Summary of Tweedsmuir Caribou Modelling Project: Lichen Workshop

held February 29, 2008

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Purpose: the purpose of the workshop was to develop a "lichen model" to predict the abundance and spatial distribution of terrestrial lichens. Participants also discussed arboreal lichens briefly.

Summary of discussion

Existing lichen models

Wildlife Informetrics (Randy Sulyma) produced a lichen model for the Vanderhoof TSA portion of the greater Tweedsmuir ecosystem (GTE), based on existing forest conditions. The Vanderhoof model may not have taken full advantage of existing inventories. This project will use existing inventories, where they exist, and supplement them with modelled lichen habitat. Furthermore, this project is focused on predicting the future supply of lichen and its availability to woodland caribou so requires information on lichen ecosystem's dynamics.

Terrestrial lichens

Tweedsmuir caribou feed primarily on terrestrial lichens, but also eat arboreal lichens, especially when snow is deep and/or crusty. Food on the winter range is not limiting, but the spatial distribution and accessibility of lichens could potentially limit the ability of caribou to distribute themselves in a manner that reduces predation.

Preferred site conditions

Terrestrial lichens grow best on cold, dry, nutrient-poor sites where growing conditions are more difficult for their competitors, mosses and vascular plants (e.g., kinnickinnick). Such sites also favour sparse stands of pine. Canopy trees use most of the moisture and nutrients on these dry sites, effectively limiting vascular plant growth. Lichen dominance and recovery from disturbance varies by site type (Table 1; also see figures below).

Table 1. Lichen dominance period on different sites.

Edaphic condition	Lichen sites[1]	Lichen dominance period
xeric, sub-xeric	DLLM, DLLM-Mosaic	mature and old climax
sub-mesic, mesic	LM, MDLLM, MS/AF	mature seral
mesic to rich		mature seral

Don will obtain 1987 lichen/caribou habitat maps from Allen Banner.

Parent material and soil texture influence moisture and nutrient status. Poor sites include sandy soils, coarse textured soils, exposed plateaus, gravel out-washes and moraines. Terrain maps may help to identify poor sites.

Climate change

Increased moisture and/or increased warmth will tend to increase organic litter, microbial activity (decomposition) and nutrient availability, shifting poor, dry sites towards zonal site types. Kinnickinnick overgrows lichen when nutrients become available after MPB. If open woodland can persist then lichens can survive. With canopy closure and increased litter fall, nutrients increase. If IDF-type climatic conditions move

[1] Cichowski, D. B., and A. Banner. 1993. Management strategy and options for the Tweedsmuir-Entiako caribou winter range. B.C. Min. For., Land Manage. Rep. No. 83., Victoria, B.C., Canada. 48 p. .

into the study area, temperatures will increase and current dry lichen sites will remain dry but will favour grasses. Grasses decompose easily and increase the nutrient status of the site, further reducing the suitability of the site for lichens. Moister sites will favour moss.

Soils change slowly and thus limit the rate of ecosystem shifts.
Existing "dry lichen" sites will persist longer than other lichen sites.
High elevation plateaus may make good lichen sites in future under climate change.
Site preparation and other management practices that disfavour lichens may speed the loss of lichen sites during a changing climate (e.g., lichen/moss sites → moss).

Two approaches to dealing with climate are "armour-plating" current state or nudging towards new state.

Disturbance

Historically, fires have affected large parts of the winter range. By removing the litter layer, hot fires remove nutrients and maintain the nutrient poor status of the site (although available nutrients increase for a short period). Without periodic fires, only the very poor dry sites will continue to support lichens (Figure 1). More mesic sites will shift towards moss and vascular plants over successional time as the canopy closes, litterfall increases and nutrients increase, moisture increases due to changes in microclimate conditions (not sure if this is the best way to describe this) (Figure 2 and 3). Also, in older stands, lichens get "mossed over". Fires can burn off moss layer allowing lichens to re-establish. Lichens are more flammable than moss and burn off before the moss, however once moss is gone the site conditions are more favourable than when mosses were there for lichens to re-establish. Canopy removal (e.g., from logging) shocks moss, allowing lichens to compete better.

After beetle-killed snags blow down and new canopy begins to form, fire hazard may increase. When a fire does start, fire intensity will be high because of all the large fuels on the ground.

Mechanical soil disturbance, from logging machinery or site preparation equipment may be beneficial or detrimental to lichens, depending on site conditions. Soil disturbance from harvesting reduces organic matter and the nutrient status of the site. Disturbed soil also facilitates germination of vascular plants that compete with lichens. On poor dry sites, soil disturbance and the related loss of organic matter has a stronger effect and favours lichens. On moister, richer sites, soil disturbance and related vascular plant competition hamper lichens. Further, whether soil disturbance is beneficial or detrimental to lichens also depends on the time scale. Since lichens are slow growing and unrooted, soil disturbance almost always has negative impacts on lichens in the short run. Over medium and longer time scales, soil disturbance may be favourable or detrimental to lichens, depending on site conditions (as noted above), and on the nature and severity of the disturbances. On nutrient-poor and especially borderline (e.g. submesic, submesotrophic) sites, soil disturbances that cause scalping of surficial soil layers will remove competing vegetation and soil organic matter, creating conditions in which lichens will tend to have a competitive advantage (as after repeated wildfire). Light soil disturbances (e.g. machine traffic) on such sites may also encourage fragmentation and reproduction of existing lichens. On better sites, soil disturbance will tend to favour more rapidly growing species such as grasses that invade more rapidly than lichens. In general, soil mixing treatments or other site preparation treatments that incorporate rather than scalp soil organic layers and increase, rather than decrease site productivity for tree growth, will tend to decrease lichen abundance by favouring the growth of other species, including planted tree seedlings. In poor, clay textured soils, soil disturbance that causes compaction and puddling that makes soils wet, and this won't be good for lichens. In s: if soil disturbance reduces site productivity it will tend to favour lichens, if it increases site productivity it will tend to favour competitors. On dry lichen sites where lichen is well established and there are few competitors, soil disturbance that enhances site productivity may enhance lichen abundance by creating more favourable growing conditions and encouraging reproduction through fragmentation.

The amount of soil disturbance and lichen mortality varies with the type of disturbance and affects other ecological processes (Table 2).

- Fire kills most lichens and exposes mineral soil.
- Site prep mixes the litter layer and mineral soil, increasing decomposition and nutrient availability and favouring vascular plants.
- Summer logging causes some soil disturbance and a smaller increase in vascular plant competition than on “prepped” sites.
- Winter logging retains more lichens and produces little soil disturbance.
- MPB retains lichens and produces very little soil disturbance.

Management for lichens should aim to maintain nutrient-poor status of sites, and to limit competition. Lichens grow where microbial activity is least. On poor sites, lichens will compete well; thus, no need to plant. On zonal sites, lichens compete less well; thus, may be better to plant pine to limit competing vegetation.

Table 2. Relative increase or decrease in physical and biological processes following different disturbances

	Short term ecological change							Long term ecological change[t]	
	(light & temperature	Post disturbance lichen cover	Exposed soil	Litter layer (Fine OM) *	Microbial activity	short term nutrient release	Vascular plant competition	soil nutrients available	lichen growth and dominance
Fire	↑↑↑↑↑	↓↓↓↓	↑↑↑	↓↓↓	↑**	↑↑↑↑	↑	↓↓↓	↑↑↑
Site prep	↑↑↑↑	↓↓↓	↑↑↑	↓↓	↑↑↑	↑↑↑	↑↑↑	↑↑	↓↓
Summer log	↑↑↑	↓↓	↑	↓	↑↑	↑↑	↑↑	↑	↓
Winter log	↑↑	↓	---	↑	↑	↑	↑	---	---
MPB	↑	↓	---	↑	↑	↑	↑	---	---

Notes
*Litter layer – needs revision
**Depending on severity
[t] Winter vs. Summer logging may not be different over the long term except to the extent that competing species are able to become established, with persistent effects.

This table is dependent on whether you have a dry lichen site or a borderline mesic site, because the effects of competing vegetation (see Figures below). The short term and long term might not work, because some of the effects of fire –e.g. Vascular plant competition, might just be a delayed effect over what you get with site prep or logging alone. A curve instead of a table may provide a better tool for modelling.

Arboreal lichens

Tweedsmuir caribou feed mainly on Bryoria, however, this may reflect the abundance of Bryoria rather than a strong preference.

Arboreal lichen abundance is difficult to predict but generally reflects stand age and site conditions. Arboreal lichens (Bryoria) are generally most common in wetlands, in spruce/pine stands and in stands that are close to wetlands.

Arboreal lichens require high humidity and good ventilation (e.g., subalpine forest exposed to wind). Heavy snow loads on trees and or very wet years that cause prolonged wetness can cause lichens to rot. Once MPB killed trees fall, arboreal lichens on those trees are expected to deteriorate within a few years.

Trees act as substrate; thus tree mortality does not have large affect lichen abundance.

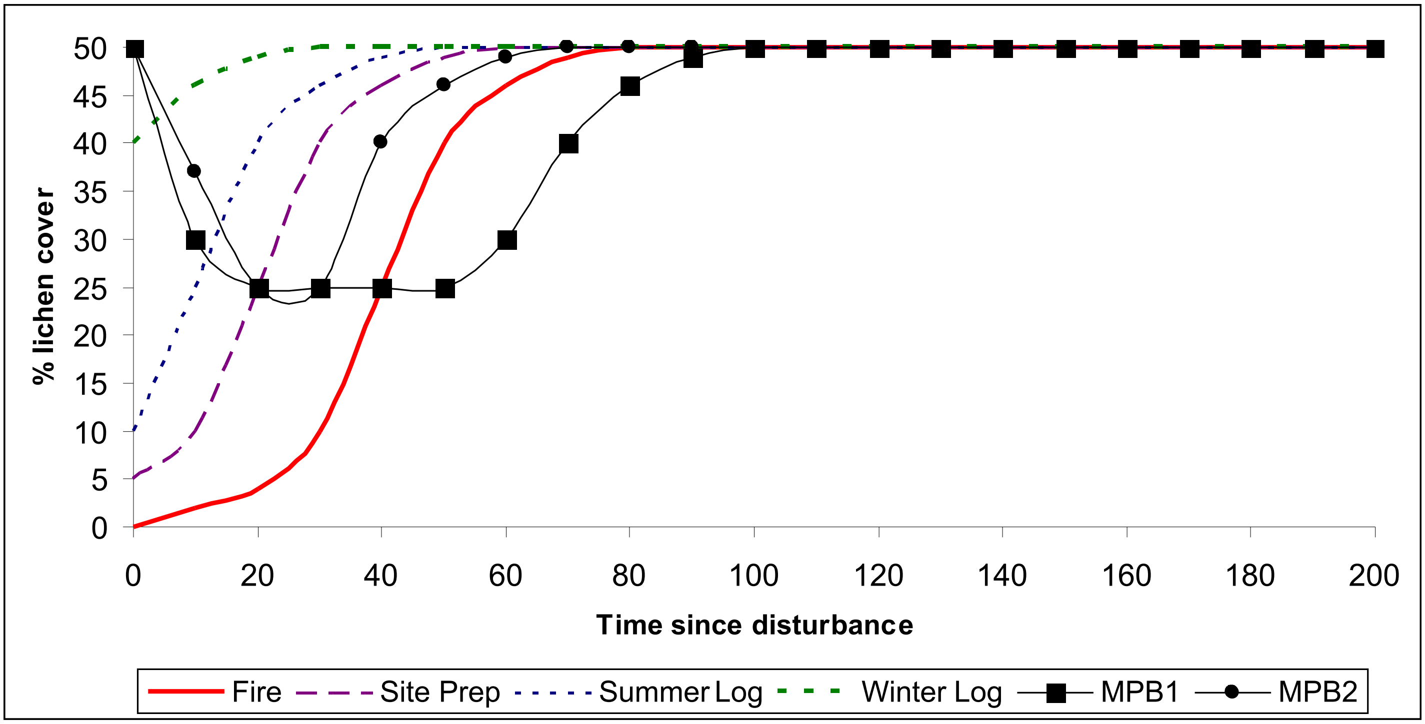

Figure 2. Lichen cover versus stand age for different disturbance types (dry sites). MPB1 and MPB2 reflect uncertainty about the speed of decline and recovery.

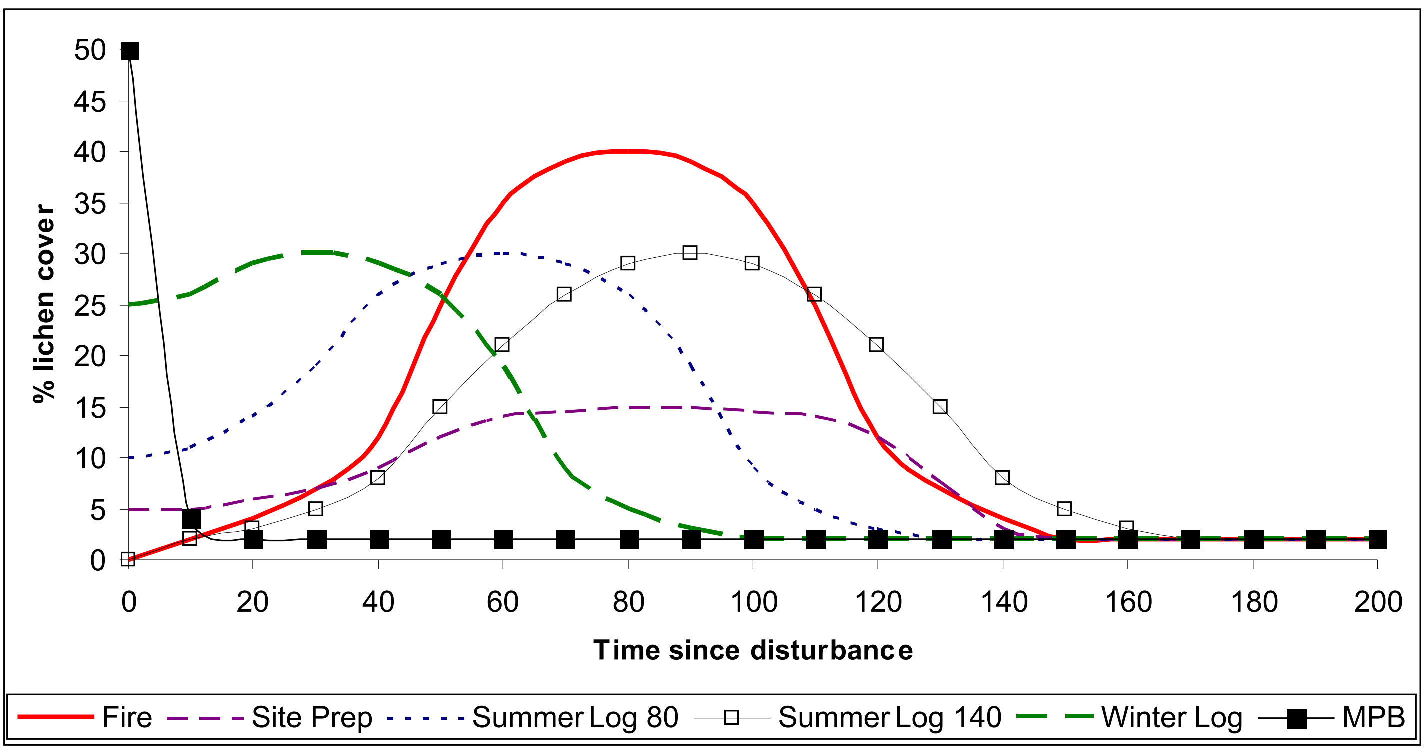

Figure 2. Lichen cover versus stand age for different disturbance types (mesic sites).

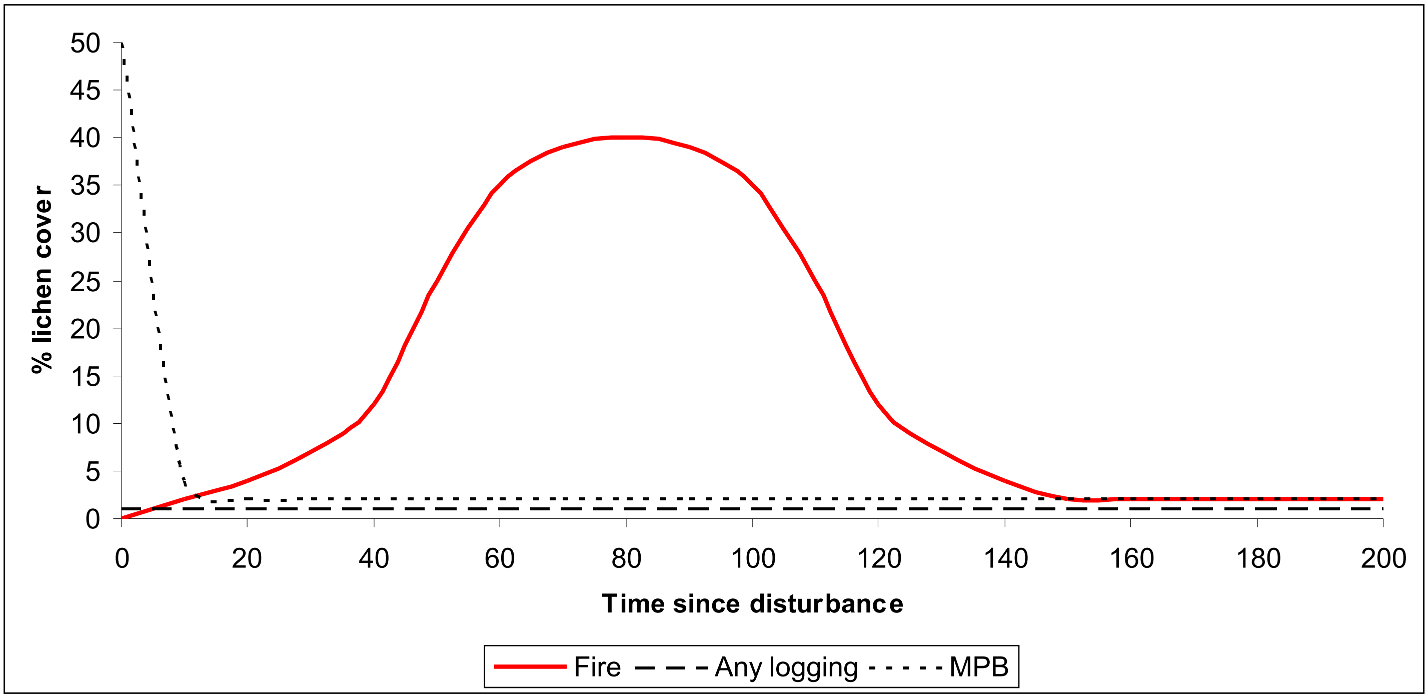

Figure 3. Lichen cover versus stand age for different disturbance types (mesic to rich sites).

Comments on figures:

- Debbie thinks that may not get any lichen cover on rich sites that are 80-100 years old. More likely on mesic to submesic sites rather than mesic to rich sites.
- Debbie thinks the starting point (% cover lichens) should differ for the 3 different site types, as should the maximum recovery % cover. For example, for Figure 3, the starting point for MPB should probably be lower than 10% and the peak of the fire curve should also be about the same height (lower than 10%).
- Figure 1 – Sybille thinks that % cover after winter logging should drop a bit more than to 40%
- The % cover values on mesic vs dry sites will depend on Subzone according to Sybille. Debbie should have some values that will help calibrate these Figures by ecosystem We could use Adrian's % cover over whole plot/site values rather than Sybille's % cover within photoplot data because the photoplots are focussed on patches that have lichen in them and thus are upwardly biased. These can be added later.
- Sybille's whitebark pine ecosystem work suggests that xeric woodland (very dry) sites in the ESSF respond very differently to MPB/climate/successional change than submesic mixed forest sites. It appears to supports the work done by Sulyma & others in the PG area– that there are some sites where lichen is +/- seral and other sites where it is persistent. It also supports our hypothesis that sites with competing vegetation will tend to lose lichens in response to MPB and other increases in resource availability while sites with little competing vegetation and few resources will tend to gain lichens over a 20-30 yr time scale. The threshold between where you go from a seral to a persistent lichen cover varies with climate and past disturbance regime. It is therefore difficult to describe in terms of the relative moisture regime (xeric, subxeric, submesic, mesic) as you have done in the Figures above (though this would work within a single subzone). For example in the SBSmc where the climate is relatively moist and the fire cycle is relatively long, the threshold will be much further to the left (very xeric//xeric) than in the SBPS where the climate is drier and the terrain favours frequent large fires (submesic//mesic).