IDENTIFICATION and MANAGEMENT OF MOOSE WINTER HABITAT IN THE CARIBOO REGION: LITERATURE REVIEW AND MAPPING PILOT STUDY

prepared for

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Williams Lake

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EXECUTIVE SUMMARY

The Ministry of Environment has asked Keystone Wildlife Research to develop a methodology for identification of moose winter range and develop Best Management Practices (BMPs) for moose winter range in the various subzones within the Cariboo Region.

Keystone completed the detailed analysis in two distinct areas (Kluskus and Gerimi), in two BEC zones (SBPS, SBS) for this contract. Key components of this assignment included:

- a review of recent literature on moose winter range characteristics
- a review of management guidelines used for moose winter range
- a draft of recommended BMPs appropriate for each biogeoclimatic zone occupied by moose in the region for consideration by Regional staff.
- overlaying the moose winter survey data and the high value wetlands coverage, in two test areas, on available GIS data layers to identify attributes that can be used to complete the moose winter range coverage in unsurveyed parts of the Region.

Predation, availability of food, climate, parasites and disease are the most important natural factors potentially limiting moose populations. Availability of food and climate factors are probably most critical during the winter. Several authors have reported that moose winter habitat selection appears to be more influenced by food availability than by snow cover, particularly where snow depths are below critical levels (<90 cm). Moose can tolerate relatively deep snow, so snow interception cover may not be a critical factor in many areas where snow depths rarely inhibit movement (e.g. SBPS). Hiding and thermal cover are important in all areas and must be available in proximity to feeding habitats. Mixed stands that provide both food and shelter are probably the most valuable to moose.

Hunting is a major limiting factor of moose populations in areas accessible to humans. Road access and hunting are suspected to have depressed moose populations in some parts of the Cariboo Region. The presence of roads and the juxtaposition of hiding cover are therefore important components of winter ranges, which may determine habitat effectiveness and observed use by moose.

The Cariboo-Chilcotin Land Use Plan indicates that the habitat needs of moose should largely be met through application of the Forest Practices Code (now the Forest and Range Practices Act, FRPA). Conservation of wetlands and riparian areas (including forested buffers) will provide winter habitat throughout the region. Increasing wetland buffers beyond the sizes specified in the Riparian Management Area Regulation may be required to maintain habitat values for moose.

Management of moose winter ranges focuses on providing abundant forage in locations where moose can access it. On the landscape scale, this corresponds to areas where snow depths are tolerable (<90 cm). At the stand level, this corresponds to areas where hiding and thermal cover are nearby (within 200 m). Strategies developed to manage seasonal habitat for moose must recognize the distinct differences in habitat quality and winter mobility of moose in dry, moist and wet ecosystems. Best management practices are specified for each snow depth zone based on the expected requirements of moose in each area.

Key winter habitats and moose winter range management objectives by BEC zone.

Zone	Key winter habitats	Optimal buffer widths (m)	Minimal buffer widths (m)	Forage/ hiding/ thermal ratio	Important elements
SBPS	Plateau wetlands, riparian	200	100/2	40/30/30	Increase forage
IDF	Riparian forest, wetlands	200*	none	40/30/30	Select harvest
MS	Wetlands (few areas)	200	100/2	40/30/30	N/a
SBS	Mesic, moist, riparian	none	none	33/33/33	Small patches
ICH	Riparian valley bottom wetlands	100	100	20/20/60	Snow interception
ESSF	Very few areas	N/a	N/a		N/a

* only required where selections systems do not provide cover, 100/2 is 100 m over ½ of perimeter or adjacent to shrubby sites

BEC zones have been used as a temporary surrogate, however, snow depth zone mapping is required specifically for moose in order to classify moose winter range areas correctly.

Habitat objectives for moose winter ranges, which include amount and distribution in each subzone, have been specified, however, application of those guidelines requires explicit spatial delineation of the management areas, consideration of current management under FRPA and snowzone confirmation. The planning cell approach defines the current extent and location of feeding habitat, hiding cover and thermal cover, and the areas which are currently constrained, protected or available for harvest. Land management options which are discretionary under FRPA, such as wildlife tree patches and allocation of seral stage targets, should be used to create or maintain favourable conditions for moose in each designated winter range area.

Analysis of the digital data, which was available to define moose winter range areas, was completed in two test areas: Kluskus in the SBPSdc subzone and Gerimi in the SBSmh/mw subzones. Wetlands are a key winter habitat on the Chilcotin Plateau (Kluskus) and patch size (> 450 ha) and amount of interior habitat were the best predictors of high value wetlands. For small wetlands no reliable means to distinguish high value or occupied wetlands from others was found. In the Gerimi area, TEM suitability for food and thermal cover corresponded well with the observed winter distribution of moose. The proposed criteria to define moose winter ranges in each area should be reviewed and approved or modified by regional staff. Draft MWR defined using map based inventory data should be field truthed using reconnaissance level surveys prior to designating them as ungulate winter range.

A list of next steps includes:

1. regional staff should review and approve or modify the proposed BMP's for each subzone,
2. regional staff should review and approve or modify the recommended means to identify key moose winter ranges within each subzone,
3. develop a moose snowzone map for the region,
4. define draft moose winter range areas for the region using the approved methodologies,
5. truth draft winter range areas on the Chilcotin plateau, using reconnaissance (pre-stratification) flights scheduled when conditions are optimal for sighting moose tracks in wetlands,
6. obtain landbase classification maps used for timber supply analysis and forest development plan information for the draft moose winter range areas,
7. obtain current forest inventory mapping (VRI) and beetle risk mapping and format it for use in assessing the current and future status of each MWR planning cell,
8. apply the approved management objectives on each MWR and assess the compatibility with existing management,
9. develop specific prescriptions to maintain habitat for moose where existing management is or is expected to be deficient.

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1.0 INTRODUCTION

The British Columbia Ministry of Environment (MoE; Cariboo Region) has asked Keystone Wildlife Research to develop a methodology for identification of moose (*Alces alces*) winter range and develop Best Management Practices (BMPs) for moose winter range (MWR) in the various subzones within the Cariboo Region.

Originally, the Ministry asked for MWR areas to be identified based upon mapped wetlands combined with results of moose survey flights completed between 1994 and 2002 (Intrepid Biological Consulting 2004). Since surveys have not been completed for the entire Region, Keystone instead proposed examining physical and habitat characteristics of the identified high value wetlands using predictive ecosystem mapping (PEM), TRIM data, forest cover data, vegetation resource inventory (VRI) data, and terrestrial ecosystem mapping (TEM; where available) within the Cariboo Region. If the high value wetlands can be characterized using mapped attributes, then these parameters should be applied across the entire study area to create a uniform coverage of suitable moose habitat. Due to the size of the study area and the availability of survey data, Keystone proposed completing this detailed analysis in two distinct areas (Kluskus and Gerimi), in two BEC zones (SBPS, SBS), for this contract. Although identification of high value MWR would not be completed across the entire study area, establishing a solid basis for selecting high value wetlands is a critical step in identifying winter ranges that will most benefit moose. Use of physical and habitat characteristics of wetlands, in addition to moose usage data, will allow defensible decisions to be made about the location of moose winter ranges.

Best management practices within winter range areas must recognize the large differences in climate, forest productivity and snow depths in different parts of the Region. SBPS and MS variants tend to have relatively poor forage in forested site series, whereas SBS and ICH produce abundant forage in young seral sites. IDF variants are also less productive for moose but can provide important wintering areas, particularly in the moist site series. Moose are typically excluded from high elevation variants (ESSF) by deep snow in winter but those areas can provide important summer range and calving habitat. Best management practices are, therefore, expected to vary across the Region depending on the local habitat conditions.

Key components of this assignment included:

- a review of recent literature on moose winter range since the last comprehensive review by Sopuck *et al.* (1997).
- a review of management guidelines used for moose winter range in other regions of BC and in other provinces.
- a draft of recommended best management practices appropriate for each biogeoclimatic zone occupied by moose in the region for consideration by Regional staff.
- overlaying the moose winter survey data and the selected high value wetlands coverage, in the Kluskus and Gerimi test areas, on available GIS data layers to

identify attributes that can be used to complete the moose winter range coverage in unsurveyed parts of the Region.

2.0 STUDY AREA AND BACKGROUND

The general study area includes the northern portion of the Southern Interior Forest Region, which is made up of the Central Cariboo, Williams Lake, 100 Mile, Chilcotin, and Quesnel Forest Districts. Important moose winter habitat is located within the Sub-Boreal Pine Spruce (SBPS), Montane Spruce (MS), Sub-Boreal Spruce (SBS), Interior Cedar Hemlock (ICH), and Interior Douglas-fir (IDF) biogeoclimatic zones (Sopuck *et al.* 1997).

Moose winter surveys have been completed in a large number of variants within the region. The number of moose counted in each is shown in Figure 1 but they cannot be directly compared since the areas surveyed and numbers of surveys vary for each variant. Variants with larger numbers of moose observed generally indicate a larger number of surveys over a more extensive area. The survey results provide a list of variants to be considered for winter range modelling and the relative importance of different variants within the Region.

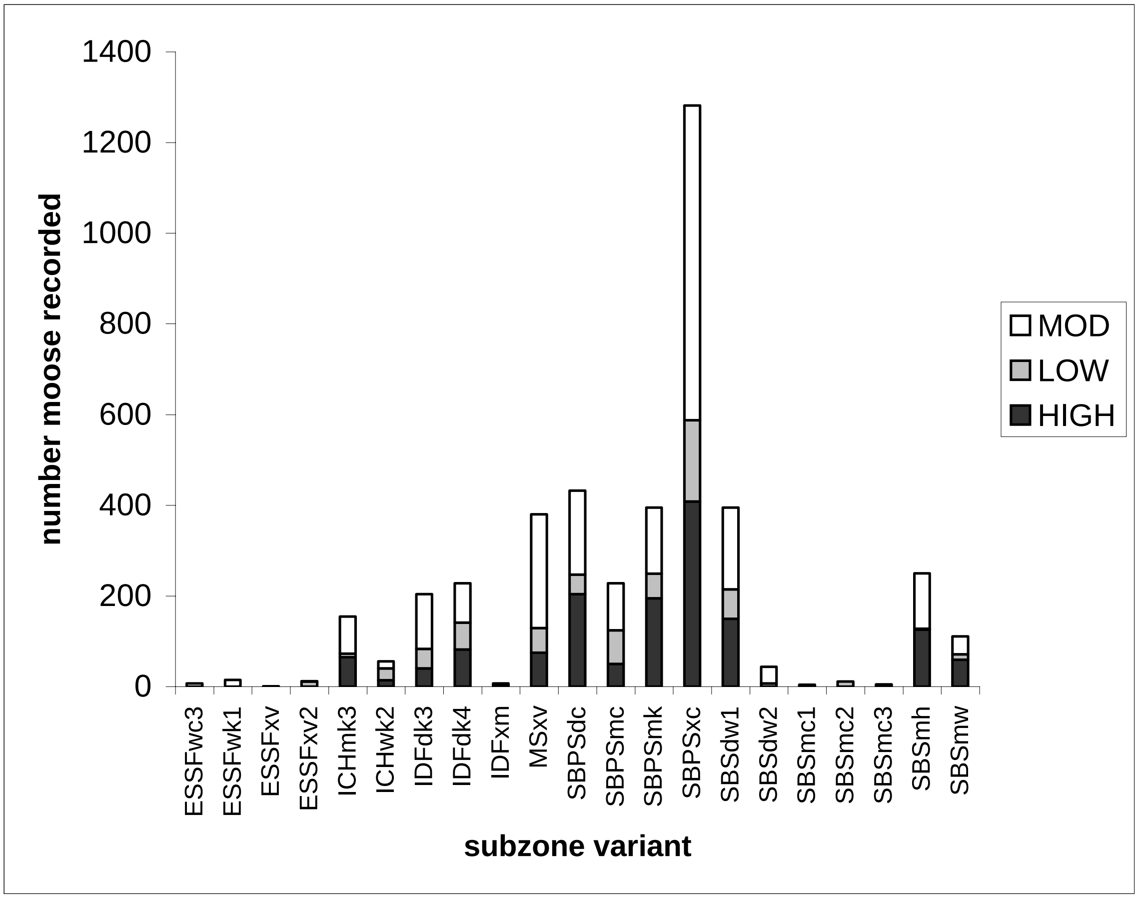

Figure 1. Number of moose recorded by survey strata (high, moderate and low) during MoE winter survey flights (Jan-Feb), 1994-1998.

The study area can be subdivided based on expected snowpacks in each zone (Figure 2). Shallow snowpack zones include IDF, SBPS (and MS) where snow rarely inhibits moose mobility in winter. In the SBS, moderate snow depths may restrict moose movements in some areas or during some periods in winter. In the deep snowpack zone (ICH), moose are restricted to the lower half of the zone in riparian habitats along main river corridors. In the very deep snowpack zone (ESSF), moose are excluded in winter but may make extensive use of the zone in summer. The moose survey blocks, moose sighting locations and ecological mapping used to assess habitats are shown in Figure 3.

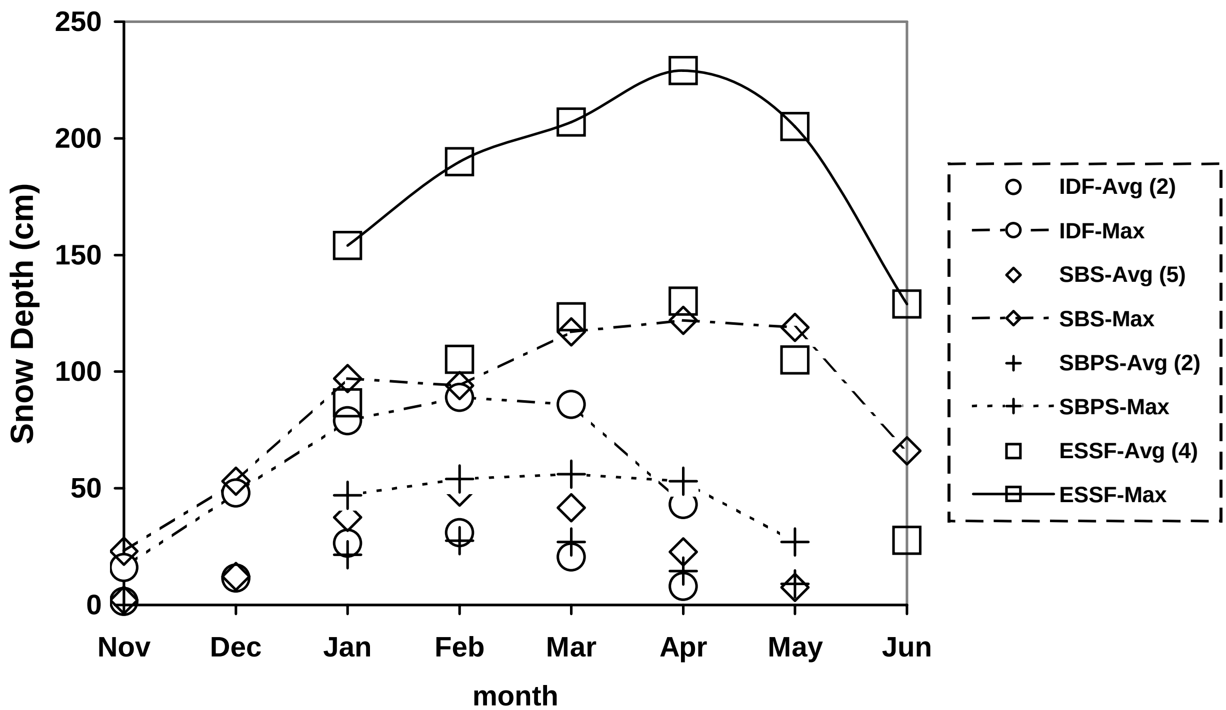

Figure 2. Snow depth characteristics of the main BEC zones in the Cariboo Region.

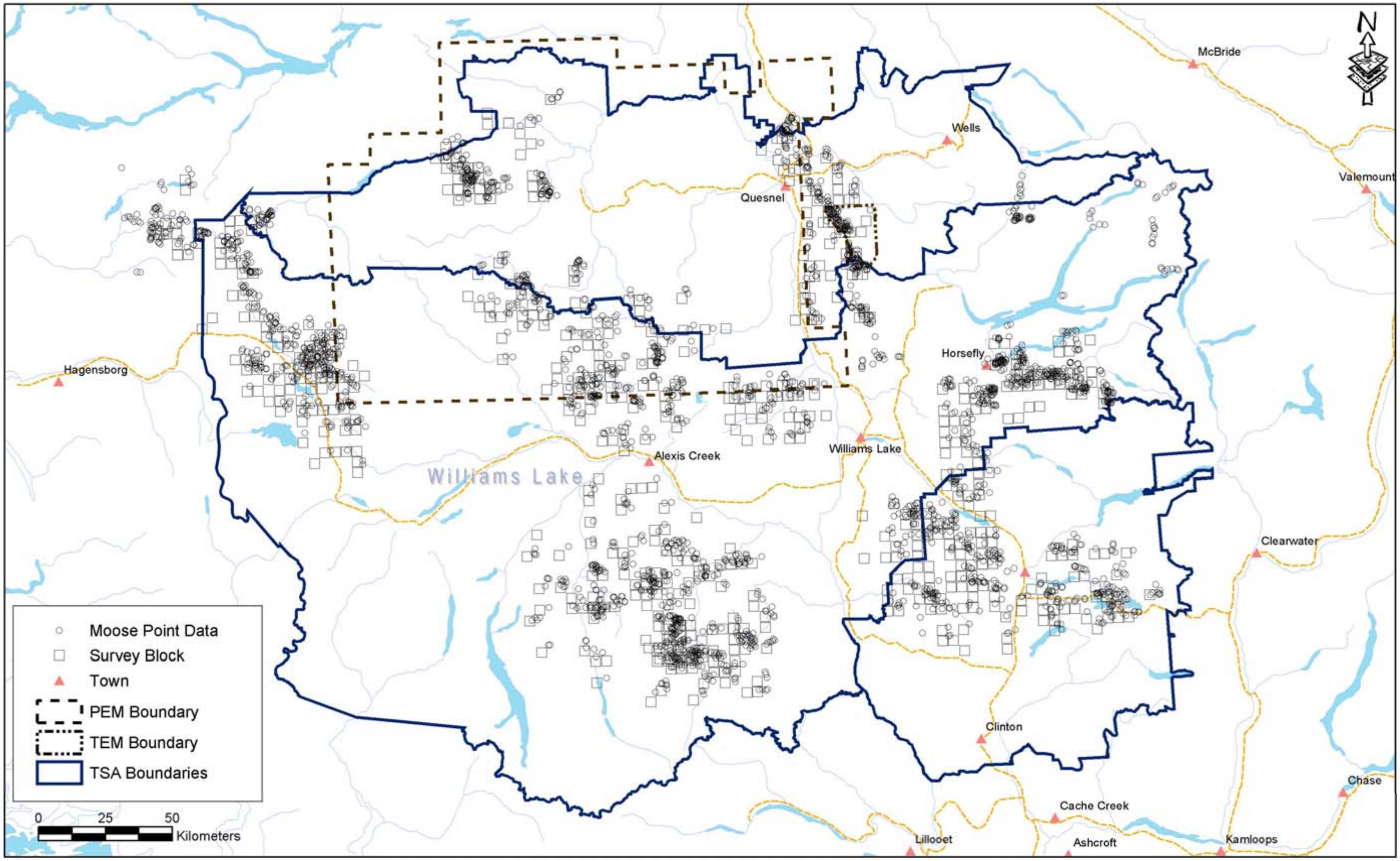

Figure 3. Cariboo Region moose survey blocks, moose sighting locations and ecological mapping used to assess habitat.

3.0 METHODS

Optimal management regimes for moose habitat will vary depending on the snowpack zone and productivity of the forested ecosystems. The recent literature has been assessed for interpretations relative to the shallow, moderate and deep snowpack subzones. Map data assembled will also be grouped and assessed relative to the appropriate subzone.

3.1 Literature Review

An extensive literature review on moose-forestry interactions in the former Cariboo Forest Region was prepared in 1997 (Sopuck *et al.* 1997). The purpose of the current literature review is to summarize any additional relevant research published since the original review was completed (i.e. after 1995).

Electronic searches of e-published literature (theses, journal articles) were conducted through University of BC databases. Additional information was obtained from Ministry of Environment staff. Moose species accounts prepared for various Terrestrial Ecosystem Mapping (TEM) projects were obtained through the BC Ministry of Sustainable Resource Management's Ecocat website. Relevant recent unpublished reports from Keystone Wildlife Research Ltd.'s library files were also reviewed. Although research published since 1997 was the main target of the review, relevant reports that had not been included in Sopuck *et al.* (1997) were also reviewed.

3.2 Map Data Sources

Map data sources obtained and reviewed for their possible use in the project are listed in Table 1. Data was received from the Integrated Land Management Bureau (ILMB), the Ministry of Environment and Base Mapping and Geomatic Services of the Ministry of Agriculture and Lands (BMGS).

Table 1. Data sources used in the project.

Data Description	Source, date
Quesnel district PEM and TEM Mapping	ILMB Victoria
High Value Moose Wetlands -Cariboo Region	ILMB
Buffered High Value Wetlands	ILMB
Moose Capability Mapping - Cariboo Region	MOE, 1995
Moose Location Data – winter survey data	MOE
TRIM/NTS mapping	BMGS
Vegetation Resource Inventory/Forest Cover	ILMB
1:20,000 wetlands mapping	MOE, 2005
Roads Data	MOE

3.3 Data Compilation and Analysis

Winter survey points representing moose sightings were plotted for the Region. Digital map data was not available for the entire region so areas where data was available were identified. Two survey areas, Kluskus (SBPS) and Gerimi (SBS) along the Quesnel River were chosen to assess the relationship between moose locations and land classification data. Characteristics of the high use wetlands were compared to wetlands where no moose were seen and to other areas that were never surveyed. The map characteristics of the high use wetlands and other areas where moose were observed were identified and used to identify other potential high value sites within each assessment area.

No data was obtained on the future risk of beetle infestation to existing stands, however, that information would be most useful in determining best management once the winter range areas are identified.

4.0 RESULTS

There has been substantial new literature published on moose since 1997 and provincial management practices for moose winter range have also evolved. The review identifies critical elements of moose winter habitat and management regimes that have been used successfully in other jurisdictions. A summary of management guidelines from other jurisdictions is provided in Appendix I.

4.1 Literature Review

Predation, availability of food, climate, parasites and disease (in that order) are the most important natural factors potentially limiting moose populations in North America (Van Ballenberghe and Ballard 1998; as cited in Dussault *et al.* 2005a). Availability of food and climate factors are probably most critical during the winter. Moose winter range refers to areas on the landscape to which moose move in response to snow accumulation. The levels of snow accumulation as they pertain to winter range have been defined based upon the effects of snow on animal mobility: nominal (where snow does not affect mobility); inhibiting (where snow is deep enough to affect mobility); and critical (where snow is deep enough to severely restrict mobility) (Ungulate Winter Range Technical Advisory Team 2005). Critical snow depths are also those in which most rooted forage in forest openings is buried by snow.

There are wide variations in moose density across the species' range (Maier *et al.* 2005) and high levels of individual variation in moose foraging strategies (Dussault *et al.* 2005b). Moose winter range use differs as winter progresses, and appears to vary with available topography and snowfall (Poole and Stuart-Smith 2002). Much of this variation may be due to temporal and spatial variation in snow depths within and between study areas, the quality and type of browse available and the differing scales of analysis used between studies (Vander Wal 2004). A further confounding factor is that density of animals in general may not actually correlate to habitat quality, as is often assumed (Van Horne 1983).

In general, areas with a mosaic or diversity of habitat types in close proximity are considered best for moose (Yukon Department of Renewable Resources 1996; Maier *et al.* 2005, Keystone Wildlife Research 1995b). Disturbances such as fire, logging and insects may (but not always) increase habitat quality for moose (Yukon Department of Renewable Resources 1996).

Osko *et al.* (2004) compared habitat preferences of two groups of moose in northeastern Alberta. The two groups occupied areas in which similar habitats were available, but differed in their relative abundance. The authors noted significant variation in habitat use between individual animals, as well as large contrasts between the two groups in preference for some habitat types. The 'Disturbance' habitat type was avoided by moose in that study, although that habitat type included cutblocks and burns of 'various ages', often cited as important moose foraging habitat. However, this anomaly could be due to the age of the disturbances. Maier *et al.* (2005) reported that moose in Alaska were positively associated with areas burned between 11-30 years ago but negatively associated with areas burned less than 10 years or greater than 30 years ago.

Some moose in a population occupy the same general area year round, but some are migratory and move between two or more separate seasonal ranges (Keystone Wildlife Research 1995a). Migration distances may be up to 75 km (Nass Wildlife Area; Demarchi 2003). Migrations of moose between ranges are related to snow depth and timing of migration by individuals may vary between years (MacCracken *et al.* 1997; Keystone Bio-Research 1991).

Moose in northeastern Alberta selected well-drained habitat in preference to fens and bogs (James *et al.* 2004). In contrast, wintering moose along the route of the Okanagan Connector Freeway in southern BC selected wetlands, mixed deciduous-coniferous forest, aspen grassland and regenerating burns in the winter (Keystone Bio-Research 1991). Mature lodgepole pine (*Pinus contorta*) forest was probably an important cover and bedding habitat for moose but because of the lack of forage species in the understorey, most use of that forest type was recorded adjacent to more open, forage-producing habitats. Open rangeland and new cutblocks were avoided in all seasons.

Early winter habitat for moose in central BC was defined in Perry (1999) as having a combination of abundant shrub forage and adjacent cover (for predator avoidance and thermal cover). Wetlands and associated spruce forest were identified as key winter habitats, along with burns and cutblocks during peak shrub production periods (15 – 20 years post-disturbance). Deciduous or mixed forest stands, especially southwest aspects in river valleys, may also be favoured habitats. Riparian willow habitats at low elevations were listed as particularly important in deep snow areas.

Halko *et al.* (2001) used aerial photo interpretation combined with field tracking surveys to identify moose winter range near Creston in southeastern BC. Snow depth, canopy closure, stem density, leading tree species within a stand and browse species presence all showed little correlation with moose track density during the midwinter period. Moose track densities were over five times higher in flat areas than those on slopes >30%. Track densities were significantly higher in areas within 100 m of water compared to areas >200 m from water.

Winter aerial surveys of the Robson Valley, BC, found most moose in four forest categories:

- deciduous forests >60 years old
- deciduous stands <60 years old
- cleared sites and brush-dominated sites
- mixed forests (Ingham 1994, as cited in Safford 2004).

A number of RIC (1999) standard wildlife habitat suitability models have been done for moose in the Southern Interior Forest Region (Geowest Environmental Consultants Ltd. and Keystone Wildlife Research Ltd. 2001; Geowest Environmental Consultants Ltd. 1998a, b; Keystone Wildlife Research Ltd. 1999; Sinclair *et al.* 1997; Wildstone Resources Ltd. 1999; JMJ 2000). The species accounts and ratings tables in the models rated the habitats mapped in each mapping project for their suitability as moose habitat for a number of life requisites, depending on the project. Ratings were based on literature review of habitat requirements, but relatively little field-truthing was done for most projects.

For the Chilcotin West TEM project, wetlands, riparian areas and fens of structural stage 3, when dominated by deciduous shrubs were assumed to provide abundant forage for feeding for both winter and growing seasons (JMJ 2000). If shrub cover was greater than 15% then the rating given was class 1 (high), if 10-14% then the rating was class 2 (moderately high), if 5-10% then the rating was class 3 (moderate), if 1-4% then the rating was class 4 (low). Wetlands with less than 1% shrub cover were rated Nil.

Winter Foraging Habitats

Several authors have reported that moose winter habitat selection appears to be more influenced by food availability than by snow cover (Romito *et al.* 1999; Collins and Helm 1997; Serrouya and D'Eon 2002). Browse availability (willow) was the principal factor affecting moose winter habitat selection in the Susitna River floodplain in Alaska (Collins and Helm 1997).

Dussault *et al.* (2005b) examined the influence of temporal and spatial changes in food availability on home range size and movements of moose in Quebec. The moose in their study concentrated 60% of their activities in areas 2.5-15 times smaller than the total home range size in winter. During the winter, the proportion of food-rich habitat types increased with smaller home range sizes, core area sizes and movement rates. The correlation was more pronounced during the period when moose movements were constrained by deep snow.

Maier *et al.* (2005) found that moose densities in Alaska were highest at moderate elevations, and near rivers. The reported preference for habitats with extensive river margins (riparian habitats) is likely due to the greater amounts of high-quality forage, and/or the high diversity of habitat types present in riparian areas (Maier *et al.* 2005).

Willows (*Salix* spp.), aspen (*Populus tremuloides*), and cottonwood (*Populus trichocarpa*) are probably the most important winter browse species for moose. Other common winter foods include saskatoon (*Amelanchier alnifolia*), snowbrush (*Ceanothus velutinus*), falsebox (*Pachistima myrsinites*), red-osier dogwood (*Cornus stolonifera*), Sitka mountain ash (*Sorbus sitchensis*) chokecherry (*Prunus virginiana*), hazelnut (*Corylus cornuta*), soopolallie (*Shepherdia canadensis*), gooseberries (*Ribes* spp.), and arboreal lichens (*Alectoria* spp.) (Halko *et al.* 2001; Romito *et al.* 1999) but these other species commonly grow in low densities and thus make up smaller proportions of the diet. In low productivity forests where deciduous vegetation is limited, moose browse on balsam fir (*Abies balsamea;* Crete and Cortois 1997). Dwarf birch (*Betula nana*) is generally thought to be of low palatability to moose, but it may be an important forage item in some areas (i.e. Alaska; Collins 2002). Western redcedar (*Thuja plicata*) has been reported as a preferred browse species of moose in the Kootenays (Serrouya and D'Eon 2002). Bog birch (*Betula glandulosa*) is browsed as intensively as willows in wetlands east of Williams Lake, BC (Catton, in review). Bark stripping sometimes occurs, particularly on alder and aspen in late winter (Perry 1999).

Many species of willow seem to be universally important foods for moose. Riparian associated species such as cottonwood and red-osier dogwood and a wide variety of upland shrubs (saskatoon, aspen) appear to be preferred foods while bog associated species (bog birch, Labrador tea) are generally not preferred. Subcanopy species such as falsebox and redcedar may be important in deep snow areas, where moose forage in mature forests.

Vander Wal (2004) examined moose use of foraging habitat during the summer in Ontario. He found that total browse density was a better predictor of moose use than individual forage species cover. A qualitative ranking system is used to estimate potential value of wetlands in Ontario to moose, based on accessibility, size, vegetation and evidence of moose use (Berube 2000). Sites with no potential are water bodies with no aquatic vegetation, sites with low potential are bogs or areas moose would have difficulty accessing (i.e. due to steep banks), sites with moderate potential are wetlands <1 ha in size, either dominated by graminoid vegetation or else surrounded by jack pine and black spruce, sites with high potential are >1 ha in size with <50% of aquatic vegetation composed of preferred forage species, and sites with very high potential are >1 ha in size with >50% of aquatic vegetation composed of preferred forage species.

Moose prefer willows with low concentrations of phenolic compounds, and field investigations have found that variation in phenolic compounds can predict 47% of the variation in moose browsing (Stolter *et al.* 2005). Smaller diameter twigs of Barclay's willow (*Salix barclayi*) in an Alaskan study had higher digestibility and protein content but less fibre than larger-diameter twigs (Spaeth *et al.* 2002). Older twigs also contained less protein than younger ones, indicating that forage quality of willow in the winter varied on a fine spatial scale. Regelin *et al.* (1987) also studied moose forage quality in Alaska. They found that the quality of forage species varied dramatically in an annual cycle. Digestibility and crude protein were highest in June, then dropped sharply in October and remained low during the winter. Nutritional quality in different forest successional stages was similar for all species during fall and winter.

Another study in Alaska found that the proportion of preferred browse species (willow) in the diet declined as winter progressed, and was replaced by birch and poplar (Seaton 2002). The author suggested that the dietary shift may reflect the depletion of willows as a result of winter browsing. Although low-growing shrubs may be buried by deep snowfalls, preferred species may still be sought out and browsed by moose (Collins 2002).

Spaeth *et al.* (2004) conducted feeding trials of captive Alaskan moose to test the hypothesis that sexual segregation was the result of competitive exclusion of males by females. Female moose had higher intake rates than males, but this difference disappeared when the animals foraged on previously browsed willows. That result caused the authors to reject the hypothesis that selective foraging by female moose could lead to competitive exclusion of males.

Catton (in review) examined moose use of lodgepole pine forest adjacent to wetlands in central British Columbia (east of Williams Lake) in an attempt to determine the appropriate width of forested buffer zones or leave strips around wetlands. Moose track presence and numbers were higher within shrubby versus non-shrubby wetlands and cutblocks. The probability of moose presence increased with shrub height, levelling at 4 m. Distance from wetland edge did not influence the probability of moose track presence, nor did crown closure or snow depth.

Roberts (1985) found that moose browse utilization along the Cariboo River in central BC was greatest in floodplain swamps. Other wetland habitat sites were used to a lesser degree, often in proportion to the availability of browse. In forested habitats, moose used the structural stages where the greatest numbers of browse species were present. This occurred in early successional stages for some habitat units, and in climax stands for other units. Sitka willow (*Salix sitchensis)* was the most important winter food for moose in the Cariboo River valley, as well as red-osier dogwood, subalpine fir (*Abies lasiocarpa*), Pacific willow (*Salix* lasiandra), Drummond's willow (*S. drummondiana*), balsam poplar, paper birch, red elderberry (*Sambucus racemosa*), Sitka alder (*Alnus viridis*), and saskatoon. Douglas maple (*Acer glabrum*) was an important winter food on drier forest slopes, but browse species growing in logged sites at a distance from the river were poorly utilized. Western redcedar saplings were heavily browsed in habitats where the forest canopy improved conditions for winter mobility. Browsing frequency was increased in the vicinity of large cottonwood trees. Hardhack-willow treed mineral swamps had heavy use of preferred species, and heavy use was also observed on some species in hardhack-peat moss treed bogs, Labrador tea-velvet-leaved blueberry treed bogs, and spruce-sedge treed organic fens. Sedge-horsetail marshes, scrub-birch peat moss shrub bogs, scrub birch-sedge shrub fens, and red cedar-alder treed swamps received little winter use (Roberts 1985).

Schwab *et al.* (1987) examined burial of moose browse by snow in the Sub-boreal Spruce zone in the Prince George Forest Region. They found that, contrary to other published reports, increasing browse burial corresponded with increasing canopy closure during both the snow accumulation and snow melt periods. The authors suggested that wind blew snow from browse more easily in the more open sites, and that the more prostrate growth forms of shrubs growing under lower light conditions were more easily buried than the more erect growth forms of shrubs in open sites.

Security and Thermal Cover Habitat

Moose have a relatively low upper critical temperature (14^{o}C in summer and –5^{o}C in winter) and may thus be vulnerable to thermal stress on unusually warm days (Dussault *et al.* 2004). Collins and Helm (1997) noted that moose showed some degree of preference for cover while resting on warm sunny days in late winter.

Moose in Jacques Cartier Park in Quebec selected winter habitats that provided high food abundance interspersed with habitats providing shelter against snow (Dussault *et al.* 2005a). Females with calves had a higher preference for stand types providing protection from predation, while solitary moose preferred stand types providing moderate food abundance, moderate protection from predation and substantial shelter against deep snow. Moose were selective at both the landscape and the home-range scale, avoiding areas used by wolf packs (=areas with low snowfall) and concentrating, at the landscape scale, where habitats with the best food availability were highly interspersed with those providing snow interception cover. Moose appeared to trade off food availability with the cost of locomotion in deep snow. Preference for habitats providing snow interception cover increased during periods with lying snow, however, the most preferred snow interception habitats were those interspersed with stands providing abundant food.

A four-year study of moose habitat selection in Quebec (Cortois *et al.* 2002) found that moose home ranges had higher edge and interspersion among habitat patches. Mixed stands were preferred in all seasons, mature conifer stands were preferred in early winter while young conifer stands were preferred in late winter. Differences in habitat selection pattern between scales were noted. The preference for mixed stands suggested to the authors that dense cover is not a major component of late winter habitat in regions where snow depth is usually <90 cm.

Serrouya and D'Eon (2002) also noted that neither snow depth nor mature forest cover affected moose winter habitat use near Revelstoke. The mappable variables most strongly affecting moose use were elevation (below 1000 m), abundance of forage (particularly willow), slope, structural stage and Douglas-fir cover. It is interesting to note that two of the significant correlates are also associated with lower snow depths (elevation and presence of Douglas fir).

Moose can tolerate relatively deep snow, so snow interception cover may not be a critical factor in many areas where snow depths rarely inhibit movement (e.g. SBPS). Hiding and thermal cover are important in all areas and must be available in proximity to feeding habitats. Mixed stands that provide both food and shelter are probably the most valuable to moose.

Human Effects

Hunting is a major limiting factor of moose populations in areas accessible to humans (Dussault *et al.* 2005a). However, Schneider and Wasel (2000) found that moose densities in northern Alberta declined linearly with increasing distance from human settlement zones. Moose density was also positively associated with road density and with the highest intensities of legal hunting. It is likely that road density, hunting intensity and decreasing distance from human settlement are all correlated. Maier *et al.* (2005) also found that moose densities in Alaska were highest closest to towns. The association of moose with human settlement may be due to the lowered predator density near towns, or it may reflect a greater abundance of early seral vegetation in disturbed areas where people are active. A study of moose along the route of the Okanagan Connector Highway in BC found that cow moose were found significantly further from secondary roads in the fall (i.e. during hunting season) than in the summer or winter (Keystone Bio-Research 1991).

Although wolves often travel on roads (especially during the winter), a study of wolf-kill locations in the Flathead River drainage in BC found little evidence to indicate that the level of logging in the study area significantly increased the vulnerability of moose to wolf predation (Kunkel and Pletscher 2000). The authors also reported that moose were less likely to be killed by wolves in areas with higher road densities.

Serrouya and D'Eon (2002) also found that moose near Revelstoke, BC, exhibited heavy use of forestry roads and cutblocks during the winter, with those two habitat types accounting for more than 65% of moose use. Structural stages 3 and 4 were selected even during deep snow periods, with use of structural stages 5-7 progressively declining. Moose preferred low canopy cover, avoided intermediate cover and did not select against high cover. However, riparian and wetland habitats were very rare in their study area due to flooding by hydroelectric development.

The effect of cutblocks on moose seems to be dependent on a number of factors, including the time since harvest, the other habitat in the vicinity of the blocks, the quality of the forage present in the blocks (which is dependent on brushing and herbicide treatments), the amount of snow, the amount of legal and illegal hunting within the area and the scale of analysis used. A four-year study of moose habitat selection in Quebec found that at the home range scale, moose habitat selection did not appear to be affected by the presence of clearcuts (Cortois *et al.* 2002). At the finer scale, however, recent clearcuts were avoided except in early winter. As snow accumulated, the moose left clearcuts to use undisturbed stands in late winter. Cow moose increased home range size, but not movements, in the presence of cuts. Annual home ranges rarely changed as timber harvesting progressed, with only 3 of 47 animals gradually shifting their home ranges as cutting continued. Mortality and productivity were not related to the abundance of clearcuts (Cortois and Beaumont 2002), and the authors suggested that small cuts regularly interspersed with residual stands should be beneficial to moose.

A review of the potential effects of salvage logging in mountain pine beetle-infested areas concluded that 'provided that riparian areas and trees other than lodgepole pine are left unharvested, salvage logging should have few negative impacts on moose' (Bunnell *et al.* 2004). This expectation is supported since old pine stands may have limited value to moose except when adjacent to higher use habitats. However the avoidance of very large clearcut areas may limit moose movements where large clearings are created to eliminate beetle-infested stands.

Typically, forest harvesting produces a cluster of cutblocks separated by relatively narrow strips of forest. An investigation of such a landscape in Quebec found that retained forest strips were not used preferentially to cutblocks by moose (Potvin and Bertrand 2004). In the black spruce-moss forests of that study area, the proportion of residual forest within each landscape had no effect on moose density.

Road access and hunting are suspected to have depressed moose populations in some parts of the Cariboo Region (J. Youds - pers. comm.). The presence of roads and the juxtaposition of hiding cover are therefore important components of winter ranges that may determine habitat effectiveness and observed use by moose.

Moose Winter Range Management

The Ungulate Winter Range Technical Advisory Team (2005) framed a number of guiding principles for ungulate winter range management in south-central BC. Those principles pertaining to moose in particular include:

- Energy balance is the primary factor determining the overwinter survival of ungulates. Maximizing the availability of preferred forage and minimizing energy loss due to movement in snow should be the principal goal of ungulate winter range management
- Many winter, spring, summer, and fall range areas in the Southern Interior have been degraded by forest succession (exacerbated by fire suppression and resulting conifer in-growth), overgrazing by domestic livestock, and invasion by non-preferred forage species
- There is an inverse relationship between rooted forage and forest canopy cover
- Snow is intercepted by forest canopies and, for a given snowfall, snow depth on the ground decreases with increasing canopy cover. This relationship appears strongest at low elevations and on warm aspects
- Caution must be exercised when inferring preference from studies of diet composition and habitat use
- Ungulates use traditional winter ranges and occupancy of areas should be the overriding criterion of identifying winter ranges

- Movement in deep snow can be energetically expensive; therefore, minimizing mobility costs is an important consideration in identification and management of ungulate winter range.

The Ungulate Winter Range Technical Advisory Team (2005) reviewed data from a number of published studies and produced estimates of critical, inhibiting and nominal snow depths for moose (Table 2). Using the measurements given in Table 2, the SBPS is classified as having nominal snow depths for moose, on average, while the SBS has critical winter snow depths (Table 3).

Table 2. Critical, inhibiting and nominal snow depths for moose (from Ungulate Winter Range Technical Advisory Team 2005).

Description	Depth (cm)
Nominal: snow does not inhibit movement	<60
Inhibiting: snow inhibits movement	60-90
Critical: snow severely restricts movement	>90

The Ungulate Winter Range Technical Advisory Team (2005) cited desired conditions for moose winter range (MWR) as 'vigorous growth of preferred forage species in, or in association with, shallow snow conditions (generally <60 cm) in areas used traditionally by wintering moose'. Their suggested management objectives for MWR in areas of nominal snowfall include encouraging forage cover on wet sites by burning or slashing conifer ingrowth, controlling invasive plants and livestock grazing, and burning/slashing mature shrubs above browsing height to encourage vigorous lower growth of shrubs.

Suggested management objectives for MWR in inhibiting snow depth areas include the maintenance of forage as for nominal snowfall areas, as well as the maintenance of variably sized patches of evergreen cover. Strategies for cover maintenance include burning/slashing to thin excessive regeneration and poor quality stems, or using thinning-from-below to open the canopy, using a mix of single (large) tree and group retention, and planning for the distribution of snow interception throughout the MWR area, concentrated at lower elevations adjacent to forage, along travel routes and terrain breaks. Forage management strategies recommended by the Team included fertilization, group selection, juvenile and irregular spacing, reduced stocking density, and slashing deciduous trees and tall shrubs to promote suckering and re-sprouting. The promotion of rooted forage in small openings within snow interception cover patches was also recommended. Forage and snow interception cover management recommendations for deep snow winter range areas were similar to those provided for MWR in inhibiting snow depth areas (Ungulate Winter Range Technical Advisory Team 2005).

Cortois and Beaumont (2002) also produced two alternative recommendations for moose habitat management in Quebec. Those recommendations included 1) the maintenance of deciduous browse at >10,000-15,000 stems/ha, and maintenance of adequate cover (shrub layer >=2-3 m high, lateral obstruction >=50% at 3 m), or 2) distribute 50-100 ha cuttings over the landscape while keeping about 50% of the area uncut.

Halko *et al.* (2001) recommended that management of moose winter range near Creston, BC, focus on maintaining a mosaic of cutblocks of various ages interspersed with patches of mature timber with adequate snow interception qualities. The Washington Department of Fish and Wildlife recommends that buffers wide enough to conceal an adult moose be provided around one-half or more of the perimeter of moose aquatic feeding sites (Knutson and Naef 1997).

Lemke (2001) recommended that planning for moose cover habitat in the Lillooet Forest District include providing connectivity between riparian/wetland areas with 5 m height security cover at least 100 m wide, and requiring 5 m green-up of cutblocks adjacent to important winter habitat for moose before additional blocks are harvested. Visual screening should be maintained along the edges of wetlands. Main haul roads should be located no closer than 200 m (preferably 400 m) from important foraging areas. Livestock management recommendations for foraging habitat included not seeding livestock forage species in cutblocks where browse species are present, to avoid concentrating livestock in moose foraging habitat. Minimum stocking standards or natural regeneration were suggested to reforest cutblocks on rich soils and mesic to subhygric sites. The use of herbicide-free zones and rapid and early replanting will allow reforestation while promoting moose browse species.

Keystone Wildlife Research (1995b) produced habitat management guidelines for TFL 5 near Quesnel, BC. The guidelines pertaining to moose management included:

- Maintaining and encouraging the deciduous component in the TFL's forests with the use of both uniform and patch retention of deciduous trees
- Avoiding herbicide use adjacent to forest corridors, along wetland edges and along roads in order to promote deciduous growth for forage and visual screening
- Using harvesting to create a mix of shrub-producing openings and forest in a variety of age classes within areas managed for moose
- Minimize ground disturbance on wetland edges
- Retaining deciduous trees and defect conifers along wetland edges and in moist depressions.

Simpson *et al.* (1988) recommended that habitat management for moose near Revelstoke, BC, include:

- Retaining cover blocks of 2-5 ha in cutblocks over 100 ha, spaced so that moose are no further than 200 m from shelter over 6 m in height. Shelter patches should be at least 1/3 conifer and have about 11m^2/ha basal area in conifers, and at least 60% canopy closure.
- Maintain 100 m wide forest cover reserves surrounding lakes, ponds, rivers and wetlands, especially western redcedar swamps.

Some authors have suggested that it is not necessary to have cover maintained in a band all around wetlands used by moose, but only directly adjacent to feeding sites and along the access routes that moose use to travel to feeding sites (Timmerman and Racey 1998, as cited in Berube 2000). The Ontario Moose Management Guidelines include the provision of a 120 m buffer around aquatic feeding sites and clearcut sizes limited to 80-130 ha (Crouse 2003). A study comparing moose condition indices between an area where the Ontario Moose Management Guidelines were followed, and an area where large blocks were progressively clearcut found that calf survival was greater in the area where harvesting followed the guidelines, although health status, nutritional condition and reproductive effort of cow moose did not differ between the two areas (Crouse 2003).

The effects of brushing of deciduous forage in moose winter range areas can be varied according to the time that the brushing is carried out. Rea and Gillingham (2001) conducted brushing trials in central BC and found that brushing in early to mid-July (mid-summer) resulted in shoots that were lower in lignin, higher in digestible protein and lower or not different in tannin content compared with shoots from earlier brushed or unbrushed willows. Willows brushed later in the year had negligible regeneration in the first year after brushing, and/or delayed leaf flush in the first post-brushing spring.

Bulldozers have been used to enhance moose foraging habitat in Alaska (Hicks 1999). Bulldozers with special blades were used to shear-cut tall old willows and aspen to encourage growth of browse accessible to moose. As willows sprout from the root crown, care must be taken to keep the bulldozer blade at least 30 cm above ground level to avoid damaging the roots or uprooting the shrub entirely. The treatment was quite successful for feltleaf (*Salix alaxensis*) and littletree (*Salix arbusculoides*) willows and for aspen, but was less successful for Bebb's willow (*Salix bebbiana*), which showed little sprouting a year after treatment.

Management of moose winter ranges focuses on providing abundant forage in locations where moose can access it. On the landscape scale, this corresponds to areas where snow depths are tolerable (<90 cm). At the stand level, this corresponds to areas where hiding and thermal cover are nearby (within 200 m).

The Cariboo Chilcotin Land Use Plan (CCLUP)

The Cariboo Chilcotin Land Use Plan (MSRM 1995) indicates that the habitat needs of moose should largely be met through application of the Forest Practices Code (now the Forest and Range Practices Act, FRPA). Specifically, application of the biodiversity guidelines as well as the conservation of wetlands and riparian areas (including forested buffers) will provide winter habitat throughout the region. Increasing wetland buffers beyond the sizes specified in the Riparian Management Area Regulation may be required to maintain habitat values for moose. Options to increase buffer widths will depend on specific management practices and other constraints on harvesting that may be in place on moose winter range areas. Specific recommendations include:

- Maintain at least 50% of the perimeter of wetlands over 5 ha in security/thermal cover
- Avoid herbicide treatments in areas where browsing is evident

Access management should be considered in all habitats that are particularly important to moose, since excessive access can result in high poaching and hunter harvest levels. Some specific recommendations include:

- limitation on permanent access and deactivation of temporary roads within 500m of wetlands
- road crossings of wetlands and riparian areas should be as limited as possible
- buffers of wetlands (up to 200 m) may be required adjacent to key wetlands or riparian habitats, particularly on the Chilcotin Plateau.

No information was available in the CCLUP with regards to moose management in beetle-infested stands, however, that information would be most helpful in determining best management once the winter range areas are identified. The literature review indicated that salvage logging in mountain pine beetle-infested areas should have few negative impacts on moose as long as riparian management rules are followed (Bunnell *et al.* 2004).

4.2 Moose Population Characteristics in the Cariboo Region

Sopuck *et al.* (1997) recognized the diversity of habitats and climatic conditions in the Cariboo Region. Strategies developed to manage seasonal habitat for moose must recognize the distinct differences in habitat quality and winter mobility of moose in dry, moist and wet ecosystems.

In drier ecosystems (SBPS, MS, IDF), where forested sites support limited amounts of shrub forage species, wetlands and riparian areas provide a substantial portion of the feeding habitat available to moose. Moose densities have been estimated at 0.3 /km^2 based on gross area. Snow depths rarely restrict the movements of moose in these ecosystems so seasonal migrations are not required. Many moose are therefore expected to be non-migratory resident animals in drier ecosystems. In moist ecosystems (SBS), moose forage productivity in seral forests is relatively high and moose may be less dependent on wetlands when disturbances provide abundant young seral foraging areas. Densities of moose may reach 2 /km^2 under favourable habitat conditions. Since snow depths can restrict moose movements, some seasonal migration and concentration is expected, particularly in severe winters. In wet ecosystems (ICH, ESSF), forage production is very high in disturbed sites and wetlands but snow depths severely restrict movements. Moose are excluded from the ESSF in winter and are confined to lowest elevation parts of the ICH (< 1000 m) in winter. A high proportion of moose in those ecosystems is expected to be seasonal migrants and will take advantage of abundant forage at higher elevations in the growing seasons. Estimated densities of moose (0.3 /km^2) are lower than in the SBS since the available winter range is a small portion of their annual range.

Best management practices should be tailored to meet the needs of moose in the three distinctly different forest types (dry, moist and wet). Best management practices are specified for each snow depth zone based on the expected requirements of moose in each area. Subzones are used as surrogates for snow zones, however, correct snow zone mapping, which will be variant specific, is required to apply management regimes correctly. Snowzone mapping has been completed for the Cariboo region for mule deer. That mapping should be reassessed and adjusted, using the snow depth thresholds relevant to moose, to develop a snow zone map specific to the needs of moose.

4.3 Moose Winter Range Best Management Practices

The current best management practices used for high value wetlands in the Cariboo region were reviewed in Intrepid Biological Consulting (2003). Management practices differed according to whether the wetland in question was an isolated polygon or part of a larger wetland complex. Isolated high value wetlands were protected with a 200 m forested buffer (100 m in the Chilcotin Forest District), plus targeted placement of wildlife tree patches to increase the amount of forest cover adjacent to the wetland. Management practices for high value wetlands that were part of wetland complexes included, implementing extended harvest rotations, using seral stage management, and limiting the area of harvest to one third of the wetland complex. Retention of sufficient forest to provide connectivity between wetlands for use as moose travel corridors was also recommended. Recommended access management included closing all forestry roads within 1 km of high value wetlands once forest harvesting is complete, and avoiding road construction in proximity to or crossing high value wetlands.

The current guidelines will serve to protect the high value wetlands that have been identified. More comprehensive guidelines may be required for variants where wetlands form a small component of the key winter ranges. Moose habitat management scenarios used in the Kamloops-Okanagan and in Alberta, Manitoba and Ontario were reviewed and summarized (Appendix I). Most of the Provincial management guidelines have been established and in use for 5-20 years. All approaches focus on providing thermal (snow) cover, hiding cover and feeding areas in close proximity and on preventing motorized disturbance and over-harvest. Winter is the most critical season, however, spring access to minerals and calving areas are also recognized as key elements of moose annual ranges. In areas where moose are not migratory those habitats will overlap with their winter ranges so management should consider other seasons of use.

Buffer zones are commonly used to define special management zones around high use winter habitats. Sopuck *et al.* (1997) recommended 50 m no harvest buffers be established around small (1-5 ha) wetlands, 200 m around larger (>5 ha) wetlands and 400 m around high value wetlands. Buffers of 100-200 m are commonly recommended in other jurisdictions (Appendix 1). The rationale relates to observed use by moose, which is usually concentrated within 100 m of an edge (Sopuck *et al.* 1997), as well as distances needed to obscure moose from view and distances needed to reduce disturbance from human activities.

BMPs for Dry Ecosystems (IDF, SBPS and MS)

In dry zones, moose are generally unrestricted by snow, but abundant forage is mainly available only in riparian forests and wetlands. Since foraging habitat is limited, moose probably use the same areas and resources year round. Security (hiding) cover will be an important habitat component in winter, to prevent disturbance. Thermal cover will be important in summer when high temperatures may stress moose. Wetlands, lake margins and riparian areas, which provide the main foraging sites in winter, also provide aquatic feeding sites in spring and summer. Upland and riparian forests will provide the main thermal and hiding cover. Since forage is expected to be limiting, a higher proportion of the managed area should be forage (60%) and less in cover (40%). The extent of cover should be determined based on the area of foraging habitat available in each wetland/riparian complex. In variants where selective harvest is the primary harvest system (IDF), it should be possible to maintain cover and forage in all treated areas. Adequate hiding cover must be maintained in and around riparian forests and wetlands.

On plateaus with moderate terrain and more open forest stands (SBPS, MS), wider buffers (200 m) are advisable to discourage access and provide adequate visual and escape cover. Some disturbance may be permitted within buffers if the intended functions can be maintained, however most should be designated as no access and no harvest zones. Where interior forest is provided within wetland/forest complexes, the width of the exterior buffer may be reduced, provided that the forage/cover ratio remains favourable (> 40% cover). Increasing the patch size of interior forest will be most beneficial for calving. Mature cover should make up 40% of each wintering area.

BMPs for Moist Ecosystems (SBS)

In moist zones, moose are expected to concentrate in low snow areas during deep snow periods, but wintering options for moose will be more variable and not as closely associated with wetlands. Wetlands and riparian forests will provide some foraging habitat, but extensive short-term foraging habitat can be created or enhanced using well-planned disturbances. Warm aspect slopes with lower snow depths, where moose congregate during severe winters, should be identified. In these congregation areas, where snow depths are rarely expected to be restrictive, a higher proportion (60%) of the habitat should be maintained as forage to support the high numbers of animals that may move into the areas in deep snow winters. Hiding and thermal cover should be permanently maintained adjacent to long-term forage areas and rotated in other wintering areas. Thermal cover, hiding cover and forage are equally important in these habitats and should average 1/3-1/3-1/3. Where hiding cover can be provided by deciduous or mixed stands, the area available for forage and numbers of moose supported can be greatly increased.

In moist plateau forests (SBS), the fast re-growth of deciduous species after disturbance can provide excellent feeding habitat and relatively dense hiding cover for moose. Cut/leave harvesting using small (20 ha) blocks can create favourable conditions for moose as long as young seral (tall shrub, 5-40 years), young forest (pole sapling, 40-80 yrs) and mature forest (> 80 yrs) components are available in close proximity. Ideal management should maintain approximately equal quantities of each component over the long term. If larger openings are used, maximum widths should be 400 m with similar sized leave areas. Mature cover should make up 1/3 of each wintering area. Wetlands will be most valuable for calving and summer habitat. Buffers of 100 m should, therefore, be maintained around larger wetlands and wetland complexes.

BMP for Wet Ecosystems (ICH, ESSF)

In wet zones, winter ranges will be very discrete and restricted to relatively few low elevation riparian valley bottoms. Snow interception cover is an essential component on the low elevation winter range areas and desirable forage/cover ratios should be 40/60. Mature forest cover should be maintained adjacent to all long term foraging habitat (riparian valley bottoms) and the 40/60 target should be applied in all moose wintering areas below 1000 m elevation. Forage areas are highly productive so less area is needed to provide adequate food for moose. Maintaining movement corridors and snow shelter adjacent to foraging areas and understory food species become overriding concerns in deep snow winter ranges.

In the wet mountains (ICH) where snow depths are severely restrictive to moose, emphasis should be placed on maintaining snow interception cover within defined winter ranges and in proximity to key riparian feeding areas. A higher proportion of cover is required in these areas to enable movement between feeding areas and to provide sub-canopy forage such as falsebox. Moose may be restricted to high crown closure stands for significant periods each winter. Any openings created should be less than 100m across to enable moose to access forage. Mature or older cover should make up 60% of each wintering area.

BMP Overview

General management objectives for timber harvesting on moose winter ranges were summarized by Simpson (1995) for TFL 5 in the Quesnel District. The TFL includes the SBSmh and mw variants. Explicit objectives included maintaining a mix of young shrub producing habitats, hiding cover (3 m conifer) and thermal cover (>19 m conifer). Shrub production was extended on moist sites by reduced conifer stocking and by restricting deciduous control programs (herbicide use). Hiding cover was enhanced and sight distances reduced by retaining deciduous vegetation along roads and in linear bands through cutting units.

Green-up criteria on TFL 5 were also defined to ensure adequate hiding cover has developed prior to harvest in adjacent areas. In that area, three metre tall, well-stocked conifers were sufficient to completely obscure moose 50 m away. The time periods required to obtain 3 metre green-up were estimated based on site index. They were 15 years in Douglas fir types (SBSmh), 11 years in mixed pine-fir types on the plateau (SBSmw) and 19 years in wetter habitats (spruce types) on the plateau. Green-up time required may be greater (20-30 years) in poorer growing sites (SBPS). Management objectives by subzone are summarized in Table 3.

Table 3. Key winter habitats and moose winter range management objectives by subzone.

Zone	Key winter habitats	Optimal buffer widths (m)	Minimal buffer widths (m)	Forage/ hiding/ thermal ratio	Important elements
SBPS	Plateau wetlands, riparian	200	100/2	40/30/30	Increase forage
IDF	Riparian forest, wetlands	200*	none	40/30/30	Select harvest
MS	Wetlands (few areas)	200	100/2	40/30/30	N/a
SBS	Mesic, moist, riparian	none	none	33/33/33	Small patches
ICH	Riparian valley bottom wetlands	100	100	20/20/60	Snow interception
ESSF	Very few areas	na	na		na

* only required where selections systems do not provide cover, 100/2 is 100 m over ½ of perimeter or adjacent to shrubby sites

General guidelines from Ontario provide good guidance for local forestry planning on all moose winter ranges.

> "*The best habitat should provide conditions enabling a moose to be within 200 m of shelter patches or other cover. These shelter patches should preferably be of conifer but could be of mixed-wood, with at least 1/3 in conifer. They should be at least 3-5 ha in size, be spaced 300-400 m apart and be at least 6 m high…*".
> *"In late winter concentration areas, the width of individual cuts should not exceed 400 m. Uncut areas equal in size to cut areas should be left. To protect aquatic feeding areas, mineral licks and calving sites, generally reserves are required with the shape and extent dictated by surrounding habitat conditions. Usually a 120 m reserve should be left around these areas. Some merchantable conifer may be removed by selection cutting provided the general nature of the reserve remains intact.*"

More local planning for moose winter ranges can be completed once the size, distribution and characteristics are defined. Ideally a "planning cell" approach should be used. This approach considers the size and location of each designated winter range, the forest land status (contributing, non-contributing) and the current structure (% shrub, young, mature). With this information in hand, the most compatible options to achieve integrated management for moose and forestry can be tailored in each area. Map criteria that can be used to identify high quality moose winter range within the Region are discussed below using two example areas, Kluskus and Gerimi.

Road access should not be provided into the managed wetlands. At least 50% of the area in managed wetlands should be >500 m from roads and open feeding habitats should not be visible from roads. Screening cover should be maintained or topographic breaks should be employed to reduce sight lines from roads. High value feeding areas, where known, should be at least 200 m from roads and forest cover should be maintained between high use areas and the roads. Road beds that may be accessible to oversnow vehicles should be revegetated to prevent their use in winter.

Habitat objectives for moose winter ranges, which include amount and distribution in each zone, have been specified, however, application of those guidelines requires explicit spatial delineation of the management areas and consideration of current management under FRPA. The planning cell approach defines the current extent and location of feeding habitat, hiding cover and thermal cover, and the areas that are currently constrained, protected or available for harvest. Land management options that are discretionary under FRPA, such as wildlife tree patches and allocation of seral stage targets, should be used to create or maintain favourable conditions for moose in each winter range area. Optimal management will differ in each area depending on the current extent and distribution of key moose habitat components and the existing forest management regime. For example, the buffer widths required to achieve the desired forage/cover ratios will change depending on the size and shape of each wintering area and the proportion of wetland in each. Standard prescriptive guidelines, although easy to apply, will not provide optimal habitat conditions in all cases nor will they allocate scarce resources in the most efficient way.

4.4 Moose Winter Range Identification

Moose winter ranges in the Cariboo Region have been previously identified using the compiled results of winter surveys from 1994 to 2004 and from local knowledge (Intrepid 2004). Wetlands where four or more moose have been counted were included in a high value wetland coverage being assembled for the region. Since the survey data has not covered the entire region, significant gaps occur in the current coverage, therefore a method to identify important wetlands in other parts of the region has been investigated.

Two study areas (Kluskus and Gerimi), which occur within two variants (SBPSdc and SBSmh/mw), were chosen where both moose survey data and digital mapping data were available. Digital data from a variety of sources was compiled and used to describe the characteristics of the currently identified high value wetlands and other areas occupied by moose in winter. The level of correspondence between known moose winter locations and areas defined using mapping parameters was used to judge the effectiveness of a map-based selection of winter ranges. The objective was to determine if map data could be used effectively to identify potential moose winter range areas. All areas identified based only on map data should be subject to winter surveys in order to confirm occupancy by moose before designating and applying special UWR management.

GIS Map Data Assembly: Kluskus SBPSdc

The following steps were used to create a base map for defining moose winter range areas in the Kluskus survey area:

- Obtained relevant data sources: PEM, Structural Stage, VRI, high value wetlands, Cariboo Region capability, ILMB moose location data
- appended VRI mapsheet data
- identified VRI attributes that are associated with moose location data and High Value Wetlands data. This included NP_DESC = swamp, lake and NPBR (non-productive brush).

- The 1:20,000 BEC Variant lines were included within the study area
- Swamps, lakes and NPBR were buffered by 100 m to create continuous wetland complex patches. Patches were classified into 3 classes (small <550 ha, medium 550-2450, large > 2450) using Jenks Natural Breaks classification (ESRI 2005).
- Inclusions of forest that were completely surrounded by the wetland complex patches were included in each patch
- A coverage representing dominant cover types was created using VRI: low and tall (> 2 m) shrub, and treed classes (mixed, conifer, broadleaf)
- an interior buffer (300 m from the buffer edge) was used to determine which wetland complex patches contained interior habitat areas
- TRIM roads, and forestry roads from LRDW were appended together and classified as motorized and non-motorized.
- The motorized classified roads were converted to raster (10m pixel), and a distance from roads grid was created using 4 classes (0-100, 101-200, 201-500 and >500 m from roads).
- The classified distance from roads grid was converted to a polygon coverage and overlaid onto the buffered patch coverage
- The PEM forest site series were grouped into 4 classes: 02 and 03 were classified as D (dry); 01,04 and 05 were classified as M (mesic); 06, 07, 08 were classified as W (wet), and other units were classified as N.
- The structural stage coverage was classified into 5 classes (0-1 =non-vegetated, 2 =herb, 3 =shrub, 4 =pole, and >4 =young, mature, old)
- Survey block locations were digitized from the PDF file and block corner UTM locations.
- Moose location data and blocks surveyed were overlaid onto the wetland coverage to classify each as surveyed/not surveyed and moose present or not present.
- The Ministry high value wetland coverage was also overlaid to ID high and low quality wetlands
- All of the above layers and datasets were overlaid into one resultant spatial database.

Within the Kluskus survey area, 1010 wetland complex polygons were identified in the buffered coverage. Complexes larger than 2450 ha were classed as large, 550-2450 were classed as medium and polygons less than 550 ha were classed as small. The wetland complexes included the 100 m forest buffers and interior polygons. In Kluskus, 168 of the 1010 wetland complexes were included, at least partially, in a surveyed block (Table 4). Moose were recorded in only 17 (10%) of the 168 complexes that were surveyed.

Table 4. Wetland complexes identified in the Kluskus study area.

Kluskus Survey area	Number	Hectares	No. surveyed	# where moose seen	# moose seen	# designated High value
Large complexes	4	18,704	3	2	101	4

Kluskus Survey area	Number	Hectares	No. surveyed	# where moose seen	# moose seen	# designated High value
Medium complexes	14	15,583	7	5	26	3
Small wetlands	992	42,913	158	10	48	31
Total	1010	77,200	168	17	175	38

The large and medium complexes capture all of the larger wetlands currently designated as high value by MOE. Eleven additional medium wetlands (not classed as high value) are also identified, two of which contained moose during winter surveys. A large number of small wetlands were also identified (992). The descriptive variables available in the resultant dataset were not effective in differentiating the 10 wetlands where moose were sighted from 148 others with no moose, or in distinguishing those designated as high value (38) from those that were not (130, Table 4).

It is recognized that most moose sighting data was based on single surveys, which may not reflect the actual importance of the various wetland areas to moose. Since moose spend about 2/3 of their time in forests adjacent to wetlands, where they cannot be seen, small wetlands with few moose have a lower chance of being classed as “moose present” than larger complexes, using a moose-sighted model. A quantification of numbers of tracks observed in or near each wetland may provide a more reliable index to moose use since moose activity over a longer period (days since snow) could be used to determine occupancy. Multi-year surveys would also be valuable since moose may use small wetlands only in alternate years while large and medium wetlands would likely be occupied by some moose in every year.

Large and medium wetlands accounted for most (72%) of the moose seen on winter surveys (Table 4). The area surveyed within each class of wetland was approximated by overlaying the surveyed blocks on the wetland coverage (L= 10,856 ha, M = 3316 ha, S = 5632 ha). Densities of moose may be slightly higher in large wetlands (0.91 / km^2) compared to medium and small wetlands (0.78 and 0.82 / km^2 respectively).

Summing the shrub, broadleaf forest and mixed forest classes can best approximate the area of feeding habitat available to moose. In each wetland class (large, medium and small), the available foraging habitat makes up only a small portion of the total area (11.8, 13.9 and 13.1 % respectively, Table 5). Broadleaf and mixed forests also provide cover so the cover available is 48.8, 52.9 and 60.7%, respectively for large, medium and small wetland classes (Table 5). Based on objectives from Table 3 (20-40% of area for foraging), the actual area available for moose to forage may be quite limited within the wetland complexes. Opportunities to increase forage in dry and mesic upland forests are also limited by the low productivity of those sites and their lack of shrub production. Moist forests, specifically site series 06, 08 (Spruce-horsetail) and 07 (Black spruce-scrub birch) may provide better shrub forage after disturbance. Many of those sites are considered non-harvestable due to low productivity and cold air ponding, which makes regeneration difficult. The most practical management scenario, considering the limitations, is to ensure that cover is maintained adjacent to the high quality feeding areas. Most of these will be the wetland margins with significant shrub cover.

Table 5. Moose habitat components (from VRI) of wetland complexes in the Kluskus study area.

		Large		Medium		Small	
Land Class	Description	Ha	%	Ha	%	Ha	%
Forest	treed broadleaf	310	1.7	267	1.7	688	1.6
	treed mixed	602	3.2	657	4.2	1,266	3.0
	treed conifer	8,208	43.9	7329	47.0	24,075	56.1
Wetland	herb	5,715	30.6	3247	20.8	7,362	17.2
	shrub	1,296	6.9	1254	8.0	3,651	8.5
Water	lake, river	2,260	12.1	2440	15.7	5,001	11.7
Other	rock, urban, cleared	312	1.7	389	2.5	836	1.9
TOTAL		18,704	100.0	15583	100.0	42,878	100.0

There are a number of features of the large and medium wetlands that may make them more valuable than small wetlands. Large wetlands incorporate a greater proportion of wet site series, which may contribute substantially to the forage available to moose (Table 6). We suspect this occurs because the large complexes contain more forested depressions between the open wetland sites, while upland forest types usually surround small wetlands. Wetland size and proximity to other wetlands are therefore important considerations when prioritizing wetlands for management attention.

Table 6. Proportions of wetland and shrubland within the Kluskus study area.

Measure	Large	Medium	Small	Totals
Ha of wetland	18,704	15,583	42,878	77,165
% wetland of gross	3.9%	3.3%	9.0%	16.2%
Ha of shrubland	1296	1254	3651	6201
% shrub of wetland	6.9%	8.0%	8.5%	8.0%
% shrub of gross	0.3%	0.3%	0.8%	1.3%
gross landbase				476,042

Within each wetland, only a small portion supports willows and other shrubs that are the main foods of moose in winter. Wetlands make up about 16% of the gross landbase and within those only about 8% is shrubland (Table 6). On the entire landbase, high value moose winter foraging habitat makes up only about 1.3% of the land. Careful management of these very limited areas is required to maintain moose populations.

The proportion of forest within large wetlands tends to be slightly less than others but the amount of interior habitat is much greater (Table 7). Consequently, large wetlands have larger patches of moist forest wetland complex, which may also be extremely valuable to moose during calving. There are also smaller portions of large wetlands close to roads although all wetlands have >70% at least 200 m away from the nearest road. Structural stage information from the PEM suggests that most forests are old enough to provide both hiding and thermal cover. There is a discrepancy in the amount of herb vs. shrub in the PEM (Table 7) vs. VRI (Table 5) data. This occurred because many wetlands were assigned a default structure of 3. We suspect that the VRI classification (Table 5) may be more accurate.

Table 7. Site series, structural stage, access and patch conditions in wetlands.

	Wetland complex size		
	Large	**Medium**	**Small**
Forest type (PEM - SBPS only)			
Dry	7.3%	8.3%	8.0%
Mesic	63.5%	52.3%	47.6%
Wet	22.2%	15.8%	11.5%
Other	7.0%	23.6%	32.9%
Structural Stage (PEM)			
0-1 none, sparse	12.9%	17.7%	12.0%
2 herb	4.8%	5.3%	5.0%
3 shrub	32.7%	24.1%	21.3%
4 pole	1.0%	1.8%	1.4%
>4 young, mature	48.7%	51.2%	60.3%
Distance to road (m) (TRIM, MOE)			
0-100	6.2%	10.7%	8.0%
101-200	6.1%	7.4%	8.0%
201-500	16.9%	13.4%	21.2%
>500	70.9%	68.4%	62.8%
Patch Conditions			
Edge <600 m across	65.2%	85.4%	97.6%
*Interior >600 m across	34.8%	14.6%	2.4%

* interior refers to distance from edge, not pure forest patches

Based on this analysis, wetland size and shape, as represented by the amount of interior habitat, provided the best means to identify high value wetlands. All of the large and medium complexes identified as "high value" using the aerial survey data were also selected using the GIS data. Within smaller complexes, we were not able to distinguish wetlands designated as high value or areas where moose were seen from other sites. Of the 158 wetlands surveyed, moose were sighted in 10 and 31 were designated as high value. For the small wetlands, the sample size was too small to provide a good test of the numerous variables used in the analysis.

GIS Map Data Assembly: Gerimi-Nyland Area SBSmh, SBSmw

In the Gerimi-Nyland study area, TEM data for the SBSmh and SBSmw subzones was available to assess the observed winter distribution of moose within the surveyed blocks. Each moose point was buffered to determine the habitats in proximity. The habitats used by moose were compared to the habitats available within the areas that were surveyed using the survey block coverage. Expected use was calculated as the proportion of each habitat available within the surveyed areas. Although this is not a true use/availability analysis it does indicate that moose locations were not closely associated with wetlands (Table 8) in either subzone. Moose were most often recorded in mesic and moist forests within the SBSmh subzone and in immediately adjacent areas of the SBSmw subzone, primarily in mesic forest, seepage and floodplain units. The SBSmh occurs mainly on warm aspect slopes of the Quesnel River where snow depths rarely restrict moose. The river breaks and the adjacent crests in the SBSmw zone are likely winter concentration areas for moose, particularly in deep snow winters.

Table 8. Gerimi Nyland ecological mapping data and moose winter locations.

	Ecosystems Surveyed				
Eco units	Site series Description	Moose use (ha)	Expected use	Total Area surveyed (ha)	Obs-Exp
SBSmh_SN*	01 D Fir hazelnut	68.01	49.88	1713.34	18.13
SBSmh_SD*	07 Birch Devil's club	6.44	4.49	154.08	1.96
SBSmh_SC*	06 D Fir coltsfoot	8.02	7.00	240.39	1.03
SBSmh_CB	Cut bank	1.22	0.61	21.12	0.60
SBSmh_AH	Aspen hazelnut floodplain	0.72	0.08	2.70	0.64
SBSmh_SH	09 Spruce horsetail	1.25	0.99	34.01	0.26
SBSmh_RP	Road	0.24	0.16	5.42	0.08
SBSmh_PS	Rose dogbane grassland	0.51	0.51	17.62	0.00
SBSmh_RO	Rock	0.00	0.01	0.41	-0.01
SBSmh_ES	Exposed soil	0.00	0.02	0.78	-0.02
SBSmh_PD	Pond	0.00	0.07	2.33	-0.07
SBSmh_GP	Gravel pit	0.00	0.12	4.18	-0.12
SBSmh_AD	Alder red osier floodplain	0.00	0.13	4.57	-0.13
SBSmh_RR	Rural	0.00	0.20	6.76	-0.20
SBSmh_OW	Shallow open water	0.00	0.34	11.51	-0.34
SBSmh_WS	Sedge wetland	0.37	0.85	29.36	-0.48
SBSmh_OF	08 Spruce ostrich fern floodplain	1.11	2.03	69.60	-0.92
SBSmh_LV	03 Pine v leaf blueberry	0.00	1.10	37.81	-1.10
SBSmh_DC	02 D Fir cladonia	0.05	2.03	69.59	-1.98
SBSmh_SF	05 D Fir feathermoss	0.63	3.49	120.01	-2.86
SBSmh_DD*	04 D Fir Douglas maple	6.20	11.77	404.14	-5.57
SBSmh_CF	Cultivated field	5.55	14.45	496.36	-8.90
		100.32	100.32	3446.09	
SBSmw_SF*	01 D Fir falsebox	84.81	73.15	4381.00	11.66
SBSmw_SP	05 Spruce pink spirea	6.34	3.34	200.08	3.00

	Ecosystems Surveyed				
Eco units	**Site series Description**	**Moose use (ha)**	**Expected use**	**Total Area surveyed (ha)**	**Obs-Exp**
SBSmw_AD	Alder red osier floodplain	4.68	1.88	112.49	2.80
SBSmw_SH*	09 Spruce horsetail	9.29	8.65	518.28	0.63
SBSmw_SB	Sedge buckbean wetland	0.53	0.03	1.65	0.50
SBSmw_DH	02 D Fir huckleberry	0.53	0.10	6.03	0.43
SBSmw_SA	Spruce alder lady fern	0.08	0.04	2.57	0.04
SBSmw_ES	Exposed soil	0.00	0.06	3.43	-0.06
SBSmw_AT	Alder twinberry swamp	0.00	0.13	8.04	-0.13
SBSmw_SS	Scrub birch sedge fen	0.92	1.07	64.21	-0.15
SBSmw_HC	Hardhack marsh	0.00	0.20	11.89	-0.20
SBSmw_LT	07 Pine bunchberry	0.00	0.24	14.47	-0.24
SBSmw_PD	Pond	0.01	0.28	16.74	-0.27
SBSmw_WS	Sedge wetland	0.00	0.31	18.83	-0.31
SBSmw_OW	Shallow open water	0.10	0.55	32.73	-0.45
SBSmw_BS	Black spruce bog	0.63	1.13	67.92	-0.51
SBSmw_WW*	Willow sedge fen	0.00	0.89	53.12	-0.89
SBSmw_ST*	07 Spruce twinberry	7.20	9.09	544.45	-1.89
SBSmw_SD*	08 Spruce devil's club	0.00	2.60	155.73	-2.60
SBSmw_SK	04 D Fir knights plume	5.41	8.60	515.02	-3.19
SBSmw_SO	06 Spruce oak fern	1.79	5.36	320.87	-3.57
SBSmw_LH	01 cold, Pine huckleberry	0.00	4.60	275.41	-4.60
	Totals	122.31	122.31	7324.96	

* predicted high suitability winter habitat for moose (Keystone 1999).

The units where moose were observed in the SBS subzone (Table 9) correspond well with those identified as high value winter habitat in the wildlife suitability ratings for the Gerimi-Nyland area (Keystone 1999). Wetlands are expected to form only a minor component of moose winter range in those zones.

Table 9. The TEM ecosystems rated high value for growing (G) and winter (W) habitat for moose (from Keystone 1999).

Subzone	Ecosystem unit	Structural stage	Life requisites	Season	Rating
SBSmh	SN, DD, SC, SD, AH, WS	3, 6-7	LI FD	G	2
	SN, DD, SC, SD,	3, 6-7	LI FD LIST	W	2
SBSmw	SD, SH, WW, WS, WD, SA, BW, AD, AT	3, 6-7	LI FD	G	2
	SH, SD, SF, ST, WD, WW	3, 6-7	LI FD LI ST	W	2

The winter suitability of the Gerimi area was defined for the TEM area using the Gerimi-Nyland ratings table and MOE ratings tool. It identifies some extensive areas in both zones, which can provide winter range for moose. The actual suitability is expected to change over time as the seral distribution changes. Managing those changes to produce habitat distributions favourable to moose would be the most effective means to improve winter habitat quality for moose. Since the winter concentration areas will vary annually and as seral changes occur to the forest, forested buffers are not required to maintain value to moose as winter range. Some wetlands and shallow open water habitats may require buffering to protect their integrity as summer habitat.

5.0 RECOMMENDATIONS

Management objectives recommended for the various subzones in the Cariboo Region should be reviewed by Regional biology staff to ensure that the information used in our analyses has been correctly interpreted. Some anomalies exist in the data, such as moose locations in areas where no surveys were recorded. This data likely came from telemetry studies or stratification flights (J. Youds – pers. comm.). The snow zone mapping completed for mule deer should be adjusted to allow interpretations for moose, which can tolerate much deeper snow than deer. The management regimes are prescriptive, however they should not and often cannot be applied without consideration of current habitat conditions in each area. For example, areas with small proportions of forest may never meet the desired cover requirements. In such cases, alternatives should be identified.

Defining critical moose winter ranges should be a priority for the SBPS and MS subzones. Winter range areas in the ICH are a low priority due to mountain caribou management concerns (J. Youds – pers. comm.). Wintering options for moose in the SBS and IDF zones are expected to be fairly extensive and wetlands, although valuable, are not a critical winter habitat component. Traditional selection or cut-leave harvest systems should benefit moose in those subzones. Some winter concentration areas, which have lower snow depths and abundant forage, could be identified using TEM mapping and special management could be implemented if current habitat conditions are below their capability.

The winter forage resources in the SBPS and MS subzones are mainly associated with wetland fringes, which are very limited in extent (16% of the Kluskus study area is wetland and only ~1.3% is shrub producing). A substantial portion of the regional moose population is found in those subzones. Removal of cover and disturbance from road access can severely degrade habitat effectiveness for moose. While all wetlands are potentially important, the larger complexes provide more foraging opportunities in moist forest sites and also provide interior habitats and larger cover patches, which may be critical for calving. Recommended management guidelines should be applied to as many wetlands as possible with first priority on the large and medium patches. A method to identify wetland complexes and assess their status has been proposed for consideration by Regional staff. The method appears compatible with the current direction and is expected to add a number of new areas, which should be considered for "high value wetland" designation.

Confirming winter use by moose of new areas could be completed most efficiently using the pre-stratification methods used to classify blocks prior to intensive surveys. Counts of tracks and animals 4-6 days following fresh snow would provide a good indication of the value of each wetland to moose, particularly if repeat surveys were possible. Occupied wetlands would almost certainly show signs of use in the open highly visible portions of each wetland complex using this method and a high number of wetlands could be surveyed on a single flight.

Other options to better distinguish wetlands, such as satellite imagery, could be explored as a means of differentiating and classifying the many small wetlands as winter habitat for moose. Pine beetle data was not available for use in this project. That information could be useful to assess the current and future status of mature pine forests adjacent to the wetland complexes. No information on forest tenures or harvest plans was used in our analyses. Since forestry has a major influence on moose habitat, it may be useful to identify fully contributing, partially contributing and non-contributing areas, which could also influence the spatial layout of moose habitat areas.

6.0 NEXT STEPS

A list of activities required to complete the moose winter range identification project and implement management within them is as follows:

10. regional staff should review and approve or modify the proposed BMPs for each subzone,
11. regional staff should review and approve or modify the recommended means to identify key moose winter ranges within each zone,
12. develop a moose snowzone map for the region,
13. define draft moose winter range areas for the region using the approved methodology,

14. truth draft winter range areas on the Chilcotin plateau, using reconnaissance (pre-stratification) flights scheduled when conditions are optimal for sighting moose tracks in wetlands,
15. obtain landbase classification maps used for timber supply analysis and forest development plan information for the draft moose winter range areas,
16. obtain current forest inventory mapping (VRI) and beetle risk mapping and format it for use in assessing the current and future status of each MWR planning cell,
17. apply the approved management objectives on each MWR and assess the compatibility with existing management,
18. develop specific prescriptions to maintain habitat for moose where existing management is or is expected to be deficient.

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List of Appendices

Appendix 1. Moose winter habitat management guidelines for BC, Alberta, Manitoba and Ontario.

Moose Winter Range Management Prescriptions from the Okanagan-Shuswap and Kamloops LRMPs

The direction given in the Okanagan-Shuswap LRMP for Moose Winter Range has been used to provide approaches for consideration in the Williams Lake area. The management recommendations below were also compiled from the Kamloops LRMP objectives for Critical Moose Winter Range.

A primary objective of the Kamloops LRMP was to ensure moose thermal and visual cover is maintained and browse production is enhanced. This includes:
_ maintaining or enhancing forage production,
_ maintaining or enhancing security and thermal/snow interception cover and
_ minimizing the adverse impacts of access.

To achieve these objectives, critical habitat areas have been identified where moose winter range habitat values should be maintained at prescribed levels. Moose winter range management prescriptions agreed to by the Okanagan Shuswap LRMP have been summarized below. Ideally, small clearcuts and partial or selective cutting should be used to provide a mosaic of seral stages.

A. Maintain suitable forest cover attributes with respect to thermal cover and forage production.
i) maintain approximately 50% of the cover requirements on MWR in units of 20 ha or greater to provide security cover.
ii) maintain forest cover adjacent to key forage areas and mineral licks
iii) maintain 33% of the forested area of MWR at greater than or equal to 16 metres in height (age ≥ 50 years, average crown closure ≥ 50%).

B. Ensure adequate forage is maintained during silvicultural activities (brushing, weeding and stand tending).
i) maintain a minimum of 15% of the net forested land base in MWR in young forest
ii) avoid use of broadcast treatments; spot treatment is acceptable when brush species are in competition with commercial species
iii) retain a component of deciduous within cutblocks.

C. Provide visual screening of swamps and openings along main forestry roads.
i) in early seral patches greater than 40 ha, retain sufficient understorey vegetation to break up sight lines.

D. Pursue mixed forest management with similar species distribution to natural stands (including deciduous).
i) approximate the pre-harvest deciduous component of the stand.

ii) clumps or patches are preferred.
iii) these measures are not to preclude meeting “free to grow”.

E. Ensure grazing management practices that maintain browse species such as red-osier dogwood and willow.
i) “top rail” or lay down the portion of fences that intersect trails
ii) on new fences, the bottom strand on fences must be no lower than 18”, and the fence height is not to exceed 42”.

F. Establish access management guidelines.
ii) block access to new roads within cutblocks that are greater than 100 metres in length, provided that such roads are not required to provide imminent access to future cutblocks
iii) permanently deactivate new in-block roads within 200 m of wetland complexes immediately after silviculture treatments have been undertaken, provided that such roads are not required to provide imminent access to future cutblocks
iv) unless no other practical option exists, avoid the construction of mainline and operational roads within 200 metres of a wetland complex greater than five hectares
v) reduce the amount of “open” (4x4 accessible) road
vi) ensure that slash is not piled in linear bands along roadsides in a manner that impedes moose (including moose calves) travel.

G. Incorporate management objectives for critical moose habitat into stand level planning for the area.

Harvest Planning
_ Where possible, forest harvest plans should be directed towards stands with lower shelter suitability and higher forage capability in areas where more forage is desirable
_ harvest plans should maintain connectivity of suitable shelter areas
_ WTPs within capable MWR should be directed to wet forest types, deciduous stands and riparian areas
_ open road density should be minimized through suitable MWR
_ open roads through suitable MWR should have access control implemented during the winter where significant human disturbance is anticipated.

Reforestation
_ Maintain screening cover on roads within suitable MWR.
_ Consider prescribed burning on harvested blocks adjacent to suitable shelter to clear heavy slash accumulations and to provide spring range
_ Replant capable MWR with a mixture of species, and maintain the deciduous component.

Stand Tending
_ Thinning operations should maintain well-distributed small thickets (>30 m diameter) of unthinned trees for cover.

_ maintain deciduous browse species in cutblocks adjacent to suitable shelter (no chemical weed control).

Alberta Moose/ungulate
Govt of Alberta, Sustainable Resource Development, Fish and Wildlife Section

For deer, elk and moose in Alberta, key ungulate winter range is often found, but not always, in major river valleys. These landforms contain the topographic variation and site productivity conditions that provide good winter browse conditions in proximity to forest and topographic cover. Also, south-facing valley slopes have relatively lower snow accumulations and warmer resting sites. The valley landform itself provides protection from high wind chills. Traditional, high use and high quality winter ranges have been identified and mapped on the basis of several decades of winter aerial population surveys, supplemented by habitat assessments using air photo interpretation and ground surveys.

GUIDELINES:
1. Mature/overmature forest provides habitat for numerous species of wildlife and contributes to the biodiversity of the forest. A minimum of 10 percent of the gross productive forest land base of each forest management unit (FMU) should be managed as mature/overmature forest that is representative of stand types in the area. Unmerchantable stands, watercourse protection buffers and other areas not scheduled for harvest may contribute to the 10 percent.

Where special wildlife management objectives require more than 10 percent mature/overmature forest, such areas will be identified in the Forest Management Plan or the cruise report. Proposals by Alberta Fish and Wildlife Services to manage more than 10 percent of an area as mature/overmature forest should be justified based on management objectives for wildlife species associated with older forests.

The stands managed as overmature/mature should be distributed throughout the disposition and be of a variety of sizes from 4 ha or larger; large patches are preferred. The amount and distribution of overmature/mature timber in a particular disposition should be arrived at by the Land and Forest Services and Alberta Fish and Wildlife, in consultation with the timber operator, at the cruise report stage.

2. In deciduous timber dispositions where there are no coniferous stands suitable for providing winter thermal cover over large areas, special effort will be made to developing future thermal cover through understory protection where such understories exist.

3. Using the following guidelines, timber operators should design, construct and manage their roads to minimize the impact on fish and wildlife.
a. Roads and trails should be constructed away from important wildlife habitat areas,

including reproductive habitat for selected management species, key features such as mineral licks, and important feeding habitats and watering sites.
b. In designated areas, road construction and hauling activities should avoid critical wintering, breeding and birthing periods when populations may be more vulnerable to sensory disturbance and harassment.
c. In designated areas, the Forest Superintendent may request timber operators to restrict road access during specified periods, implemented in accordance with departmental policy. Road access in some key habitats should be removed after all operations have been completed.
d. Cutblock access roads should be managed to minimize the secondary impacts of vehicle access (e.g., hunting pressure, poaching and animal harassment). Roads may be closed by removing stream crossings, rolling back slash, roots and other logging debris on portions of the ROWs, scarifying and planting, or other similar techniques.

4. Cutblocks and clearings beside long-term roads should be managed to minimize the line-of-sight.

5. In cutblocks, the distance to winter hiding cover should not exceed 200 m. Cutblocks where the distance to cover is 150 m to 200 m will be acceptable provided measures are taken to improve cutblocks for wildlife use (e.g., creating irregular edges, leaving residual stands in cutblocks, ensuring understories and leaving debris piles). Where these features are not provided within cutblocks, distances to hiding cover should not exceed 150 m.

6. The distance to winter thermal cover should be considered when designing cutblocks, especially during planning of subsequent harvest passes. Unmerchantable, deferred, isolated, inoperable or other timber cover not scheduled for harvest may provide adequate thermal cover. Where such cover is unavailable, timber stands that will provide thermal cover should be retained as required.

7. Timber operators should incorporate irregular and natural boundaries in their harvest layout wherever possible, and limit the line of sight. Adjacent to roads that will be used five years or longer, the sight distance should be less than 400 m.

8. Wildlife travel corridors are required in well-defined valleys or along permanent streams and rivers. These should contain timber stands on the floodplain of well-developed valleys, and forested areas at the top of well-developed valley breaks. These corridors should be at least two "sight distances" in width to allow undisturbed movement of wildlife. Where the stream buffer provides adequate sight distance, no additional consideration is needed. Harvest designs may include selective harvest, narrow cutblocks, and other techniques designed to maintain or enhance travel corridors.

9. Dead standing trees and some live trees should be left for snag recruitment (8 per ha) in the cutblock to provide habitat, wherever this does not jeopardize worker safety. Large-diameter dead and selected live trees of unmerchantable species should be identified as a high priority for retention. Trees are preferred in a clumped distribution.

10. Scattered pieces of large woody debris (8 cm diameter and greater) should be retained within cutblocks for small mammal habitat.

11. Piles of large woody debris should be left within cutblocks to provide denning sites for furbearers and their prey species, and cover for small mammals and birds. The piles should be randomly located in the cutblocks (approximately 50 m apart). For fire protection, however, the piles should not be left within 8 m of cutblock edges.

12. Mineral licks, springs that are frequented by wildlife, and water-source areas that are potentially significant for fish spawning and egg incubation should be protected. They should be identified on logging plans and mineral licks, and springs should be protected by a buffer with the width of one sight distance. When sites are encountered during harvest operations, specific prescriptions shall be applied incorporating procedures such as relocation of cutblock boundaries and retention of undisturbed vegetation buffers.

4.3.3 Ungulate Zone

OBJECTIVE: To enhance habitat in important ungulate winter range and other key habitats that have relatively high ungulate populations when compared to surrounding areas in the Forest Management Unit.

All standards and guidelines stated for the General Wildlife Habitat Maintenance Zone shall apply to the Ungulate Zone, in addition to the following standard and guidelines.

STANDARD:

1. The ungulate species and the area of concern shall be identified in the cruise report.

GUIDELINES:

1. A three-pass harvest pattern should be used to enhance moose and elk habitat. This will extend the availability of early successional vegetation for forage, and maintain thermal cover and snow-interception cover. Regeneration should be 10 m tall in first-pass cutblocks before third-pass cutblocks are approved for harvest. The objective is to have adequate and well-distributed thermal cover after the third pass; this may be achieved in some areas with unmerchantable stands. Normally, one third of the merchantable timber will be harvested in each harvest pass. In special situations (e.g., poor stand condition), cut proportions may be altered, if at least 20 percent of the merchantable timber is retained for the third pass. Distribution of mature stands after the second pass must allow for optimum use by ungulates. Other systems of forest management may be acceptable if ungulate habitat enhancement objectives are met.

2. To provide security and encourage use of cutblocks by ungulates, cutblock design should include vegetation management methods that will limit the line of sight adjacent to long-term roads (i.e., roads used five years or longer). This could be accomplished, for example, by using an offset layout with 100 m - 200 m wide cutblocks adjacent to roads.

3. Operations should be scheduled to avoid vehicle access and disturbance of ungulates during the critical late winter period (January 1 to April 30). Operations that cannot be avoided during this time should minimize or localize access and disturbance through a low-impact strategy to be devised by the operator, Alberta Fish and Wildlife Services and Land and Forest Services.

4. In ungulate zones specified for elk, the distance to winter thermal cover should not exceed 300 m from any point in a cutblock.

5. In ungulate zones specified for mule deer, forest management prescriptions should be developed to retain suitably distributed stands for winter habitat.

http://www3.gov.ab.ca/srd/fw/landuse/index.html

Manitoba Wildlife and Ecosystem Protection Branch

Moose are found throughout the province of Manitoba ranging south from the U.S border, north to the Nunavut Territory. Until recently, there has been only occasional reports of moose in the prairie region of southern Manitoba, but populations have now become established in the Pembina and Souris River Valleys. They are also found in Spruce Woods Provincial Forest and Turtle Mountain Provincial Park in southwestern Manitoba from where they were absent until as late as the early 1970's.

The moose population in Manitoba has increased from an estimated 28,000 in 1992 to about 32,000 currently. The demand for consumptive use of moose continues to exceed supply in the more accessible areas. Renewed cooperative management programs are required to encourage continued growth in moose populations. First Nations moose harvest was estimated at double the annual licenced harvest of 1,500 animals. Equitable distribution of sustainable harvest, providing opportunity for all stakeholders, will require constructive consultation.

TIMBER HARVESTING PRACTICES
FOR FORESTRY OPERATIONS IN MANITOBA
October 1996
Manitoba Natural Resources
Forestry Branch

DEFINITION AND PURPOSE OF RESOURCE BUFFERS:
A resource buffer is defined as a strip of land that is managed to reduce or eliminate the impacts of land use practices on sensitive areas or natural features. As such the primary objective of the Manitoba Natural Resources Buffer Management Guidelines is:
To provide field managers and the forest industry with the minimum standard buffer zone widths and the conditions for operating within buffers that maintain the integrity of sensitive areas or natural features.

As long as the integrity of the sensitive area or natural feature is maintained a buffer may be actively managed. A variety of management prescriptions are available and can be applied. These prescriptions will take into account such factors as vegetation, slope, soil, wildlife and fisheries values, unique features, line of sight, recreational interests, location, and time of year.

TABLE #3 BUFFER CONSIDERATIONS FOR OTHER SIGNIFICANT RESOURCE VALUES.

SPECIAL RESOURCE VALUE	BUFFER WIDTH*	OBJECTIVE OF BUFFER	CRITICAL PERIOD**
COLONIAL WATERBIRD NESTS	200 m	- Provide a visual barrier. - Protection from disturbance.	April 1 to July 31
MINERAL LICKS AND SPRINGS	200 m	- Provide a visual barrier. - **Protect ground water and maintain soil stability.**	April 1 to June 30
EAGLE OR OSPREY NESTS	200 m	- Protect nest tree. - Provide a visual barrier between the nest and worksite. - Maintain the site integrity.	April 1 to July 31
SPECIAL HABITATS AND AREAS (SUCH AS ENDANGERED SPECIES, PROTECTED SITES, ETC.)	200 m	- Protect the security of the habitat on a year round basis. - Maintain the long term existence of the habitat or area.	Year round
RECREATIONAL VALUES (SUCH AS, COTTAGES, CANOE ROUTES, ETC.)	200 m	- Provide a visual and sound barrier between recreational value and harvesting operations.	Seasonal to year round.

Generally speaking and to guide harvest planners and operators the following points about buffers need to be taken into consideration. Where necessary and feasible, strips of residual timber (buffers) are to be left standing to:

a) serve as escape cover and travel corridors for wildlife populations in the area.
b) act as a visual barrier to aide in preventing the harassment of wildlife from roadways and trails located along side of cut-overs.
c) serve as a filter strip around lakes and streams to slow surface run-off from adjacent cut-overs thereby reducing the erosion hazard and water sedimentation.

Ideally a buffer should be safeguarded from accidental harvesting by placing ribbons along the length of its boundary prior to the commencement of harvest operations.

http://www.gov.mb.ca/conservation/forestry/forest-practices/pdfs/timber_harvesting_practices.pdf

Timber Management Guidelines for Provision of Moose Habitat
Ministry of Natural Resources, Ontario, February 1988.

The objective of habitat management is to provide all of the necessary habitat components within the area of activity normally inhabited by moose. The size of this area will be dictated to a large extent by topography, the nature of the forest, and the size of the moose population. The purpose of these Guidelines is to demonstrate how to produce good vegetation patterns necessary to meet moose requirements.

Moose are animals of the forest edge requiring young deciduous growth for food, and semi-mature and mature coniferous forest as shelter from weather and predators. To benefit moose, timber management should produce irregularly shaped cuts with scattered shelter patches and a high diversity of age classes and species of vegetation.

Where new access is created to harvest the forest, the potential for local overharvest of moose exists. Although legislation (e.g. Public Lands Act, Game and Fish Act), may be used to inhibit or prevent hunting within these areas for either short or long periods of time, it tends to postpone problems of overharvest rather than solving them. In special cases where it is desirable to minimize hunting by controlling access, roads may be closed by signing or they may be kept away from the area of concern, or wood may be extracted using winter roads. As well, in some circumstances it may be appropriate to scarify and remove access roads after extraction is complete.

The timber management undertaking involves five basic processes. These are: (i) forest access, (ii) harvest operations, (iii) site preparation, (iv) regeneration, and (v) maintenance operations. The last four steps (ii-v) are referred to as the silviculture system. Each of these procedures may directly impact the quality of moose habitat and indirectly affect the size of the moose population. The impacts cited below are normally related to the immediate areas of the treatment. They are concerns of a general nature and in practice the impact may be substantially mitigated by vegetation surrounding the area of timber operations. The real potential significance of these impacts must be assessed within the entire context of each operating plan. Local managers must try to balance potential negative impacts by positive ones.

Harvest Operations. The moose management objective of maintaining or enhancing the quality of moose habitat includes the concept of protecting key features (e.g. aquatic filling areas) and providing food (early successional plant communities) close to shelter (semi-mature or mature conifer stands). This objective may be met by no or modified cutting in the vicinity of key features, by reducing the size of planned clear cuts or by providing shelter patches within cutovers. Additionally, a diverse vegetative pattern may be obtained if cutting is dispersed among all eligible stands rather than cutting them in a contiguous manner during the planning period. In some areas, clear-cutting in blocks of 80-130 ha (200-320 acres) with buffer zones between cuts, and scattered clumps of trees within the cutovers, will provide the desired conditions. Clearcuts greater than 100 ha (250 acres) should have scattered shelter patches within the cut area. This would keep the overall vegetative diversity of the area high and still provide a reasonable timber harvest.

The best habitat should provide conditions enabling a moose to be within 200 m (650 feet) of shelter patches or other cover. These shelter patches should preferably be of conifer but could be of mixed-wood, with at least 1/3 in conifer. They should be at least 3-5 ha (7-12 acres) in size, be spaced 300-400 m (1000-1300 feet) apart, be at least 6 m (20 feet) high, and have about 11 square metres/ha basal area (50 square feet/acre). The stocking densities of immature and mature stands with this basal area will be approximately 70% and40% respectively. If the objective of the shelter patches is to provide late winter cover for moose, shelter patches should be conifer with stocking of 70% or greater. Where these shelter patches are composed of mature conifer, basal areas will be greater than 11 square meters/ha. It may be beneficial to moose and advantageous to the timber industry to leave shelter patches large enough to inhibit blowdown problems and to warrant future harvest (e.g. > 8 ha). If late winter habitat will be adequate in the area, a return cut of shelter patches can occur when nearby regeneration has reached 2 metres in height. Regeneration of this size will provide lateral shelter, and function as early winter habitat if the regenerated site contains sufficient browse. If late winter habitat will be inadequate in the area after an early return cut, the cutting of shelter patches should not occur until nearby regeneration has reached 6 metres in height, thereby providing overhead cover for moose.

Clear cut and shelterwood harvesting techniques can produce these patterns, but selection cutting, seldom practiced in the Boreal Forest, may not disturb the forest canopy enough to create significant successional growth. Some selection harvesting of conifer could be practiced within mixed wood shelter patches provided adequate protection remains. There may be a need or opportunity to provide early winter habitat where it does not currently exist. This can be achieved by-election cutting within mature conifer and mixedwood stands to remove some of the larger conifers. In late winter concentration areas, width of individual cuts should not exceed 400 m (1300 feet). Uncut areas equal in size to cut areas should be left. To protect aquatic feeding areas, mineral licks and calving sites, generally reserves are required with the shape and extent dictated by surrounding habitat conditions. Usually a 120 m reserve should be left around these areas. Some merchantable conifer may be removed by selection cutting provided the general nature of the reserve remains intact.

5.1.3 Site Preparation

To benefit moose, mechanical preparation should not destroy shelter patches. Residual clumps of conifer or mixed wood within the cut should not be destroyed unless these seriously threaten the success of regeneration. Chemical site preparation is acceptable provided there is adequate browse in nearby stands.

5.1.4 Regeneration

Natural regeneration, on suitable sites that produce deciduous woody growth, is of benefit to moose where food supplies are inadequate. Harvest methods which facilitate this should be encouraged in these areas. Artificial regeneration to conifer may be best where moose shelter is in short supply.

5.1.5 Maintenance This aspect of the silviculture system, as those above, should be considered in relation to the vegetation surrounding the treatment area.

Early Winter Habitat - Early winter habitat is defined here as habitat used until snow and/or crust forces moose into heavy coniferous areas. It is not necessarily a simple function of time of year. **Late Winter Habitat** -Late winter habitat is defined here as those areas used by moose once movements are restricted by snow conditions. Animals may still use cutover areas during Ns period, but most abandon them entirely in favour of uncut forest, especially in March. Some areas used in late winter contain high moose density and have variously been called yards, winter concentration areas or high density areas. As with early winter concentration areas, late winter yards are generally found in upland habitat but are more densely forested (Telfer 1967, Poliquin *et al.* 1977). These areas may be more or less heavily used in successive years, although the reason for this different rate of occupancy is not understood. There is in general, reduced use of open areas in late winter caused apparently either by a rapid accumulation of snow and/or crusted deep snow conditions. **Summer Habitat -** This is perhaps the least known component of moose habitat due in part to the difficulty in studying moose at that time of the year. It appears that until mid-July habitat use is strongly influenced by areas used for aquatic feeding (Keamey and Gilbert 1976, Loyal and Scherrer 1978, Brusnyk and Gilbert 1983).

Aquatic Plants - There is strong evidence that moose feed on aquatic plants due to a seasonal sodium hunger (Jordan *et al.* 1973, Fraser *et al.* 1982). Species which are highest in sodium content or most abundant, although containing slightly less sodium, are most important. In some traditionally well-used lakes certain preferred species, such as *Potamogeton filiformis and Nuphar variegatum***,** have largely been eliminated. Sodium rich species from Sibley Provincial Park include *Utricularia vulgaris, Sparganium angustifolium, Myriophyllum exalbescens, Potamogeton epihydrus, P. gramineus, P. filiforimis and Nuphar variegatum.* One other species, *Eleocharis acicularus,* was reported as high in sodium in the Chapleau Game Preserve but low at Sibley, (Fraser *et al.* 1980, 1982) indicating some regional differences in species ability to concentrate this element.

Browse Species - Preferences, Importance and Abundance - Recent studies where use of available browse by moose was assessed are summarized in Table1. While the methods of collection differed among all studies, prohibiting direct comparison, certain generalizations can be made. In early winter, when snow does not impede movement and does not cover many stems, *Salix* spp. are the most important (% of total eaten) browse species. In late winter shade tolerant species become important, including *Corylus cornuta and Amelanchier* spp. The wide range of other abundantly eaten species reflects the variety of micro-site types and cosmopolitan nature of the diet of the moose. Among the preferred browse species (% removed greater than % available), *Sorbus americana* and *Salix spp.* are commonly eaten over Ontario's boreal range.