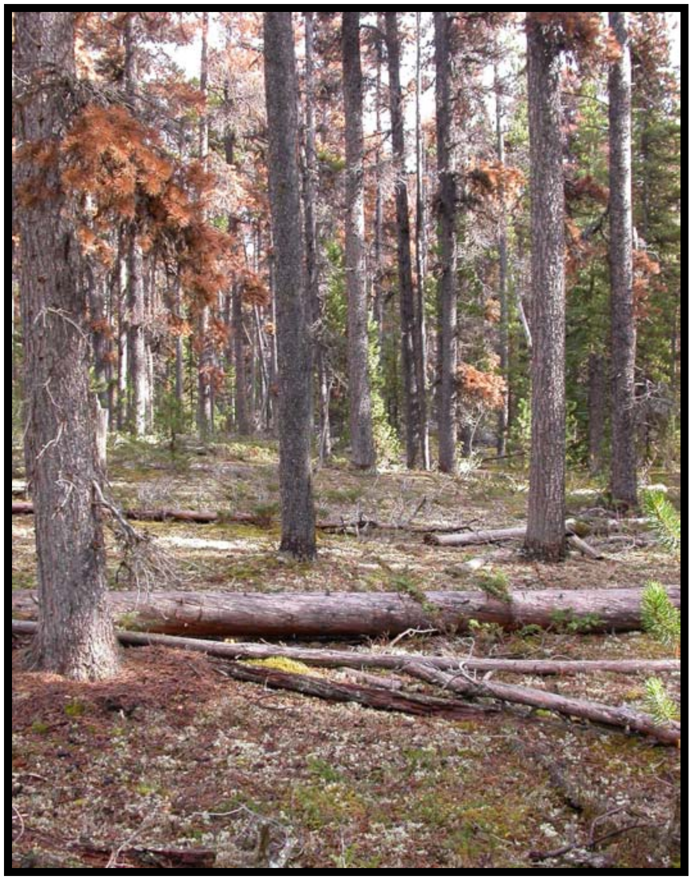
MOUNTAIN PINE BEETLE / LICHEN PROJECT QUESNEL TSA

YEAR 1 – 2005/06



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- Anne Macadam, Boreal Research and Development Ltd.; and,
- Adrian de Groot, Drosera Ecological Consulting.

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I would also like to thank Harold Armleder and Michaela Waterhouse of the Ministry of Forests in Williams Lake for loaning us the hoops and associated equipment, for providing us with datasheet templates and Ministry of Forests Research Installation signs, for providing initial training in using the hoop methodology, and for assisting with modifying the methods to accommodate the objectives of this project.

And, finally, I would like to thank John Youds with the Ministry of Environment in Williams Lake for providing us with vegetation maps (TEM, etc.), air photos, and for assisting with some of the fieldwork.

Table of Contents

List of Tables

List of Figures

INTRODUCTION

The Itcha-Ilgachuz caribou (*Rangifer tarandus caribou*) population winters in low elevation forested habitat east of the Itcha Mountains, and in high elevation subalpine habitat in the Ilgachuz Mountains. On the low elevation winter range, caribou select mature lodgepole pine (*Pinus contorta*) forests and forage primarily by cratering through the snow to obtain terrestrial lichens (Cichowski 1993). The recent mountain pine beetle (*Dendroctonus ponderosae*) outbreak has affected a large part of the Itcha-Ilgachuz caribou low elevation winter range. Preliminary results suggest that terrestrial forage lichen abundance has declined in the Tweedsmuir-Entiako caribou winter range with a corresponding increase in kinnikinnick (*Arctostaphylos uva-ursi*) (Williston and Cichowski 2004). This study was initiated in the Quesnel TSA in the northeastern most portion of the Itcha-Ilgachuz caribou winter range, to compliment lichen studies already being conducted in the southern and central portion of their winter range (Miege *et al*. 2001a, 2001b).

The objective of this project in 2005/06 was to establish permanent sampling plots in the Modified Harvest portion of the Itcha-Ilgachuz caribou winter range in the Quesnel TSA to monitor changes in terrestrial forage lichen abundance in response to the current mountain pine beetle epidemic.

STUDY AREA

The study area is located in west-central B.C., approximately 100 km west of Quesnel and lies in the Modified Harvest portion of the Itcha-Ilgachuz caribou winter range in the Quesnel TSA. The very dry, very cold subzone of the Montane Spruce (MSxv) biogeoclimatic zone covers most of the study area with the moist, cool subzone of the Sub-Boreal Pine Spruce (SBPSmk) at lower elevations. Lodgepole pine forests are the dominant forest cover in the area.

METHODS

Methods for the project follow those used in the southwestern and central part of the Itcha-Ilgachuz winter range (Miege *et al*. 2001a, 2001b, Smith and Puckett 1997). Methods are based on using a 2 m^2 aluminum hoop with an inlaid triangle and tape measure along one of the triangle sides.

SITE SELECTION

Sampling sites were selected using a combination of air photos, recent TEM mapping, and on ground inspections. In August 2005, potential terrestrial lichen sites were identified on the TEM map or identified while driving along the main 3900 Road and branch roads above 41 km. In addition, air photos were used to locate open pine forests near the road. Each site was then visited on the ground. Sites were selected based on the following criteria:

- proximity to the road;
- presence of terrestrial lichens in an area approximately 6 ha in size; and,
- presence of at least 50% red mountain pine beetle attack.

A sign was attached to a tree along the road near the centre of the site to indicate the presence of a research site.

PLOT SELECTION

Thirty plots were established on each site in a grid spaced 50 meters apart. The first transect was located at least 50 m away from the road, using a bearing that was parallel to the road. If terrestrial lichens were not present at a plot location, the plot was moved to capture terrestrial lichens. In some cases where terrestrial lichens were not present in a large area surrounding the potential plot, that plot location was skipped and the next plot was located another 50 meters along the transect. The 50m x 50 m grid was adjusted to fit the shape of the overall terrestrial lichen patch, such that transect lines were shortened in one direction when they moved out of terrestrial lichen bearing habitat and lengthened in the other direction to capture adequate terrestrial lichen habitat.

Each plot was marked with two blue permanent marker pins (rebar welded to a steel plate), which were labelled with the site, plot and pin number and put into the ground. A 1.5 m length of polypropylene rope was attached to each marker pin to ease the relocation of each plot. Every effort was made to ensure that the pin heads were flush with the ground to prevent accidental removal.

An aluminum anchor pin was placed over top the first permanent marker pin. The hoop was placed so that the corner with the multidirectional level was secured on the anchor pin. The hoop was oriented so that the left side of the triangle as observed from the first pin laid along the direction of travel from pin 1 to pin 2 (Figure 1). The third corner was oriented to the right of pin 1 and pin 2. A second blue permanent marker pin was placed at the other corner of the triangle along the direction of travel. The hoop was placed as closely online as possible with the middle of pin 2. Once the hoop was aligned, three aluminum rods were fixed into place at each point and were levelled accordingly before the readings were taken.

If there was an obstruction in the way of laying the hoop in a normal position, the hoop was rotated in a clockwise direction until it could be placed. The pin was rotated to avoid rocks and trees. The hoop was placed over slash, logs etc., but placing the hoop over trees greater than 2 m was avoided. Once the hoop was anchored, it was levelled using the appropriate size of aluminum rods.

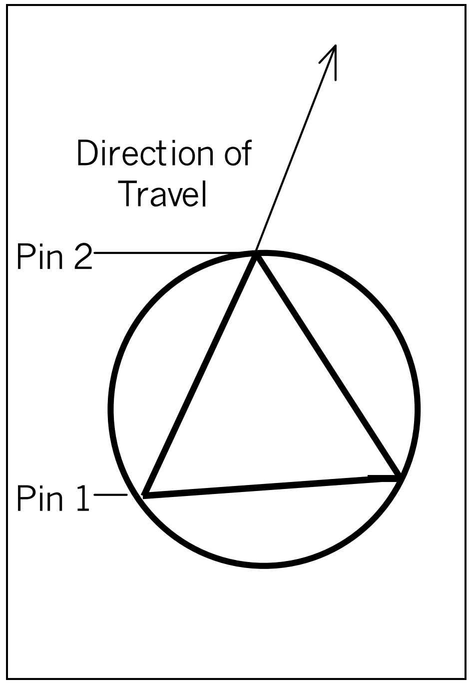


Figure 1. Hoop and plot layout.

PLOT DATA

General Site Information

The following site information was collected for each plot:

- date;
- plot number;
- GPS location (taken at Pin 1);
- slope (recorded only if slope exceeded 2%); and,
- aspect (for <2 degrees slope, aspect =999);

Photographs were also taken at one or more locations in each site to document stand and site characteristics. A digital photograph of each plot was taken obliquely from a height of approximately 1.5 m and a distance of approximately 80 cm back from the edge of the hoop and facing the lichen sampling line (Figure 2). The camera's widest angle setting was used (equivalent to 38 mm), and the entire hoop area included in the frame. Occasionally, because of the proximity of the hoop to a tree, the picture was taken from a slight angle relative to the sampling line, or two pictures were taken, one from either side of the tree. In the few cases where the hoop was located on a steep slope with the sampling line on the down-slope side, photos were taken from the usual side, facing the sampling line, and also from above, facing the back of the sampling line.

An elevation was recorded using the GPS unit at at least one of the plots. Where elevation was taken at more than one plot, the average elevation was used for site elevation.

Figure 2. Example of a plot photograph (Site 3, Plot 16).

Peg Map

The peg map was used to describe the orientation of the hoop at the plot. When the hoop was aligned normally along the direction of travel, the peg map was recorded as “Normal”. When the hoop was offset and/or rotated, the distance and direction of offset, and the direction of rotation was recorded and/or drawn.

Mesoslope Position and Shape

The mesoslope position was used to describe the position of the plot within a catchment area on a macroslope, and described topography affecting water flow with a vertical distance of between 3 and 300 m. Mesoslope shape described the general shape of the mesoslope position and included: convex; concave; straight; or hummocky. Mesoslope positions included:

- Crest (C) - uppermost portion of a hill, generally convex in all directions with no distinct aspect;
- Upper Slope (US) - generally convex upper portion of a hill immediately below the crest having a specific aspect;

- Mid Slope (MD) - area between the upper and lower slope, usually straight or sigmoid shape with a specific aspect;
- Lower Slope (LO) - area towards the base of the slope of a hill, usually concave with a specific aspect;
- Toe (T) - area separated from the lower slope by an abrupt decrease in slope gradient, often the site of seepage;
- Depression (DP) - area that is concave in all directions, generally located in a level area or at the base of the slope or toe, with no aspect; and,
- Level (LV) - generally horizontal surface with no specific aspect.

Microslope Position and Shape

The microslope position was used to describe the position of the area immediately around the plot with a vertical distance of usually less than 3 m. If more than one microslope position was encountered in the plot, the dominant position was recorded. Microslope shape described the general shape of the microslope position and included: convex; concave; or, straight. Microslope positions included:

- High Crest (CH) - generally a steep mound that is convex in all directions with no distinct aspect;
- Low Crest (LC) - a shallower mound also convex in all directions and lacking a distinct aspect;
- Mid Slope (MD) - the area between the crest and lower slope generally straight with a distinct aspect;
- Low Slope (LO) - area towards the base of the slope, generally concave in shape;
- Depression (DP) - any area that is concave in all directions, usually positioned at the base or toe of a slope or on a level area, with no aspect; and,
- Level (LV) - generally horizontal surface with a straight shape.

Moisture Regime

Moisture regime was determined based on type of vegetation, humus depth, soil texture, slope gradient, drainage, mesoslope, microslope and biogeoclimatic classification, with slope position as the most influential factor. Moisture regime was categorized as one of the following 9 classes:

- 0: very xeric;
- 1: xeric;
- 2: subxeric;
- 3: submesic;
- 4: mesic;
- 5: subhygric;
- 6: hygric;
- 7: subhydric; or,
- 8: hydric.

Drainage

Drainage was used to describe the relative amount of water flowing through the site. Drainage was determined based on type of vegetation, soil texture, slope gradient, drainage, mesoslope, microslope, and the amount of water flowing into and out of the site. Drainage was categorized as one of the following classes:

- rapidly drained (RD) - water removed rapidly compared to the supply; soils usually coarse;
- well drained (WD) - water removed readily but not rapidly compared to the supply; soils usually have an intermediate texture;
- moderately well drained (MWD) - water removed slower than the supply; soils range from medium to fine in texture;
- imperfectly drained (ID) - water removed sufficiently slow keeping the soil wet for a significant part of the growing season; a wide range of soil textures possible;
- poorly drained (PD) - water removed so slow the soil remains wet for a large part of the time the soil is not frozen; a wide range of soil textures possible; and,
- very poorly drained (VPD) - the water table remaining at or on the surface; a wide range of soil textures possible.

Soil texture

Soil texture was sampled outside of the plot at a depth of 10-cm depth in all but a few cases (Figure 3). Soils were sampled for texturing at 5 cm only in rare cases where there was either free water or an excessively high coarse fragment content at 10 cm. Soil texture was classified into the following categories:

- sand (S);
- loamy sand (LS);
- sandy loam (SL);
- loam (L); and,
- silty loam (SiL),

Where fine sandy soils with low coarse fragment contents were observed, they were designated with a lower case “f” prefix (e.g., fS, fLS, fSL), denoting a soil particle size distribution dominated by sand-sized particles < 0.25 mm in diameter.

Humus

Humus was classified a Mor or Moder for each plot. Humus depth was measured at three locations approximately 10 cm away from the outside edge of the hoop. In most cases, measurements were made opposite each of the three apices of the triangle. This location was less often disturbed (compressed) by crew members during the positioning of the hoop and other sampling procedures, than were points at the corners of the triangle. Where the usual sampling location had been disturbed, was occupied by a stone or piece of wood, or was not representative of the types of surface substrate observed within the plot, the closest acceptable location was used.

Figure 3. Soil texture samples.

Where there was a thick layer of erectly-oriented moss cover, humus depth was measured from the mineral soil- forest floor interface only up to the base of the green portion of the moss. In the absence of moss cover, fresh needle and fine woody litter were not included in the humus depth – only that material between the mineral soil interface and the top of dark-coloured, partially decomposed litter was measured.

Vegetation Cover

Percent cover was determined to the nearest 1% for each vascular plant species within the hoop area and for the following categories of vascular plants:

- shrubs (e.g. juniper, soopolallie, rose, willow);
- dwarft shrubs (e.g. crowberry, grouseberry, kinnikinnick, twinflower);
- herbs (e.g. sedges, grasses, fireweed);
- regeneration (<1.3 m); and,
- poles (>1.3 m).

If only one or two small representatives of a species was located within the hoop, the percent cover was recorded as 0.1% or 0.2% respectively. Percent cover less than 1% but consisting of more than 2 small individuals was recorded as 0.5%.

Average height for each category within the hoop was also recorded. Where heights varied drastically, the height of the individual giving the majority of cover was recorded.

Percent cover of poles >1.3 m originating outside of the hoop, but providing cover over the hoop was measured using a moosehorn over pin 1 (Figure 4). The moosehorn measurement was taken at 1.5 meters above the ground, facing the lichen transect line. Where branches of trees from outside the plot were less than 1.5 meters above the ground, the percent cover of those branches was also determined. In addition, average height of poles originating outside the plot was recorded.

Figure 4. Moosehorn measurement of canopy cover over the plot.

Plot Disturbance/Windthrow

Type and percent cover of disturbance and windthrow was recorded for each plot. Disturbance type was categorized as:

- wildlife trampling/feeding (W);
- human disturbance (H);
- frost (F); and,
- water erosion (E).

Regeneration

The number of stems that occurred within the hoop was recorded by substrate (humus vs. mineral/mixed soil) for each of the following categories of regeneration:

- lodgepole pine <1 year in age;
- lodgepole pine >1 year in age but <10 cm in height;
- lodgepole pine >10 cm in height;
- hybrid spruce <1 year in age;
- hybrid spruce >1 year in age but <10 cm in height; and,
- hybrid spruce >10 cm in height.

Cones

Cones found in the plot were counted and classified into the following categories:

- lodgepole pine new cones - closed;
- lodgepole pine new cones – open;
- lodgepole pine new cones – partly open;
- lodgepole pine old cones - closed;
- lodgepole pine old cones – open;
- lodgepole pine old cones – partly open;
- hybrid spruce new cones - closed;
- hybrid spruce new cones – open;
- hybrid spruce new cones – partly open;
- hybrid spruce old cones - closed;
- hybrid spruce old cones – open; and,
- hybrid spruce old cones – partly open.

New cones were those that were greater than 50% tan in colour. Old cones were those greater than 50% grey in colour. A cone was considered closed if less than 1/3 of the scale bonds had opened. A cone was classified as open if more than 2/3 of the scale bonds were broken. A partially open cone had greater than 1/3 of the bonds broken, but less than 2/3 broken. Cones with greater than 1/3 of its scales missing were not recorded. Cones positioned underneath the hoop edge were recorded if more then half of it was in the hoop.

Pellet Groups

The number of pellet groups within each plot was recorded for the following species:

- moose;

- caribou;
- deer;
- grouse; and,
- hare.

Once pellet groups were counted, they were removed from the plot to avoid counting them again in subsequent years.

Line Intercept

A line intercept method was used to quantify the substrate and lichen. The intercept was performed along the measurement bar along the side of the triangle opposite the first permanent marker pin. This side was chosen to avoid trampling that may have occurred along the direction of travel while the grid was being established. The intercept was read from right to left, along the outside edge of the triangle. An adjustable T-square was used so the observer could look directly over the area to be measured. The T-square was moved along the back side of the measurement bar (Figure 5).

Figure 5. Line intercept measurement of substrate, lichens and mosses.

The intercept was used to measure substrate as well as lichen and mosses for a total length of 130 cm. Intercept data was recorded using the start and finish of the substrate/lichen sample rounded to the nearest half centimeter (i.e., 5 - 7.5 cm) and was recorded for intercept lengths of .5 cm and greater. Vegetation categories were classified as normal, sickly, and dead.

Substrate was divided into five categories:

- mineral soil - exposed mineral soil;
- humus - all humus and fine litter (less than 1 cm in diameter);
- mixed - a mixture of humus and mineral soil;
- rock - rock intercepting more than 1 cm of the line;
- medium litter (>1 cm but <7.5 cm in diameter at the point of intercept); and,
- coarse litter (>7.5 cm in diameter at the point of intercept).

Litter included branches, twigs and undecomposed cones. Substrate that was completely covered by vegetation and could not be seen was considered humus.

Lichens and mosses were measured along the intercept for intercepts for the following categories:

- boreal feathermosses;
- *Dicranum* sp.;
- other mosses;
- *Cladonia gracilis/C. phyllophora*;
- *Cladonia cornuta*;
- *Cladonia ecmocyna*;
- *Cladonia crispata*;
- *Cladonia unicialis*;
- *Cladonia* spp.;
- *Cladina mitis*;
- *Cladina rangiferina*;
- *Cladina stellaris*;
- *Cladina* spp.;
- *Peltigera apthosa/P. leucophlebia*;
- *Peltigera* spp.;
- *Stereocaulon* spp.;
- *Cetraria* spp.;
- Other terrestrial lichens.

In addition, intercepts were recorded for kinnikinnick and twinflower (*Linnaea borealis*).

Arboreal Lichen Samples

The three trees closest to the first pin with a diameter at breast height (dbh) greater than 10 cm were assessed for the abundance of the arboreal lichens (*Bryoria spp., Alectoria spp*.). Each of the three trees was painted with the numbers 1, 2, or 3 for easier identification in the future (Figure 6). The following information was collected for each tree:

- species;
- dbh (cm);
- distance from Pin 1 to the sample tree (m);

- bearing from Pin 1 to the sample tree;
- lichen class (based on the total amount of lichen below 4.5 m according to Armleder *et al*. 1992 - Land Management Handbook Field Guide Insert No. 7. Estimating the Abundance of Arboreal Forage Lichens);
- *Parmeliopsis* height (cm) (as an indicator of snow depth) measured from the ground to the top of the majority of the *Parmeliopsis*); and,
- tree status:
    - alive;
    - mountain pine beetle – green attack;
    - mountain pine beetle – red attack;
    - mountain pine beetle – red/grey attack;
    - mountain pine beetle – grey; and,
    - dead (not due to mountain pine beetle attack).

At least one of the trees used for arboreal lichen abundance was aged at each site. A codominant tree was selected and whenever possible, a green attack or a live tree was used. At some sites, an appropriate tree was selected that was not one of the three trees selected for measuring arboreal lichen abundance.

Figure 6. Marking arboreal lichen sample trees.

RESULTS AND DISCUSSION

SITE SELECTION

In August 2005, 20 potential sites were scouted for the project. Of those 20 sites, 8 were considered high priority sites with good levels of terrestrial lichen abundance and mountain pine beetle attack, and 6 were considered moderate priority sites due to lower levels of terrestrial lichen abundance. The other 6 sites were considered marginal for conducting the project.

In October 2006, 6 sites were established with 30 plots, and 1 site was established with 15 plots (Site 7). The other 15 plots on Site 7 were not established due to onset of a heavy snowfall, but will be completed in 2006. The 7 sites were distributed across the study area with 4 plots located along the 3900 Road (Sites 1, 2, 4 and 6), one plot located along the 6800 Road (Plot 3), 1 plot located along the 6500 Road (Plot 5), and 1 plot located along the 64A Road (Plot 7) (Figures 7 and 8). Appendix 1 contains basic information about site layout and plot orientation at each site.

GENERAL SITE CHARACTERISTICS

Methods from Miege *et al*. (2001a, 2001b) and Smith and Puckett (1997) were modified to ensure that lichens occurred along the hoop's lichen line. Therefore, average characteristics of the plots at each site were not necessarily representative of the average conditions on the site, rather they were representative of the average conditions of the plots that were established on the site.

Mesoslope and microslope positions were generally level for Sites 1, 2 and 7 and ranged from level to crest for the other four sites, while mesoslope and microslope shape were predominantly straight for all 7 sites (Figures 9, 10). Site 3 contained glacial features such as kames providing some diversity to the landscape. Site 4 was located on a gentle to moderate slope with the greatest number of plots on midslope positions. Most sites contained some relief either as hummocky features or terraces over parts of the site.

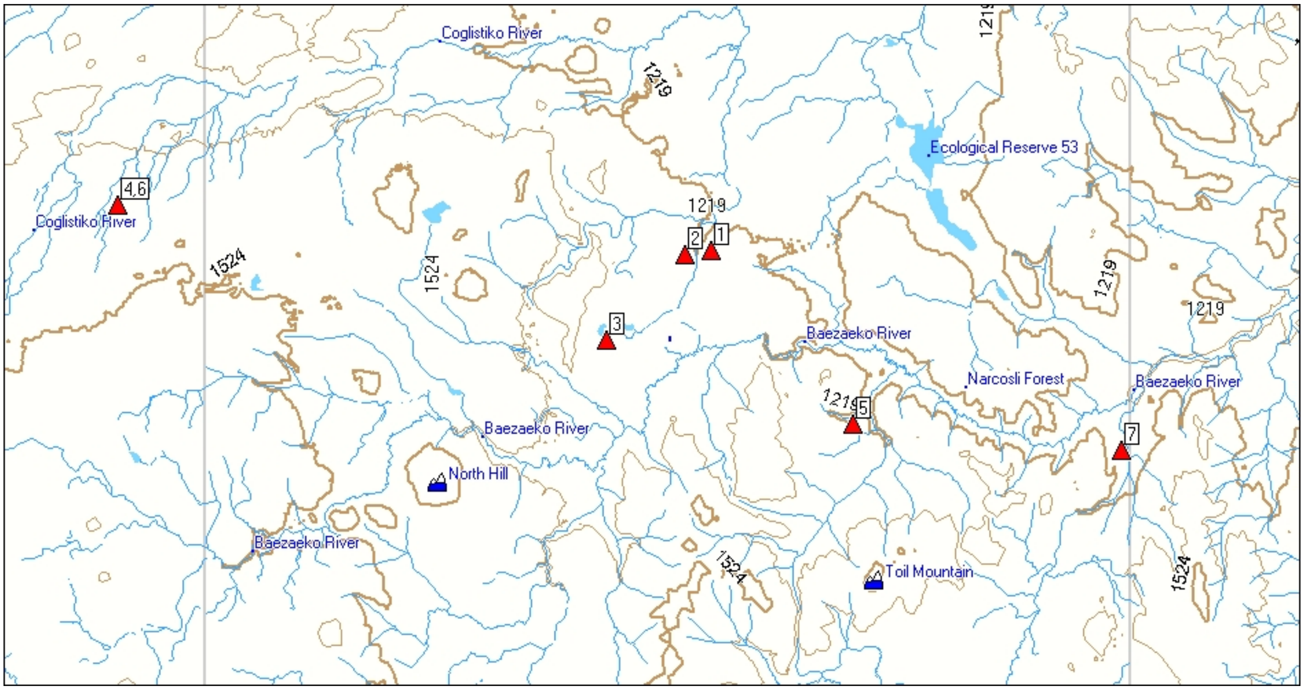


Figure 7. Location of sites in the study area.

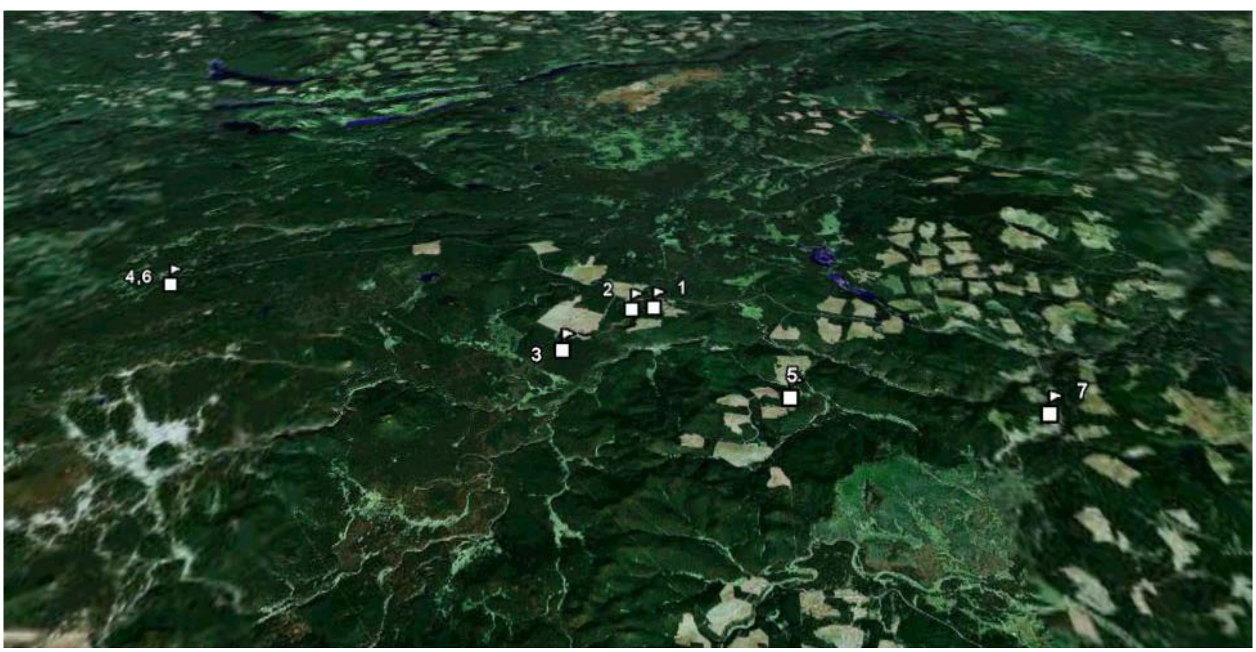
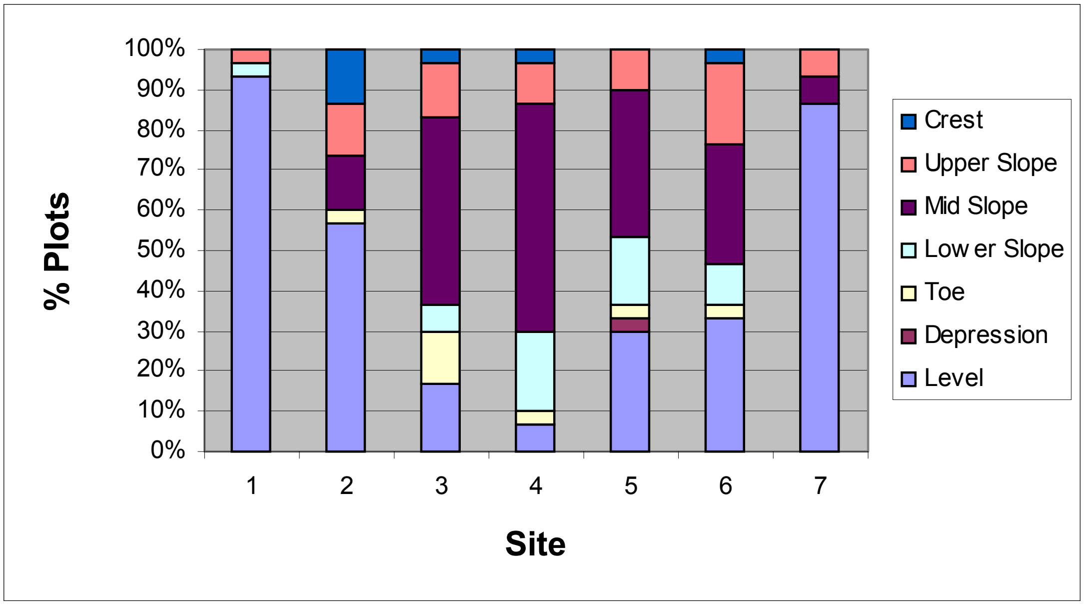


Figure 8. Location of sites on the landscape.



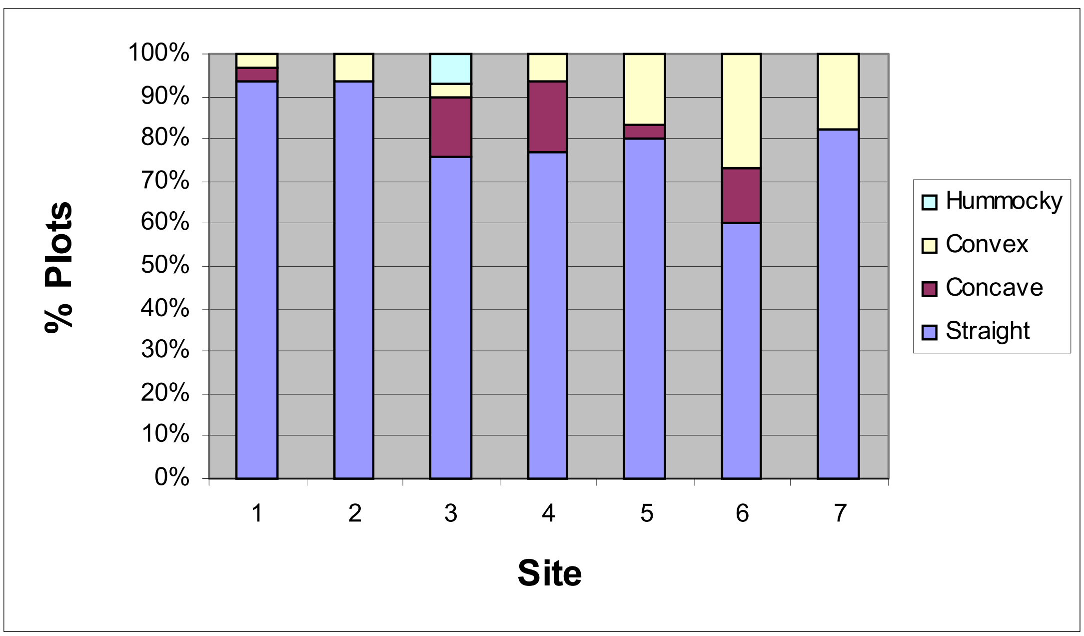
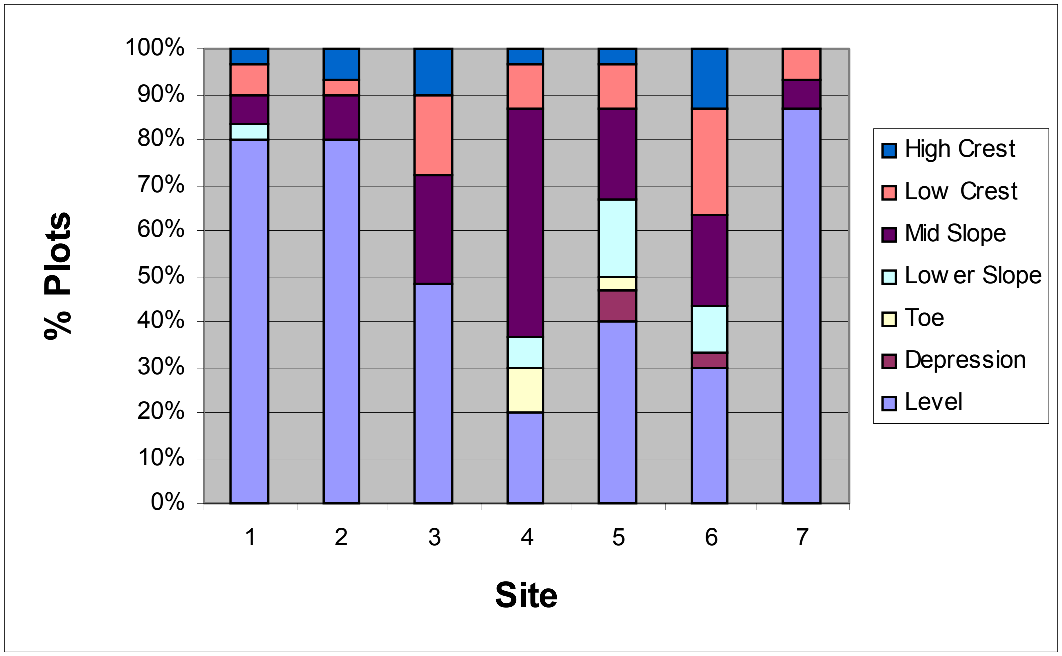


Figure 9. Mesoslope position and shape at 7 study sites in the Modified Harvest Zone in the Quesnel TSA.



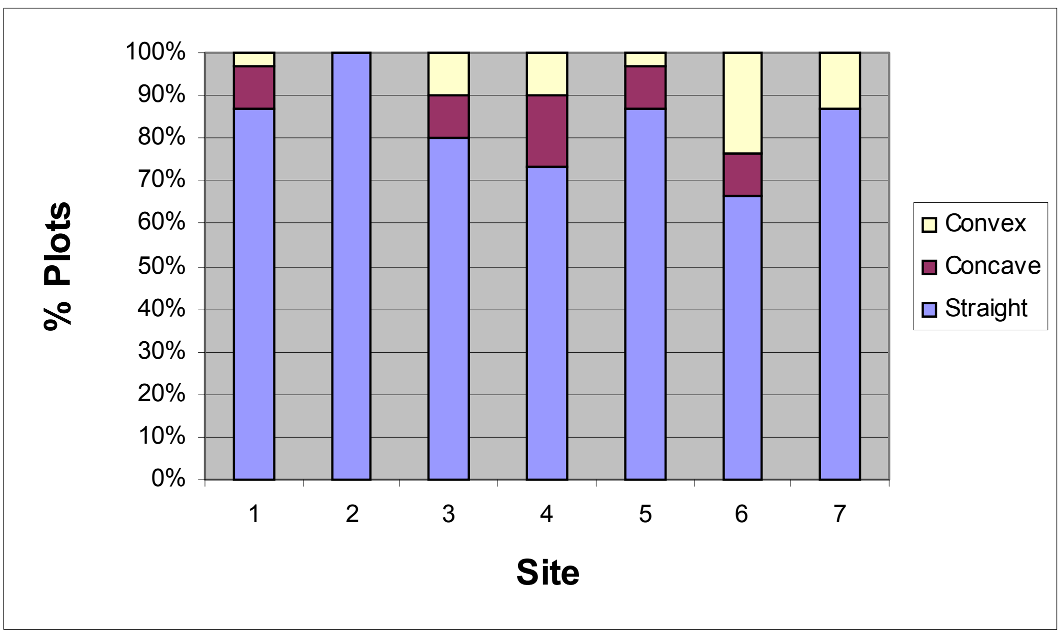


Figure 10. Microslope position and shape at 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

Table 1 shows general site characteristics for the 7 sites established in October 2005. Elevation ranged from 1175 meters at Site 7 to 1424 meters at Site 4. Age ranged from 91 years on Site 7 to 278 years on Site 3. Site 3 contained the largest, oldest trees, while Site 7 contained the youngest, smallest trees.

Table 1. General characteristics of 7 study sites established in the Modified Harvest Zone in the Quesnel TSA, October 2005.

Site	N	Elevation (m)	Age (years)	Average DBH[1] (cm)	Average % Canopy cover (moosehorn)	Average Parmeliopsis height (cm)
1	30	1234	154	16.3	27.5	7.6
2	30	1263	122	16.5	38.0	7.4
3	30	1352	278	20.8	30.0	12.0
4	30	1424	94	15.9	39.3	13.1
5	30	1237	135	15.6	24.1	16.5
6	30	1375	92	18.3	23.4	7.1
7	15	1175	91	14.9	23.7	8.8

[1] DBH based on trees with a diameter of 10 cm or greater

On average, although trees on Site 6 were larger than trees on nearby Site 4, their ages were similar (Table 1). Site 6 also had a more open canopy structure than Site 6. Soils on Site 6 were finer and contained fewer coarse fragments (see Soils) than Site 4, which may contribute to the differences between stand characteristics.

Snow depth, using *Parmeliopsis* height as an indicator, was variable across the sites (Table 1). In general, height was greater for higher elevation sites (Plots 3, 4) than for lower elevation sites (Plots 1, 2, 7). However, *Parmeliopsis* height was also high for Site 5 (lower elevation site) and low for Site 6 (higher elevation site). On Site 6, the low *Parmeliopsis* height may have been due to a combination of larger tree canopies for individual trees, reducing snow accumulation near the bole, and low stand density increasing insolation, which may have contributed to earlier snow melt. It is unclear why *Parmeliopsis* height was highest on Site 5.

MOUNTAIN PINE BEETLE ATTACK

All sites, except Site 4, were made up of stands with over 50% mountain pine beetle attack (Figure 11). Site 4 consisted of just under 45% mountain pine beetle attack. Mountain pine beetle attack on Sites 2, 3, 5 and 7 consisted of primarily red attack, while mountain pine beetle attack on the other three sites was made up of predominantly green attack. Two of those sites (Sites 4, 6) were the highest elevation sites in the study area and were geographically closer to the Itcha Mountains than the other sites.

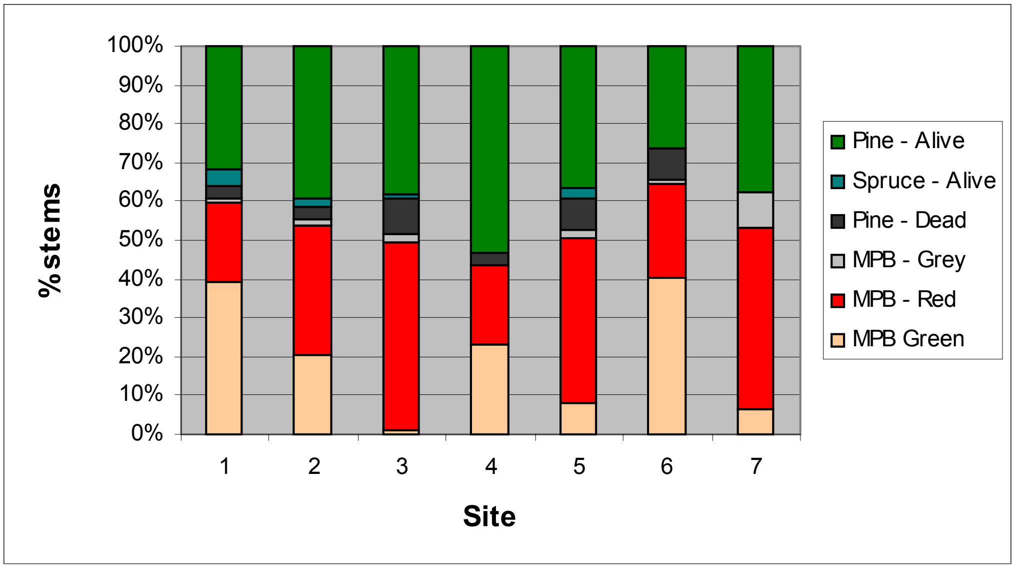


Figure 11. Status of mountain pine beetle attack at 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

Data collected on mountain pine beetle status represents the status of the sites in 2005 and may not necessarily represent the total extent of mountain pine beetle attack at the conclusion of the outbreak. Additional mountain pine beetle attack will likely occur since up to 50% of the stands still consist of live lodgepole pine trees. Mountain pine beetle status will continue to be monitored throughout the life of the study.

SOILS

Of the seven sites that were sampled, all but Site 5 had predominantly very coarse-textured soils. Sites 1, 2, 3, 4, and 6 were most often sand to loamy sand in texture, usually with a high coarse fragment content (Figure 12). On those sites, the few plots with textures classified as sandy loam tended to be low in clay content (<5%), and were often borderline between sandy loam and loamy sand. Site 6 was distinct from the others in that group in that fine sandy soils with low coarse fragment contents were observed at several, though not all, of the plots. Those were designated with a lower case "f" prefix (e.g., fS, fLS, fSL), denoting a soil particle size distribution dominated by sand-sized particles < 0.25 mm in diameter. Many of the plots at Site 6 had particularly thin forest floors. Soils at Site 7 were also relatively coarse in texture, but sandy loams were observed somewhat more frequently than at the other 5 sites.

The finest soil textures were observed at Site 5, which included several plots whose soils ranged from sandy loam to silt loam and loam in texture, often with very low coarse fragment contents. The clay content of those soils was significantly higher than what was observed at any of the other sites.

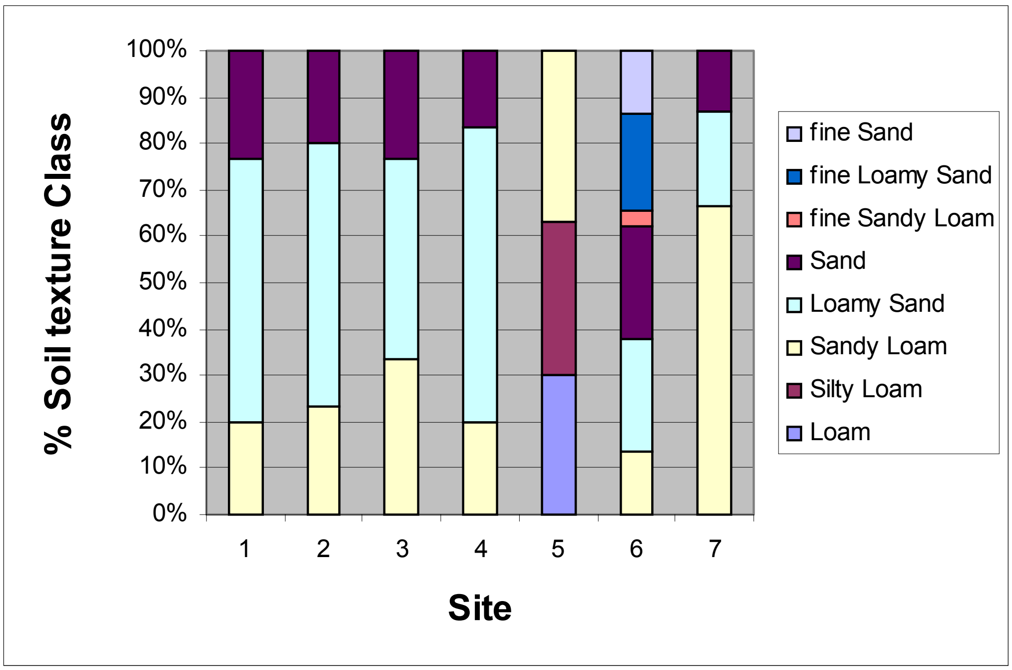


Figure 12. Soil texture at 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

Humus depth was greatest on Sites 4, 5 and 7 and lowest on Site 6 (Figure 13). Site 6 had generally thin forest floors, likely associated with a severe burn. Humus form for all plots on all sites was Mor. Moisture Regime was generally subxeric with primarily rapidly drained soils for all sites except Site 5 (Figures 14, 15). Site 5 contained primarily well drained to imperfectly drained soils with a submesic moisture regime.

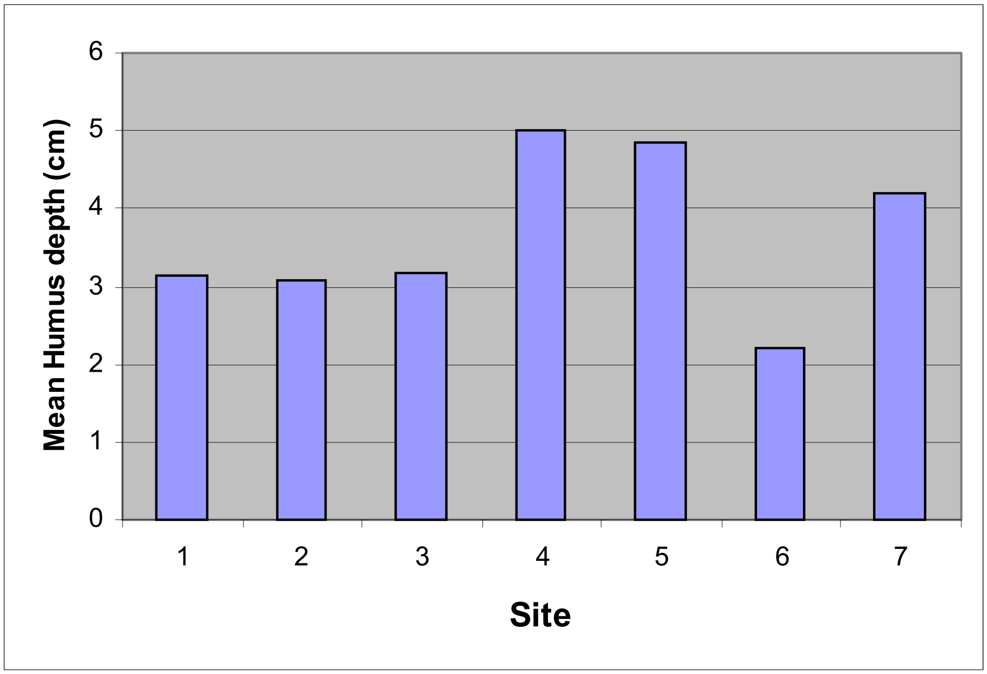


Figure 13. Mean humus depth at 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

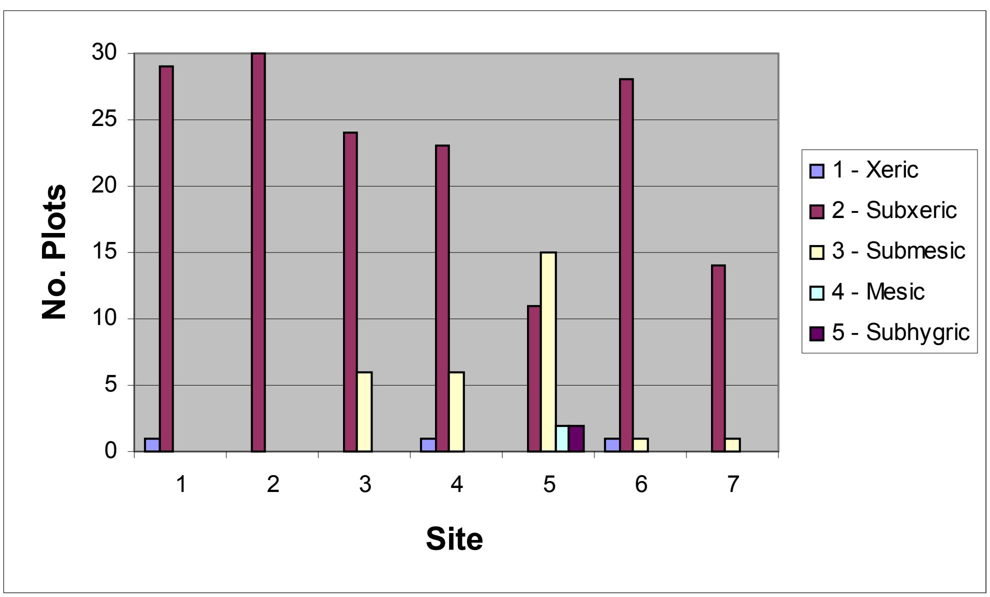


Figure 14. Moisture Regime at 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

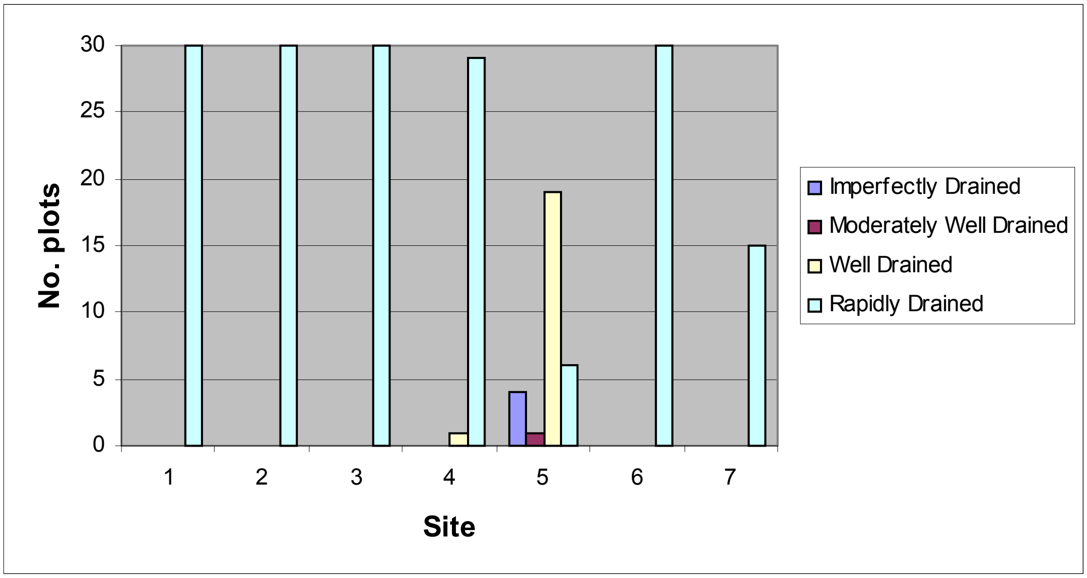


Figure 15. Drainage characteristics of 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

For future studies of this type, it is recommended that estimates of soil coarse fragment content be included in assessments to better characterize differences in soil properties between sites. Knowing only the soil textural class information can be misleading when comparing sites with widely varying coarse fragment contents. Rooting zone particle size classes, as described in Land Management Handbook No. 25 (Field manual for describing terrestrial ecosystems), are a convenient way to integrate information about both soil texture and coarse fragment content, and would likely provide a sufficient level of precision for this type of study. The system uses a smaller number of categories for particle size distribution within the < 2 mm fraction (i.e., sandy, coarse loamy, fine loamy, coarse silty, etc.), but provides a "skeletal" modifier for soils with ≥ 35% coarse fragments, as well as a "fragmental" category for soils with ≥ 70% coarse fragments.

VEGETATION COVER

Shrubs and dwarf shrubs were the dominant vegetation cover on all 7 sites (Figure 16). Herbaceous vegetation, although low on all sites, was most abundant on Site 5, the site with higher soil moisture, poorer drainage, finer textured soils and lower coarse fragment content than the other 6 sites. Site 5 also contained the lowest percent cover of shrubs and dwarf shrubs combined. Site 4 contained almost no shrubs and a high level of dwarf shrubs (Figure 16). This reflected the lack of juniper (*Juniperus communis*) and soopolallie (*Shepherdia canadensis*) and predominance of twinflower (*Linnaea borealis*) and crowberry (*Empetrum nigrum*) on this site (Figure 17).

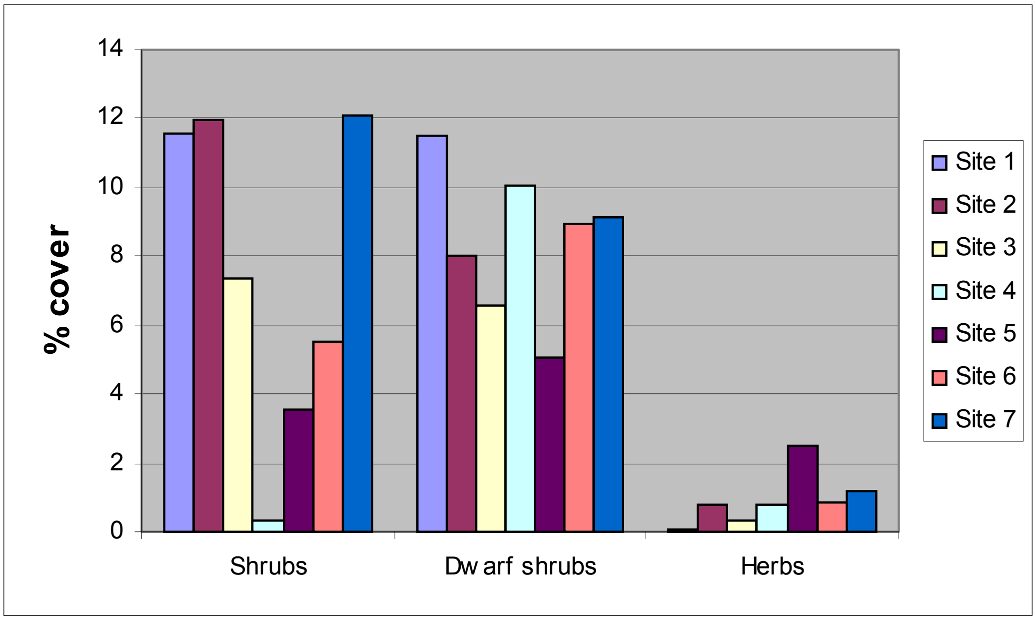


Figure 16. Average percent cover of shrubs, dwarf shrubs and herbs in 2 m^2 plots on 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

Kinnikinnick, juniper, soopolallie and twinflower were the dominant vascular plant species on most sites (Figure 17). Crowberry and *Vaccinum scoparium* were also present in moderate abundance on Sites 3, 4 and 6, the highest elevation sites. Bunchberry (*Cornus canadensis*) was also moderately abundant on Site 5 (Figure 16). All other shrubs and herbs averaged less than 1% cover on all sites (Figures 18, 19). The greatest abundance and diversity of herbs occurred on Site 5 (Figures 16, 17, 18).

Percent cover of conifer regeneration was greatest on Sites 1, 6 and 7 (Figure 20). Most regeneration was less than 1.3 meters in height. This could partially be a result of the methods as the hoop was positioned to avoid large trees and poles greater than 2 meters in height.

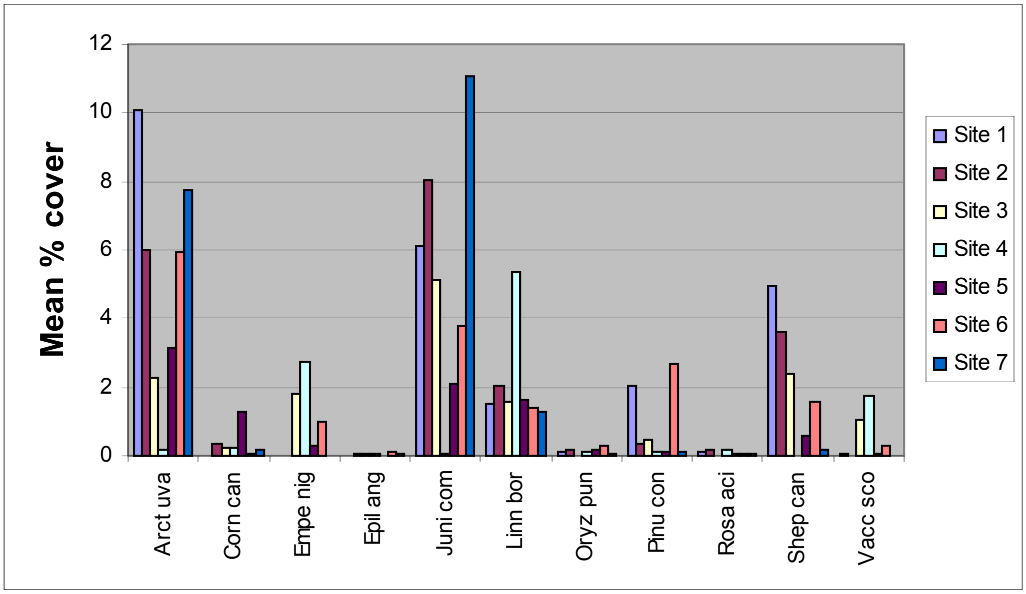


Figure 17. Average percent cover of vascular plant species in 2 m^2 plots contained on at least 4 of the 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

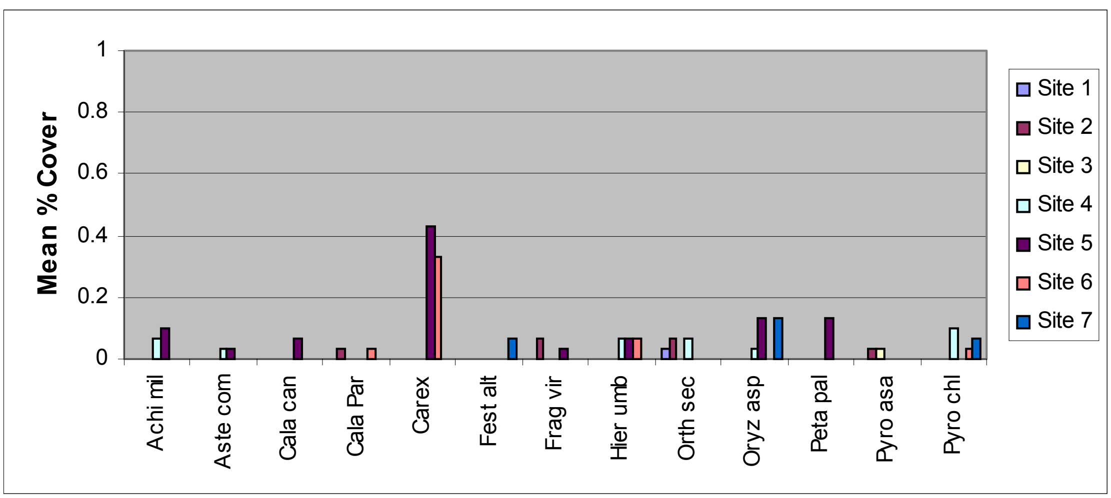


Figure 18. Average percent cover of other herbs in 2 m^2 plots contained on the 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

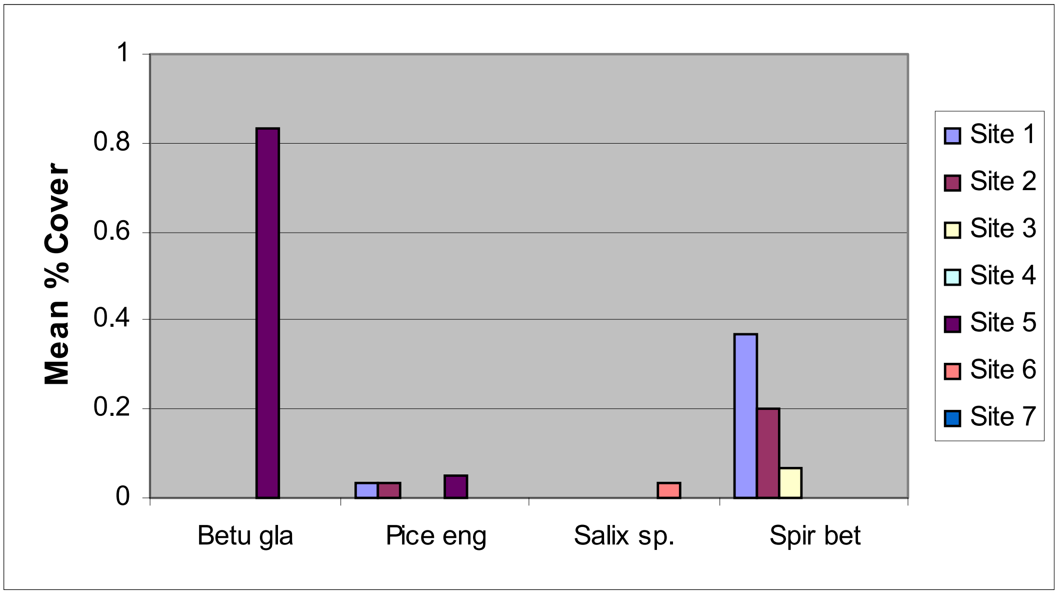


Figure 19. Average percent cover of other shrubs in 2 m² plots on the 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

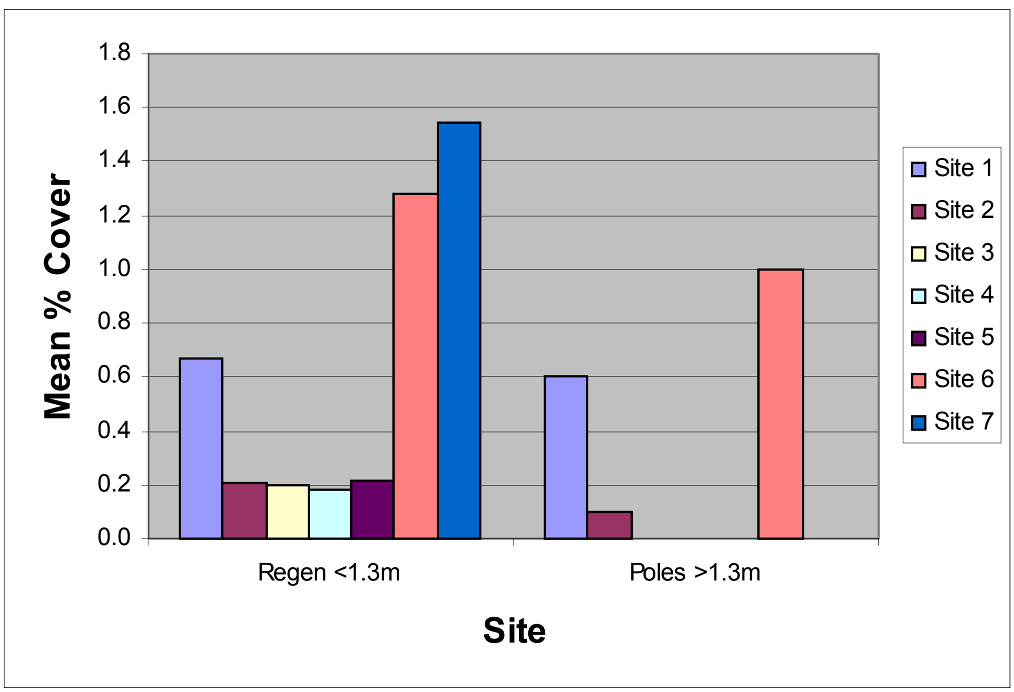


Figure 20. Average percent cover of regeneration in 2 m² plots on the 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

REGENERATION

Pine seedlings accounted for the majority of regeneration on the 7 study sites (Figure 21). Regeneration was predominantly made up of pine seedlings less than 10 cm in height but greater than 1 year in age. Site 6 contained the highest abundance of seedlings with pine seedlings greater than 1 year and less that 10 cm in height contributing over 18 000 stems/ha. Site 6 was the most open of all 7 sites with the thinnest forest floors. Sites 2, 3 and 4 contained the fewest seedlings; however, total regeneration still exceeded 1300 stems/ha. Spruce seedlings were found on Sites 2 and 6 and contributed significantly to regeneration on Site 5 (less well drained and finer soils). The majority of seedlings were growing on humus substrate, and most seedlings were of an acceptable quality (Figure 22, Table 2).

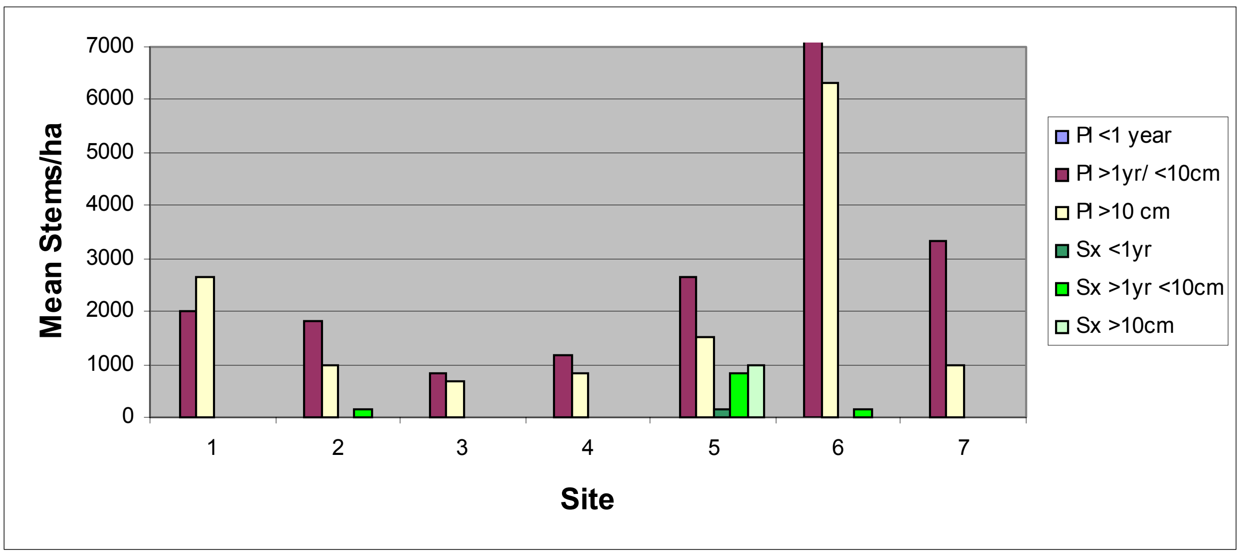


Figure 21. Average stems/ha of regeneration in 2 m^2 plots on 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

CONES

The majority of cones on all sites were old closed lodgepole pine cones (Figure 23). New partly open lodgepole pine cones were less abundant and old open lodgepole pine cones were even less abundant. Other cone classes occurred rarely.

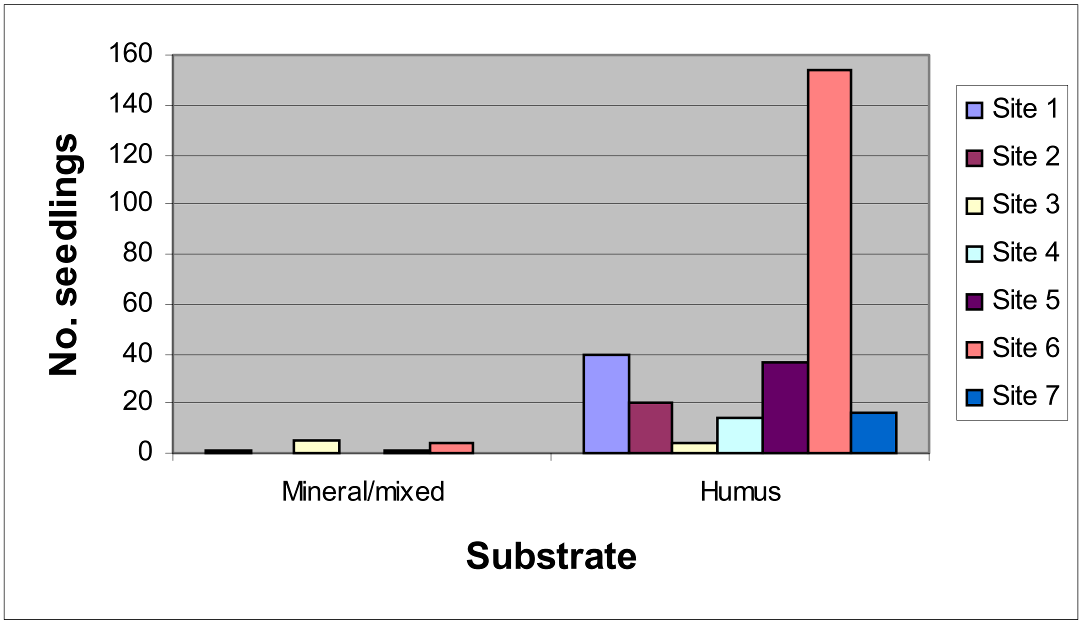


Figure 22. Number of seedling on mineral/mixed and humus substrate in 2 m^2 plots on 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

Table 2. Number of acceptable and unacceptable seedlings on the 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

Site	Acceptable	Unacceptable
1	28	13
2	18	2
3	9	0
4	12	2
5	37	0
6	158	0
7	13	3

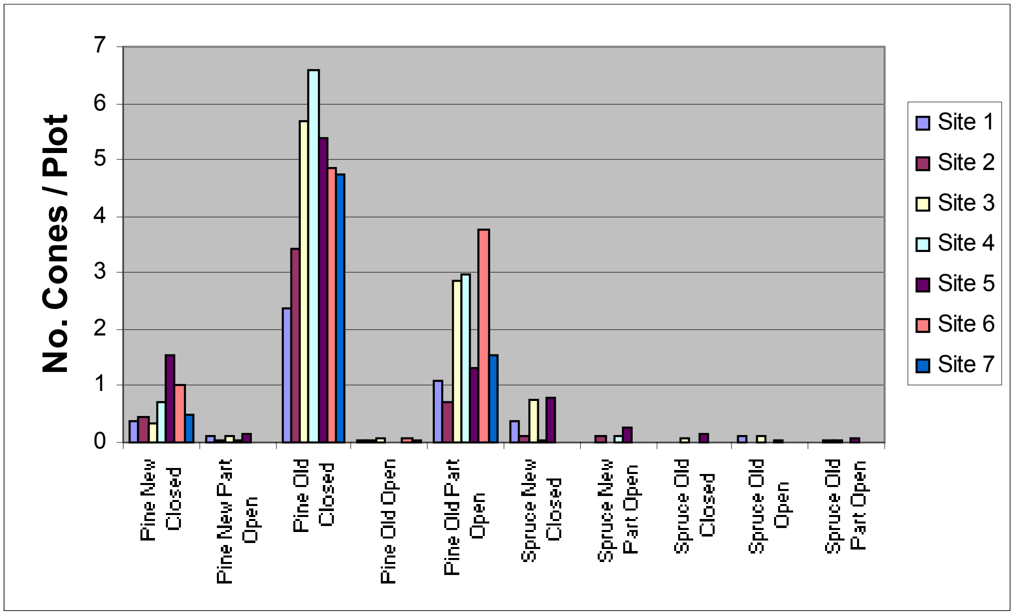


Figure 23. Average number of cones/plot in 2 m^2 plots on 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

WINDTHROW

Windthrow accounted for generally less than 3% of the plot for all sites except Site 1, which contained just over 6% windthrow (Figure 24).

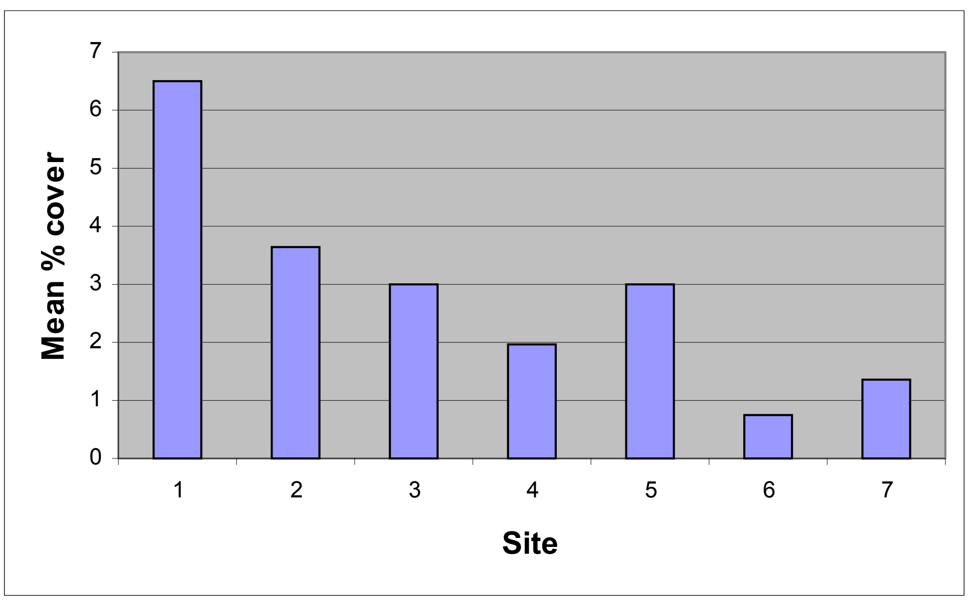


Figure 24. Average percent cover of windthrow in 2 m^2 plots on 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

WILDLIFE SIGN AND PLOT DISTURBANCE

Very little wildlife sign or disturbance occurred in plots on all 7 sites (Table 3). Wildlife disturbance was the only disturbance found but generally only covered 1% of the plot. Out of a total of 195 plots, moose pellets were found on 4 plots, hare pellets were found on 17 plots and grouse pellets were found on 9 plots. No caribou pellets were found in any plots.

Table 3. Number of plots containing wildlife disturbance and pellet groups for each of 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

	Number of plots containing wildlife disturbance and pellet groups			
Site	**Wildlife Disturbance**	**Moose Pellets**	**Hare Pellets**	**Grouse Pellets**
1		1	3	1
2	1		11	2
3	2			
4	3		1	2
5	3	1	2	3
6	2	2		
7	1			1

TERRESTRIAL LICHENS AND MOSSES

Terrestrial lichens, mosses, kinnikinnick, twinflower and substrate were measured using the line intercept method. The majority of substrate on all 7 sites was humus (Figure 25). Almost no mineral soil was encountered with coarse and medium litter, and rock occurring occasionally.

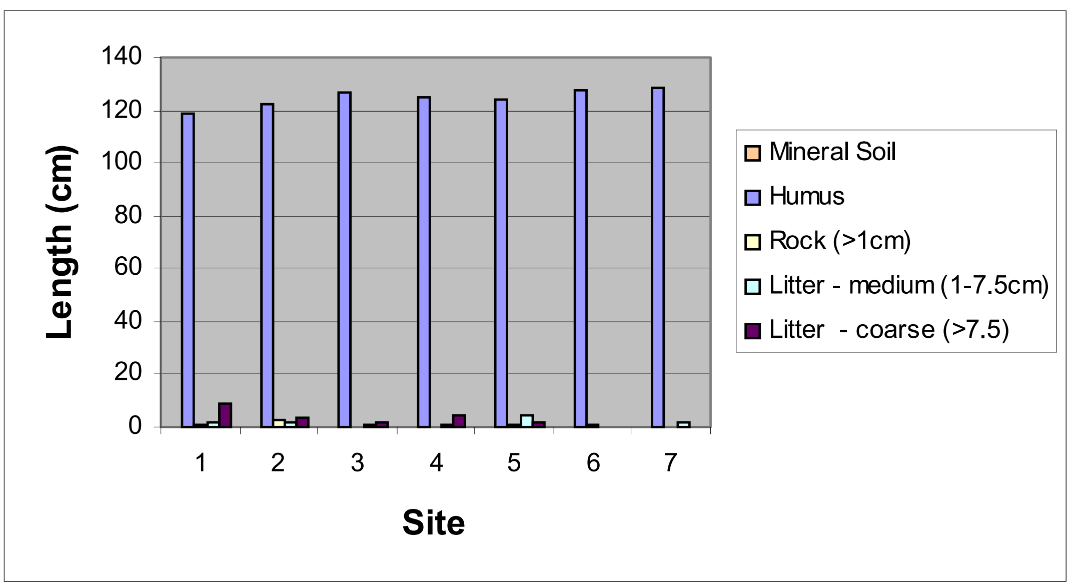


Figure 25. Average length of each substrate class along a 1.3 meter transect in 2 m^2 plots on 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

Boreal feathermosses were the most dominant ground cover on all sites except Sites 6 and 7 (Figure 26). Boreal feathermosses were almost absent on Site 6 and were less abundant than *Cladina* lichens on Site 7. *Cladina* lichens were the most abundant terrestrial lichen on all sites except Site 6, where *Cladonia* and *Stereocaulon* lichens were more prevalent. This is in contrast to results from lichen studies in the southwestern and central portion of the Itcha-Ilgachuz caribou winter range, where *Cladonia* lichens are the most abundant terrestrial lichen (H. Armleder, pers. comm.). Abundance of *Stereocaulon* and *Cladonia* lichens was greatest on Site 6 and was lower on all other sites. *Peltigera* lichen abundance was relatively consistent on all sites and ranged from an average length of 8 to 16 cm.

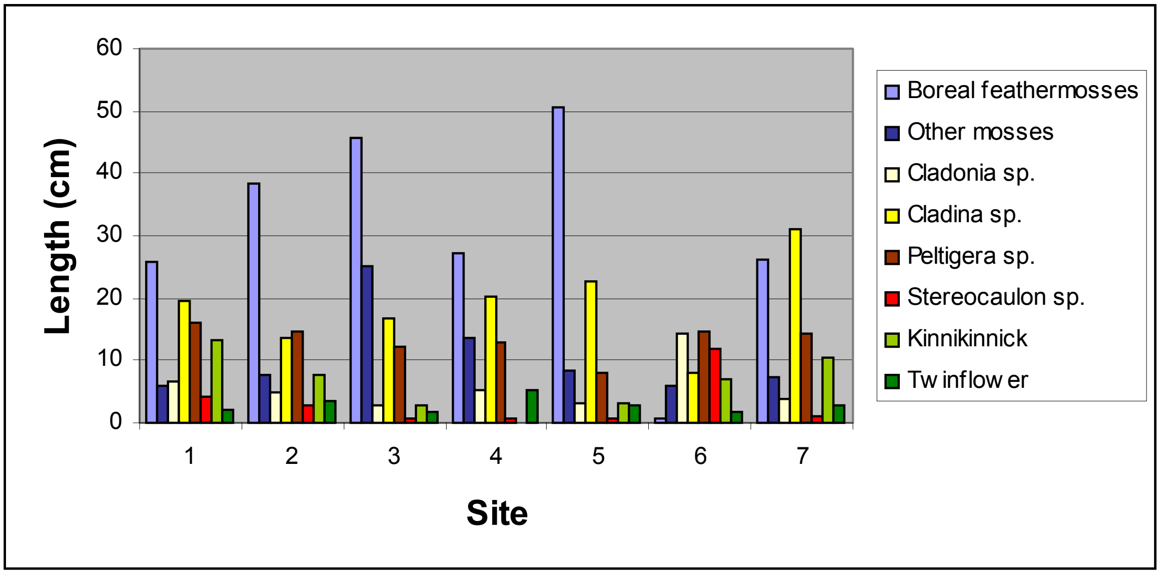


Figure 26. Average length of mosses, lichens, and kinnikinnick along a 1.3 meter transect in 2 m^2 plots on 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

Kinnikinnick abundance was variable but was highest on Sites 1, 2, 6 and 7 and nearly absent on Site 4. Kinnikinnick abundance may be inversely related to snow depth, using *Parmeliopsis* height as an indicator. Kinnikinnick was most abundant on sites with low *Parmeliopsis* height, and was least abundant on sites with high *Parmeliopsis* height (Figure 26, Table 1).

Cladina mitis and *Cladina rangiferina* were the dominant *Cladina* lichens in the study area (Figure 27). *Cladina mitis* was the most abundant *Cladina* lichen on all 7 sites; *Cladina rangiferina* was abundant on all sites except Site 3 and Site 6, which were the two largest diameter stands in the study (see Table 1). Most of the *Cladonia* lichens were not identified down to species; however for those that were, *Cladonia ecmocyna* was the most abundant and was most prevalent on Site 6 (Figure 28).

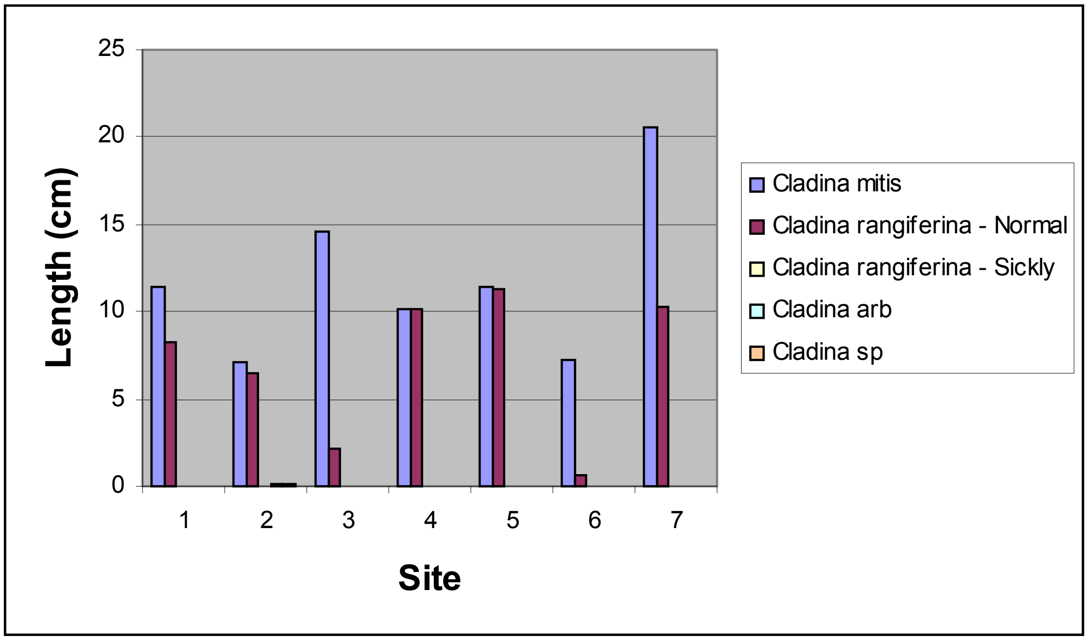


Figure 27. Average length of *Cladina* lichens along a 1.3 meter transect in 2 m^2 plots on 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

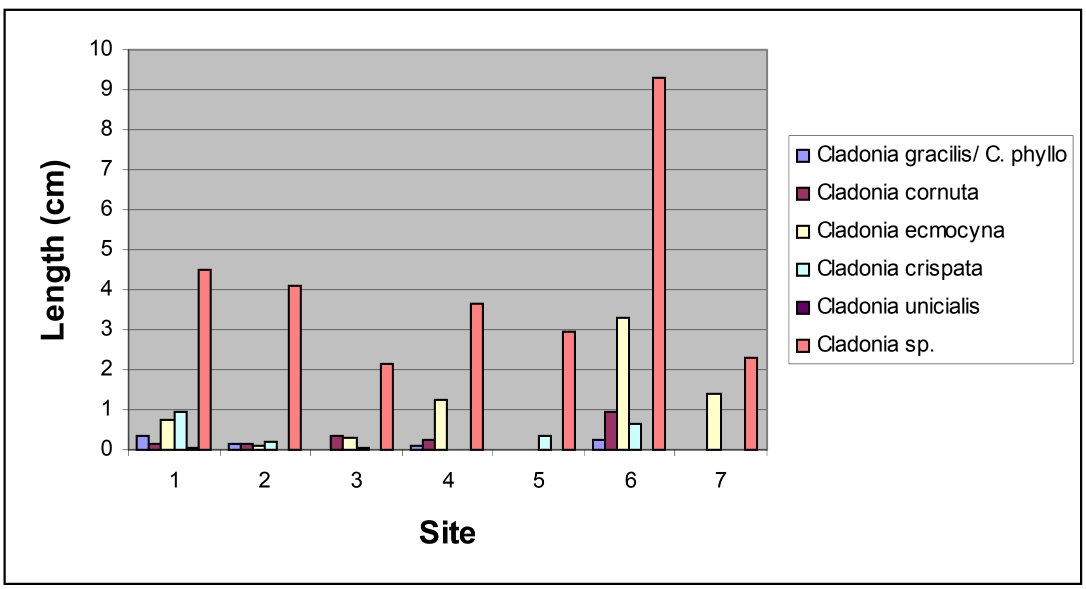


Figure 28. Average length of *Cladonia* lichens along a 1.3 meter transect in 2 m^2 plots on 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

ARBOREAL LICHENS

Abundance of arboreal lichens was generally low on all sites with the majority of trees containing Class 1 or 2 arboreal lichen abundance (Figure 29). Overall, arboreal lichen abundance was highest on Plots 4, 5 and 7 and lowest on Plots 1 and 2.

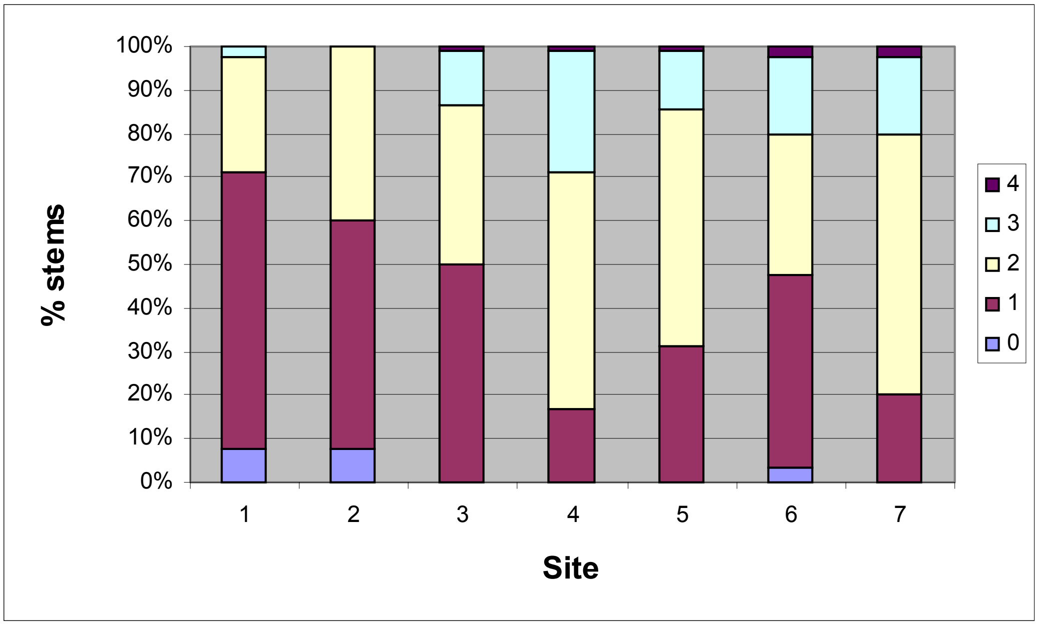


Figure 29. Frequency of arboreal lichen classes on 3 nearest trees to plots on 7 study sites in the Modified Harvest Zone in the Quesnel TSA.

SITE SUMMARIES

Table 4 summarizes characteristics of each of the 7 plots in the study. The following sections provide an overview of general characteristics of each plot with unique characteristics highlighted in bold type.

Table 4. Characteristics of the 7 study sites in the Modified Harvest Zone in the Quesnel TSA.							
	Site 1	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**
Number of plots	30	30	30	30	30	30	15
Elevation (meters)	1234	1263	1352	1424	1237	1375	1175
Canopy Characteristics							
Age (years)	154	122	278	94	135	92	91
Mean DBH (cm)	16.3	16.5	20.8	15.9	15.6	18.3	14.9
Mean canopy cover (%)	27.5	38.0	30.0	39.3	24.1	23.4	23.7
MPB Attack (% stems)	60.2	53.9	50.0	41.5	50.0	61.3	53.9
Dominant canopy	MPB-Green Pine-Alive MPB-Red	Pine-Alive MPB-Red MPB-Green	MPB-Red Pine-Alive Pine-Dead	Pine-Alive MPB-Green MPB-Red	MPB-Red Pine-Alive MPB-Green	MPB-Green Pine-Alive MPB-Red	MPB-Red Pine-Alive MPB-Green
Mean *Parmeleopsis* height (cm)	7.6	7.4	12.0	13.1	16.5	7.1	8.8
Slope Features							
Mean Slope (%)	1.2	3.9	8.5	8.4	2.9	6.6	2.2
Domimnant Mesoslope position	Level	Level	Midslope Level	Midslope Lower slope	Midslope Level	Level Midslope	Level
Dominant Mesoslope shape	Straight	Straight	Straight	Straight	Straight	Straight	Straight
Dominant Microslope position	Level	Level	Level Midslope Low Crest	Midslope Level	Level Midslope Lower slope	Level Low crest Midslope	Level
Dominant Microslope shape	Straight	Straight	Straight	Straight	Straight	Straight	Straight
Soil Features							
Dominant soil texture	Loamy Sand Sand Sandy Loam	Loamy Sand Sandy Loam Sand	Loamy Sand Sandy Loam Sand	Loamy Sand Sandy Loam Sand	Sandy Loam Silty Loam Loam	Loamy Sand Sand Fine Loamy Sand	Sandy Loam Loamy Sand Sand
Average humus depth (cm)	3.1	3.1	3.2	5	4.9	2.2	4.2
Dominant Moisture Regime	Subxeric	Subxeric	Subxeric	Subxeric	Submesic	Subxeric	Subxeric
Dominant Drainage	Rapidly Drained	Rapidly Drained	Rapidly Drained	Rapidly Drained	Well Drained	Rapidly Drained	Rapidly Drained
Vegetation (based on % cover data)							
Dominant vegetation structure (% cover)	Shrub Dwarf Shrub	Shrub Dwarf Shrub	Shrub Dwarf Shrub	Dwarf Shrub Herb	Dwarf Shrub Shrub	Dwarf Shrub Shrub	Shrub Dwarf Shrub
Dominant vegetation (% cover)	Kinnikinnick Juniper Soopolallie	Juniper Kinnikinnick Soopolallie	Juniper Soopolallie Kinnikinnick	Twinflower Crowberry Vaccinium	Kinnikinnick Juniper Soopolallie	Kinnikinnick Juniper Lodgepole pine	Juniper Kinnikinnick Twinflower

Table 4. Characteristics of the 7 study sites in the Modified Harvest Zone in the Quesnel TSA.							
	Site 1	**Site 2**	**Site 3**	**Site 4**	**Site 5**	**Site 6**	**Site 7**
REGENERATION AND WINDTHROW							
Dominant Regeneration	Lodgepole pine	Lodgepole pine	Lodgepole pine	Lodgepole pine	Lodgepole pine	Lodgepole pine	Lodgepole pine
Dominant Seedling substrate	Humus	Humus	Humus	Humus	Humus	Humus	Humus
Dominant Cone condition	Pine – old closed	Pine – old closed	Pine – old closed	Pine – old closed	Pine – old closed	Pine – old closed	Pine – old closed
Mean windthrow (% cover)	6.5	3.6	3.0	2.0	3.0	0.7	1.4
TERRESTRIAL LICHENS AND MOSSES (based on line intercept data)							
Dominant Substrate	Humus	Humus	Humus	Humus	Humus	Humus	Humus
Dominant ground cover	Feathermosses *Cladina* *Peltigera* Kinnikinnick	Feathermosses *Peltigera* *Cladina* Other mosses	Feathermosses Other mosses *Cladina* *Peltigera*	Feathermosses *Cladina* Other mosses *Peltigera*	Feathermosses *Cladina* Other mosses *Peltigera*	*Peltigera* *Cladonia* *Stereocaulon* *Cladina*	Feathermosses *Cladina* *Peltigera* Kinnikinnick
Dominant moss cover	Feathermosses	Feathermosses	Feathermosses	Feathermosses	Feathermosses	Other mosses	Feathermosses
Dominant *Cladina* cover	*C. mitis* *C. rangiferina*	*C. mitis* *C. rangiferina*	*C. mitis*	*C. mitis* *C. rangiferina*	*C. mitis* *C. rangiferina*	*C. mitis*	*C. mitis* *C. rangiferina*
ARBOREAL LICHENS							
Dominant Arboreal Lichen Class	Class 1 Class 2	Class 1 Class 2	Class 1 Class 2	Class 2 Class 3	Class 2 Class 1	Class 1 Class 2	Class 2 Class 1

SITE 1

Figure 30. Site 1.

- Moderate elevation (1234 m)
- Site predominantly level with a mean slope of **1.2% (lowest of all sites)**
- Moderate aged stand (154 years) with moderate diameter trees (16.3 cm)
- Moderate canopy cover (27.5%)
- Over 50% of trees sampled are attacked by mountain pine beetles
- Soils predominantly coarse textured loamy sands, sands, and sandy loams
- Moisture and Drainage primarily subxeric and rapidly drained
- Dominant vegetation structure:
  - shrubs
  - dwarf shrubs
- Dominant vegetation:
  - kinnikinnick
  - juniper
  - soopolallie
- Regeneration is predominantly lodgepole pine on humus
- Cones are primarily old closed lodgepole pine
- Substrate for ground cover is predominantly humus with average depth (3.1 cm)
- Dominant ground cover:
  - boreal feathermosses
  - *Cladina* lichens
  - *Peltigera* lichens
  - kinnikinnick
- Dominant moss cover: feathermosses
- Dominant *Cladinas*:
  - *Cladina mitis*
  - *Cladina rangiferina*
- Dominant arboreal lichen classes:
  - Class 1
  - Class 2

SITE 2

Figure 31. Site 2.

- Moderate elevation (1263 m)
- Site predominantly level with a mean slope of 3.9%
- Moderate aged stand (122 years) with moderate diameter trees (16.5 cm)
- **High canopy cover (38.0%)**
- Over 50% of trees sampled are attacked by mountain pine beetles
- Soils predominantly coarse textured loamy sands, sandy loams and sands
- Moisture and Drainage primarily subxeric and rapidly drained
- Dominant vegetation structure:
  - shrubs
  - dwarf shrubs
- Dominant vegetation:
  - juniper
  - kinnikinnick
  - soopolallie
- Regeneration is predominantly lodgepole pine on humus
- Cones are primarily old closed lodgepole pine
- Substrate for ground cover is predominantly humus with average depth (3.1 cm)
- Dominant ground cover:
  - boreal feathermosses
  - *Peltigera* lichens
  - *Cladina* lichens
  - other mosses
- Dominant moss cover: feathermosses
- Dominant *Cladinas*:
  - *Cladina mitis*
  - *Cladina rangiferina*
- Dominant arboreal lichen classes:
  - Class 1
  - Class 2

SITE 3

Figure 32. Site 3.

- Moderate elevation (1352 m)
- Site predominantly level **but with hummocky and kame features resulting in a mean slope of 8.5%**
- **Old aged stand (278 years) with large diameter trees (20.8 cm)**
- Moderate canopy cover (30.0%)
- Over 50% of trees sampled are attacked by mountain pine beetles
- Soils predominantly coarse textured loamy sands, sandy loams and sands
- Moisture and Drainage primarily subxeric and rapidly drained
- Dominant vegetation structure:
  - shrubs
  - dwarf shrubs
- Dominant vegetation:
  - juniper
  - soopolallie
  - kinnikinnick
- Regeneration is predominantly lodgepole pine on humus
- Cones are primarily old closed lodgepole pine
- Substrate for ground cover is predominantly humus with average depth (3.2 cm)
- Dominant ground cover:
  - boreal feathermosses
  - other mosses
  - *Cladina* lichens
  - *Peltigera* lichens
- Dominant moss cover: feathermosses
- **Dominant *Cladinas*:**
  - ***Cladina mitis (Cladina rangiferina* abundance low)**
- Dominant arboreal lichen classes:
  - Class 1
  - Class 2

SITE 4

Figure 33. Site 4.

- **Higher elevation (1424 m)**
- **Site generally sloped with a mean slope of 8.4%**
- **Younger aged stand (94 years)** with moderate diameter trees (15.9 cm)
- **High canopy cover (39.3%) (highest of all 7 plots)**
- **Less than 50% of trees sampled are attacked by mountain pine beetles**
- Soils predominantly coarse textured loamy sands, sandy loams and sands
- Moisture and Drainage primarily subxeric and rapidly drained
- Dominant vegetation structure:
    - Dwarf shrubs
    - **herbs**
- Dominant vegetation (**Note: kinnikinnick, juniper and soopolallie nearly absent)**
    - **twinflower**
    - **crowberry**
    - **Vaccinium**

- Regeneration is predominantly lodgepole pine on humus
- Cones are primarily old closed lodgepole pine
- Substrate for ground cover is predominantly humus with average depth (5.0 cm)
- Dominant ground cover:
  - boreal feathermosses
  - *Cladina* lichens
  - other mosses
  - *Peltigera* lichens
- Dominant moss cover: feathermosses
- Dominant *Cladinas*:
  - *Cladina mitis*
  - *Cladina rangiferina*
- Dominant arboreal lichen classes:
  - **Class 2**
  - **Class 3**

SITE 5

- Moderate elevation (1237 m)
- Site predominantly level / midslope with a mean slope of 2.9%
- Moderate aged stand (135 years) with moderate diameter trees (15.6 cm)
- **Lower canopy cover (24.1%)**
- Over 50% of trees sampled are attacked by mountain pine beetles
- **Soils predominantly fine textured sandy loams, silty loams and loams**
- **Moisture and Drainage primarily submesic and well drained**
- Dominant vegetation structure:
  - dwarf shrubs
  - shrubs
- Dominant vegetation:
  - kinnikinnick
  - juniper
  - soopolallie
- Regeneration is predominantly lodgepole pine on humus
- Cones are primarily old closed lodgepole pine
- Substrate for ground cover is predominantly humus with average depth (4.9 cm)
- Dominant ground cover:
  - boreal feathermosses
  - *Cladina* lichens
  - other mosses
  - *Peltigera* lichens
- Dominant moss cover: feathermosses

- Dominant *Cladinas*:
    - *Cladina mitis*
    - *Cladina rangiferina*
- Dominant arboreal lichen classes:
    - Class 2
    - Class 1
- **this site contained the highest abundance and diversity of herbaceous vegetation**

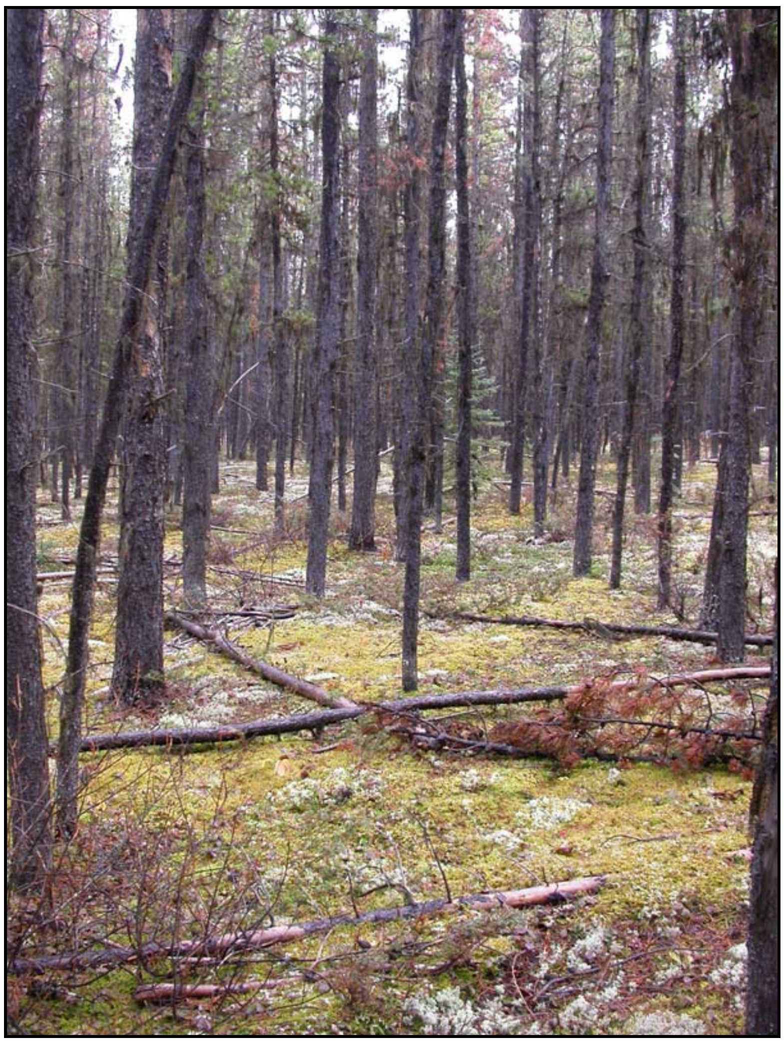


Figure 34. Site 5.

SITE 6

Figure 35. Site 6.

- **Higher elevation (1375 m)**
- Site predominantly level / midslope with a mean slope of 6.6%
- **Younger aged stand (92 years) with large diameter trees (18.3 cm)**
- **Lower canopy cover (23.4%)**
- Over 50% of trees sampled are attacked by mountain pine beetles
- **Soils predominantly loamy sands, sands, and fine loamy sands with few coarse fragments**
- Moisture and Drainage primarily subxeric and rapidly drained
- Dominant vegetation structure:
  - dwarf shrubs
  - shrubs
- Dominant vegetation:
  - kinnikinnick
  - juniper
  - lodgepole pine
- Regeneration is predominantly lodgepole pine on humus
- Cones are primarily old closed lodgepole pine
- Substrate for ground cover is predominantly humus with average depth (3.1 cm)
- Dominant ground cover:
  - ***Peltigera*** **lichens**
  - ***Cladonia*** **lichens**
  - ***Stereocaulon*** **lichens**
  - ***Cladina*** **lichens**
- **Dominant moss cover: other mosses – (Note: boreal feathermosses nearly absent)**
- **Dominant *Cladinas*:**
  - ***Cladina mitis (Cladina rangiferina*** **abundance low)**
- Dominant arboreal lichen classes:
  - Class 1
  - Class 2

SITE 7

Figure 36. Site 7.

- Moderate elevation (1175 m)
- Site predominantly level with a mean slope of 2.2%
- **Younger aged stand (91 years) with small diameter trees (14.9 cm)**
- **Lower canopy cover (23.7%)**
- Over 50% of trees sampled are attacked by mountain pine beetles
- Soils predominantly coarse textured sandy loams, loamy sands and sands
- Moisture and Drainage primarily subxeric and rapidly drained
- Dominant vegetation structure:
    - shrubs
    - dwarf shrubs
- Dominant vegetation:
    - juniper
    - kinnikinnick
    - **twinflower**
- Regeneration is predominantly lodgepole pine on humus
- Cones are primarily old closed lodgepole pine
- Substrate for ground cover is predominantly humus with average depth (4.2 cm)
- Dominant ground cover:
    - boreal feathermosses
    - *Cladina* lichens
    - *Peltigera* lichens
    - kinnikinnick
- Dominant moss cover: feathermosses
- Dominant *Cladinas*:
    - *Cladina mitis*
    - *Cladina rangiferina*
- Dominant arboreal lichen classes:
    - Class 2
    - Class 1

ECOLOGICAL CHANGES DUE TO MOUNTAIN PINE BEETLES

This project represents the first year of a multi-year study that will document the effects of mountain pine beetles on the ecology of terrestrial lichens in the northeastern portion of the Itcha-Ilgachuz caribou winter range in the Quesnel TSA. Because the effects of mountain pine beetles will be documented over time, this report summarizes the initial conditions on the 7 study sites established in October 2005, at the beginning stages of mountain pine beetle attack. Ecological changes due to mountain pine beetles will be interpreted from data collected in subsequent years.

Although terrestrial lichens grow very slowly and any potential increase in terrestrial lichen abundance may take many years, vegetation that competes with terrestrial lichens can respond quickly, resulting in a rapid decline in terrestrial lichen abundance. A research study conducted on the response of terrestrial lichens to mountain pine beetles in the East Ootsa and Entiako areas, northwest of the Quesnel TSA, has documented a decline in terrestrial lichen abundance with a corresponding increase in competing vegetation, primarily kinnikinnick, on many study plots from 2001 to 2005 (Williston and Cichowski, in prep.). Other competitors that have increased with a corresponding decrease in terrestrial lichen abundance include red-stemmed feathermoss and twinflower, but these competitors have had less impact overall than kinnikinnick. Analyses are currently being conducted to correlate changes in terrestrial lichen abundance with changes in light availability and canopy mortality. One of the greatest changes in ecological conditions following mountain pine beetle attack that will influence vegetation cover is soil moisture. However, changes in soil moisture are difficult to document since soil moisture can be affected by individual rainfall events.

Although the 7 sites in the Quesnel TSA study area are located in a different biogeoclimatic subzone (MSxv) than the subzones in the East Ootsa/Entiako study (SBSmc2, SBSdk, SBPSmc, ESSFmc), vegetation responses to mountain pine beetles may be more similar to the East Ootsa/Entiako area than to the western part of the Itcha-Ilgachuz caribou range. *Cladina* lichens are the most abundant terrestrial lichen on 6 of the 7 sites in this study area, similar to the East Ootsa/Entiako area, but different from the western portion of the Itcha-Ilgachuz caribou winter range where *Cladonia* lichens are the most abundant terrestrial lichens (H. Armleder, pers. comm.). All 7 sites in the Quesnel TSA study area contain boreal feathermosses, kinnikinnick and twinflower; although feathermoss abundance is very low on Site 6 and kinnikinnick abundance is very low on Site 4. If response of competing vegetation on sites in this study area is similar to that in the East Ootsa/Entiako area, a response in terrestrial lichen abundance could occur in as little as 2 years time. It is therefore recommended to repeat these measurements in 2007.

Recommendations for managing terrestrial lichens in the study area are deferred until data measurements are repeated and changes in terrestrial lichen abundance and competing vegetation are documented.

FUTURE DATA COLLECTION

The following are some comments/suggestions for future data collection.

- Site 7 will be revisited in 2006 and an additional 15 plots will be established at that site.

- There is still 1 more high priority site and up to 6 moderate priority sites that have already been identified as potential sites for the project. Additional sites should be established as soon as possible to not miss the initial effects of mountain pine beetle attack.

- Consideration should be given to using an alternative method of estimating canopy openness /light availability, such as fisheye photographs. The response of terrestrial lichens may be at a microsite (plot) level rather than at the site level so a more accurate representation of canopy openness / light availability than the moosehorn method could provide better plot specific information for measuring change.

- Consideration should be given to include an estimate of soil coarse fragment content when revisiting plots to better characterize differences in soil properties between sites (see Results and Discussion – Soils).

- Data should be remeasured in 2007 to document initial changes in terrestrial lichen abundance and competing vegetation.

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APPENDIX 1. SITE LAYOUT AND PLOT ORIENTATION

Table A. Site layout.

	Bearing to first plot	Transect bearing	Comments
Site 1	8	98	• Direction of travel parallel to the road
Site 2	178	88	• Direction of travel parallel to the road
Site 3		20	• Follow flagging from sign on road to reach the site • Direction of travel was opposite (180 degrees) to normal direction of travel
Site 4	170	170	• Direction of travel perpendicular to the road
Site 5	45	135	• Direction of travel parallel to the road • 6 plots established on the other side of the road
Site 6	30	90	• Follow flagging from sign for about 300 meters at 30 degrees to Plot 3
Site 7		270	• Direction of travel perpendicular to the road

Site 1 – Approximate plot orientation				
26	27	28	29	30
21	22	23	24	25
16	17	18	19	20
11	12	13	14	15
6	7	8	9	10
1	2	3	4	5
Road				

Site 2 – Approximate plot orientation					
25	26	27	28	29	30
20	21	22	23	24	
	16	17	18	19	
	11	12	13	14	15
	6	7	8	9	10
	1	2	3	4	5
Road					

Site 3 – Approximate plot orientation					
30	29	28	27	26	25
24	23	22	21	20	19
18	17	16	15	14	13
	12	11	10	9	8
		7	6	5	4
			3	2	1
Road					

Site 4 – Approximate plot orientation					
30					
29	25	20	15	10	5
	24	19	14	9	4
28	23	18	13	8	3
27	22	17	12	7	2
26	21	16	11	6	1
Road					

Site 5 – Approximate plot orientation				
	22	23	24	
17	18	19	20	21
12	14	14	15	16
8	9	10	11	
4	5	6	7	
1	2	3		
Road				
27	28	29	30	
	25	26		

Site 6 – Approximate plot orientation				
26	27	28	29	30
21	22	23	24	25
16	17	18	19	20
11	12	13	14	15
6	7	8	9	10
1	2	3	4	5
Road				

Site 7 – Approximate plot orientation							
							3
15	14	13	11	9	7	5	2
		12	10	8	6	4	1
Road							