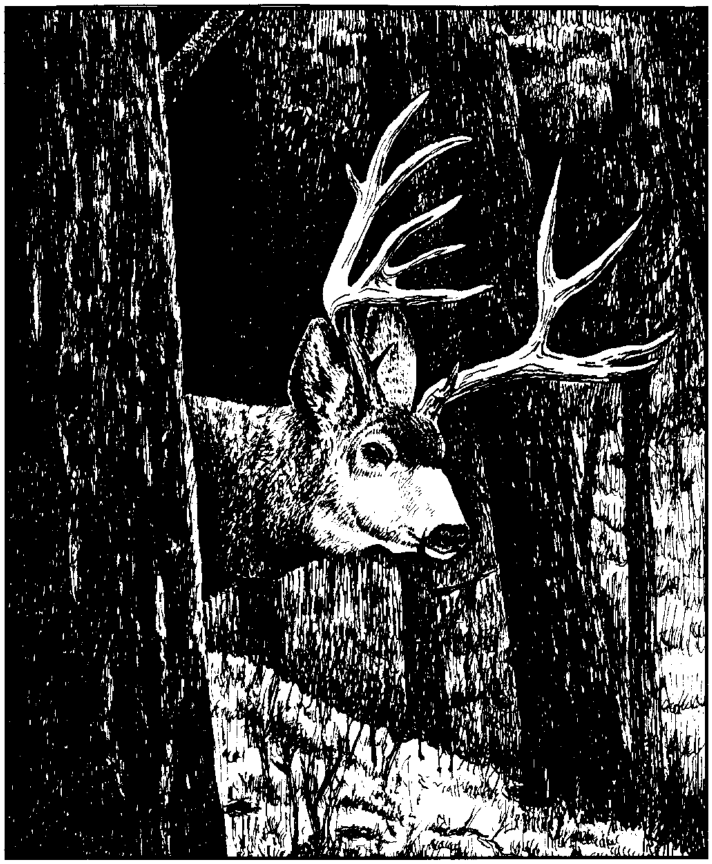
Cariboo-Chilcotin
Land Use Plan

# Regional Mule Deer Winter Range Strategy

## INFORMATION NOTE #3

## Basal Area Requirements for Initiating Group Selection Harvest in Transition and Deep Snowpack Zones



Drawing by J. Youds

**Prepared by: Mule Deer Winter Range Strategy Committee**

**Prepared for:**

**The Regional Management Team**

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**Mule Deer Winter Range Strategy Information Notes are prepared by the Cariboo-Chilcotin Mule Deer Winter Range Strategy Committee for purposes of technical clarification of the General Wildlife Measures, established under the Government Action Regulations of FRPA. These notes are prepared in response to issues and questions presented to the MDWR Committee or recognized by the members of the Committee.**

**Members of the Mule Deer Winter Range Committee include: Becky Bings – chair (FLNRO) and Michaela Waterhouse (FLNRO).**

**Information Note #3 Basal Area Requirements for Initiating Group Selection in Transition and Deep Snowpack Zones has been prepared collaboratively with Rick Dawson.**

## **Information Note #3** Basal Area Requirements for Initiating Group Selection Harvest in Transition and Deep Snowpack Zones

## 1. Introduction

This note describes the logic, data and key literature references used to develop the stand basal area pre-requisite of 40m$^2$/ha before group selection can be initiated in certain BEC zones in transition and deep snowpack mule deer winter ranges and will also discuss silvicultural options for several situations. It will also provide background information to help practitioners understand mule deer habitat requirements in these deeper snow areas and how the recommended management system is designed to meet these requirements.

General Wildlife Measure 6 from the Transition and Deep Snowpack Mule Deer Winter Range GAR Order (2007) states:

6.(a) The first pass of group selection is to be applied when the stand basal area is:
(i) ≥45m$^2$ in Interior Cedar Hemlock (ICH), or
(ii) ≥40m$^2$ in other Biogeoclimatic Zones.
(b) No timber harvesting is to occur where the conditions set out in 6(a) are not met, and GWMs 14, 15 or 16 do not apply.

**Definition pertaining to GWM 6**:

- Basal area is to be calculated as the total live conifer basal area of trees greater than 12.5 cm dbh.

## 2. Users Guide

This Information Note includes the following sections:

**Background:** A brief summary of mule deer winter habitat requirements and how the special management system in the Cariboo Region is designed to meet these requirements at multiple spatial scales.

**Mule Deer Energetics and the Design of Managed Winter Habitat:** An explanation of how snow depth affects the energetics of deer in the winter and how the stand structure created by the group selection silvicultural system provides both good forage availability and snow interception if properly implemented.

**Relationship of Snow Depth to Stand Basal Area:** Data and explanation of the relationship between forest basal area and snow interception. In the group selection system, the forest matrix between group selection openings must have enough snow interception capacity to adequately reduce energy consumption by deer.

**Silviculture and Timber Management:** Discusses several situations where stands proposed for harvest do not meet the target basal area for initiating group selection harvest. Management options for each situation are recommended.

**Summary and Conclusions:** A condensed summary.

**References:** Information sources for users wanting a broader understanding.

## 3. Background

For mule deer, winter is a time when food quality is low, energy expenditure for movement is high and concentration of deer in smaller areas increases predation risk. Good winter range functions to reduce energy consumption while deer move through their habitat to find food and avoid predation. Deer need to minimize energy expenditure and be able to access the best quality, highest energy foods. Maintaining this energy balance will reduce inevitable losses in fat reserves to allow animals to survive the winter and produce healthy fawns.

Snow depth is a key factor affecting deer in the winter. It varies across the Cariboo Region and can change significantly both within and between winters. Habitat must be available on every winter range to deal with the worst snow conditions even though they may not occur every year. Likewise each winter range must also include habitat that optimizes shrub forage production for good nutrition. The appropriate balance between forage production and snow interception habitat functions will depend on the snow zone. While any winter range can experience both mild and severe conditions, the severe conditions will occur more often and for longer duration in deep snow zones. Therefore, winter range in deeper snow zones requires more habitat to optimize snow interception but still provides good forage production. Winter range in shallow snow zones can have more habitat to optimize forage production, but still need some good snow interception habitat.

Winter range habitat management in the Cariboo Region is designed to provide appropriate forage production-snow interception balance at two different spatial scales: 1) stand or site scale and 2) whole winter range scale. At the stand or site scale, objectives are designed to provide habitat suitable for mild, moderate or severe winter conditions. For example, habitat for severe winter conditions may be located in lower elevation, warm aspect slopes in some winter ranges with forestry prescriptions to optimize snow interception cover while still providing some forage. Habitat for mild winter conditions is designed to provide more open forest that provides greater shrub productivity and some security cover, but with significantly reduced snow interception cover.

In the transition and deep snow zones of the Cariboo Region, a group selection silvicultural system with three different levels of removal at each harvest cycle is used to balance snow interception and forage habitat for three different winter conditions. Land Management Handbook 59 (Dawson *et al*. 2006) describes this approach in detail, in addition to stand level objectives and strategies, for winter ranges in the transition and deep snowpack zones. Each of the 86 winter ranges in the Cariboo Region has a plan with spatially designated objectives for mild, moderate and severe winter habitat conditions. Allocation was based on local factors including snow zone, slope, aspect, elevation, topography, forest type and connectivity.

The Southern Interior Ungulate Technical Advisory Team (2005) has recommended a two-scale management system that closely parallels that used in the Cariboo Region (Dawson *et al*. 2006, Armleder et al. 1986). As in the Cariboo Region, they defined different snow zones and recommended allocation of habitat for mild, moderate and severe conditions for each winter range based on local conditions. They also defined snow depth categories as an important aid to understanding deer needs and designing managed habitat. The management system in the Cariboo Region is essentially a full application of the approach recommended by the Southern Interior Ungulate Technical Advisory Team (2005) report taking advantage of insight provided by many years of focussed research, and in-depth local knowledge of deer habitat, forest ecology and silviculture across deer habitat in the Cariboo Region. In addition to research on deer ecology, the local work included testing of silvicultural systems, implementing of operational trials, consulting with local practitioners, and planning within the Ministry. It also included extensive ground and aerial survey of winter ranges across the Region.

## 4. Mule Deer Energetics and the Design of Managed Winter Habitat

In the transition and deep snowpack zones of the Cariboo Region (Dawson *et al.* 2006), snow interception is especially important for good winter habitat because of the high snow depths in these areas. Energy costs for moving through snow increase exponentially with increases in snow depth (Parker *et al*. 1984). Two points in the deer anatomy are key in relation to snow depth and energy use: the front knee height (about 34 cm for an adult deer of 75 kg or more) and the brisket height (about 57 cm). At a snow depth of 34 cm, deer use approximately 140% more energy for movement as compared to no snow. Parker *et al.* (1984) state that "energy costs for locomotion are dramatically elevated in snow depths above front knee height." For example, when deer walk through 50 cm (approaching brisket height) of low density snow they use 500% more energy when compared to no snow (Figure 1).

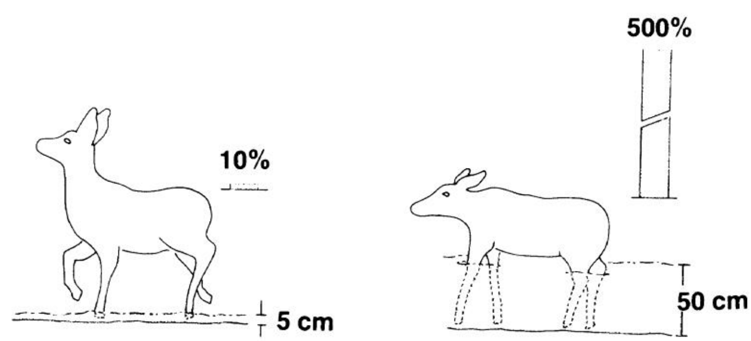


Figure 1. Relative increase in energy expenditure for movement of an adult deer through snow as compared to movement with no snow based on data from Parker *et al*. 1984.

In higher density snow, deer do not sink as far but the energy expenditure for a given sinking depth is higher and breakable crusts, when present, further exaggerate energy expenditure (Parker *et al*. 1984). The energy cost estimates described above are for an adult deer. Energy use for deer in their first winter would be higher because they have shorter legs.

> "energy costs of locomotion are dramatically elevated in snow depths above front knee height." (Parker *et al*. 1984). Front knee height is approximately 34 cm for an adult deer and less for fawns.

Many studies have documented the behavioral changes of mule deer with increasing snow depth. At open snow depth of 25 cm, deer initiate movements to winter range habitats (Kelsall 1969). At 40 cm deer movement is restricted to avoid areas with greater snow and select older forest stands (Kelsall 1969, Poole and Mowat 2005, Pauley *et al*. 1993, Woods 1984). Snow depths of 50 cm are avoided and can completely prevent use (Serrouya and D'Eon 2008, Loveless 1967). A radio-telemetry study south of Williams Lake, BC, (Armleder *et al*. 1994) found that older forests with high crown closure on warm aspects were favoured at all snow levels but that proportionate use increased with increasing snow depth. Also, as snowpack deepens, rooted forage (e.g. rose, Oregon grape) availability is reduced and energy required to find it goes up (Figure 2). Waterhouse *et al*. (1994) document a shift to reduced shrub consumption as the winter progresses.

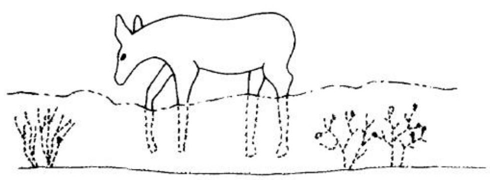

Figure 2. Ground forage becomes increasingly unavailable as snow depth increases and energy expenditure to find it and move to it also increases.

A management goal in the Cariboo Region GAR Order for transition and deep snowpack winter ranges is to keep the snow depth, in snow interception habitat, below 34 cm for as long as possible during the winter and maintain snow below 50 cm in all but the very deepest snow years.

To meet this management goal in the SBS and ICH zones where open depth can exceed 60 cm, a group selection system is recommended (Dawson *et al.* 2006, GAR Order 2007). It provides interspersed forage and snow interception habitats to meet the key winter requirements for deer. Small harvested openings, which produce more shrub forage, are dispersed within a matrix of forest that has enough snow interception capacity to allow deer to move efficiently as the snow deepens. This intimate mix of good snow interception cover, with small dispersed openings, will minimize energy use, provide good access to food both in the openings and the matrix, and provide enough useable space to reduce predation risks. Once the snow gets deeper, foraging use of these openings is very limited. However, forage is then still available within the matrix in the form of arboreal lichen, Douglas-fir litterfall, conifers such as western redcedar, subalpine fir and some tall shrubs. Poole and Mowat (2005) have also recognized that "interspersion of forage and snow interception cover may provide the greatest benefit to deer."

Harvesting group selection openings within a matrix of poor snow interception forest would have a very negative impact on deer energetics. In this situation, deer have to expend energy moving around openings in addition to a high energy cost move through deep snow in the matrix forest. Therefore, to provide good deer habitat, matrix forest must be able to maintain snow well below energetically limiting depths before the group selection silvicultural system is initiated.

For example, in a stand managed as "moderate stand structure class", (Dawson *et al.* 2006) 25% of the stand is harvested in small dispersed openings every 40 years. Assuming that each group selection opening takes at least 80 years to recover reasonable snow interception, this means that after the second group selection cut, about one half of the stand will always have poor snow interception because it will be in group selection openings less than 80 years old. If the residual forest matrix around the openings does not have good snow interception capacity, then the stand as a whole would have greatly reduced deer habitat value except in the shallowest of snow conditions. Based on the analysis presented above, a stand basal are of 40 $m^2$/ha would be the minimum desired for this matrix and higher would be better.

In winter ranges with strong elevation gradients, deer can move down slope to areas of lower snow depth as deeper snow depths develop through the season. The higher elevation parts of these winter ranges may only be useful as late fall/early winter habitat in deeper snow years even if 40 $m^2$/ha or higher basal area is maintained. Availability of this early winter range habitat provides important early season forage and can reduce deer density which lowers predation risk. It also reduces foraging pressure on rooted forage on the parts of the winter range that will become critical habitat when the snow gets deeper.

## 5. Relationship of Snow Depth to Stand Basal Area

Data from a uniform shelterwood research trial located in the SBSdw1 (northeast of Williams Lake, BC) provides valuable information on the relationship between forest canopies and snow depth for mule deer winter habitat in the transition snowpack zone. The study includes three replicate blocks; one on designated mule deer winter range and two others just outside of designated winter range (Burton *et al*. 2000). The trial was cut in 1991, and a second time in 2001 resulting in five residual basal area treatments: 15, 20, 30, 40 and 60 $m^2$/ha. It was uniformly thinned from below at each entry preferentially removing non-Douglas-fir species and smaller diameter Douglas-fir stems. In 2002 and 2006, snow depth, basal area (conifers ≥7.5 cm. DBH) and canopy density were measured at 225 permanent plot centres in the treatments with additional measurements in adjacent clearcuts. This study examined relationships between basal area and snow depth. Percent snow interception ((open snow depth - stand snow depth)/ open snow depth) X 100)) was also calculated to separate the effects of the forest canopy on snow depth from differences in snow depth over time and between sites. Calculation of percent snow interception is based on the methodology presented in McNay (1985) which named this variable "apparent snow interception". The original data presented below was extracted from Dawson (2004), and Sagar and Waterhouse (2009).

Both snow depth and percent snow interception were strongly related to stand conifer basal area in 2002 and 2006, as indicated by high $r^2$ values (0.71 and 0.74 for snow depth (Figure 3)), and 0.74 and 0.82 for snow interception (Figure 4). Averaging the 2002 and 2006 regression lines, predicted snow interception is 33%, 44% and 70% respectively with basal area values of 30, 40 and 65 $m^2$/ha. Using these snow interception values with 60 cm open snow depth, predicts snow depths of 40, 34, and 18 cm respectively in stands of 30, 40 and 65 $m^2$/ha basal area.

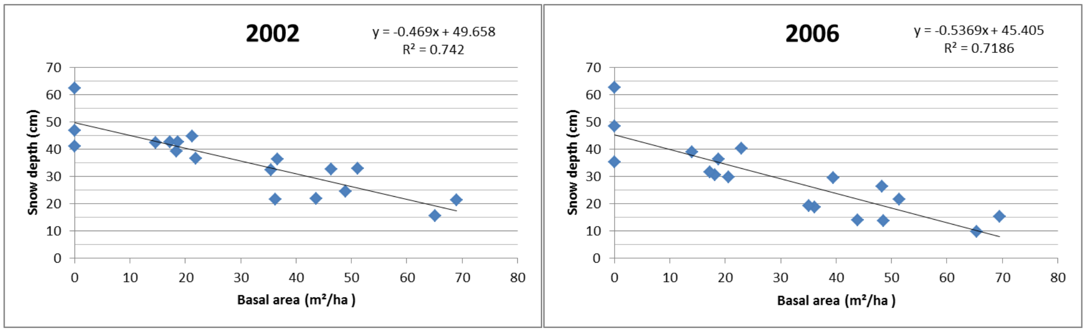


Figure 3. Relationship of average snow depth to conifer stand basal area ≥7.5 cm in experimental stands for two different years in the SBSdw1. The open snow depth when these two snow measurements were taken was approximately 50 cm.

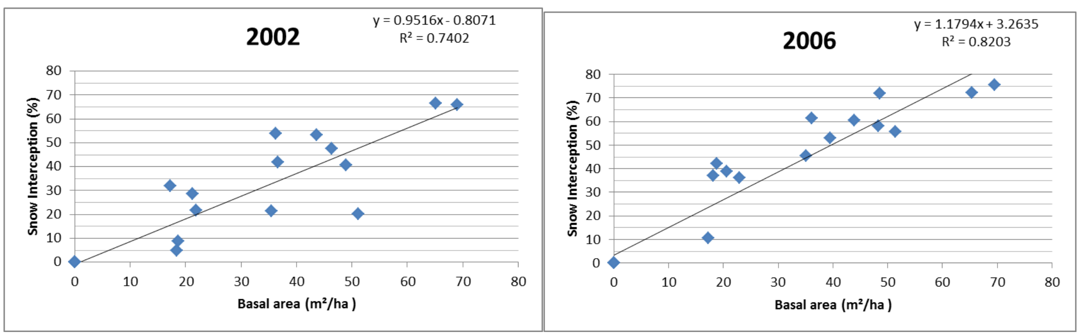


Figure 4. Relationship of average percent snow interception to conifer stand basal area ≥7.5 cm in experimental stands for two different years in the SBSdw1.

Predicted within-stand snow depths at an open snow depth of 60 cm are 40, 34, and 18 cm respectively in stands of 30, 40 and 65 $m^2$/ha basal area. At snowfall depths of 60 cm in the open, forested stands with a basal area of 40 $m^2$/ha should be able to intercept enough snow to maintain a 34 cm average within stand snow depth, which is a management goal for mule deer energetics.

In exceptional winters, the open snow depths can reach 100 cm or more on winter range areas in the SBS and ICH. Extrapolation of the percent snow interception relationship shown here with 100 cm of snow would estimate average the snow depths of 56 cm in a 40 $m^2$/ha stand and 67cm in a 30 $m^2$/ha stand. At a snow depth of 56 cm, which is the approximate brisket height of an adult deer, a forest stand of 40 $m^2$/ha is essentially non-functional habitat. In the deepest snowpack areas such as the ICH, 45 $m^2$/ha basal area is recommended to provide increased snow interception.

Other studies have shown significant relationships between snow interception and measures of canopy density (McNay 1985, D'Eon 2004). Our study measured both canopy density from wide angle photographs and basal area. Both were strong predictors of snow interception (Dawson, 2004). Basal area was chosen as the best variable to use in management of mule deer winter ranges in the Cariboo

Region because it provided the best estimate of snow interception, is easily and reliably measured and has precise meaning for foresters responsible for managing these stands.

## 6. Silviculture and Timber Management

Most forest stands in transition and deep snow winter ranges have the capability to meet these basal area targets (conifer basal area of 40 - 45m²/ha respectively) as mature, well stocked stands. The average pre-harvest basal area on the three blocks in Uniform Shelterwood (SBSdw1) trial was 62.5m²/ha at 120 years. Measurements from a variety of winter ranges (Australian-Alix, Beaver Valley North, Drewry Lake North, Horsefly Lake, Niquidet, Timothy-Rail) confirm that the targets are realistic for mature, well-stocked stands.

All sites having the capability to grow Douglas-fir are expected to be harvested using the group selection system (other than exceptions listed in the GAR Order), including stands that have currently low suitability (e.g. mixed stands or stands with predominantly other species). Mixed species stands are very common in the SBS and ICH, and although other conifer species do not provide the preferred habitat of Douglas-fir, they do provide some snow interception value and are important to maintain while managing towards an increased Douglas-fir component.

There are several possible reasons for current stands not meeting the basal area targets, and each reason could suggest differences in possible management options (Note that some options will require an exemption from the GAR Order before a stand can be harvested). Potential reasons why stands proposed for harvest may not meet the basal area targets are:

**a.** ***Stands are too young***. Younger SBS or ICH stands below 40/45 m²/ha are still growing rapidly, so harvesting them early reduces potential longer-term timber yield (i.e. cutting before the point of culmination) and reduces habitat value for deer.

**Group selection should not be initiated in these stands until they meet the specified basal area targets.**

b. ***Stands where conifer stocking has been reduced by forestry treatments and/or various mortality agents but the stand is still reasonably well stocked with few gaps.*** Where residual stocking is reduced by mortality agents or thinning but the stand is still reasonably well stocked and well distributed, the remaining conifers can take advantage of the increased growing space. As an illustration, in stands in the uniform shelterwood trial where 30% of the stand was cut *i.e*. 60 m²/ha to 40 m²/ha (mostly pine removal), the residual stands continued growing at 0.31 m²/ha per year in basal area (4.2 m³/ha/year gross volume) over the following 20 years (Waterhouse 2017).

**Group selection should not be initiated in these stands until they meet the specified basal area targets.**

c. ***Stands where conifer stocking has been significantly reduced by forestry treatments and/or various mortality agents leaving significant gaps in stocking and patches of mature trees.*** This type of stand will typically result from bark beetle or other mortality agents killing parts of the stand, for example, patches or scattered pine that may have been killed by pine beetle. Group selection may be useful to get some of these the stands on track towards a regular group selection regime. However this this needs to be carefully done so as to maintain the existing areas of Douglas-fir currently capable of providing the best snow interception cover in the current stand. This option may not be applicable to all stands.

**These stands should be left to develop before initiating group selection OR**

**Group selection could be initiated, centering group selection openings on existing gaps to leave most of the higher stocked portion of the stand unharvested. After harvest, the basal area of the matrix forest outside of the group selection openings should meet the target basal area.**

d. ***Stands with a large deciduous component .*** Serrouya and D'Eon (2008) report significant use of this type of stand by deer. These stands tend to have good forage resources in low snow conditions, and if they include patches or strings of Douglas-fir to aid with access, they can provide valuable winter habitat.

   **Where possible these stands should be left to develop through natural succession. Removal of the any of the Douglas-fir component will greatly reduce their habitat value. Group selection could be initiated as long as harvest groups were focussed on the deciduous component with very little or no harvest of the Douglas-fir component. Harvesting of aspen patches should be done on a snowpack to protect the root mass.**

e. ***Sites with low capability for tree growth.*** A very small proportion of low basal area stands may be present on thin soil or very rocky sites that result in reduced growing season moisture and poor nutrition. These sites may not have the capability to meet the basal area targets even when mature and well stocked.

   **Two management options are suggested for these relatively rare sites: 1) Leave them unharvested and remove them from the AAC calculation. 2) Allow group selection harvest at stand basal area levels below the specified targets and consider lengthening the cutting cycle beyond 40 years to compensate for the slower growth potential of the stands.**

## 7. Summary and Conclusions

- In most cases, residual conifer basal area of a stand should be at least 40 $m^2$/ha in all BEC zones (except ICH) in Transition and Deep snowpack zones and 45 $m^2$/ha in ICH (Deep snowpack zone) before group selection is initiated. Basal area above these targets will retain functional habitat in typical winters. Based on our data, a basal area of 40 $m^2$/ha is just maintaining the snowpack below levels required to maintain deer energy balance in typical midwinter conditions. In deeper snow conditions that can sometimes occur, even stands with 40 $m^2$/ha may provide limited habitat value and exponentially increase energetic costs for deer.
- All winter range stands harvested with group selection should retain post-harvest residual forest between the group selection openings of at least the minimum target basal area. Ideally the basal area in this matrix should be higher to provide better snow interception habitat.

- For stands below 40 $m^2$/ha, the added impact of harvesting openings (20 – 33% every 40 years depending on the stand structure class) would result in high energy use by deer and likely significant habitat avoidance.
- Most well stocked, mature stands in the SBS have the site capability to exceed 40 $m^2$/ha. Harvesting them before this point would reduce net timber production for the site and reduce habitat quality for deer.
- Thinning from below (GWM 16) can be initiated before the stand is 40 $m^2$/ha. Up to 25% of the conifer basal area can be cut < 37.5 cm dbh. The thinning should concentrate harvest on species other than Douglas-fir. This will set the snow interception capacity back in the short-term, but will in the longer term produce higher diameter trees with wide, interlocking crowns which will improve snow interception and provide Douglas-fir foliage for forage.
- Table 1 below summarizes stand conditions with less than target basal area and describes management options, some of which require an exemption from the GAR Order.

**Table 1. Summary of Stand Conditions and Recommendations**

<table>
<tr><th>Stand Condition</th><th>Recommendation</th></tr>
<tr><td>1. Stand is less than 120 years old.</td><td rowspan="2">Group selection should <u>not</u> be initiated in these stands until they meet the specified basal area targets.</td></tr>
<tr><td>2. Conifer stocking reduced by forestry treatments and/or various mortality agents but still reasonably well stocked and well distributed.</td></tr>
<tr><td>3. Conifer stocking reduced by forestry treatments and/or various mortality agents leaving poorly stocked stand with significant gaps in stocking.</td><td>1)Leave the stand to develop before initiating group selection<br>or<br>2)Initiate group selection by centering group selection openings on existing gaps to leave the most of the higher stocked portion of the stand unharvested. After harvest, the basal area of the matrix forest outside of the group selection openings should meet the target basal area. GAR Order exemption required.</td></tr>
<tr><td>4. Large portion of stand is deciduous with scattered conifer clumps.</td><td>1) Leave stand to develop through natural succession before considering any harvest prescription.<br>or<br>2) Initiate group selection focussing harvest on deciduous component with minimal harvest of Douglas-fir. No patches or strings of Douglas-fir should be cut. Isolated Douglas-fir can be included in group selection openings. GAR Order exemption required.</td></tr>
<tr><td>5. Sites with low capability for tree growth. These sites will be rare and usually of limited extent. Good documentation must be provided on the extent of the site type and rationale for classification as low capability.</td><td>1) Leave sites unharvested and remove from the AAC calculation.<br>or<br>2) Allow group selection harvest to be initiated and increase the cutting cycle beyond 40 years to compensate for the slower growth potential of the stand. GAR Order exemption required.</td></tr>
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- The exemption process (Appendix 1, pg. 8 GAR Order) can be used to deal with specific anomalies such as root rot infected sites, poor growing sites, deciduous leading stands, stands with low stocking and large gaps from various mortality agents. There is guidance on preparing exemption requests (Mule Deer Strategy Committee 2014), especially when dealing with insect killed stands.

## 8. References


Armleder, H.M., R.J. Dawson, R.N. Thompson. 1986. Handbook for Timber and Mule Deer Management Coordination on Winter Ranges in the Cariboo Forest Region. Land Manage. Handb. 13. BC Min. For. Research Br., Victoria. BC. 98 pp. https://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh13-1.pdf

Armleder, H.M, M.J. Waterhouse, D.G. Keisker, R.J. Dawson.1994. Winter Habitat Use by Mule Deer in the central interior of British Columbia. Canadian Journal of Zoology, 1994, 72(10): 1721-1725, 10.1139/z94-232

Burton, P.J., C. Sutherland, N. Daintith, M. Waterhouse and T. Newsome. 2000. Factors influencing the density of natural regeneration in uniform shelterwoods dominated by Douglas-fir in the Sub-Boreal Spruce zone. B.C. Min. For., Res. Br., Victoria, B.C. Work. Pap. 47. http://www.for.gov.bc.ca/hfd/pubs/docs/wp/Wp47.htm

Dawson, R.J. 2004. EP1104.01 Uniform Shelterwood: Summary of 2001/02 canopy and snow measurements. Unpublished file report. FLNRO, Williams Lake, B.C.

Dawson, R.J., H.M. Armleder, B. Bings, and D. Peel. 2006. Management Plan for Transition and Deep Snowpack Zones. Management Strategy for Mule Deer Winter Ranges in the Cariboo-Chilcotin Part 1b:

D'Eon, R.G. 2004. Snow Depth as a function of canopy cover and other attributes in a forested ungulate winter range in Southeast British Columbia. J. Ecosystems and Management 3:1-9.

Kelsall, J.P. 1969. Structural adaptations of moose and deer for snow. J. Mammal. 50:302-310.

Loveless, C.M. 1967. Ecological Characteristics of Mule Deer Winter Range. Colorado Dept. of Game, Fish and Parks, Tech.Pub. 20.

McNay, S.R. 1985._ Forest Crowns, Snow interception and Management of Black-tailed Deer Winter Habitat. Research, Ministries of Environment and Forests IWIFR-19. Victoria, B.C.

Mule Deer Winter Range Strategy Committee. 2014. Regional mule deer winter range strategy. Information Note #2. Guidance for MDWR General Wildlife Measure Exemption Requests for Salvage of Insect-killed Douglas-fir. https://www.for.gov.bc.ca/tasb/slrp/lrmp/williamslake/cariboo_chilcotin/plan/biodiv/2014_June_Final_Information_Note2.pdf

GAR Order for Transition/Deep Snowpack MDWRs. 2007. http://www.env.gov.bc.ca/wld/documents/wha/Amendment_TransDeep_Feb07_ord.pdf

Parker, K.L., C.T. Robbins, and T.A. Hanley. 1984. Energy expenditures for locomotion by mule deer and elk. Journal of Wildlife Management 48:474-488.
http://web.unbc.ca/~parker/Pubs/Parker%20et%20al%201984%20JWM.pdf

Pauley, G.R., J.M. Peek, and P. Zager. 1993. Predicting white-tailed deer habitat use in northern Idaho. Journal of Wildlife Management 57:904-913.

Poole, K.G. and G. Mowat. 2005. Winter habitat relationships for deer and elk in the temperate interior of British Columbia. Wildl. Soc. Bul. 33(4):188-1302.

Sagar, R.M. and M.J. Waterhouse. 2009. Summary of 2006 canopy density and snow interception measurements for the Uniform Shelterwood Project, EP1104.01. Unpublished file report. FLNRO, Williams Lake, B.C.

Serrouya, R. and R.G. D`Eon. 2008. The influence of forest cover on mule deer habitat selection, diet, and nutrition during winter in a deep-snow ecosystem. Forest Ecol. and Manag. 256:3 452-461

Telfer, E.S. and J.P Kelsall 1984. Adaptations of some large North American mammals for snow. Ecology 65:1828-1834.

Southern Interior Ungulate Winter Range Advisory Technical Team. 2005. Desired conditions for Mule Deer, Elk, and Moose winter range in the Southern Interior of British Columbia. B.C. Ministry of Water, Land and Air Protection. Biodiversity Branch. Victoria B.C. Wildl.Bull. No.B120. 18pp.

Waterhouse, M.J. 2017. SBS Uniform Shelterwood Trial: overstory growth and development over 20 years. Unpublished file report. FLNRO, Williams Lake, B.C.

Waterhouse M.J. 1999. Uniform Shelterwood Systems for Douglas-fir /Lodgepole Pine stands, Update – Year 8. Cariboo Forest Region Research Update Note # 28.

Waterhouse, M.J., H.M. Armleder, R.J. Dawson. 1994. Winter Food Habits of Mule Deer in the Central Interior of British Columbia. B.C. Ministry of Forests, Research Note 113.

Woods, G.P. 1984. Habitat selection of white-tailed deer in the Pend d'Oreille Valley, British Columbia. Thesis, University of Idaho, Moscow, USA.