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MODELING

**Recommended Changes to the High-Elevation
Winter Range Sub-Model
(Version 10b) of the CHASE Model**

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RECOMMENDED CHANGES TO THE HIGH-ELEVATION WINTER RANGE
SUB-MODEL (VERSION 10b) OF THE CHASE MODEL

Prepared for:
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TABLE OF CONTENTS

Table of Contents.....	ii
List of Figures.....	ii
Introduction.....	1
Approach.....	2
Revision Rationale.....	4
Terrestrial Lichen Forage Abundance (<i>TLFA</i>).....	7
Ecological Unit (<i>ECO</i>).....	7
Topographic Curvature (<i>CURV</i>).....	7
Arboreal Lichen Forage Abundance (<i>HEWR_ALFA</i>).....	8
Arboreal Lichen Ecological Potential (<i>AL_POTENTIAL</i>).....	8
Ecological Unit (<i>ECO</i>).....	8
Species Composition (<i>SPP_COMP</i>).....	8
Aspect (<i>ASP</i>).....	9
Stand Conditions (<i>AL_STD_COND</i>).....	10
Stand Age (<i>SA</i>).....	10
Stand Structure (<i>SS</i>).....	10
Tree Size (<i>TS</i>).....	11
Slope (<i>SLP</i>).....	12
Elevation (<i>ELE</i>).....	12
HEWR Habitat Preference (<i>HEWR_PREF</i>).....	13
HEWR Habitat Value (<i>HEWR_VAL</i>).....	13
Assumptions.....	13
Summary.....	14
Literature Cited.....	15
Appendix A.....	16

LIST OF FIGURES

Figure 1 Version 10b High-Elevation Winter Range Sub-model.....	3
Figure 2 Version 11a High-Elevation Winter Range Sub-model.....	5

INTRODUCTION

Over the past few years, within the Mackenzie TSA, work has been conducted developing the Caribou Habitat Assessment and Supply Estimator (CHASE) model. The model evaluates seasonal ranges, movement corridors, and the influence of predation to determine the value of habitat available for northern caribou. Three seasonal ranges are considered in the model, each of which has been coined a sub-model. The seasonal ranges are: pine-lichen winter range (PLWR), calving and summer range (CSR), and high-elevation winter range (HEWR).

Within each of the seasonal range sub-models, a final value is calculated that represents a resource selection function expressing the relative value of habitat for caribou. Key factors in each of the sub-models include cover attributes, forage supply, forage availability and mortality. Within the PLWR sub-model the factors associated with forage are summarized in a node (*TLHC: Terrestrial Lichen Habitat Capability*) that represents the foraging potential of a site. In turn, when the sub-model is run to identify the sites that have potential to support terrestrial lichen on a landscape, the spatial outputs appear to provide explicit range areas that meet the expected values that are being modeled for. Accuracy testing of the sub-models is currently underway whereby potential range areas are assessed against observed use by caribou.

The existing HEWR sub-model (v. 10b), however, does not appear to be as successful at rating the potential value of sites. It is too general and does not permit the identification of critical areas necessarily required by northern caribou as high-elevation winter range. This relatively poor success has led to further work to identify areas of improvement for the sub-model. The recommendations of which are identified in this report. Activities that were conducted involved

literature reviews, assessments of ecological based mapping work (Klawlie TEM and Akie and Pesika TEM projects), assessments of BCGS forest cover maps (.fc1 and .fip), and revisions of Netica belief networks.

APPROACH

The v. 10b sub-model assesses a cell/site for both terrestrial lichen and arboreal lichen availability (Figure 1). The lichen availability is then modified to reflect usability, which is done by considering slope and aspect factors. Sites that are suitable, and contain lichen, are then modified by a predation factor to determine the resource selection function value.

For this project we have set the scope to address issues related to the prediction of lichen values as they relate to forage supply and have not adjusted the impacts of predation. In the v. 10b sub-model arboreal lichen availability was based on three main factors: ecological unit, inventory type group, and stand age. Terrestrial lichen availability was based on topographic curvature and ecological unit. In the revised HEWR sub-model (v. 11a) factors related to stand conditions have been added to improve predictions associated with the identification of arboreal lichen values.

Most of the data inputs into the HEWR sub-model are attributes directly out of other databases (.fip, TRIM derivatives, etc.). Data input to the *ECO: Ecological Unit* node, however, is pre-classified. In the v. 10b sub-model ecological units were ranked on a combination of the suitability of an ecological unit to provide habitat conditions for a type of lichen and by the suitability of a biogeoclimatic zone to provide high-elevation winter range for caribou

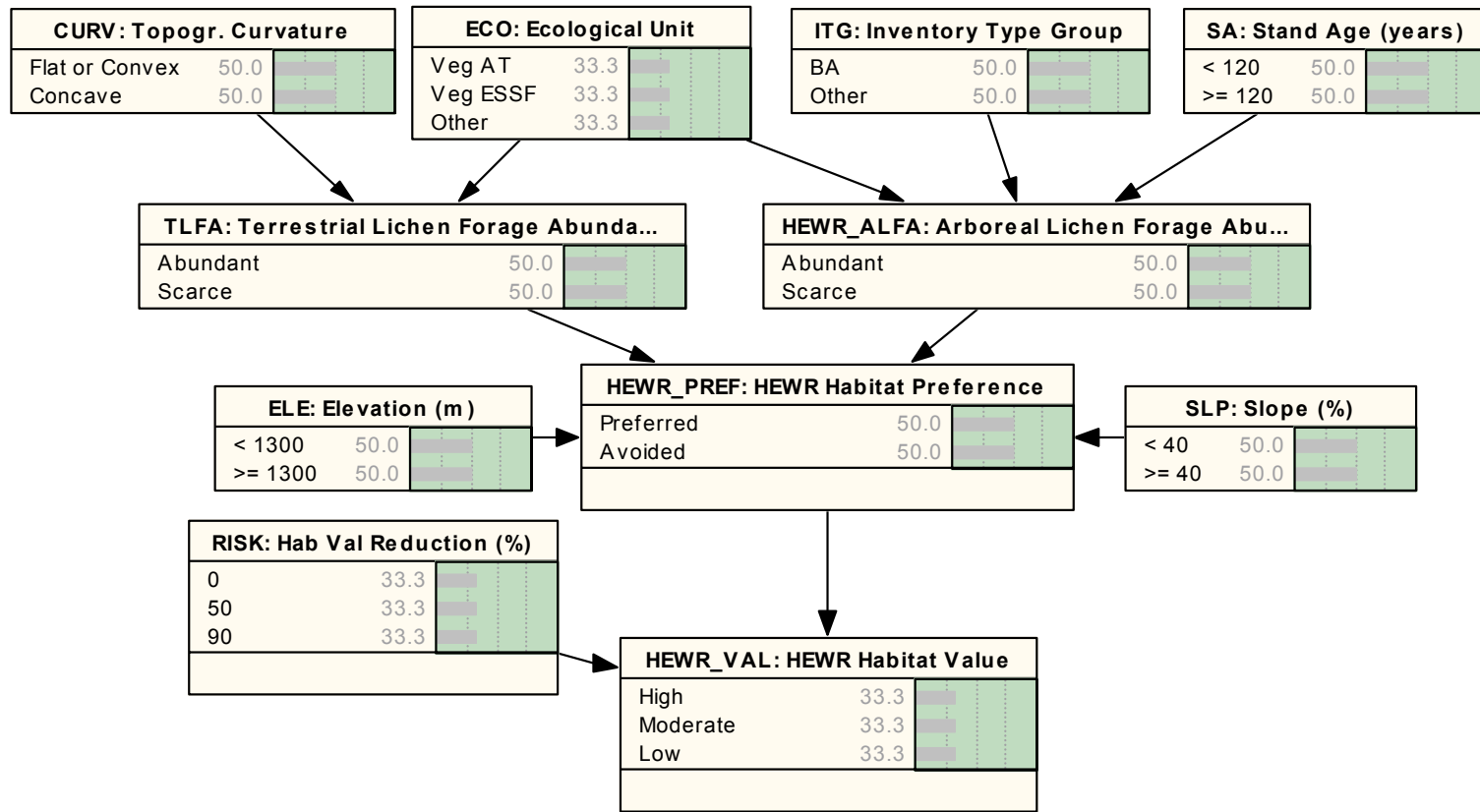


Figure 1 Version 10b High-Elevation Winter Range Sub-model.

(McNay and Zimmerman In Progress). For example, all vegetated sites in the alpine tundra were considered to provide habitats for terrestrial lichens, conversely all sites in the SBS, regardless of lichen potential, were considered of no value for terrestrial lichens.

In the v. 11a sub-model we have stopped the pre-classification by BGC unit, and have allowed the appropriate factors to identify the value of a site (Figure 2). The goal of taking this approach was to ensure transparency of the sub-model such that all decisions made were evident in the structure of the belief network.

The other conceptual change made to the sub-model was to separate, or make more specific, the decision components of the belief network. In the v. 10b sub-model, all factors related to the availability of arboreal lichens were considered direct inputs to the *HEWR_ALFA: Arboreal Lichen Forage Abundance* node. We modified the structure to consider factors at a site level separate from those at a stand level. This concept is based on the supposition that a site may have suitable ecological potential to support arboreal lichen, however, due to stand factors the conditions may be such that arboreal lichens are not present.

REVISION RATIONALE

For ease of comparison between the v. 10b and v. 11a sub-model structure, This document follows the heading format set fourth in the Caribou Habitat Assessment and Supply Estimator (CHASE) document (McNay and Zimmerman In Progress).

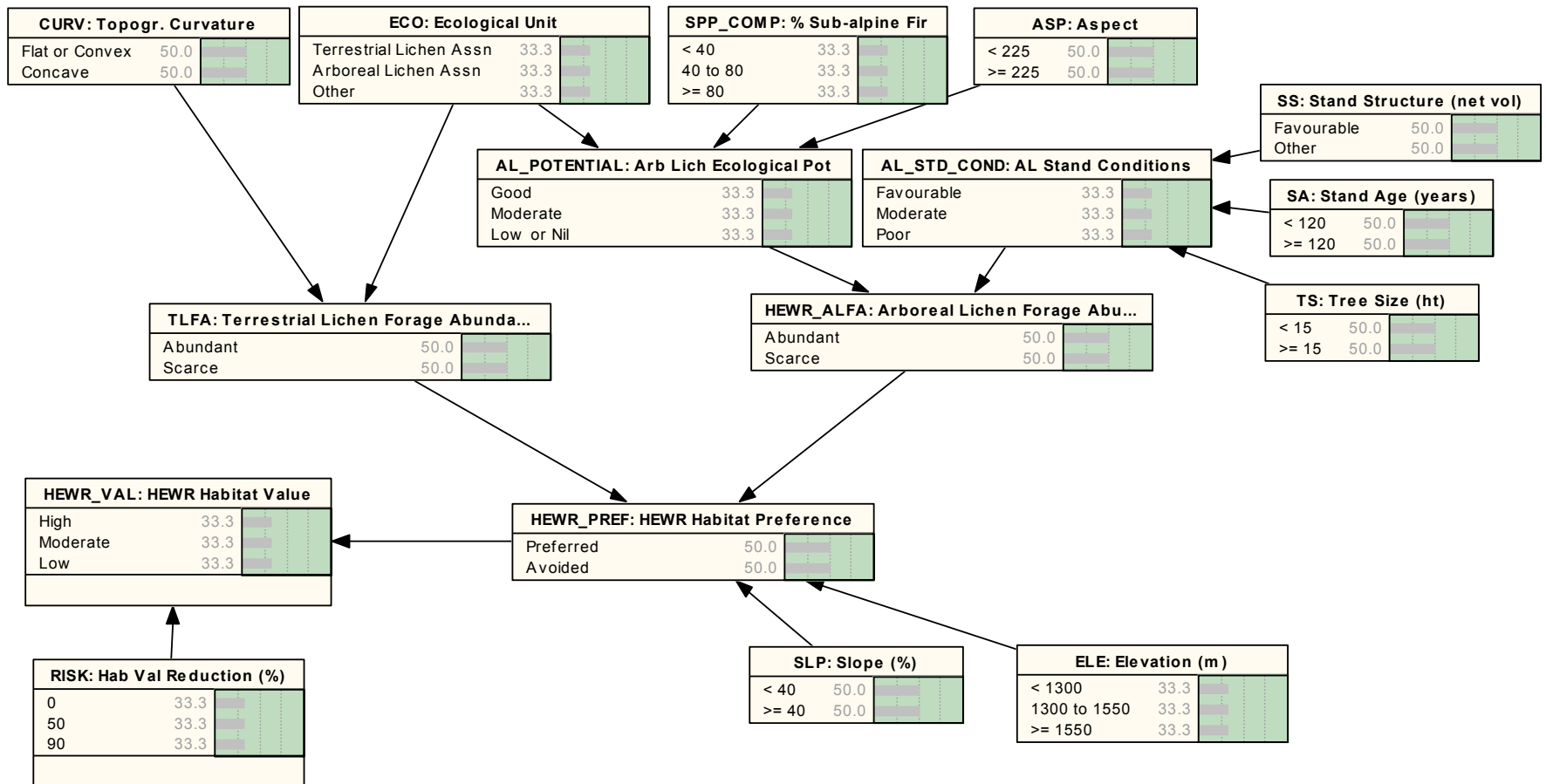


Figure 2 Version 11a High-Elevation Winter Range Sub-model.

In order to facilitate the new factors being incorporated into the v. 11a sub-model, a restructuring of the nodes was required. Among the major changes to sub-model are:

- Modification of the conditional probability table (CPT) for the *AL_POTENTIAL: Arb Lich Ecological Pot* node to reflect site factor variables such as ecological unit, leading tree species, and aspect.
 - Revision of the *ECO: Ecological Unit* node to include a more descriptive classification of lichen abundance. Ecological units have been reviewed and updated to represent the plant association and corresponding type of lichen community (arboreal versus terrestrial) that could be present. The potential of an ecological unit to support a lichen type was identified regardless of the elevation or biogeoclimatic zone that the type was found in. This is a departure from the pre-classification that was conducted in the v. 10b sub-model. For a complete listing of the biogeoclimatic zones and their assigned ranking refer to Appendix A.
 - Revision of the *SPP_COMP: % Sub-alpine Fir* node to better represent the amount of sub-alpine fir on the site.
 - Addition of the *ASP: Aspect* node, which is used to represent prevailing winds and the ventilation of the stand.
- Addition of the *AL_ST_COND: AL Stand Conditions* node that is used to summarize the influence of aspect, stand structure, stand age, and tree size.
 - Addition of the *SS: Stand Structure (net vol)* node into the sub-model that will be used as a measure of stand ventilation.
 - Addition of the *TS: Tree Size (ht)* node.

- Adjustment of the relationship associated with the *SA: Stand Age* node to reflect the importance of it at a stand level.

Terrestrial Lichen Forage Abundance (*TLFA*)

This node remains relatively unchanged from the v. 10b sub-model. Terrestrial lichen association sites located on a flat or convex terrain are considered 100 % available and, sites classed as a terrestrial lichen association, located in a concave slope position are still considered unavailable.

Ecological Unit (ECO)

The v. 10b sub-model classifications ruled out the potential for higher elevation (>1300m) stands in the ESSF and SWB to support terrestrial lichen, likewise, lower elevation sites in the SBS and BWBS were not considered to provide arboreal lichen potential. Since we are simply assessing a site's potential to support either arboreal or terrestrial lichen, it was felt that all ecological units capable of supporting terrestrial lichen growth should be included at this stage.

Topographic Curvature (CURV)

Topographic curvature remains unaltered from the v. 10b sub-model. Flat or convex sites were considered favourable HEWR terrestrial lichen habitat since they are more exposed to wind scouring. Conversely concave areas were considered less favourable since they do not receive the wind scouring required to reduce snow depths and expose terrestrial lichen.

Arboreal Lichen Forage Abundance (*HEWR_ALFA*)

Improving the accuracy of identifying high-elevation arboreal lichen sites was the main focus for changes to the v. 10b sub-model. In order to increase the accuracy of predicting arboreal lichen sites in the v. 11a sub-model, ecological site factors, were isolated from stand-level factors.

Arboreal Lichen Ecological Potential (*AL_POTENTIAL*)

This node has been added to the v. 11 sub-model to summarize site-specific factors known to influence the abundance of arboreal lichen. The factors assessed are ecological unit, species composition (% sub-alpine fir), and aspect.

Ecological Unit (ECO)

Arboreal lichen is considered to be relatively abundant in those ecological associations that are forested and contain a leading component of sub-alpine fir. The alpine tundra, due to its lack of trees, is considered to have a low ranking with respect to the ability to support arboreal lichen growth. Cool, mesic sites with good ventilation (or slopes facing the prevailing winds) tend to provide optimum conditions for arboreal lichens. These have been ranked as such in Appendix A.

Species Composition (SPP_COMP)

In the v. 10b sub-model, sub-alpine fir was considered a key factor in determining the presence and/or abundance of arboreal lichen within a site. The sub-model, however, used a generalized “inventory type group” value to differentiate between favourable and

unfavourable forested types. In the v. 11a sub-model, more detailed thresholds have been applied to identify the importance of leading tree species as it relates to arboreal lichen abundance. The most desirable stands contain >80% cover of sub-alpine fir (Terry et al. 2000). These stands provide the greatest volume of arboreal lichens and the greatest level of access to forage for caribou (Terry et al. 2000, Rominger and Oldemeyer 1989, Campbell and Coxson 2001). Given the importance of sub-alpine fir in high-elevation winter range the ITG node was relabelled *SPP_COMP: % Sub-alpine Fir*, and three new categories were introduced:

- Stands with <40% BI – These stands are considered to have little or no potential to support abundant arboreal lichen.
- Stands with between 40 and 80% BI – These stands are given a moderate potential to support abundant arboreal lichen.
- Stands with >80% BI – These stands are considered to support abundant arboreal lichen.

Aspect (ASP)

Arboreal lichens tend to be most prevalent on windward facing slopes. In the Omineca, where the CHASE model was developed, prevailing winds tend to be from the west. Likewise, caribou in the Omineca region (Takla herd) have been found to express a preference for use of stands with a west to north aspect (Poole et al. 2000). West-facing slopes are subject to increased exposure of wind action and therefore will have increased ventilation. The improved ventilation leads to increased growth and dispersion of arboreal lichens throughout the stand resulting in higher arboreal lichen availability.

As a result, aspects between SW and North (between 225° and 0°) are considered to have the highest preference for caribou use within the v. 11a sub-model.

Stand Conditions (*AL_STD_COND*)

The v. 10b sub-model took a general approach at estimating the availability of arboreal lichen and did not explicitly separate stand from site factors. It did, however, consider stand age as an important factor related to the abundance of arboreal lichen. A series of new nodes have been introduced to summarize the stand level factors that relate the potential for a site to support arboreal lichens. These new nodes are described below and are summarized in the *AL_STD_COND: AL Stand Conditions* node as creating Favourable, Moderate or Poor conditions for arboreal lichen growth.

Stand Age (SA)

The stand age node was not modified from the v. 10b sub-model. The trend that continues to be modelled is stands greater than 120 years old have a greater potential to support high arboreal lichen biomass when compared to stands younger than 120 years (Armleder and Stevenson). The relationship of stand age, however, has been updated to express the importance of this factor at a stand level rather than a site level.

Stand Structure (SS)

The relative openness of a stand increases the ability of a site to produce arboreal lichen. Moderately open stands create an environment more suitable for colonization through enhanced dispersal (Goward 1998). In addition moderately open stands likely contain

trees with larger crowns and therefore larger branches. Over 95% of arboreal lichen biomass is generally found on branches and 5% or less is located on the main stem (Arseneau et al. 1998). More open stands, containing large crowns, create favourable conditions for arboreal lichen growth. Within the .fip database we found stand volume, in our opinion, to be the best correlate to stand structure. Also in the .fip database projected stand volume is more readily available and precise than basal area. Terry et al (2000) found that caribou prefer stands with a gross volume estimates between 200 and 300 m³/ha. The .fip database does not contain gross stand volume but rather a net volume based on primary utilizations standards for the leading tree species. The net volume for the leading species is determined as gross volume less decay, waste and breakage. A reduction in gross volume of 12% is recommended to account for waste and breakage (2%) and decay (10%) thus reducing the volume criteria for identifying preferred sites to 180-270 m³/ha.

Tree Size (TS)

Tree size has been postulated to exert a positive influence on lichen loading with bigger trees supporting more abundant and diverse lichen flora (Arseneau et al. 1998). Within the available attribute databases, tree height from the .fip database provides the closest correlate to size. Campbell and Coxson (2001) found trees >15m in height hosted more lichen biomass than those below this height. Within the v. 11a sub-model we have identified that stands with trees above 15m in height are considered favourable while stands with shorter trees are unfavourable.

Slope (*SLP*)

This node was not altered from the v. 10b sub-model and therefore still contains the two slope criteria of less than 40% being favourable and slopes steeper than 40% being unfavourable.

Elevation (*ELE*)

The v. 10b elevation node included a cut-off for identifying high-elevation areas (>1300m) All sites below this elevation were considered unsuitable as HEWR. The v. 10b sub-model elevation categories were too broad and did not provide adequate separation between alpine tundra, parkland, and forested sites.

The elevation node was assessed and three new categories were established. These are <1300m, 1300 to 1550 m and >1550 m. The impacts of the elevation thresholds are:

- <1300m – these sites are considered too low to be suitable for high-elevation winter range habitat. Though these sites may support terrestrial or arboreal lichen biomass, they are avoided by caribou during late winter and are deemed unfavourable.
- 1300 to 1550m – these sites will provide the most favourable conditions for arboreal lichen. Due to potential snow loading, these sites are considered unfavourable for high-elevation terrestrial lichen habitat.
- >1550m – sites located above this elevation are considered mainly open stands (parkland) and alpine tundra (vegetated sites). These sites are considered the only suitable sites for high-elevation terrestrial habitat and provide some high-elevation arboreal lichen habitat in the parkland areas.

HEWR Habitat Preference (*HEWR_PREF*)

The biggest change to this node is that the v. 11a sub-model eliminates the potential for a site to be classified suitable for both terrestrial and arboreal lichens. This resulted in the removal of six categories that are not considered possible within the v. 11a sub-model structure. The CPT was also updated to include additional inputs from the *ELE: Elevation (m)* node.

HEWR Habitat Value (*HEWR_VAL*)

This section of the sub-model remains unaltered from the v. 10b sub-model.

ASSUMPTIONS

Listed below are some of the assumptions made during the revision of the sub-model:

- Sites cannot support favourable conditions for both terrestrial and arboreal lichen.
- Terrestrial lichen sites below 1550m are unavailable as High-elevation Winter Range.
- Stand volume is a suitable indicator for the relative openness of a stand. Stands with less than 200m³/ha (gross volume) are too open and stands above 300m³/ha (gross volume) are considered too dense.
- Moderately open stands provide better ventilation/conditions for arboreal lichen growth as well as improved predator detection (Terry et al. 2000) and are therefore the most favourable.

SUMMARY

The v. 11a HEWR sub-model has been revised to provide an improved prediction of arboreal lichen cover that is based on both site and stand level factors. In general most other factors have remained constant between v. 10b and v. 11a.

Very little testing has been done on the relationships expressed in the v. 11a sub-model.

Individual stand factors were evaluated on a test area of 9 forest cover mapsheets, but no multi-factor review has been completed. In addition, peer review of the v. 11a HEWR sub-model needs to be conducted and updates completed where necessary.

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APPENDIX A

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
AT	00	CF	1	Cryptogam-Altai fescue			Devoid of trees.	Xeric to subxeric sites on steep, rugged terrain. Low lichen coverage.
AT	00	FK	3	Subalpine fir krummholz	Bl*		*Extremely stunted trees.	Liverwort common and the most abundant species, often forming a mono-species carpet.
AT	00	FW	1	Altai fescue-Dwarf willow			Devoid of trees.	Common coral lichen abundant. Found on upper crests and exposed slopes.
AT	00	MH	1	Mountain heather-Leafy liverwort snow bed community.			Devoid of trees.	Heavy snow accumulations and snow melt in spring retards development of most species.
AT	00	SD	3	Sedge-Dwarf willow moist meadow			Non-forested site.	Area is dominated by sedges, coltsfoot, buttercup, sagewort.
AT	00	AD	3	Mountain arnica-Subalpine daisy meadow.			Non-forested site.	Soils are well to imperfectly drained, with mesic to subhygric moisture regime. The understorey is dominated by sagewort, subalpine daisy, willow, and grasses.
AT	00	AW	3	Mountain avens-Dwarf willow			Non-forested site.	Site located on steep slopes or undulating terrain. Dominant vegetation species are mountain avens and dwarf willows.
AT	00	FL	1	Alpine fescue-Lichen dry meadow			Non-forested site.	Common on crest and upper slope positions. Usually weathered bedrock, or colluvium veneers. The sites are dominated by bluegrass, altai fescue, and lichens.
AT	00	VH	3	Sitka valerian-Indian hellebore avalanche track.			Non-forested site.	Occurs on deep, medium textured soils on significant slopes. Usually common but small in area. These sites are dominated by mountain sagewort, sitka valerian, and Indian hellebore.
BWBSdk1	00		3				Several Non-forested types not assessed here. Low likelihood of AL	Several Non-forested types not assessed here. Low likelihood of TL.

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
BWBSdk1	00	SO	3	Sw-Oak fern	Sw		Bl lacking in the overstorey.	Rich site with a well-developed shrub and herb layer.
BWBSdk1	00	SO ao	3	At-Oak fern	At		Deciduous leading type.	Rich site with a well-developed shrub and herb layer.
BWBSdk1	00	KS	3	Kinnikinnick-Sage			Non-forested site.	Very xeric subxeric soil moisture regime. Grass dominated.
BWBSdk1	00	BP	3	Bluejoint-Cow parsnip avalanche track			Non-forested site.	Steep slope position with mesic to hygric moisture regime. Well -developed herb layer.
BWBSdk1	00	KR	3	Kalm's lobelia-Rush marl flats			Non-forested site.	Depressional water receiving site. Characterized by mainly rushes and water sedges.
BWBSdk1	00	BB	3	Scrub birch-Beaked sedge fen			Non-forested site.	Poorly drained site with a hydric moisture regime.
BWBSdk1	00	WE	3	Scrub birch-Willow fen edge	Sb		Scattered stunted black spruce.	Dominated by sphagnum mosses and feather mosses.
BWBSdk1	00	HG	3	Horsetail-Giant water moss oxbow marsh			Non-forested site.	Poorly drained swamp.
BWBSdk1	00	FS	3	Slender sedge-Fen moss fen			Non-forested site.	Seasonal flooding occurs.
BWBSdk1	00	FB	3	Scrub birch-Sedge fen			Non-forested site.	Semi-saturated soil conditions. Periodic flooding occurs.
BWBSdk1	00	PW	3	Pacific willow-Dogwood low bench riparian			Non-forested site.	Semi-saturated soil conditions. Periodic flooding occurs.
BWBSdk1	00	SE	3	Sedge-Asphodel fen.			Non-forested site.	Surficial material is organic. Poorly drained with a hydric moisture regime. Hummocks dominated by sphagnum.
BWBSdk1	00	RS	3	Rush-Sedge shallow lake marsh			Non-forested site.	Shallow lake marshes dominated by sedges and rushes.
BWBSdk1	01	SM	3	Sw-Knight's plume-Step moss	Sw, PI	Bl, At, Ac, Ep	Due to tree spp. being dominated by Sw, PI this type automatically drops in AL value. Based on the current model this would be addressed through the ITG node.	This type is generally too wet to allow TL to grow. Herb, shrub and moss layers well developed.

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
BWBSdk1	02	LL	1	PI-Lingonberry-Feathermoss	PI	Sb,Sx, At	BI generally lacking in the overstorey. Dry sites, dominated heavily by PI. Some sites can have AL on lower tree branches, however, branches are small and amount of AL is limited	Rapidly drained soils. Xeric to subxeric moisture regime. Juniper haircap moss lichens present in the mature stand. High value TL site
BWBSdk1	03	SW	3	Sw-Wildrye-Feathermoss	PI,Sw	At	PI leading type. Generally a lack of BI in Overstorey.	Submesic to mesic site dominated by herbs, shrubs and mosses.
BWBSdk1	04	BL	1	Sb-Lingonberry-Knight's plume	PI, Sb	Sw	BI lacking in the overstorey.	Rapidly drained soils with a xeric to mesic soil moisture. Poor tree growth is typical. Some lichen present in the understorey.
BWBSdk1	05	SS	3	SwPI-Soopalallie-Twinflower	PI	Sw, BI, Sb	Often south facing, likely too dry to support good AL biomass. BI lacking in the overstorey.	Dry site, some TL potential, not as good as the LL
BWBSdk1	06	SR	3	Sw-Scouring rush-Stepmoss	Sw		This type is generally located in lower slope receiving sites, it likely does not receive adequate ventilation to promote abundant Broria spp. BI lacking in the overstorey	Too Rich and Wet
BWBSdk1	07	BC	3	Sb-Lingonberry-Coltsfoot	Sb, PI, Sw		BI lacking in the overstorey.	Moisture receiving sites with a subhygric to hygric moisture regime. Dominated by mosses.
BWBSdk1	08	SC	3	Sw-Currant-Horsetail	Sx, PI, BI		Flood Plain - if open enough it could provide scattered trees with abundant arboreal lichen. BI lacking in the overstorey. Small in size and generally associated with streams.	Too Rich and Wet Shrub layer well developed. Subhygric to hygric moisture regime. Thick organics.
BWBSdk1	09	BH	3	Sb-Horsetail-Sphagnum	Sb		Poor tree growth. BI lacking in the overstorey. Bog-vegetation, organic soils. If open enough stand conditions this association could have AL on Sb.	Thick organics and a subhygric to hygric moisture regime. Shrub layer well developed.
ESSFmv3	00	FC	1	BI-Crowberry			Stunted tree growth. General absence of tree canopy.	Abundant crowberry. More lichen than moss.

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
ESSFmv3	00	FM	2	BI-White mountain heather	BI		Located generally above 1460m. BI dominated stands with a relatively open canopy structure. (Stunted tree growth in some cases). Likely favorable conditions for arboreal lich growth. Late snowpack in spring could be favorable to caribou usage. (Reaching arb. Lich.)	Carpet of mountain heather and Barbilophozia spp.
ESSFmv3	00	FV	2	BI-Sitka valerian	BI		Widely spaced overstorey layer likely low abundance of arb. Lich.	Lush and diverse assortment of herbs.
ESSFmv3	00	ST	3	SxwFd-Toad flax	At	PI	Aspen dominates the overstorey layer. Unfavorable arboreal lichen conditions	Moderately well developed shrub layer.
ESSFmv3	00	BS	2	Sb-Sphagnum bog	Sb		Lack of BI and scattered tree layer lead to poor arboreal lichen conditions.	High water table not conducive to terrestrial lichen growth.
ESSFmv3	00	CF	1	Cryptogram-Altai fescue			No tree cover present	Rocky areas , xeric to subxeric moisture. Dwarf shrubs present.
ESSFmv3	00	CS	2	Cottongrass-Sphagnum wetland			Void of trees. Deep organic soils.	High water table. (Swamp)
ESSFmv3	00	FK	3	Fir krummholz	BI		Extremely stunted tree growth. High elevation. Avalanche occurrence frequent leading to stunted trees.	Carpet of herbs and shrubs often present.
ESSFmv3	00	FW	1	Altai fescue-Dwarf willow			Void of trees.	Exposed crests and hilltops. Wind scouring likely to occur. Mainly grasses with some lichen being present.
ESSFmv3	00	FW y	3	Altai fescue -Dwarf willow (wetter than avg.)			Void of trees.	Water receiving site. Dominated by grasses.
ESSFmv3	00	SB	3	Sedge-Buckbean wetland			Void of trees.	Subhydric to hydric depressions.
ESSFmv3	00	SF	3	Sedge-Fuzzy fen moss			Generally void of trees.	Dominated by sedges. Deep organic soils.
ESSFmv3	00	TC	3	Timothy-Sedge-Herb meadow			Clumps of trees sometimes present.	Dominated by grasses, sedges and herbs.
ESSFmv3	00	VG	3	Sitka valerian-Arrow-leaved groundsel moist meadow.			Void of trees.	Very lush herb dominated sites.

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
ESSFmv3	00	WB	2	Willow-Birch sedge wetland	Se, PI		Scattered clumps of trees, often stunted	Wetland areas dominated by sedges, scrub birch and willow.
ESSFmv3	00	WF	3	Willow-Birch floodplain	Se, BI		Scattered trees.	Dense tall willow cover.
ESSFmv3	01	FR	2	BI-Rhododendron-Feathermoss	BI	Sx, PI	Variable conditions result in this plant association. Variations occur due to elevation differences and aspect.	Overall too rich, however, Cladina and Cladonia were noted as present in the plots.
ESSFmv3	02	LC	1	BIPI-Crowberry-Cladina	PI		Poor nutrient site. Frequent fire initiating events. Unlikely that stands become old/overmature. Lack of BI in the overstorey. Unfavorable conditions for arboreal lich.	Generally the site supports equal amounts of mosses and lichens. Moderate TL values.
ESSFmv3	02	LC w	3	BIPI-Crowberry-Cladina (warm aspect)	PI		Poor nutrient site. Frequent fire initiating events. Unlikely that stands become old/overmature. Lack of BI in the overstorey. Unfavorable conditions for arboreal lich. South-facing drier slopes.	Most often occurs on south-facing slopes on coarse soils. Moss and lichen less abundant than the LC.
ESSFmv3	02	LC x	1	BIPI-Crowberry-Cladina (drier average)	PI		Poor nutrient site. Frequent fire initiating events. Unlikely that stands become old/overmature. Lack of BI in the overstorey. Unfavorable conditions for arboreal lich..	Dry, poor nutrient site. Ground cover dominated by diverse lichen layer.
ESSFmv3	03	BT	2	BISb-Labrador tea	PI		Typically found near fringes of lakes and wetlands. Lodgepole pine dominates the overstorey with Sx and BI being present in the understorey.	Moss dominated site.
ESSFmv3	04	FO	2	BI-Oak fern-Knight's plume	BI, Se		Occurs on wet receiving sites. Rich site. Usually located in gullies or drainages. Ventilation may not be favourable to arboreal lichen dispersal and development.	Well-developed herb and shrub layers.
ESSFmv3	05	FD	2	BI-Devil's club-Rhododendron	BI, Se		Relatively open canopy. BI leading type may be conducive to arboreal lichen development. Plot data is limited for this Ecosystem.	Nutrient rich site.

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
ESSFmv3	07	FH	2	BI-Horsetail-Feather moss	BI		Dense BI canopy with open areas where the water table is close to the surface. Arboreal lichen likely present near these openings but overall not abundant.	High water table.
ESSFmv4	00	FW	3	BI-Rhododendron-Wildrye	PI, BI		Located in the upper to crest slope position. BI present in the mature stand and Old forest stage. Areas are rare and usually small in area.	Terrestrial lichens are generally absent from the understorey.
ESSFmv4	00	VH	3	Sitka valerian-Indian hellebore avalanche track.			Non-forested area.	Site is dominated by willows, cowparsnip, Sitka valerian., Indian hellebore.
ESSFmv4	00	FF	3	BI-Feathermoss avalanche track.			Non-forested site.	Terrestrial lichens are present but not the dominant species. The site is generally dominated by scrub birch, willow, and feathermosses.
ESSFmv4	00	WG	3	Willow-Groundsel shrub carr.			Non-forested site.	The site is dominated willows, scrub birch, arrow-leaved groundsel, cowparsnip, and tall bluebells.
ESSFmv4	00	BJ	3	Bluejoint-Avens high meadow			Non-forested site.	Imperfectly drained soils. Site is dominated by Bluejoint, arctic bluegrass, arrow-leaved groundsel, large-leaved avens.
ESSFmv4	00	ME	3	Horsetail-Giant water moss oxbow marsh			Non-forested site.	Poorly drained with hydric moisture regime. Dominated by horsetail, moss and sedges.
ESSFmv4	01	FR	2	BI-Rhododendron-Feathermoss	BI, Se		Very common and extensive throughout. BI is present in the mature canopy.	Understorey dominated by white rhododendron and feathermosses.
ESSFmv4	02	LC	3	BIPI-Crowberry-Cladina	PI, BI		Rare and usually small in area. Located on crest or upper slope position. Xeric to submesic moisture regime. Tree growth is probably poor.	Lichens present but not a dominant species. Site dominated by rhododendron, and black huckleberry.

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
ESSFmv4	03	BT	2	BISb-Labrador tea	PI, BI		Subxeric to subhygric moisture regime. Common and occasionally large in area. BI present in overstorey of mature stand.	Site is dominated by white rhododendron, Labrador tea, and feathermosses.
ESSFmv4	04	RH	2	BI-Rhododendron-Horsetail	BI, Se		Mid to toe slope position, these sites are common and usually small. BI present in the overstorey.	Site dominated by willows, black huckleberry and white flowered rhododendron.
ESSFmv4	05	FH	2	BI-Alder-Horsetail	Se, BI		Located on poorly drained sites. Uncommon and usually small in size. BI present in the overstorey.	Site is dominated by sitka alder, horsetail, and willow.
ESSFmvp3	06	FC	1	BI-Crowberry	BI	PI,Se	Stunted trees. Scattered distribution	Xeric to sub-xeric. Reindeer lichen abundant. High elevation above 1450m
ESSFmvp3	07	FV	3	BI-Valerian	BI		Widely spaced trees. Likely to a high percentage of live crown. Though BI leading, arboreal lichen not likely to be abundant.	Very lush herb layer.
ESSFmvp3	08	CF	1	Cryptogam-Altai fescue			Void of trees.	Steep, rubbly talus slopes at high elevation. Relatively unvegetated except for crustose lichens.
ESSFmvp3	09	CS	3	Cottongrass-Sphagnum wetland			Devoid of trees and tall shrubs.	Deep organic soils. Wet sites.
ESSFmvp3	00	FK	3	BI-Krummholz			Extremely stunted BI.	Dominated by Dense shrub layer.
ESSFmvp3	00	FW	3	Altai fescue-Dwarf willow			Generally void of trees, or trees stunted where present.	Abundant grasses and Stereocaulon tomentosum. Located on exposed ridges and hilltops.
ESSFmvp3	00	FW y	3	Altai fescue-Dwarf willow (moister than average).			Devoid of trees.	Receiving site supports vigorous growth of bluejoint, and other wet-site herbs. Green kidney, and reindeer lichen present.
ESSFmvp3	00	MH	3	Mountain heather-Leafy liverwort snow bed community.			Devoid of trees.	Heavy winter snow accumulations. Primarily a carpet of white mountain heather.

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
ESSFmvp3	00	VG	3	Sitka valerian-Arrow-leaved groundsel moist meadow.			Devoid of trees.	Subhygric sites with a well developed herb layer.
ESSFmvp4	00	SD	3	Sedge-Dwarf willow moist meadow.			Non-forested site.	Dominated by sedges, dwarf willows, shrub willows and sweet coltsfoot.
ESSFmvp4	00	AD	3	Mountain arnica-Subalpine daisy meadow			Non-forested site.	Site is dominated by arctic bluegrass, mountain sagewort, sitka valerian, and Indian hellebore.
ESSFmvp4	00	WA	3	Willow-Mountain arnica moist meadow			Generally a non-forested site with scattered stunted sub-alpine fir.	The site is dominated by willows, subalpine daisy, sitka valerian and arrow-leaved groundsel.
ESSFmvp4	00	AW	3	Mountain avens-Dwarf willow			Non-forested site.	Area is dominated by mountain-avens and dwarf willow.
ESSFmvp4	00	FL	1	Alpine fescue-Lichen dry meadow			Non-forested site.	Typically occurs on rapidly drained soils on gentle slopes. Terrestrial lichens are among the dominant species on these sites.
ESSFmvp4	00	FH	3	BI-Heather mesic krumholtz	BI*		* BI are extremely stunted.	Site is dominated by mountain sagewort, arctic bluegrass, and leafy liverworts.
ESSFmvp4	00	FR	2	BI-Rhododendron-Feathermoss	BI, Se		Very common and extensive throughout the landscape. Submesic to mesic moisture regime. BI present in the mature stand.	Understorey is dominated by white-flowered rhododendron, feathermoss.
ESSFmvp4	00	LC	1	BIPI-Crowberry-Cladina	BI, PI		BI present in the overstorey, however moisture regime is xeric to subxeric and tree growth is likely poor.	Understorey is dominated by white-flowered rhododendron, and crowberry. Lichens are present but not among the dominant species.
ESSFmvp4	00	BT	2	BISb-Labrador tea	BI, PI		This site is common and occasionally large and generally found on gentle north slopes. BI is present in the overstorey.	Lichen is present in the understorey however it is not among the dominant species.

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
ESSFmvp4	00	RH	2	BI-Rhododendron, Horsetail	BI, Se		These sites are located within the subhygic moisture regime and contain BI in the overstorey.	The understorey is dominated by white-flowered rhododendron.
ESSFmvp4	00	FW	2	BI-Rhododendron-Wildrye	PI, BI		BI present in the mature overstorey.	The understorey is dominated by white-flowered rhododendron, wild rye, and feathermosses. Terrestrial lichens are present but not among the dominant species.
SBSmk1	00	BS	3	Scrub birch-Sedge poor fen			Devoid of trees.	Wet sites dominated by scrub birch and willows.
SBSmk1	00	SF	3	Sedge-Fuzzy fen moss fen			Devoid of trees.	Dominated by sedges.
SBSmk1	00	SM	3	Sedge-Moss bog wetland			Devoid of trees.	Continuous moss cover present.
SBSmk1	00	TC	3	Timothy-Sedge herb meadow			Generally devoid of trees. (Some clumped trees).	Vegetated by low grasses, sedges and herbs.
SBSmk1	00	WB	3	Willow-Bluejoint floodplain			Devoid of trees.	Regular flooding occurs. Dominated by low willow.
SBSmk1	01	SB	3	Sxw-Black huckleberry-Highbush cranberry	PI,Sx	BI	PI dominated stands versus BI leading.	Moss layer present and abundant.
SBSmk1	03	LC	1	PI-Feathermoss-Cladina	PI		PI dominated.	Open stands with good visibility. Terrestrial lichen relatively abundant.
SBSmk1	05	ST	3	SxwFd-Toadflax	At, PI		Mature stands often dominated by lodgepole pine. Early successional stages are often dominated by aspen.	Dominated by shrubs and herbs.
SBSmk1	06	BH	3	Sb-Huckleberry-Spirea	PI	Sb	Relatively dense pine canopy.	Moss layer is well-developed. Red-stemmed feather moss being the most common.
SBSmk1	07	SO	2	Sxw-Oak fern	Se,BI	PI	BI leading stands likely support moderate to abundant arboreal lichen. Stand density varies within the site series. Understorey regeneration may lead to poor visibility.	Nutrient rich sites. Well-developed herb and moss layers.
SBSmk1	09	SH	3	Sxw-Horsetail	PI,Sx		Lack of BI in overstorey.	Water receiving sites (hygic).

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
SBSmk1	10	BB	3	Sb-Scrub birch-Sedge	Sb		Stunted trees, open canopy.	Sites dominated by sphagnum mosses. High water table present.
SWBmk1	00	VH	3	Sitka valerian-Indian hellebore avalanche track			Non-forested site.	Subhygric to hygric moisture. Well-developed shrub layer.
SWBmk1	00	WG	3	Willow-Groundsel shrub carr			Non-forested site.	Lower or depressional slope position. These sites are generally cold air drainage basins with mesic to hygric moisture regime.
SWBmk1	00	BJ	3	Bluejoint-Avens high meadow			Non-forested site.	Mesic to subhygric moisture regime. Dominated by herbs and mosses.
SWBmk1	00	FF	3	BI-Feathermoss avalanche track			Non-forested site.	Rapid to well-drained soils with a mesic to subxeric moisture regime. These sites are dominated by scrub birch, willows and feathermosses. Lichens are present but not abundant.
SWBmk1	00	WM	3	Scrub birch-Beaked sedge fen			Non-forested site.	Micro-relief is flat with organic surficial materials with hygric moisture regime.
SWBmk1	00	WP	3	Water sedge-Bristle stalked sedge perched fen			Non-forested site.	Areas are frequently flooded. Dominated by sedges and mosses.
SWBmk1	00	LG	3	Labrador tea-Glow moss sloping fen			Non-forested site.	Ground seepage is present and these sites are dominated by mosses, Labrador tea, scrub birch and bunch berry.
SWBmk1	01	SB	3	Sw-Grey-leaved willow-Scrub birch	Sw		Lack of BI in the overstorey.	Moderately well drained mesic site. Well-developed herb and shrub layer. Lichens present but not abundant.
SWBmk1	02	PL	1	Sw-Scrub birch-Cladina	PI, BI		BI in overstorey. Site is rapidly drained (very xeric to xeric). BI is likely to be smaller diameter trees. Arboreal lichen likely present but not abundant. Site is rare and generally small in size.	Dry, relatively poor site. Terrestrial lichens present but site is rare and generally small in size.

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
SWBmk1	03	SK	3	Sw-Juniper-Wildrye	Sw	PI	BI lacking in the overstorey.	Well-drained sites with a subxeric moisture regime. Understorey appears to be lacking lichen and is dominated by soopolallie, Labrador tea, juniper and mosses.
SWBmk1	04	SW	3	Sw-Artic lupine-Step moss	Sw,PI		BI lacking in the overstorey.	Well-drained site with a submesic to mesic moisture regime. The understorey is dominated by herbs and moss layer.
SWBmk1	05	SL	3	Sw-Willow-Crowberry	Sw	Sb,PI	BI lacking in the overstorey.	Imperfectly drained soils with a submesic to subhygric moisture regime. Shrubs and mosses dominate the understorey.
SWBmk1	06	SS	2	Sw-Willow-Step moss	Sw,BI		BI present in the overstorey. Site is fairly moist and relatively rich. Canopy closure unknown and ventilation could impact on lichen propagation.	Understorey layer is well developed and dominated by mosses.
SWBmk1	07	SC	2	Sw-Scrub birch-Bluejoint	Sw,Sb,BI		BI present in the overstorey as is Sw and Sb. BI leading stands are likely to be favorable for arboreal lichen development.	Understorey layer is well developed and dominated by mosses.
SWBmk1	08	SH	3	Sw-Shrubby cinquefoil-Horsetail	Sw		BI lacking in the overstorey.	Understorey is well developed and not favorable for terrestrial lichen development.
SWBmks	00	SD	3	Sedge-Dwarf willow moist meadow			Non-forested site.	Uncommon and small and dominated by sedges, willows, and coltsfoot.
SWBmks	00	AD	3	Mountain arnica-Sub-alpine daisy meadow.			Non-forested site.	Sub-alpine daisy, sitka valerian, and willows dominate this stand.
SWBmks	00	WA	3	Willow-Mountain arnica moist meadow			Non-forested site.	Shrub meadow dominated by willows, scrub birch, etc.
SWBmks	00	AW	1	Mountain avens-Dwarf willow			Non-forested site.	Rapidly to well drained sites with subxeric to submesic moisture regime. Dominant species are mountain avens, dwarf willows and scrub birch but lichens are present throughout.

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
SWBmks	00	SA	1	Scrub birch-Altai fescue			Non-forested site.	Soils are rapid to well drained with subxeric to mesic moisture regime. Small and rare. Areas are dominated by scrub birch, grasses and lichens.
SWBmks	00	HS	3	Horsetail-Sedge fen			Generally a non-forested site. Very scattered BI.	Dominated by scouring rushes, horsetail, dwarf willow and sedges.
SWBmks	00	SB	3	Sw-Grey-leaved willow-Scrub birch	BI		Clumpy distribution of BI? Trees may be stunted due to elevation and exposure? Arboreal lichens present?	Terrestrial lichen present but the site is generally dominated by willows and scrub birch.
SWBmks	00	PL	1	Sw-Scrub birch-Cladina	BI		Sites are rare and small in area. Quality of BI on these sites is unknown (stunted?)	Very xeric to xeric moisture regime. Dominated by scrub birch and lichens. Sites are small and rare.
SWBmks	00	SK	1	Sw-Juniper-Wildrye	BI		Sites are rare and small in area. Quality of BI on these sites is unknown (stunted?)	Subxeric moisture regime. Upper to crest slope position. Dominated by kinnikinnick, scrub birch, willows and lichen
SWBmks	00	SW	3	Sw-Artic lupin-Step moss	BI		BI in overstorey. Sites are common but small in size. Xeric to subxeric moisture regime. Unlikely that the BI are large.	Terrestrial lichens generally absent from these sites.
SWBmks	00	SL	2	Sw-Willow-Crowberry	BI		Submesic to subhygric moisture regime. Areas are common and occasionally large in size. BI present in the overstorey. Arboreal lichen likely present.	Well to imperfectly drained soils. These sites are generally dominated by willow, Labrador tea, scrub birch and feathermoss.
SWBmks	00	SS	3	Sw-Willow-Step moss	BI		Common and often small in area. BI present but likely scattered in distribution.	Terrestrial lichens generally absent. Site is dominated by willows, scrub birch, and step moss.
SWBmks	00	SC	3	Sw-Scrub birch-Bluejoint	BI		BI present in the overstorey. Sites are located on moderately well to imperfectly drained soils and are often small in area.	Subhygric site dominated by willow, scrub birch, and step moss.

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
SBSmk2		AA	3	Sx-Huckleberry-Soopolallie (SS); Sx-Huckleberry-Highbush Cranberry (SB)				
SBSmk2		BB	3	PI-Feathermoss-Cladina (LC); Sx-Huckleberry-Soopolallie (SS)				
SBSmk2		BH	1	Sb - Huckleberry - Soopolallie				
SBSmk2		IN	3	Inundated				
SBSmk2		LA	3	Lake				
SBSmk2		LC	1	PI-Feathermoss-Cladina				
SBSmk2		RI	3	River				
SBSmk2		RO	3	Rock Outcrop				
SBSmk2		SB	3	Sx-Huckleberry-Highbush Cranberry				
SBSmk2		SH	3	Sx-Horsetail				
SBSmk2		SO	2	Hyrid White Spruce-Oak Fern				
SBSmk2		SS	3	Sx-Huckleberry-Soopolallie				
SBSmk2		WL	3	Generalized Wetland				
SBSwk2		AA	3	PI-Huckleberry-Cladina (LH); Sx-Huckleberry-Highbush-Cranberry (SC)				
SBSwk2		BF	3	SbPI-Feathermoss				
SBSwk2		LA	3	Lake				
SBSwk2		LH	3	PI-Huckleberry-Cladina				
SBSwk2		RI	3	River				
SBSwk2		RO	3	Rock Outcrop				

BGC Zone, Subzone, Variant	Site Series	Site Map Code	HEWR Ranking	Plant Association	Primary Trees	Secondary Trees	Arboreal Comments	Terrestrial Comments
SBSwk2		SC	3	Sx-Huckleberry-Highbush-Cranberry				
SBSwk2		SD	2	Sx-Devil's Club				
SBSwk2		SH	3	Sx-Horsetail				
SBSwk2		SO	2	Sx-Oak Fern				
SBSwk2		WS	3	Willow-Sedge Fen				

APPENDIX A Legend

Fill Color	Description
	HEWR ranking consistent between old sub-model and revised sub-model classification.
	HEWR ranking that upon review of TEM projects, we classified differently than the original classification; however, upon comparison and further review we maintained a ranking consistent with the original classification. Note the "original classification" refers to an exercise completed by a panel of experts and is documented in the CHASE model report (McNay and Zimmerman, In Progress).
	HEWR ranking inconsistent between the original classification and this revised classification.
	BGC Zone/sub-zone's not available within the information from past TEM projects. The values listed are copied from the original classification and have not been re-assessed.