occur. A corresponding increase in the amount of desiccated vegetation matter will be evident in the first few years after harvesting.

On areas that *good* conditions are created, lichen response should be similar to the development in the *best* regime, however, declines in both the short- and long-term outlooks may be evident. For example it is possible that disturbance and slash accumulations from the treatment will negate the benefits of creating favourable habitats for lichen growth. Thus the cover of lichen in the first years after harvesting may be in the range of 10 to 40 percent cover depending on the state of the stand prior to a disturbance. The lichen cover would subsequently increase to levels similar to those found on the *best* condition sites. Trends encountered with feather moss and desiccated vegetation matter should be consistent with those of sites managed under the *best* treatment regime.

Treatment regimes considered to create *moderate* conditions are associated with management actions that involve planting. We hypothesise that areas planted will eventually contain forest stands with trees that have uniform, well-developed crowns. This crown structure will not be conducive for the maintenance of terrestrial lichen communities, rather, it will be more suitable for mosses and forbs. Impacts to the vegetation community resulting from the development of the crowns, however, will not be evident within the first ten-years after the harvesting treatment.

Disturbing and mixing the forest floor is expected to have the most significant impacts on the development of terrestrial lichens. Areas where the *worst* conditions are established are expected to experience a reduction in the cover of terrestrial lichens and an increase in the cover of forbs. After five years, lichen cover under this treatment regime in most all situations would be expected to be below 10 percent of the site. The cover of forbs and shrubs will likely start below five percent cover at the time of disturbance but would gradually increase to above 10 - 15 percent cover as stands age beyond ten-years old.

An evaluation of the various treatment regimes, using the Netica model developed for the Omineca Northern Caribou Project produces consistent trends to those we expect to find with this project. Within Table 3 the conditional probabilities expressed at the *Terrestrial Lichen Abundance* node from the Netica PLWR sub-model (Appendix 1) are presented. The figures expressed are relative values and only represent trends that can be expected with the treatment regimes evaluated under this study. They do not provide a quantitative evaluation of lichen recovery expected from a treatment regime.

Site Specific Evaluations

Identifying specific trends for each site will be conducted on an ongoing basis. Currently, the 98-Mile site is the only one that we can hypothesise specific trends for. Trends considered are changes in lichen cover, moss cover, and the amount of desiccated vegetative material and are summarised in Table 5. The importance of the desiccated vegetation is it provides an unfavourable growing substrate for mosses and forbs to become established (Steijlen et al., 1994).

Table 5. Predicted trends for changes in the vegetation community for the 98-Mile site.

Predicted Condition For Lichen	Time from Disturbance (years)	Percent Cover ^{1, 2}		
		Terrestrial Lichens	Moss ³	Desiccated Vegetation
Best	0-5	10	3	40
	5-12	18	3	20
	12-30	45	6	10
Good	0-5	8	3	40
	5-12	14	3	20
	12-30	30	10	10
Moderate	0-5	8	3	40
	5-12	8	8	10
	12-30	15	20	5
Worst	0-5	2	3	5
	5-12	2	10	3
	12-30	5	30	0

¹ Values presented are estimates based on maximum, minimum and mean values evaluated during the retrospective study for both the reconnaissance, and detailed site evaluations.

² The significant characteristic that must be considered for each site is the existing state of the lichen community prior to treatment. The 98-Mile site has a relatively low cover of terrestrial lichens, estimated to be less than 10 percent cover and a high cover of feather moss, currently estimated at greater than 50 percent cover.

³ Includes both acrocarpous and pleurocarpous mosses

EXPERIMENTAL/MONITORING DESIGN

Sampling at each site will monitor changes of the vegetation complex, in particular changes to the forest floor vegetation, and the tree layer. In the summer of 2001 pre-harvest conditions will be evaluated on the first units scheduled for treatment activities. This data will form the baseline from which changes are measured.

A detailed monitoring plan for each study site will be established. The general approach will be to monitor in the first full summer after treatments are completed and then for the next two subsequent summers. Additional monitoring will be conducted in years five and seven after the completion of treatments.

The cost of modifying forestry practices will also be assessed. This will involve evaluating costs associated with administration and conducting treatments for all project phases.

Vegetation

Assessing changes in the forest floor vegetation complex may provide some of the greatest challenges in this study. Lichens are slow growing and could have both a gradual and subtle response for the first years after site treatments. Designing a sampling strategy that is sympathetic to the potentially slow response is a primary objective, when deciding which techniques will be used.

Several measures will be used to evaluate the response of the ground cover vegetation. Ocular estimates and photo image analysis will provide an assessment of the percent cover and distribution of the forest floor vegetation community. The thickness of the forest floor vegetation and health, or vigour classes, will be used to document the overall condition of the ground vegetation. In addition, the area of non-vegetative functional groups, such as leaf litter and mineral soil will be determined.

Within each treatment regime a 300-metre long transect containing 42 0.5-metre squared quadrats will be established. The transect line will be divided into three equal sections with 14 quadrats being located in each section. Transect ends and quadrat locations will be permanently marked and the co-ordinates recorded using a geographic positioning system (GPS). Ocular estimates of species will be done at each quadrat. Photographs will be taken of each quadrat for an image analysis procedure.

At present, we are looking at different options for developing the image analysis process. Available procedures involve digitising scanned photographs and tabulating an area associated with the desired functional groups using a software package. Two packages that should be suitable for this project are Scion Image and SigmaScan Pro 5.

Tree Regeneration

The spacing, distribution, density and health of a regenerated stand are important factors that impact the development of terrestrial lichen mats. Pre treatment assessments will be conducted along a transect line at 50-metre intervals. At 0+50 metres from the point of commencement (and every 50-metres there after) a fixed radius plot will be established. Standard forest mensuration and silviculture survey procedures will be used to identify pre- and post-treatment features of the stand (Husch et al., 1982; Silviculture Surveyors Guidebook, 1995).

Forest Ground Cover Disturbance

Mixing surface organics into the mineral soil is hypothesised to have a detrimental effect on the success of terrestrial lichens. Disturbance to the soil and the surface ground cover

will be assessed utilising procedures outlined in the Soil Conservation Surveys Guidebook (1997). Slight modifications will be made to the procedure to permit the evaluation of light and heavy mixing of surface organics into the mineral soil. These surveys will be conducted in the first full summer after harvesting is completed.

Down Woody Debris Accumulation

The accumulation of slash can impact the structure of the lichen community in a number of ways. In the short-term, covering the lichen mat with debris results in die back of the lichens, which reduces the overall abundance. Accumulations of large debris can also have a long-term effect on lichen supply. Debris can influence nutrient cycling creating more favourable conditions for vegetation growth other than lichens. As organic debris decays, it provides a favourable habitat for feather moss (Crites & Dale, 1998). Procedures used to evaluate down woody debris will follow those outlined in the “Field Manual for Describing Terrestrial Ecosystems” (1998).

Cost of Operations

The cost of forestry operations will be monitored through all phases of this project. Costs will be separated into three categories: administration, harvesting/engineering, and silviculture.

Timing of Activities

Flexibility in scheduling activities is an important forestry management tool. However, the timing of disturbance activities has also been considered an important factor related to the success of terrestrial lichens after harvesting. Activities conducted in the winter on a snow pack are believed to have the least impact on disturbance to lichen mats. The snow minimises the disturbance to them, potentially resulting in greater retention of lichens from the pre-harvest conditions. For this project, treatment regimes incorporating both summer and winter harvesting operations will be assessed.

IMPLEMENTATION

The implementation of core project components is outlined in Table 6. A more detailed list of activities for 2001 is outlined in Table 7. The target activities for the 2001 field season are to evaluate the general lichen ecology in the Laidman Lake RMZ and to conduct pre-treatment assessments at one site in the Laidman Lake RMZ and at the 98-mile site in Mackenzie. Activities for the 98-mile site are outlined in the sample plan presented in Figure 2.

Table 6. Implementation schedule.

Activity	Timing	Responsibilities
Designation of study areas	Spring 2001	Slocan Forest Products Mackenzie and Plateau Operations Abitibi Consolidated L&M Lumber Forest Floor Contracting
Establishment of pre-treatment field plots	Summer 2001- 2002	Forest Floor Contracting
Application of treatment regimes - forest harvesting	Winter/summer 2001-2004	Slocan Forest Products Mackenzie and Plateau Operations Abitibi Consolidated L&M Lumber
Application of treatment regimes - Site Preparation and Planting	Spring/Summer 2002-2005	Slocan Forest Products Mackenzie and Plateau Operations Abitibi Consolidated L&M Lumber
Monitoring of plots	Summer 2002 – ongoing	Forest Floor Contracting

Table 7. 2001 fiscal year activity schedule

Phase	Activity	Time period (2001 fiscal year)											
		A	M	J	J	A	S	O	N	D	J	F	M
1	Approval of AMP		■										
2	Laidman Lk. RMZ lichen assessment ¹			■	■	■							
3	Establish Study Protocol at 98-Mile site			■									
4	Conduct pre-treatment assessments and other fieldwork at 98-Mile site				■	■	■						
5	Conduct pre-treatment assessments and other fieldwork at Vhoof 1 site					■	■	■					
6	Field reconnaissance of Klawli, Tsay Keh and Kennedy Siding sites				■	■	■						
7	Summarise 2001 field season							■	■	■	■	■	■
8	Communication plan	■	■	■	■	■	■	■	■	■	■	■	■

¹ This is a sub-project established by the Vanderhoof IFPA (Assessment of terrestrial lichen development in relation to ecological classification, forest cover, and time in the Laidman Lake RMZ of the Vanderhoof Forest District) that will produce results directly applicable to this AMP. The project proposal is attached in Appendix 3.

EVALUATION

In the first year of the project, data will be summarised and compared between sites to assess for variations based on site factors. The first year's data will be the baseline information from which changes will be measured.

The results from subsequent years will be tallied by treatment regime at each site and then compared between the different sites. Analysis will be done using factorial ANOVA. The evaluation of cost associated with the different forest management regime will also be assessed in a similar manner.

ADJUSTMENTS

Current strategies for terrestrial lichen management tend to focus on approaches of preserving the lichen community by minimising disturbances from industrial activities. Research regarding succession of these types indicates this approach may be detrimental to the long-term success of them. This project will provide information on whether forestry activities can be used as a disturbance mechanism to replace wildfire in these ecosystems.

Within the Vanderhoof Forest District, information will be used to set parameters identified in the District Caribou Management Strategy. In Mackenzie, information will be used to update parameters in a landscape level modelling tool being prepared under the Omineca Northern Caribou Project. Part of this model contains predictions regarding the structure of lichen communities under various disturbance regimes. This project will fill in gaps regarding the impacts of harvesting activities on terrestrial lichen development.

An emphasis of the caribou model is to provide a tool that can be used to adjust forest management policies. It also provides an avenue to apply new information, such as the information collected through this adaptive management process, and transfer the concepts to other areas of the province. In addition, the model process provides a feedback mechanism whereby results that we forecast will be regularly monitored and forestry treatments modified to reflect discrepancies.

The nine strategies identified for this project represent conditions that we hypothesise will be both good and bad for terrestrial lichen communities. Results of the treatments will help guide operational decisions made on pine lichen woodlands that are beyond the geographic scope of this study.

SECTION 3: LOGISTICS

PROJECT PARTICIPANTS

Proponents

Slocan Forest Products – Mackenzie Operations	Scott McNay Randy Hart Lars Hulstein Dan Szekely Eric Olson
Slocan Forest Products – Plateau Operations	Darryl Bokvist Dean Marshall
Abitibi Consolidated	Christy Butt Doug McComb
L&M Lumber	Susanne McElroy
Vanderhoof IFPA	Bill LaForge Ray Reilly
BC Ministry of Forests Forest Practices Branch Wildlife and Range Program Research Branch Prince George Forest Region Mackenzie Forest District Vanderhoof Forest District	Brian Nyberg Evelyn Hamilton Peter Ott Dale Seip Less Herring Jim Ladd Julie MacDougall Cathy Middleton Traci Leys-Schirok
BC Ministry of Environment, Lands and Parks	Bill Arthur Dave McAllister Jim Tuck
Forest Floor Contracting	Randy Sulyma

RESPONSIBILITIES

- | | |
|--|--|
| 1. Problem Assessment | Brian Nyberg, Scott McNay, Randy Sulyma |
| 2. Project Design | Brian Nyberg, Scott McNay, Randy Sulyma, Lars Hulstein, Evelyn Hamilton, Peter Ott, Dale Siep, Christy Butt, Darryl Bokvist, Doug McComb |
| <ul style="list-style-type: none"> • Study location | Lars Hulstein, Doug McComb, Christy Butt, Scott McNay, Randy Sulyma, Darryl Bokvist, Susanne McElroy |
| <ul style="list-style-type: none"> • Indicators and standards | Randy Sulyma, Evelyn Hamilton, Scott McNay, Brian Nyberg, Dale Seip |
| <ul style="list-style-type: none"> • Treatments/management actions | Lars Hulstein, Scott McNay, Randy Sulyma, Christy Butt, Doug McComb, Darryl Bokvist, Susanne McElroy |
| <ul style="list-style-type: none"> • Forecasted outcomes | Randy Sulyma, Brian Nyberg, Scott McNay |
| <ul style="list-style-type: none"> • Experimental/monitoring design | Brian Nyberg, Evelyn Hamilton, Peter Ott, Randy Sulyma |
| 3. Implementation | Lars Hulstein, Doug McComb, Darryl Bokvist, Susanne McElroy, Randy Sulyma |
| 4. Evaluation | Randy Sulyma, Evelyn Hamilton, Peter Ott, Brian Nyberg |
| 5. Adjustment | Brian Nyberg, Scott McNay, Randy Sulyma |

Budget

Work Phase	Person Days		Crew Days		Projected Costs: Person Day = \$520/day, Crew Day = \$870/day		Total
	Mack	V'hoof	Mack	V'hoof	Mackenzie	Vanderhoof	
Year - 2001							
Approval of AMP	13	5			6760.00	2600.00	9360.00
Establishment of field sampling protocol	10		5		9550		9550.00
Laidman Lichen ecology project and assessment		40		22		39940.00	39940.00
Pre-treatment assessments							
98-mile Mackenzie			20		17400.00		17400.00
Site 1 Vanderhoof				20		17400.00	17400.00
Field reconnaissance of proposed project sites							
Mackenzie 3 sites			10		8700.00		8700.00
Vanderhoof 3 sites				20		17400.00	17400.00
Summary of pre-treatment assessments							
Mackenzie	10		10		13900.00		13900.00
Vanderhoof		10		10		13900.00	13900.00
Communications	10	10			5200.00	5200.00	10400.00
Treatment implementation	10	10			5200.00	5200.00	10400.00
Annual Total					66710.00	101640.00	168350.00
Year - 2002							
Pre-treatment assessments							
Sites 2, 3 and 4 Mackenzie	5		60		54800.00		54800.00
Sites 2 and 3 Vanderhoof		5		40		37400.00	37400.00
Monitoring plots							
98-mile Mackenzie			10		8700.00		8700.00
Site 1 Vanderhoof				10		8700.00	8700.00
Field reconnaissance of proposed project sites							
Mackenzie (1-2)			10		8700.00		8700.00
Summary of pre-treatment assessments and monitoring activities	15	15	15	15	20850.00	20850.00	41700.00
Communications	10	10			5200.00	5200.00	10400.00
Treatment Implementation	30	25			15600.00	13000.00	28600.00
Annual Total					113850.00	85150.00	199000.00
Year - 2003							
Monitoring plots							
4 Sites Mackenzie	5		40		37400.00		37400.00
3 Sites Vanderhoof		5		30		28700.00	28700.00
Summary of monitoring activities	20	20	15	15	23450.00	23450.00	46900.00
Communications	7	7			3640.00	3640.00	7280.00
Annual Total					64490.00	55790.00	120280.00

Year - 2004								
Monitoring plots								
	3 Sites Mackenzie	10		40		40000.00		40000.00
	2 Sites Vanderhoof		10		30		31300.00	31300.00
Summary of monitoring activities		15	15	15	15	20850.00	20850.00	41700.00
Communications		3	3			1560.00	1560.00	3120.00
	Annual Total					62410.00	53710.00	116120.00
Year - 2005								
Year - 2006								
Monitoring plots								
	98 mile mackenzie	5		15		15650.00		15650.00
	1 site Vanderhoof		5		15		15650.00	15650.00
Summary of trends		20	20			10400.00	10400.00	20800.00
	Annual Total					26050.00	26050.00	52100.00
Year - 2007								
Monitoring Plots								
	3 sites in Mackenzie	15		40		42600.00		42600.00
	2 sites in Vanderhoof		10		30		31300.00	31300.00
Final Report		25	25	10	10	21700.00	21700.00	43400.00
Communications		10	10			5200.00	5200.00	10400.00
	Annual Total					69500.00	58200.00	127700.00

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Appendix 1

Netica Pine Lichen Winter Range Sub-Model from the Omineca Northern Caribou project.

The Pine Lichen Winter Range Model uses four core elements to determine the value of pine-lichen woodlands for northern caribou and has a final value expressed as a *Resource Selection Function* (RSF). The RSF for the lichen model is a relative probability of the presence of caribou in a given area, as compared to the same area under optimal conditions. For example, an optimal pine lichen winter range site would have the ecological characteristics to permit a high biomass of terrestrial lichens to grow, no hunting and no predation on caribou. The factors associated with optimal conditions are expressed as four distinct elements within the model. These are, lichen habitat capability, stand overstorey characteristics, forest floor characteristics, and the utility of the stand for caribou use. Each element is further subdivided into its core components within the Netica model.

Lichen habitat capability is an assessment that evaluates the ecological factors of a polygon to determine the capability of it for supporting a terrestrial lichen community. Throughout British Columbia a functional group of terrestrial lichens, often referred to as reindeer lichens, are commonly found on xeric, nutrient poor soils that have a forest overstorey dominated by lodgepole pine (Johnson, 1981; Rowe, 1984). Within the model these characteristics are captured by extrapolating information from TRIM, TEM and forest cover data sources. TRIM information is used to identify sites that have a flat or southerly aspect. These sites are expected to be the driest on the landscape. A classification of TEM information, done by a working group team, was completed to identify the ecological associations of all biogeoclimatic zones found within the model area that are most likely to support terrestrial lichen communities. The basis of the classification was on identifying the location of a site series on the edaphic grid for a subzone and coding it as either a dry-nutrient poor site series or others. Forest cover information is used to delineate pine sites from others. The limit for differentiating between pine leading and not pine has been set at a minimum contribution of 90 percent.

Stand characteristics captured in the model are stand age and density. The age class breakdown is based on the developmental phases of lichen woodlands. (Carroll & Bliss, 1982; Coxson et al., 1999; Maikawa & Kershaw, 1976; Thomas & Alaie, 1996). The density of trees, or stocking, has been included as a stand characteristic variable because it has the potential to modify reindeer lichen presence in young stands. On sites suitable for reindeer lichens, harvesting can create environment that fosters the development of terrestrial lichen communities (Harris, 1996). However, if a replacement stand grows in at a very high density, the shading and high levels of litterfall from it may be counterproductive for lichen development. Thus, it is believed that stands managed to restrict full crown closure, or in other words stands with a lower density, will promote lichen growth over stands with a very high density.

Forest floor characteristics is an element of the model that provides an assessment of the suitability of a site for lichen development in disturbed areas. The outlook for suitability is a long-term view and may not be realised from one rotation to the next, however, changes would be noticed when assessed over several stand rotations. The success of lichen is inversely related to the productivity of the site for higher plants and mosses. Enriching the soil with organic matter will eventually have a detrimental impact towards lichen production.

Wildfires are an important component of pine-lichen ecosystems (Klein, 1982). They provide the only sure means of creating pine lichen woodlands suitable for caribou use when stands reach an age class of 70 to 140 years of age. Wildfires reduce the accumulations of organic debris without creating alternative microsites suitable for the establishments of higher plants. Mechanical treatments, on the other hand, create a range of conditions. These vary from leaving organic mats intact to mixing them in with the mineral soil substrate. The short-term impacts from activities are not well understood. Most research focuses on how activities impact the current abundance of terrestrial lichens (Harris, 1996; Kranrod, 1996), not on the impacts of the activities towards the suitability of the site for lichen growth. Mechanical disturbances generally have a negative effect on the presence of lichen (Harris, 1996). Thus, microsites disturbed the least have the fastest rate of reindeer lichen recovery compared to sites scarified to mineral soil. Conversely, microsites containing a build-up of organic matter both decrease in lichen abundance and increase in competing vegetation (Racey et al., 1996; Steijlen et al., 1994). This combination of treatment effects has the most detrimental impact on the growth of reindeer lichens at a site. Mixing organic accumulations with mineral soils also provides an improved growing medium for herbs to develop; this can inhibit lichen development but may only be realised over a long-term assessment.

Within the Netica model stand removal, site preparation technique and season of harvest are used to relate the state (removed, mixed, or undisturbed) of the forest floor in relation to the suitability for lichen development.

The integration of information from the lichen habitat capability node, the stand characteristics node and the forest floor characteristics node provide an estimate of the abundance of lichen that may be present within a polygon. This estimate can then be modified to represent the relative value that a polygon has for supporting caribou. In the model incorporating the fourth element, or the utility of pine lichen woodlands for caribou use, at two separate locations does this.

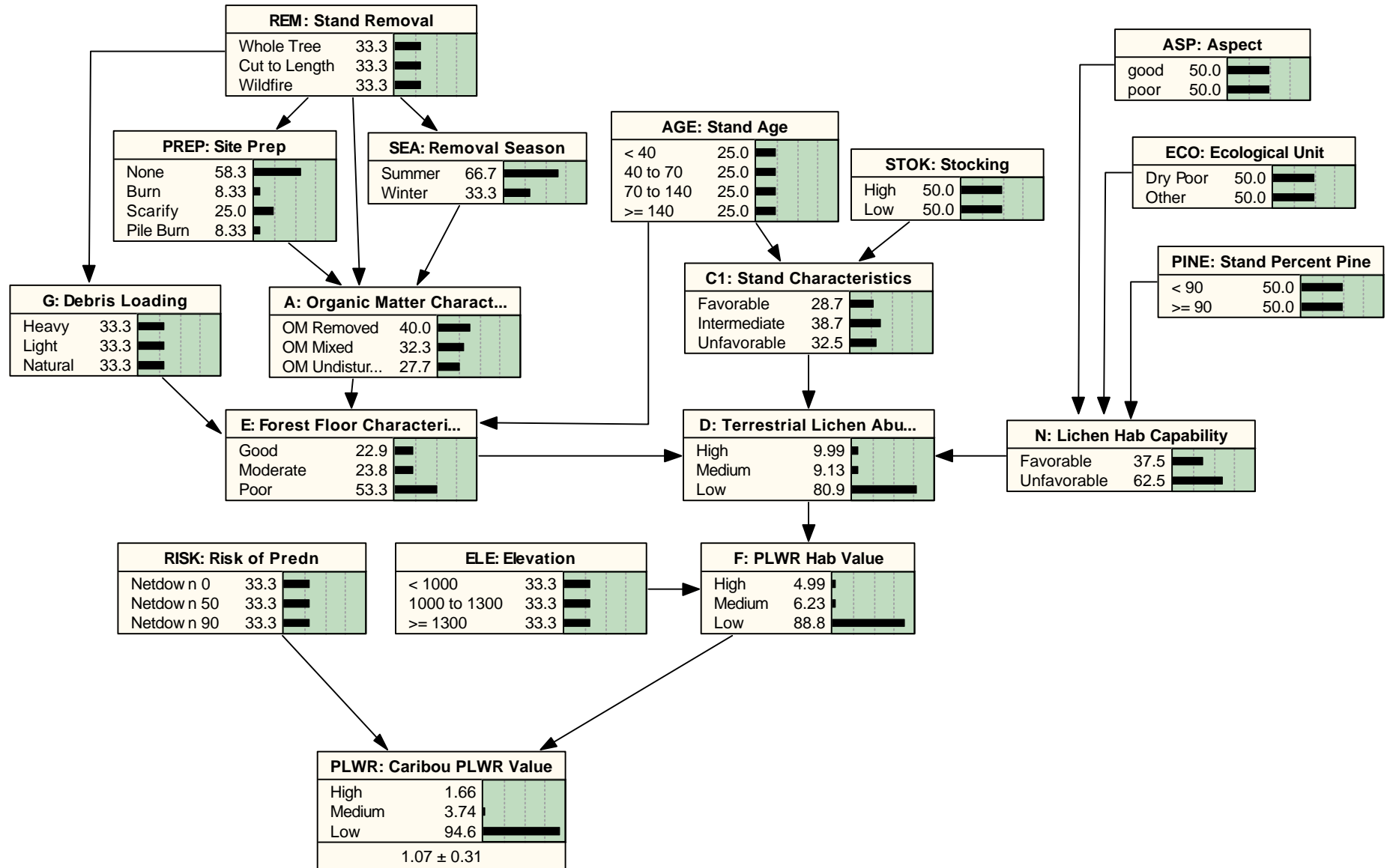
The utility function is expressed by two factors in the Netica model. These are the impacts of snow conditions and the risk of predation. In the model, snow conditions are represented through a range of elevation classes. Higher elevation sites are expected to have a greater accumulation of snow cover over the course of the winter. Snow conditions are an important factor in determining use of a site by caribou (Brown & Theberge, 1990). As snow depths exceed a metre in depth or as layers of ice accumulate through the snow profile the ability for caribou to crater is reduced. Likewise, the availability of lichen is decreased providing a negative influence on the RSF for a

polygon. The risk of predation is the final factor incorporated into the model. This node is the summary of another Netica sub-model and a GIS exercise and relates the relative likelihood of caribou being preyed upon to their overall success in an area; for instance, as the pressure of predation increases, the probability of caribou successfully existing decreases. Thus, there is a downward pressure on the RSF in areas with high predation.

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NOTE1: Complete PLWR Model - Forest Ecosystems



Appendix 2

<<Insert Vanderhoof District Beetle Strategy when available>>

Appendix 3

Project Name: **ASSESSMENT OF TERRESTRIAL LICHEN DEVELOPMENT IN RELATION TO ECOLOGICAL CLASSIFICATION, FOREST COVER AND TIME IN THE LAIDMAN AREA OF THE VANDERHOOF FOREST DISTRICT**

Project Leader: *RANDY SULYMA – Forest Floor Contracting Ltd.*

Project Status: New or Continuing

Project Location: **Laidman Lake Resource Management Zone of the Vanderhoof Forest District within the Prince George Timber Supply Area south of the Fawnie Mountain**

Project Overview

The project will assess the development of terrestrial lichen communities, an important forage of northern caribou. The development of the lichen community will be compared against the ecological classification and forest cover for varying aged stands. This information will provide:

1. a foundation for basing future caribou management decisions;
2. an understanding of the successional development of terrestrial lichens in the Laidman Lake area, and;
3. a validation or accuracy check of parameters used in modelling processes that deal with terrestrial lichen communities as a source of caribou range.

Trends noted from this information will be used to guide the development of objectives and strategies for:

1. the Vanderhoof District caribou strategy;
2. an adaptive management trial dealing with forest harvesting of pine-lichen woodlands, and;
3. for the potential implementation of a caribou model that is currently being developed in the Omineca Region of BC.

Project Objectives

To identify the trends associated with the development of terrestrial lichens (i.e. succession) from stand initiation to climax stand conditions. This information is important towards developing strategies for managing lichens as a source of forage in caribou winter ranges. Analysis will evaluate the succession of pine lichen types that will provide targets for an adaptive management forestry trial. In addition, the comparison between site factors evaluated in the field, to inventory bases (such as TEM/PEM, forest cover and habitat mapping) will be applied to verify reliability of GIS classification schemes that can be used in future habitat modelling processes.

Project Description

Terrestrial lichens belong to a classification of vegetation referred to as stress tolerators (Grime, 1977). This means they occupy a site because of the harsh conditions that are found there. Terrestrial lichen species of greatest importance to caribou are found in pine leading (>80%) forest stands on xeric, nutrient-poor sites (Johnson, 1981; Rowe, 1984; Stevenson, 1991) corresponding to the O2 associations in most Biogeoclimatic Zones in British Columbia (Medinger & Pojar, 1991). Succession on these sites occurs when the overstorey modifies the environment to create conditions that mosses and forbes can develop under.

Reindeer lichens (*Cladina* spp.) are most abundant during a range of forest ages from 80 to 140-years old (Carroll & Bliss, 1982; Coxson et al., 1999; Maikawa & Kershaw, 1976). Evidence suggests that the cooler and less ventilated conditions of forests greater than 150-years old result in microclimates with less severe drying events (Johnson, 1981; Lesica et al., 1990). In these conditions, feather mosses (e.g., *Pleurozium shreberi*) are able to establish, proliferate, and replace lichens as the dominant flora. The factors considered to be most important in causing this transition include reduced light penetration to the forest floor, an accumulation of organic matter, and decreased evapotranspiration.

Wildfires are the dominate natural disturbance of the ecosystems in which these forest types occur (DeLong, 1998). Microclimate conditions after a wildfire are too harsh (e.g., frequent and extreme drying events) for feather mosses to re-establish providing an opportunity for terrestrial lichens to thrive. In this way, wildfires “re-set” the natural succession of these sites that are dominated by *Cladonia* spp. initially and by *Cladina* spp. in mid-succession. The climax conditions that develop are dependent on a number of abiotic and biotic factors ranging from the conditions of the local climate to the development of the overstorey.

Current literature is varied on the climax conditions found in lichen woodlands across Canada. Three common phases are generally recognised (Carroll & Bliss, 1982; Johnson, 1981; Lesica et al., 1990; Maikawa & Kershaw, 1976; Morneau & Payette, 1988; Payette et al., 2000; Rowe, 1984). In eastern sub-arctic Canada a climax dominated by *Cladina stellaris* is evident. In western sub-arctic Canada *Stereoaocaulon* spp. is the lichen species most commonly associated with old sites. Right across Canada, some studies have found a complete shift in the lichen community to one dominated by feather moss (Carroll & Bliss, 1982; Maikawa & Kershaw, 1976; Payette et al., 2000). According to forest-growth models of Coxson *et al.* (Coxson et al., 1999), succession to a moss phase is evident in the Omineca region of British Columbia

Recognising the trend of succession is important for developing strategies for Northern Caribou. BC Environment has prepared a draft Caribou Management Strategy for the Laidman Lake Resource Management Zone in the southwestern portion of the Vanderhoof Forest District. The intent of this plan is to “ maintain quality caribou habitat and movement opportunities . . . this requires maintaining a variety of stand conditions,

with greatest emphasis on maintaining mature pine on terrestrial lichen sites.” The strategy promotes the exclusion of forest harvesting on sites that support terrestrial lichen communities. Applying the growth models of Coxson et al., under the proposed regime important areas of terrestrial lichen habitat could succeed to moss dominated ecological systems, reducing the area available for caribou to forage.

The proposed project will identify the succession process in the Laidman Lake RMZ. This RMZ falls within the Nazko Upland ecosection of the Central Interior (CeI) ecoprovince, thus, information collected will be relevant for a larger geographic extent than assessed under this study. It will be useful for development of lichen management strategies throughout much of the winter range area of the Tweedsmuir-Entiako caribou herd. Data collected will also support other decision tools, such as GIS queries using TEM information, or forest cover, to identify where lichen sites are located and the current developmental state of them. Finally this information can be used to validate modelling procedures such as the one currently being developed for the Omineca region by a project group that is lead by Slocan biologist Scott McNay. This model is currently in a beta phase of testing but has potential value to aid in the management of the Tweedsmuir-Entiako herd. The value is increased if data input layers are validated prior to it's application, which this project will do.

Predictions

Succession

The development of terrestrial lichen communities in lichen dominated woodlands is variable throughout their range. General patterns that have been documented contain three or four interim phases of succession (Brulisauer *et al.*, 1996; Carroll & Bliss, 1982; Johnson, 1981; Maikawa & Kershaw, 1976; Morneau & Payette, 1988; Payette *et al.*, 2000; Rowe, 1984; Thomas & Alaie, 1996). Common late-seral plant communities that have been identified are dominated by one of either *Stereocaulon spp.*, *Cladina spp.* or feather moss mats such as *Pleurozium schreberi*. In the Omineca region of north central British Columbia, Coxson et al. (1999) have identified a climax dominated by a feather moss community. By contrast, Brulisauer et al. (1996) indicate that succession is not evident in the Chilcotin region of central British Columbia.

The Omineca is characterised by the SBS mk1 and BWBS dk1 biogeoclimatic zones. The Chilcotin is in the MS xv and the SBPS xc. The Laidman contains the SBS mc3 and SPBS mc biogeoclimatic zones. Based on the premises that the Chilcoltin sites are not successional because of the extreme conditions found there, we hypothesise sites in the Laidman will follow a more similar trajectory to the Omineca succession model. Stands less than 70 years of age will contain developing terrestrial lichen mats that support a combination of both club and reindeer lichen species. Between 70- to 150-years reindeer lichens will be dominant in the stand. As stands age beyond 150-years feather moss mats will become more prevalent in these types.

GIS Queries

Lichen woodlands are associated with sites that have dry, nutrient poor, coarse textured soils and a forest overstorey dominated by lodgepole pine. In the Omineca, an assessment of BCGS forest cover map information revealed lichen sites were associated with stands that had greater than 94 percent composition of pine, a south aspect, and a site index (SI₅₀) value less than 14.5 (Sulyma and Coxson, 2001). This evaluation however had a relatively high error rate and needs to be refined. In the Laidman Lake area we expect that similar parameters will be identified for forest inventory data as were found in the Omineca. The assessment in the Laidman will also provide an avenue to consider ecological inventories and compare these to the findings from the forest inventory information.

Workplan

Phase 1 - Project organisation and GIS applications

Activities for this phase will involve the organisation of various data sources and the application of GIS queries to determine the potential location of pine lichen woodlands in the Laidman Lake Resource Management Zone. The data sources that will be evaluated in this phase will be:

- Existing and new predictive and terrestrial ecosystem mapping.
- BCGS Forest cover (.fc1) and the corresponding attribute (.fip) information.
- Cichowski and Banner (1993) caribou habitat mapping for the Tweedsmuir-Entiako caribou herd area.

Queries conducted on specific fields will include:

PEM/TEM – Ecosystem Association

Forest Cover – Leading tree species, composition of leading tree species, age, site index.

Caribou Habitat Mapping – Types that will be assessed are those identified as dry lichen/lichen moss, lichen moss, and dry lichen/lichen moss ecomosaic.

The results of the queries will be stratified by age and productivity classes. This procedure will force the evaluation of marginal pine-lichen types, which will delineate specific parameters that can be used to classify pine-lichen woodlands using a GIS.

Results from the three data sets will also be overlaid and compared. This will provide insight towards the accuracy of the classification.

Phase 2 – Field verification of GIS Queries

Field verification of GIS queries will be conducted by assessing a set of randomly selected polygons from overlays of all three data sources. Access to these sites (i.e. available heli-pad, road access, etc.) will be a factor in site selection. The goal will be to

establish a minimum of 60 plots throughout the Laidman Lake Resource Management Zone.

Each plot will contain a 100 metre transect which dissects the target polygon area. On each transect, three 7.98 m fixed radius stand level plots will be established. The density of mature stems and regen will be tallied in each plot. One of the three plots will be randomly chosen to conduct a more detailed assessment of the forest overstorey characteristics. Measurements at this plot will evaluate:

- Tree size/stand structure (diameter at breast height, tree height, crown cover, age).
- An inventory of tree species composition.
- Biogeoclimatic site series using methods identified in “Field Manual for Describing Terrestrial Ecosystems” (Prov. Of BC, 1998).
- The percent cover of the dominant forb and shrub species.
- Lichen woodland class (Lance & Eastland, 1999)

Forest floor vegetation will be evaluated using ten 0.5 m² quadrats randomly placed along the 100 metre transect line. The percent cover of ground species will be tallied in these quadrats.

Phase 3 – Office evaluation

Data will be summarised and compared using factorial ANOVA to recognise significant trends within and between data sources. Polygons identified to contain pine-lichen woodland characteristics will be collated and used as a source layer to identify study sites for the project “Adaptive Management of forestry practices in pine-lichen winter range for northern caribou in north central British Columbia.”

Product Deliverables

A report or combination of reports will be prepared that present:

A revised map of the Laidman Lake RMZ highlighting identified pine-lichen woodlands.

A summary of the successional trends found in the Laidman Lake area.

An evaluation of forest cover, PEM/TEM and the Cichowski and Banner (1993) habitat mapping for predicting the location of pine-lichen woodlands.

Data summaries for characteristics of pine-lichen woodlands

Relationships between stand characteristics (age, site index, site series) and lichen cover.

The revised map for the Laidman Lake RMZ will be produced by July 31, 2001 to facilitate the implementation of the project “Adaptive Management of forestry practices in pine-lichen winter range for northern caribou in north central British Columbia.” All other work will be completed by March 31 2002.

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