RESEARCH NOTE 113

# Winter Food Habits of Mule Deer in the Central Interior of British Columbia

M.J. Waterhouse, H.M. Armleder, and R.J. Dawson

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## EXECUTIVE SUMMARY

Mule deer (*Odocoileus hemionus hemionus*) at the northern limit of their continuous, high-density distribution use interior Douglas-fir (*Pseudotsuga menziesii*) forests as winter range. In the Cariboo Forest Region this represents 250 000 ha, or about 15%, of mapped Douglas-fir forest. The needs of mule deer and the forest industry conflict because both require large, old Douglas-fir trees. If we are to resolve this conflict, we first need a sound knowledge of mule deer habitat requirements, one of which is forage.

Sixty-one mule deer composite pellet samples were collected from seven winter ranges within the central interior of British Columbia between 1982 and 1989. Microhistological analyses found more than 87 plant species in the diet, although the bulk of the diet consisted of Douglas-fir, *saskatoon (Amelanchier alnifolia*), Oregon-grape (*Mahonia aquifolia*), red-osier dogwood (*Cornus sericea*), willows (*Salix* spp.), and soopolallie (*Shepherdia canadensis*). On a few winter ranges, subalpine fir (*Abies lasiocarpa*), snowbrush (*Ceanothus velutinus*), and sages (*Artemisia spp*.) were commonly eaten. Douglas-fir occurred in all diet samples and on average was the most abundant species ($\bar{x}$=52%, SD=24%, N=61). The source of foliage is litterfall from large, older trees.

Diet samples collected from dry winter ranges in the Interior Douglas-fir Zone (IDF) contained more Douglas-fir than those from wetter winter ranges in the Sub-Boreal Spruce Zone (SBS). As snow depth increased over the winter, the percent Douglas-fir in the diet increased, especially on the wetter winter ranges.

Faecal nitrogen (FN) and diaminopimelic acid (DAPA) correlated with the percent shrub in the diet (r=.46, P =01; and r= .52, P= .01, respectively). Both FN and DAPA are indicators of diet quality.

As important winter forage, Douglas-fir must be available to deer on winter range in managed forests. On winter ranges that can be harvested in the near future, Armleder *et al*. (1986) recommend low volume partial cutting, which includes maintenance of a large proportion of older trees to provide forage and shelter. Shrubs are a preferred forage and may be scarce on drier winter ranges. Harvesting may improve shrub production and there is some potential to enhance abundance of some species by planting or underburning.

## ACKNOWLEDGEMENTS

We wish to thank the Fish and Wildlife Branch of the B.C. Ministry of Environment, Lands and Parks, Williams Lake Northern Sub-Region, for collecting and funding the analysis of the Middle Lake mule deer diets, and Kamloops Regional Headquarters for funding the analysis of the Bonaparte River mule deer diets. Also, the advice and co-operation given by Bruce Davitt, Wildlife Habitat Management Laboratory, Washington State University, has been much appreciated.

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## INTRODUCTION

In a review of 99 studies, Kufeld *et al*. (1973) found that diets of mule deer in western North America contained hundreds of species of plants, though the bulk was usually just a few species. On average, winter diets contained 74% trees and shrubs, 15% forbs, and 11% grasses.

Most food habit studies have taken place in the south and central part of the mule deer's distribution, for example, Oregon (Skovlin and Vavra 1979), New Mexico (Stephenson *et al*. 1985), Montana (Constan 1972), and Colorado (Hansen and Reid 1975; Bartmann 1983; Hobbs *et al*. 1983). The most common southerly winter habitats are sagebrush-steppe, juniper-pinyon pine woodland and mountain mahogany / oak scrub (Wallmo 1981). In these dry habitats, mule deer predominantly consume species such as bunchgrasses, pasture sages, big sage, junipers, and pinyon pine.

Unlike the dry, open ranges, the winter ranges in the central interior of British Columbia occur in a variety of Douglas-fir dominated habitats. The literature indicates that deer eat Douglas-fir when they occupy that forest type. A study in southern British Columbia near Kamloops reported up to 42 – 49% Douglas-fir in mule deer diets (Willms *et al.* 1976). In southwestern Alberta, Berg and Hudson (1982) found 89% Douglas-fir in the winter diet. Kufeld *et al.* (1973), in their review of studies in western North America, rated Douglas-fir as eaten only moderately (5 – 20%) throughout the distribution of mule deer.

Availability of forage and access to it are determined by depth and duration of the snowpack. Several studies have documented shifts in diet as a response to snow conditions (Constan 1972; Willms *et al*. 1976; Carpenter et al. 1979). Since both habitat type and snowpack affect species composition of the diet, the overall quality of the diet could also change.

In central British Columbia, where mule deer reach the northern limit of their continuous, high density distribution, deer regularly face snow depths and temperatures not experienced on southern ranges. Because Douglas-fir may be an important forage species under these conditions, as well as being highly desired by the forest industry, knowledge of mule deer winter food habits is vital for integrated resource management.

Our study objectives were to (1) determine winter diets of mule deer at the northern limit of their continuous distribution, (2) relate variation in diets to differences in habitat types and snow depths, and (3) evaluate the nutritional quality of the diets between winter ranges and between winters of different severity.

## STUDY AREAS

Mule deer pellets were collected from seven winter ranges in the central interior of British Columbia. Lying between the Cascade and Cariboo Mountain ranges, this region is part of the Interior Plateau, which is dissected from north to south by the Fraser River. The winter ranges in this study are typical of many in the Central Interior, which tend to occur at lower elevations and on warmer aspects (Table 1).

Uneven-aged Douglas-fir is the climax forest type on these winter ranges and occurs in several biogeoclimatic subzones.[1] On drier winter ranges in the Interior Douglas-fir Zone, lodgepole pine (Pinus contorta) and ponderosa pine (Pinus ponderosa) often occur in the overstorey; on moister ranges in the Sub-Boreal Spruce Zone, white spruce (Picea glauca x engelmannii) and subalpine fir (Abies lasiocarpa) are sometimes present in both the overstorey and understorey. On drier winter ranges, understoreys are dominated by grasses such as pinegrass (Calamagrostis rubescens) and bluebunch wheatgrass (Agropyron spicatum). Shrubs and herbs are sparse in the forest, but more common in low crown closure cut blocks and forest openings. On wetter winter ranges, there is greater species diversity and abundance in the shrub and herb layers, especially in open areas.

TABLE 1. *Environmental characteristics of seven mule deer winter ranges in the central interior of British Columbia*[a]

| **Winter range** | **Lat. (°N) Long. (°W)** | **Elev. (m)** | **Aspect** | **Weather station location** | **Mean annual precip. (cm)** | **Mean annual temp. (°C)** |
|---|---|---|---|---|---|---|
| Beaver Valley | 52 25<br>121 45 | 700 – 885 | SW | Horsefly | 56 | 3.4 |
| Big Lake | 51 39<br>121 28 | 975 – 1200 | SW<br>NE | 100 Mile House | 39 | 4.0 |
| Bonaparte River | 51 12<br>121 18 | 790 – 1000 | S<br>SE | Clinton | 33 | 3.9 |
| Churn Creek | 51 28<br>122 16 | 800 – 1320 | S | Wineglass Ranch<br>Dog Creek Airport | 31<br>39 | 5.9<br>4.0 |
| Knife Creek | 52 03<br>121 53 | 700 – 1000 | S<br>SW | Williams Lake Airport | 41 | 3.9 |
| Middle Lake | 51 41<br>124 45 | 800 – 1375 | SE | Tatlayoko Lake | 41 | 3.9 |
| Tree Farm Licence 5 | 53 10<br>122 45 | 500 – 750 | SW | Quesnel Airport | 55 | 4.5 |

[a] Weather data were recorded at Environment Canada and B.C. Ministry of Environment, Lands and Parks stations located as close as possible to each winter range.

Warmer aspects generally dominate the winter ranges. Plant communities typical of mesic and drier soil moisture are most common. Moist gullies and seepage sites on dry winter ranges are important for shrub production.

[1] B.C. Ministry of Forests, Forest Sciences Section. 1989 A field guide for the identification and interpretation of ecosystems of the Cariboo Forest Region (E.P. 822.04). Unpubl. Draft rep.

Table 2 compares the vegetation characteristics of each winter range, based on plant communities representative of drier sites within each biogeoclimatic subzone.

TABLE 2. *Vegetation descriptions for seven winter ranges located in the central interior of British Columbia*

| Study area | Subzone and variant | Vegetation description |
|---|---|---|
| Beaver Valley | Sub-Boreal Spruce Fraser Plateau (SBSdwl) | Douglas-fir overstorey and regen.; spruce and subalpine fir regen.; aspen, birch, hazelnut; shrubs common (Oregon-grape, prickly rose, saskatoon, soopolallie, and birch-leaved spirea); herbs common (showy aster, pinegrass, twinflower, rough-leaved ricegrass); feathermosses common |
| Big Lake | Interior Douglas-fir East Fraser Plateau (lDFdk3) | See Knife Creek |
| Bonaparte River | Interior Douglas-fir Bonaparte River (lDFxw) | Douglas-fir overstorey and regen.; seral ponderosa pine; shrubs very sparse (prickly rose, saskatoon, birch-leaved spirea, common and Rocky Mt. junipers); herbs dominant (bluebunch wheatgrass, pinegrass, mutton grass, kinnickinnick, shrubby penstemon); mosses rare |
| Churn Creek | Interior Douglas-fir Fraser River (lDFxm) | Douglas-fir overstorey and regen.; aspen in draws; shrubs sparse except in gullies (saskatoon, snowberry, common and Rocky Mt. junipers); herbs dominant (pinegrass, bluebunch wheatgrass, timber milk-vetch); mosses rare |
| | Bunchgrass (BGxh3) | Grassland with patches of Douglas-fir (needlegrass, bluebunch wheatgrass, pasture sage, big sage, rabbit-brush) |
| Knife Creek | Interior Douglas-fir East Fraser Plateau (lDFdk3) | Douglas-fir overstorey and regen.; shrubs sparse (prickly rose, saskatoon, soopolallie, snowberry, common juniper); herbs dominant (pinegrass, twinflower, kinnickinnick); feathermosses common |
| | (lDFxm) | See Churn Creek |
| Middle Lake | Interior Douglas-fir Chilcotin (lDFdk4) | Douglas-fir overstorey and regen.; subalpine fir regen.; shrubs sparse (prickly rose, saskatoon, snowberry, common and Rocky Mt. junipers, snowbrush); in seepage areas birch, thimbleberry, Douglas maple, raspberry are common; herbs sparse (pinegrass, bluebunch wheatgrass, kinnickinnick); Dicranum mosses common |
| Tree Farm Licence 5 | Sub-Boreal Spruce (SBSmh) | Douglas-fir dominant overstorey; Douglas-fir, subalpine fir, and spruce regen.; aspen, birch, hazelnut are present; shrubs dominant (prickly rose, saskatoon, birch-leaved spirea, Douglas maple, red-osier dogwood); herbs sparse (wild sarsaparilla, twinflower, showy aster); feathermosses common |

## METHODS

Between 1982 and 1989, mule deer faecal pellets were collected from seven winter ranges. Samples were collected around mid-month, usually a few days after a snowfall. In the absence of a fresh snowfall, pellet freshness was determined by colour, texture, and sheen. Three to four pellets were picked from each of 15 – 20 fresh pellet groups found in mature to older forest types.

All samples were frozen and then later dried at 45 – 60$^0$C. Microhistological analyses of the Knife Creek and Churn Creek samples from 1982 – 1983 and 1983 – 1984 were done at the Composition Analysis Laboratory, Colorado State University, Fort Collins, Col. Pellets collected from all study areas in subsequent years and a duplicate set of Knife Creek 1983 – 1984 pellets were analyzed at the Wildlife Habitat Management Laboratory, Washington State University, Pullman, Wash.

Samples were analyzed at either the A level (complete species identification) or B level (forage class and major forage species).

Faecal nitrogen (FN) and diaminopimelic acid (DAPA) are both indicators of diet quality. At both laboratories, percent faecal nitrogen (FN x 6.25 = crude protein) was measured using the Kjeldahl method (Horwitz 1980). DAPA (mg/g of faecal dry matter) analyses were done exclusively at Washington State University using the Davitt and Nelson (1984) method. *In vitro* digestible dry matter analyses (IVDDM) of the Douglas-fir foliage collected at Knife Creek were done at the Wildlife Habitat Laboratory, Washington State University. Rumens were collected from six mule deer that were shot on the Knife Creek winter range between January and March 1985. A litre of rumen contents and several pellets were removed from each animal for comparative diet analyses. Both rumens and pellets were dried, then sent to Washington State University for diet and nitrogen analyses.

When pellets were collected in the forested habitat on each winter range, snow depth was recorded in adjacent open cut blocks.

The yearly winter severity indices, based on Williams Lake airport data, were calculated using the Picton and Knight (1971) method which uses daily open snow depth and maximum temperature as variables. A summary of the Williams Lake airport data is presented in Appendix 1. The winter severity index was used to classify winters as very mild (VM), mild (M), moderate (MO), or severe (SE).

All variables used in correlation and analysis of variance tests were normally distributed. Because sample sizes in some cases were low, equivalent non-parametric tests were also used. However, the results did not differ between methods, so the parametric test results were reported. In the analyses of variance tests using FN and DAPA, only comparable months were used to compare among years by winter range and among winter ranges by year. It was not possible to test for interactions between year and winter range using a two-way ANOVA because of the large number of empty cells.

# RESULTS

## Food Habits in Response to Douglas-fir Habitat Types and Snowpack

Microhistological analyses of 61 mule deer pellet group samples collected from seven mule deer winter ranges between 1982 and 1989 showed more than 87 plant species (Appendix 2). However, the bulk of individual diets consisted of few species. Diets based on the average from each winter range were mainly composed of conifers (45 – 76%) and shrubs (15 – 50%), while forbs and grasses contributed a small percent to the total (1 – 6% and 1 – 7%, respectively) (Figure 1).

Douglas-fir was the most consistent and abundant species in mule deer diets on all winter ranges (Table 3). Saskatoon, soopalallie, and willows were also found in diets from all winter ranges. Oregon-grape was commonly eaten on the moister winter ranges, particularly Beaver Valley, Big Lake, and Tree Farm Licence 5. Subalpine fir and red-osier dogwood were also abundant in Tree Farm Licence 5 diets. Sage species were only abundant in Churn Creek diets, while snowbrush, western hemlock, and western redcedar were found exclusively in the Middle Lake diets. Ponderosa pine only occurred in the Bonaparte River diets.

A general trend was increased shrub content in the diet with increased biogeoclimatic subzone wetness (Figure 2). A Duncan's multiple range test showed that diets from the two driest winter ranges (Churn Creek and Knife Creek) located in the IDFxm had significantly (P=05) less shrub than did diets from the two wettest ranges (Beaver Valley and Tree Farm Licence 5, SBSdwl and SBSmh, respectively). The quantity of Douglas-fir in the diet tended to decrease with increased subzone wetness (Figure 3). Knife Creek diets had significantly (P=05) more Douglas-fir than all areas except Churn Creek, while Tree Farm Licence 5 diets contained significantly less than any other area.

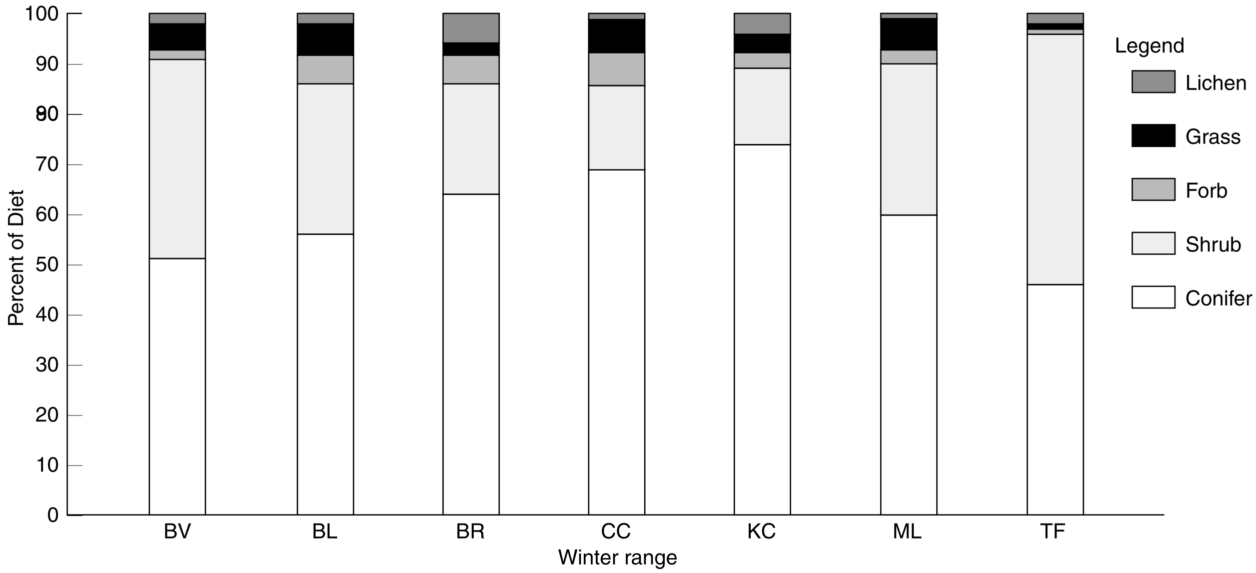


FIGURE 1. *Average composition of mule deer winter diets from seven winter ranges located in the central interior of British Columbia. The winter ranges are abbreviated as follows: BV = Beaver Valley, BL = Big Lake, BR = Bonaparte River, CC = Churn Creek, KC = Knife Creek, ML = Middle Lake, and TF = Tree Farm Licence 5 (BV N=1 1; BL N=1 1; BR N=3; CC N=9; KC N=1 1; ML N=5; TF N=11).*

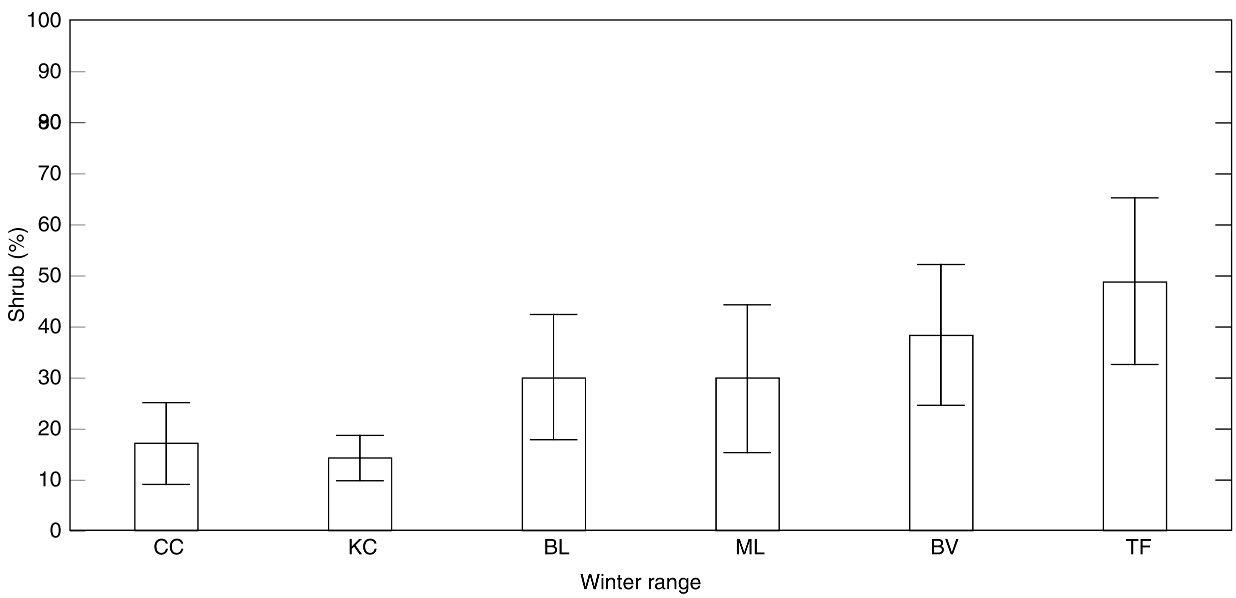


FIGURE 2. *Mean and 95% confidence limits for shrub content of mule deer diets (Nov – Mar) by winter range in the central interior of British Columbia. The winter ranges are abbreviated as follows: CC = Churn Creek, KC = Knife Creek, DL = Big Lake, ML = Middle Lake, BV = Beaver Valley, and TF = Tree Farm Licence 5 (CC N=9; KC N=1 1; BL N=1 1; ML N=5; BV N=1 1; TF N=1 1).*

TABLE 3. *Major conifer and shrub species found in mule deer diets from seven winter ranges in the central interior of British Columbia (x=mean, SD=standard deviation). The winter ranges are abbreviated as follows: BV = Beaver Valley, BL = Big Lake, BR = Bonaparte River, CC = Churn Creek, KC = Knife Creek, ML = Middle Lake, and TF = Tree Farm Licence 5.*

| | | **Winter Range** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **By (N=11)** | **BL (N=11)** | **BR (N=3)** | **CC (N=9)** | **KC (N=11)** | **ML (N=5)** | **TF (N=11)** |
| **Conifers** | | | | | | | | |
| Douglas–fir | $\bar{x}$ | 44 | 52 | 58 | 70 | 73 | 45 | 24 |
| | (SD) | (26) | (21) | (8) | (21) | (7) | (11) | (14) |
| Lodgepole | $\bar{x}$ | + | + | – | + | + | 2 | + |
| pine | (SD) | (+) | (2) | | (+) | (1) | (2) | (+) |
| Ponderosa | $\bar{x}$ | – | – | 4 | – | – | – | – |
| pine | (SD) | | | (3) | | | | |
| Subalpine fir | $\bar{x}$ | 5 | – | – | – | – | 1 | 18 |
| | (SD) | (6) | | | | | (+) | (15) |
| Western | $\bar{x}$ | – | – | – | – | – | 7 | – |
| hemlock | (SD) | | | | | | (4) | |
| Western | $\bar{x}$ | – | – | – | – | – | 2 | – |
| redcedar | (SD) | | | | | | (2) | |
| **Shrubs** | | | | | | | | |
| Blueberry | $\bar{x}$ | 1 | + | – | – | + | 3 | – |
| spp. | (SD) | (1) | (+) | | | (+) | (6) | |
| Oregon–grape | $\bar{x}$ | 16 | 13 | – | + | 6 | + | 28 |
| | (SD) | (14) | (16) | | (+) | (7) | (+) | (18) |
| Red–osier | $\bar{x}$ | 3 | 1 | 2 | – | + | + | 13 |
| dogwood | (SD) | (5) | (2) | (3) | | (2) | (+) | (16) |
| Sage spp. | $\bar{x}$ | – | – | + | 13 | + | + | – |
| | (SD) | | | (+) | (12) | (+) | (+) | |
| Saskatoon | $\bar{x}$ | 7 | 2 | 4 | + | 3 | 4 | + |
| | (SD) | (10) | (4) | (4) | (1) | (3) | (3) | (+) |
| Snowbrush | $\bar{x}$ | – | – | – | – | – | 8 | – |
| | (SD) | | | | | | (8) | |
| Soopalallie | $\bar{x}$ | 2 | 1 | 3 | 1 | + | 6 | + |
| | (SD) | (2) | (2) | (5) | (2) | (+) | (7) | (+) |
| Willow spp. | $\bar{x}$ | 2 | 1 | 2 | + | + | 3 | 1 |
| | (SD) | (3) | (3) | (3) | (1) | (1) | (3) | (2) |

– = absent, + = <1%.

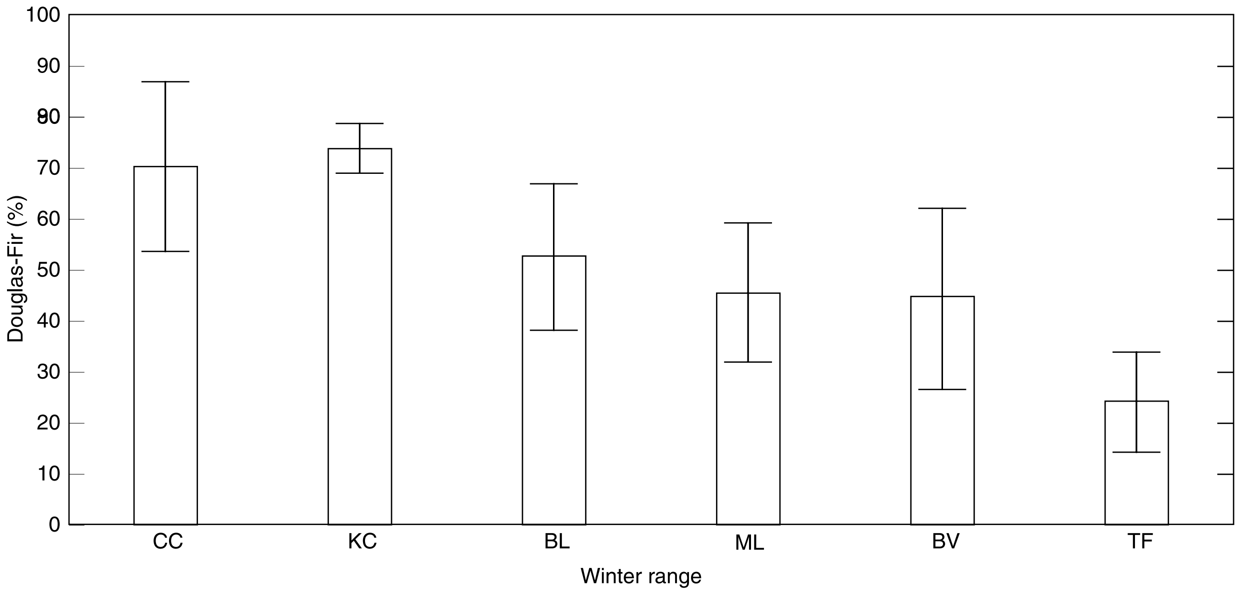


FIGURE 3. *Mean and 95% confidence limits for Douglas-fir content of mule deer diets (Nov – Mar) by winter range in the central interior of British Columbia. The winter ranges are abbreviated as follows: CC = Churn Creek, KC = Knife Creek, BL = Big Lake, ML = Middle Lake, BV = Beaver Valley, and TF = Tree Farm Licence 5 (CC N=9; KC N=11; BL N=11; ML N=5; BV N=11; TF N=11).*

On the Knife Creek, Big Lake, Beaver Valley, and Tree Farm Licence 5 study areas, where a large number of pellet samples were collected at various snow depths over several years, we found shrub content of the diet to be negatively correlated, and Douglas-fir to be positively correlated with increased snow depth (Table 4). The only exception was Knife Creek where the consumption of Douglas-fir remained consistently high (62 – 89%). Churn Creek was not included in the analysis because most snow depth values were zero. Similar trends occurred over each winter within each winter range (Appendices 3 – 9). Diets usually peaked in Douglas-fir content in January and February when snowpacks were the deepest. There are exceptions because depth and duration of the snowpack varied from year to year. For example, at Tree Farm Licence 5 in 1986 – 1987, open snow depth decreased from 25 cm in December to 0 cm in mid-February, as did the quantity of Douglas-fir.

TABLE 4. *Correlations of shrub and Douglas-fir in mule deer diets with snow depth (cm) from four winter ranges in the central interior of British Columbia.*

| **Study area** | **N**[a] | **Shrub** | | **Douglas-fir** | |
|---|---|---|---|---|---|
| | | **r** | **P** | **r** | **P** |
| Big Lake | 11 | -.75 | .01 | .77 | .01 |
| Beaver Valley | 11 | -.57 | .07 | .80 | .01 |
| KnifeCreek | 11 | -.56 | .07 | -.16 | .64 |
| Tree Farm Licence 5 | 11 | -.62 | .04 | .54 | .09 |

[a] N = sample size, r = correlation coefficient, P = probability level.

Beaver Valley low snow (0 – 39 cm) diets contained significantly more shrub and less Douglas-fir than either Beaver Valley deep snow (40+ cm) diets or Knife Creek diets in either snow category (Figure 4). This was tested by one-way analysis of variance models (Douglas-fir $r^2$=.78, P=.0001, F=21.28, N=21; and shrub $r^2$=.65, P=.0002, F=11.24, N=21). Contrast analyses confirmed the Beaver Valley diet samples collected in low snow as the source of the significant differences for both Douglas-fir (F=30.99, P=.0001) and shrub (F=61.38, P=.0001).

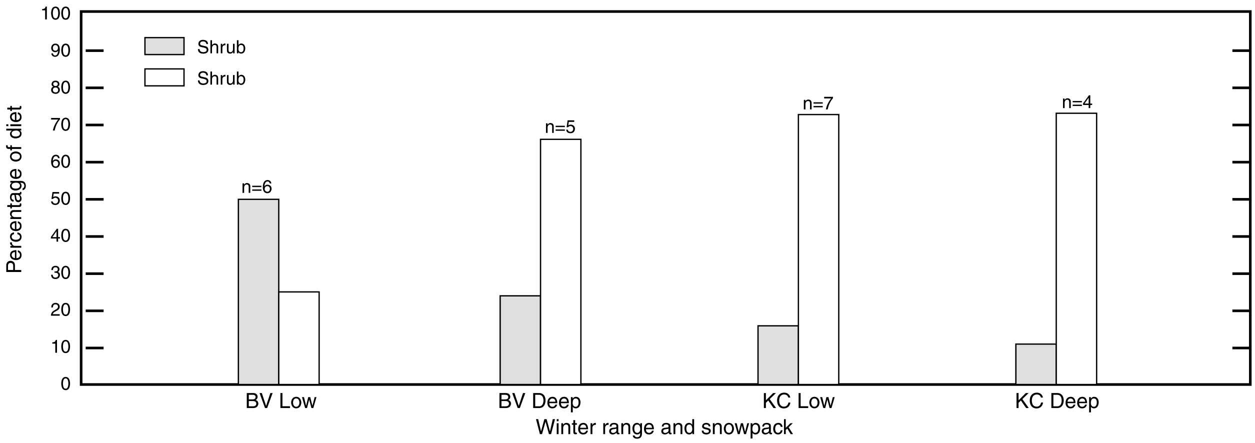


FIGURE 4. *Average shrub and Douglas-fir composition of mule deer diets from Beaver Valley (BV) and Knife Creek (KC), low snow (0 – 39 cm) and deep snow (>40 cm).*

## Comparison of Rumen and Faecal Diet Analyses at Knife Creek

Both rumen and faecal analyses found that a large part of the diet consisted of conifer (almost exclusively Douglas-fir) (Table 5). Paired comparison t-tests detected significantly (P= .05, N=6) greater amounts of lichen in rumens than in pellets. More forbs and grasses were found in faecal samples taken from the animals shot in March than in the composite faecal sample collected at the same time.

TABLE 5. *Comparison of results from rumen and faecal diet analyses from mule deer shot on the Knife Creek winter range in the central interior British Columbia in 1985*

| Sample date | Type | Conifer (%) | Shrub (%) | Forb (%) | Grass (%) | Lichen (%) | Faecal nitrogen (%) |
|---|---|---|---|---|---|---|---|
| 1 Jan | faecal | 88 | 8 | 1 | 1 | 2 | 2.32 |
| | rumen | 83 | 9 | + | 4 | 2 | 2.51 |
| 2 Jan | faecal | 79 | 10 | + | 7 | 3 | 1.52 |
| | rumen | 77 | 16 | 0 | 0 | 7 | 2.32 |
| Jan | composite faecal | 84 | 7 | + | 2 | 8 | 1.62 |
| 3 Feb | faecal | 71 | 1 | 0 | 21 | 7 | 1.48 |
| | rumen | 60 | 8 | + | 20 | 11 | 2.23 |
| 4 Feb | faecal | 70 | 11 | 1 | 3 | 13 | 1.77 |
| | rumen | 64 | 4 | + | + | 26 | 3.01 |
| Feb | composite faecal | 79 | 5 | + | 10 | 2 | 1.26 |
| 5 Mar | faecal | 49 | 9 | 8 | 31 | 2 | 1.83 |
| | rumen | 55 | 1 | 2 | 31 | 9 | 3.80 |
| 6 Mar | faecal | 54 | 6 | 10 | 29 | 1 | 2.63 |
| | rumen | 82 | 1 | 2 | 7 | 4 | 2.48 |
| Mar | composite faecal | 70 | 10 | 1 | 14 | 3 | 1.35 |

+ = <1%.

## Diet Quality Based on Faecal Nitrogen and Diaminopimelic Acid

Faecal nitrogen (FN) and diaminopimelic acid (DAPA) data are presented in Appendix 10. Though data were collected only for the winter months, some general trends within study area and by year occurred. January and February diets tended to be lower in both FN and DAPA than were the December or March diets.

Snow, which strongly affected the availability of forage, also influenced diet quality. The lowest FN values (in 7 of 11 diets) and the lowest DAPA values (in 6 of 9 diets) coincided with the deepest monthly snowpack, by study area and year.

Analysis of variance in conjunction with a Duncan's multiple range test was used to test for differences in diet quality among winter ranges by year (Table 6). In 1985 – 1986 (mild), 1986 – 1987 (very mild), and 1987 – 1988 (mild) years, DAPA was significantly higher at Tree Farm Licence 5 than at Big Lake. The same pattern emerged for FN in the mild years, but values were not statistically significant.

TABLE 6. *Comparison of faecal nitrogen (FN) (%) and diaminopimelic acid (DAPA) (mg/g) among study areas, by year, using analysis of variance and Duncan's multiple range test (different letters indicate a significant difference between study areas at P= .05)*

| **Year (severity index)[a]** | **Index** | **Sample size (N)** | **Means by winter range[b]** | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **BL** | **BR** | **BV** | **CC** | **KC** | **TF** |
| 1982 – 1983(VM) | FN | 2 | | | | A<br>1.03 | A<br>1.15 | |
| 1983 – 1984 (MO) | FN | 4 | | | | A<br>1.46 | A<br>1.57 | |
| 1985 – 1986(M) | FN | 4 | A<br>1.49 | | | | | A<br>1.97 |
| | DAPA | 4 | B<br>0.47 | | | | | A<br>0.73 |
| 1986 – 1987(VM) | FN | 3 | A<br>2.06 | A<br>1.99 | A<br>2.07 | | | A<br>1.86 |
| | DAPA | 3 | B<br>0.56 | | | | | A<br>0.70 |
| 1987 – 1988 (M) | FN | 3 | A<br>1.60 | | | | | A<br>1.90 |
| | DAPA | 3 | B<br>0.50 | | | | | A<br>0.70 |

[a] Very mild (VM), mild (M), moderate (MO), and severe (SE).

[b] BL = Big Lake, BR = Bonaparte River, BV = Beaver Valley, CC = Churn Creek, KC = Knife Creek, and TF = Tree Farm Licence 5.

Differences in diet quality were also found among years by study area (Table 7). At Big Lake, FN and DAPA were significantly higher in 1986 – 1987 (very mild) than in 1985 – 1986 (mild) or 1987 – 1988 (mild); and at Beaver Valley, FN was also higher in 1986 – 1987 (very mild) than in 1988 – 1989 (moderate). At Tree Farm Licence 5, there were no differences in diet quality between mild and very mild winters; and at Churn Creek there were no differences in diet quality between 1982 – 1983 (very mild) and 1983 – 1984 (moderate). At Knife Creek, however, where diets were similar in proportions of conifer and shrub among years, the very mild winter (1982 – 1983) diets were significantly lower in FN than the severe winter (1984 – 1985) diets.

Some interactions between winter ranges and years we were not able to test statistically. The means, however, are presented in Figures 5 and 6. DAPA indices from the Tree Farm Licence 5 in mild winters were higher than those of any other winter range in any year. And, those values for Big Lake in mild winters were similar to values for Knife Creek in more severe winters. Faecal nitrogen indices were highest for several winter ranges in very mild winters, except Knife Creek and Churn Creek. Big Lake mild winter values were similar to Knife Creek and Churn Creek in moderate and severe winters.

Faecal nitrogen and DAPA were correlated ($r= .64$; $P= .0001$; $N =38$) using samples from all years and winter ranges. Also, both FN and DAPA were significantly ($P= .05$) positively correlated with shrub content of the mule deer diet, but negatively correlated with Douglas-fir content (Table 8). However, these correlations were mostly non-significant for individual winter ranges.

TABLE 7. *Comparison of faecal nitrogen (FN) (%) and diaminopimelic acid (DAPA) (mg/g) among years, by winter range, using analysis of variance and Duncan's multiple range test (different letters indicate a significant difference between years at P= .05)*

| | | | Means by year (severity index)[b] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **winter range[a]** | **Index** | **Sample size (N)** | **1982 – 1983 VM** | **1983 – 1984 MO** | **1984 – 1985 SE** | **1985 – 1986 M** | **1986 – 1987 VM** | **1987 – 1988 M** | **1988 – 1989 MO** |
| BL | FN | 3 | | | | B 1.48 | A 2.06 | B 1.60 | |
| | DAPA | 3 | | | | B 0.49 | A 0.56 | B 0.50 | |
| BV | FN | 3 | | | | | A 2.07 | | B 1.38 |
| CC | FN | 2 | A 1.03 | A 1.36 | | | | | |
| KC | FN | 3 | B 1.19 | AB 1.41 | A 1.46 | | | | |
| | DAPA | 3 | | A 0.49 | A 0.49 | | | | |
| TF | FN | 3 | | | | A 1.77 | A 1.87 | A 1.90 | |
| | DAPA | 3 | | | | A 0.67 | A 0.70 | A 0.70 | |

[a] BL = Big Lake, BV = Beaver Valley, CC = Churn Creek, KC = Knife Creek, and TF = Tree Farm Licence 5

b Very mild (VM), mild (M), moderate (MO), and severe (SE).

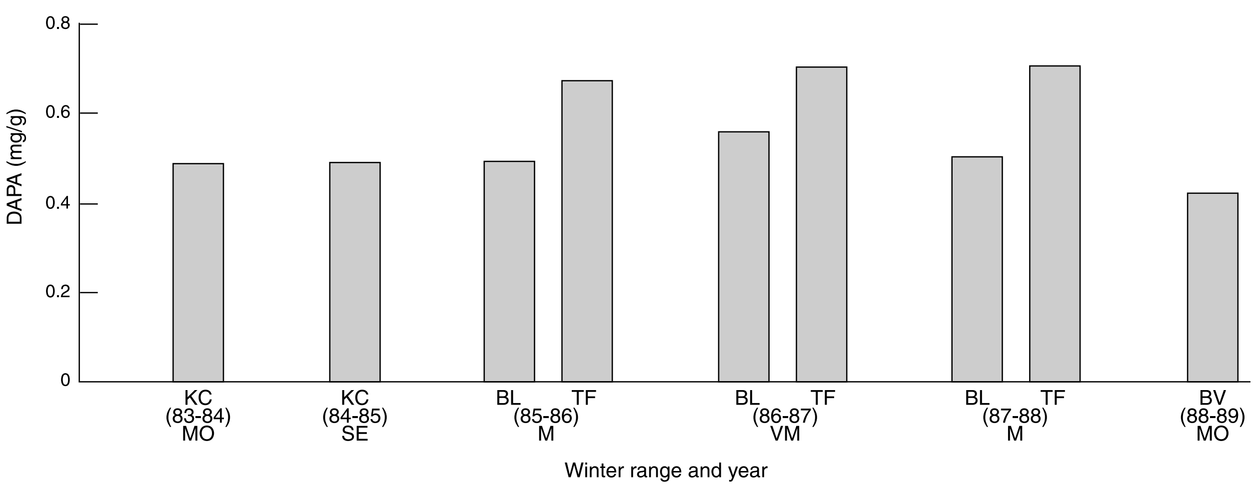


FIGURE 5. *Mean values for diaminopimelic acid (DAPA) (mg/g) by winter range and year in the central interior of British Columbia. The winter ranges are abbreviated as follows: KC = Knife Creek, BL = Big Lake, TF = Tree Farm Licence 5, and BV = Beaver Valley. The winter severity indices are abbreviated as follows: VM = very mild, M = mild, MO = moderate, and SE = severe.*

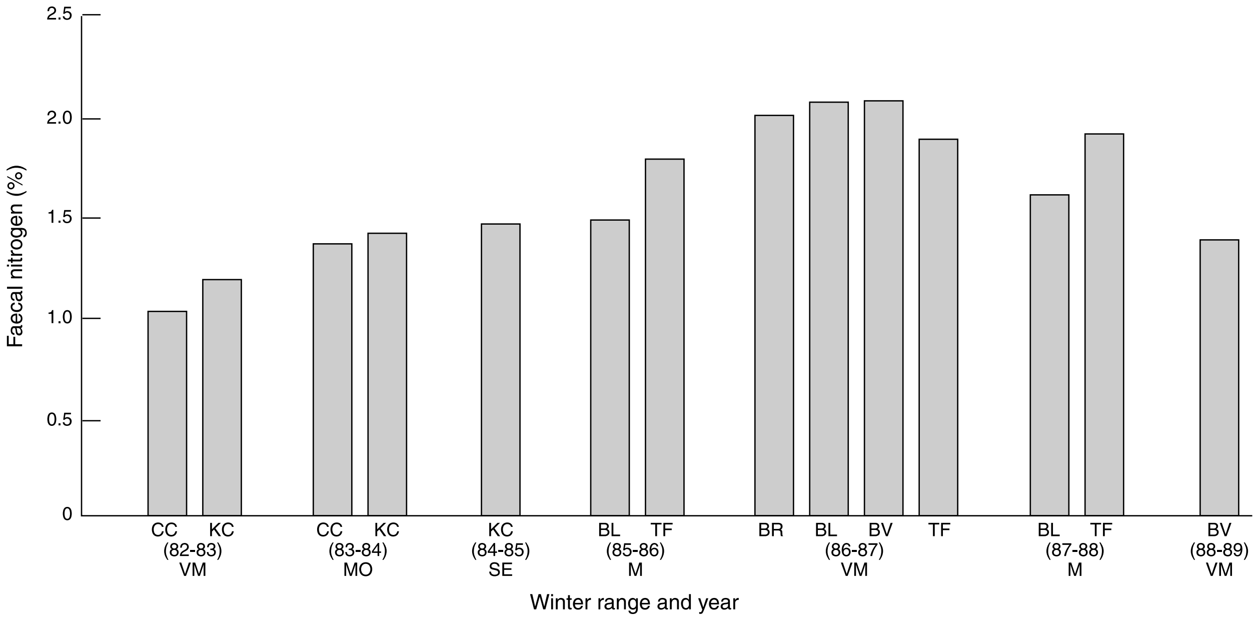


FIGURE 6. *Mean values for faecal nitrogen (FN) (%) by winter range and year in the central interior of British Columbia. The winter ranges are abbreviated as follows: CC = Churn Creek, KC = Knife Creek, BL = Big Lake, TF = Tree Farm Licence 5, BR = Bonaparte River, and BV = Beaver Valley. The winter severity indices are abbreviated as follows: VM = very mild, M = mild, MO = moderate, and SE = severe.*

TABLE 8. *Correlations of percent shrub and Douglas-fir in mule deer diets with faecal nitrogen (FN) and diaminopimelic acid (DAPA) from winter ranges in the central interior of British Columbia*

| **winter range** | **Index** | **Shrub** | | | **Douglas-fir** | | |
|---|---|---|---|---|---|---|---|
| | | **N[a]** | **r** | **P** | **N** | **r** | **P** |
| Combined ranges | FN | 61 | .46 | .0002 | 61 | -.46 | .0002 |
| Combined ranges | DAPA | 38 | .52 | .0009 | 38 | -.55 | .0004 |
| Big Lake | FN | 11 | .15 | .65 | 11 | -.29 | .38 |
| | DAPA | 11 | .42 | .20 | 11 | -.44 | .18 |
| Beaver Valley | FN | 11 | .18 | .60 | 11 | -.04 | .91 |
| | DAPA | 7 | .59 | .17 | 7 | -.30 | .51 |
| Churn Creek | FN | 9 | -.29 | .44 | 9 | -.02 | .95 |
| Knife Creek | FN | 11 | .11 | .75 | 11 | -.02 | .95 |
| | DAPA | 7 | .03 | .95 | 7 | -.25 | .58 |
| Tree Farm Licence 5 | FN | 11 | .59 | .05 | 11 | -.59 | .05 |
| | DAPA | 11 | .30 | .37 | 11 | -.21 | .53 |

[a] N – sample size, r = correlation coefficient, P = probability level.

# DISCUSSION

## Food Habits in Response to Douglas-fir Habitat Types and Snowpack

Forage availability is a function of habitat type and winter conditions, particularly snow. Kufeld *et al*. (1973) reported winter diets of mule deer to contain 74% conifers and shrubs, 15% forbs, and 11% grasses on average throughout western North America. Although the studies reviewed reported many species in the diets, most of the diets consisted of only a few species. Our results for the diets of mule deer from the central interior of British Columbia were similar.

The average amount of Douglas-fir in the diets per winter range was between 24% (Tree Farm Licence 5) and 73% (Knife Creek). On dry, IDF winter ranges, Douglas-fir can make up to 89% of the diet, regardless of snow conditions. Kufeld *et al*. (1973) found 30 studies that reported consumption of Douglas-fir during any season and 12 studies that reported use during winter. In studies from Montana and Colorado, Douglas-fir ranked moderate (5 – 20% of the diet). Wallmo (1981) found that consumption of Douglas-fir usually occurred when deer used forests as a refuge from deep snow conditions on open range.

Greater consumption of Douglas-fir is reported in more recent studies from northerly winter ranges that contain more Douglas-fir habitat. Berg and Hudson (1982) found that diets of wintering deer in a mixed Douglas-fir – limber pine forest in Alberta were composed of, on average, 89% Douglas-fir between January and May. In the south central interior of British Columbia, Willms *et al*. (1976) found that deer diets contained 42 – 49% Douglas-fir, but only when deer occupied the Douglas-fir – pinegrass habitat type. When snow deepened, deer migrated to sagebrush-steppe habitat at lower elevations. In the central interior of the province, low elevation Douglas-fir forests, usually on southerly aspects, are the common type of winter range available. Lower elevation areas with little snow are uncommon.

On some very dry winter ranges such as Churn Creek, located in the Bunchgrass Zone associated with the Fraser River south of Williams Lake, deer may have the option of using plants such as sages on exposed slopes and ridges, and shrubs in moist gullies in the grasslands if the snow is not too deep. Many deer were observed in this habitat at Churn Creek in January 1993 when about 25 cm of snow lay in the open. We observed no use of grasslands adjacent to Knife Creek in the same time period when the open snow depth was 62 cm. In the 3 years that we collected pellet samples at Churn Creek, the maximum snow depth was 10cm and certainly plants on the open grasslands were available. The consumption of Douglas-fir was consistently high, however, and therefore of importance to wintering deer.

Within the central interior of British Columbia, the variable composition and abundance of understorey vegetation in Douglas-fir forests are reflected in mule deer winter diets. On drier winter ranges such as Churn Creek, Bonaparte River, and Knife Creek, where shrubs are sparse, preferred shrubs such as saskatoon and Oregon-grape are always browsed. On moister winter ranges such as Beaver Valley and Tree Farm Licence 5, shrubs are abundant and made up a large part of the diets under shallow snow conditions. Because of distribution restrictions, some species of plants are common only to specific winter ranges. For example, sage species were eaten at Churn Creek, and ponderosa pine was eaten at Bonaparte River. At Middle Lake, where vegetation is transitional between coastal and interior habitats, western redcedar, western hemlock, snowbrush, pin cherry, and choke cherry were consumed. Deer appear to be fairly flexible in their choice of forage when it is available.

When the snowpack deepens, shrubs become buried and their availability decreases. We found significant negative correlations between the quantity of shrub in the diet and snowpack depth on moister winter ranges. In Colorado, Wallmo *et al*. (1977) found that 45 cm of snow drastically reduced the quantity of forage available, and that deer were subject to greater energy costs when foraging for the taller shrubs still available. Parker *et al*. (1984) reported a 150% increase in the relative energy that a deer expended walking in 41 cm of snow, and a 50% increase in 25 cm of snow, compared to walking on bare ground.

On the driest winter ranges, increases in Douglas-fir in the diet were only minor as the snowpack increased. The scarcity of shrubs limits forage choices under any snow condition. However, on wetter winter ranges, Douglas-fir consumption increased dramatically while shrub and subalpine fir consumption dropped. The available subalpine fir, being of regeneration size, is consequently buried by snow. Willms *et al*. (1976) also noted a shift away from low shrubs to more tall shrubs and Douglas-fir as the snow deepened. Constan (1972) reported increased use of Douglas-fir when snow fell in sagebrush types. Carpenter *et al.* (1979) found increased shrub use and decreased forb/grass consumption with increased snowpack. Also, Jenkins and Wright (1987) and Wallmo (1981) documented major shifts in diet between years of different snowpack depth.

In our study, deer that use wetter ranges have more shrubs available to them in shallow snow than those on drier ranges. Despite the abundance of shrubs, deer still consume Douglas-fir. Perhaps they optimize diet quality by consuming specific proportions of all forage types. A certain amount of Douglas-fir may be necessary for rumen pre-conditioning before large amounts are consumed. In deep snow conditions, the diets of deer become similar to those of deer on dry ranges. However, relative energy expenditure is much greater for deer in deeper snowpacks on wet winter ranges. When a cold, snowy winter occurs throughout the central interior of British Columbia, deer populations on wetter winter ranges generally experience higher mortality.[2]

Faecal fragment analysis is not as effective as directly observing foraging. The process of digestion can change the proportions of some plant species relative to others (Holecheck *et al*. 1982). Although our results show that Douglas-fir is the most common diet species, the other species should not be overlooked in winter range management.

## Diet Quality Based on Faecal Nitrogen and Diaminopimelic Acid

Leslie and Starkey (1985) suggest that FN can be used to trace seasonal diet quality for one herd, compare diet quality for one herd between years, and compare diet quality between herds within the same year. However, because there is controversy over the reliability of FN as an indicator of diet quality, we decided to use both FN and DAPA. Several researchers have found reasonable correlations between the two indices (Kie and Burton 1984; McNay and Doyle 1987; Hodgman 1988), as we did ($r=.64$, $P=.0001$, $N=38$). Nevertheless, care must be taken in interpreting results from both indices. Even though the abundance of certain forage species in the diet may have a strong influence on diet quality, the quality of the forage species (for example, crude protein and mineral content) may fluctuate annually and seasonally, and between winter ranges within the same year.

Faecal nitrogen is composed of unabsorbed dietary nitrogen, undigested microbial nitrogen, endogenous nitrogen, and endogenous nitrogen diluted by indigestible dietary dry matter. Although it has been correlated with dietary nitrogen (Leslie and Starkey 1985;

2 D. Hebert and M. Beets. 1990. Wildlife management - Cariboo plan. B.C. Ministry of Environment, Lands and Parks, Williams Lake, B.C. unpubl. draft rep.

Hodgman 1988), FN may not truly estimate available digestible energy if the diet is high in phenolic compounds. Phenolics, which include tannins, bind with proteins. This makes the proteins unavailable in the rumen for digestion, thus increasing the nitrogen content of the faeces (Mould and Robbins 1981). However, recent investigations have found that mule deer produce tannin-binding salivary proteins that reduce FN losses (Robbins *et al* 1991). Digestibility of different forage species may further influence the results (Gaare *et al*. 1977). Digestibility, which affects the rate of food passage through the rumen, could limit the rate of forage intake and the amount of nutrient extraction.

Diaminopimelic acid occurs in the cell walls of rumen bacteria. Because the amount of DAPA is proportional to the total bacterial nitrogen, it is directly related to digestible energy in the diet (Nelson *et al*. 1982). However, as for FN, the use of DAPA as an indicator of diet quality has certain drawbacks. DAPA levels may not be comparable between geographically distinct populations, because different strains of bacteria may contain different levels of DAPA (Van Soest 1982). Furthermore, DAPA may be degraded by hind gut bacteria (Mason and White 1971).

In our study, diet quality profiles by year and winter range showed both FN and DAPA to be generally lowest in either January or February. Variability in profile was due to the depth and duration of the snowpack, which influenced the quantity of forbs, grasses, and shrubs in the diet. The quality of the available diet may also have been low at that time of year. Bartmann (1983) and Kie and Burton (1984) also found diets to be poorest during mid-winter, based on dietary indices.

Both winter severity and location affect diet quality by influencing the species composition and abundance of plants. In our study, moister ranges (Beaver Valley and Tree Farm Licence 5) had higher levels of FN and DAPA in mild winters than did drier ranges. On drier winter ranges (Churn Creek and Knife Creek) where diets are dominated by Douglas-fir, the relationships between diet quality indices and winter severity were different. As expected, DAPA was not significantly different between years. At Knife Creek, however, FN was significantly higher in the severe winter than in the very mild winter, although the proportions of Douglas-fir and shrub remained fairly constant between years. There may be several reasons for this: the quality of the forage may have varied between years; the tannin content of the forage in 1984 – 1985 may have caused elevated FN; or more digestible forages may have been consumed but not detected. Mule deer wintering on Tree Farm Licence 5 in the Sub-Boreal Spruce Zone, a productive shrub area, had better quality diets (based on DAPA) than did those deer wintering at Big Lake, in the Interior Douglas-fir Zone where shrubs are not as abundant.

Although the data are incomplete, some interesting interactions between year and winter range are already apparent. For example, the diet of deer on Tree Farm Licence 5 in mild winters has consistently shown higher DAPA values than the diet of deer at Knife Creek, Big Lake and Beaver Valley, all of which are similar in a variety of winters.

On wetter winter ranges under shallow snow conditions, deer consume a higher proportion of shrubs and subalpine fir than Douglas-fir. Willms *et al*. (1976) report deer preference for shrubs, such as Oregon-grape and falsebox (Paxistima myrsinites), over Douglas-fir. This preference may be due to the crude protein levels found in shrubs and subalpine fir. Jenkins and Wright (1987) reported crude protein content for several species also found on our winter ranges: Oregon-grape - 10.3%, saskatoon - 6.2%, willow -6.8%, subalpine fir - 7.1%. Milchunas *et al*. (1978) reported crude protein content of 5.5% and 6.7%, respectively, for saskatoon and pasture sage. We found samples of Douglas-fir foliage from the Knife Creek and Big Lake winter ranges to contain 5.0 – 6.9% crude protein, which agrees with the results reported by Willms *et al*. (1976) and Tucker *et al*. (1976). Except for Oregon-grape, the reported crude protein levels for shrubs, subalpine fir, and Douglas-fir are similar and meet the crude protein requirement of 6 – 7% that is essential to maintain body functions (Milchunas *et al*. 1978; Swift *et al*. 1980).

Mule deer preference for shrubs may also be a function of digestibility, which in turn affects the rate of forage intake and nutrient release. In vitro digestible dry matter (IVDDM) is used to measure the degree to which a forage can be altered chemically or physically by the digestive process. We found Douglas-fir foliage samples from Knife Creek and Big Lake to have 32 – 43% IVDDM. Jenkins and Wright (1987) and Milchunas *et al*. (1978) reported the IVDDM of the above shrubs to be 32 – 38%; Oregon-grape was the exception at 57%. However, the crude protein, digestibility, and phenolic content of shrub species on each winter range should be investigated.

Shrub and Douglas-fir quantity and quality appear to strongly affect the diet quality indices and therefore animal condition. However, other species of plants such as arboreal lichens, grasses, and forbs are also of importance in the diet. Even small quantities of these forages may improve diet quality because mixed diets aid digestion and increase digestible energy (Rochelle 1980). For example, arboreal lichen, a highly preferred forage available throughout winter, has high carbohydrate content and high digestibility (Rochelle 1980). Forbs and grasses that are available in early winter or late spring also tend to be highly digestible and high in protein (Willms *et al*. 1976). Availability of grass early in the spring is particularly important when deer are in poor condition.

## MANAGEMENT IMPLICATIONS

Management practices such as harvesting, juvenile spacing, and grazing have a direct impact on forage availability on mule deer winter ranges. The long- and short-term implications of these practices must be considered because forage is a key element for survival of mule deer in the winter.

In the central interior of British Columbia, mule deer generally winter in low elevation, Douglas-fir forests. These old, uneven-aged stands have high forage value for wintering deer for several reasons. First, mule deer consume much Douglas-fir foliage in the form of litterfall from large, older trees (Dawson *et al*. 1990 and Waterhouse *et al*. 1991). Second, the stand as a whole effectively intercepts snow, thereby reducing the amount of energy expended by deer searching for forage, and maintaining the availability of shrubs. Third, the forest structure is conducive to shrub production in the natural openings which occur between small groups of trees. And lastly, arboreal lichen, which is also important in the diet of mule deer, is most abundant on large, older trees (Waterhouse *et al*. 1991).

The forest management practices used on mule deer winter ranges, at both stand and landscape levels, can have a large impact on the availability of winter forage. At the landscape level, an adequate proportion of high crown closure old forest must be maintained in a pattern that maximizes the continuity and minimizes the fragmentation of this forest type. If there is sufficient old forest at the landscape level, then Armleder *et al*. (1986) recommend low volume partial cutting (small group selection) at the stand level. This maintains a large percent of the forage-producing trees and the snow interception ability of the stand. Creating small openings may also increase shrub production. Fall or winter harvesting is recommended so that Douglas-fir slash can be used as forage.

While timber harvesting usually has the largest effect on forage, other practices such as cattle grazing and juvenile spacing can also affect the availability of forage. In forested areas, cattle will eat shrubs when encountered, especially if preferred grasses are not available. Control of the timing and duration of grazing would alleviate most potential wildlife conflicts. Habitat enhancement projects could further improve the shrub availability and overall diet quality on areas that have low shrub abundance because of historically high grazing pressure. The Ministry of Environment, Lands and Parks (J. Young, Williams Lake Northern Sub-Region, pers. comm.) has had initial success planting saskatoon on the Gaspard winter range (located near our Churn Creek study area). There has also been some success using underburning to promote germination of Ceanothus species. As well, juvenile spacing may enhance shrub production in the short term and will accelerate the development of litter-producing trees in the long term.

Management of winter range should also consider adjacent grasslands, because they are important foraging sites for mule deer in the early spring. This consideration is especially important after deep snow winters, because these are the first areas to become snow free.

This study has shown the critical importance of Douglas-fir forests to the diet of wintering mule deer in the Cariboo Forest Region. Forest management on mule deer winter ranges must be done carefully to maintain the unique characteristics of natural, mature Douglas-fir forests and their dependent wildlife populations.

APPENDIX 1. *Month-end open snow depths (cm) and average monthly maximum and minimum temperatures ($^0$C) recorded at Williams Lake Airport, British Columbia (940 m). Year (Severity Index / calculated from Picton and Knight (1971).*

| | | **1981 – 1982 (15798)** | **1982 – 1983 (302)** | **1983 – 1984 (10189)** | **1984 – 1985 (20310)** | **1985 – 1986 (4675)** | **1986 – 1987 (1219)** | **1987 – 1988 (2198)** | **1988 – 1989 (9161)** |
|---|---|---|---|---|---|---|---|---|---|
| Dec | Snow | 21 | 04 | 41 | 63 | 27 | 22 | 16 | 27 |
| | Max. | -04.3 | -01.7 | -11.2 | -09.2 | -04.0 | -02.1 | -01.0 | -01.7 |
| | Min. | -12.6 | -09.1 | -19.5 | -17.8 | -11.3 | -08.3 | -08.9 | -09.0 |
| Jan | Snow | 60 | 09 | 30 | 44 | 26 | 08 | 02 | 33 |
| | Max. | -09.1 | 00.4 | -01.3 | -03.8 | 01.7 | -00.1 | -04.7 | -02.6 |
| | Min. | -18.8 | -06.3 | -08.7 | -09.8 | -04.8 | -07.4 | -12.4 | -17.4 |
| Feb | Snow | 50 | 00 | 23 | 50 | 03 | 09 | 01 | 27 |
| | Max. | -01.7 | 03.3 | 03.9 | -01.6 | -03.1 | 03.5 | -00.7 | -05.6 |
| | Min. | -12.2 | -03.7 | -04.2 | -10.7 | -11.9 | -07.9 | -08.5 | -18.2 |
| Mar | Snow | 29 | 00 | 00 | 24 | 00 | 00 | 06 | 00 |
| | Max. | 03.4 | 06.4 | 07.8 | 04.7 | 08.8 | 07.2 | 05.9 | 03.6 |
| | Min. | -09.0 | -04.1 | -03.3 | -06.7 | -01.4 | -03.1 | -03.5 | -07.9 |

APPENDIX 2. *Plant species found in the winter diets of mule deer in the central interior of British Columbia*

| | |
|---|---|
| *Abies amabilis* (Dougl. ex Loud.) Forbes | amabilis fir |
| *Abies lasiocarpa* (Hook.) Nutt. | subalpine fir |
| *Acer glabrum Torr.* var. douglasii | Douglas maple |
| *Achillea millefolium* L. | yarrow |
| *Agropyron spicatum* (Pursh) Scribn. & Sm. | bluebunch wheatgrass |
| *Alnus tenuifolia* Nutt. | mountain alder |
| *Alnus crispa* (Ait.) Pursh | Sitka alder |
| *Amelanchier alnifolia* (Nutt.) Nutt. | saskatoon |
| *Antennaria* spp. (Gaertn.) | pussytoes |
| *Aralia nudicaulis* L. | wild sarsaparilla |
| *Arctostaphylos uva-ursi* (L.) Spreng. | kinnikinnick |
| *Arnica cordifolia* Hook. | heart-leaved arnica |
| *Artemisia frigida* WillId. | pasture sage |
| *Artemisia tridentata* Nutt. | big sagebrush |
| *Aster ciliolatus Lindl.* in Hook. | fringed aster |
| *Astragalu*s spp. L. | milk-vetch |
| *Astragalus miser Dougl.* ex Hook. | timber milk-vetch |
| *Balsamorhiza sagittata* (Pursh) Nutt. | arrow-leaved balsamroot |
| *Betula glandulosa* Michx. | scrub birch |
| *Betula papyrifera* Marsh. | paper birch |
| *Bromus* spp. L. | brome |
| *Bromus anomalus* Rupr. | nodding brome |
| *Calamagrostis canadensis* (Michx.) Beauv. | bluejoint |
| *Calamagrostis rubescens* Buckl. | pinegrass |
| *Carex* spp. L. | sedge |
| *Ceanothus sanguineus* Pursh | redstem ceanothus |
| *Ceanothus velutinus* Dougl. ex Hook. | snowbrush |
| *Cerastium* spp. L. | chickweed |
| *Chyrsothamnus nauseosus* (Pall.) Britt. | rabbit-brush |
| *Cornus canadensis* L. | bunchberry |
| *Cornus stolonifera* Michx. | red-osier dogwood |
| *Crataegus* spp. L. | hawthorn |
| *Equisetum arvense* L. | common horsetail |
| *Festuca occidentalis* Hook. | western fescue |
| *Festuca rubra* L. | red fescue |
| *Festuca saximontana* Rydb. | Rocky Mountain fescue |
| *Fragaria* spp. L. | strawberry |
| *Galium boreale* L. | northern bedstraw |
| *Galium triflorum* Michx. | sweet-scented bedstraw |
| *Geranium richardsonii* Fisch. & Trautv. | white geranium |
| *Geranium viscosissimum* Fisch. & Mey. | sticky geranium |
| *Geum triflorum* Pursh | old man’s whiskers |
| *Juncus* spp. L. | rush |
| *Juniperus communis* L. | common juniper |
| *Juniperus horizontalis* Moench | creeping juniper |
| *Juniperus scopulorum* Sarg. | Rocky Mountain juniper |
| *Ledum groenlandicum* Oeder | Labrador tea |
| *Linnaea borealis* L. | twinflower |
| *Lonicera involucrata* (Richards.) Banks ex Spreng. | black twinberry |
| *Mahonia aquifolium* (Pursh) Nutt. | tall Oregon-grape |

| | |
|---|---|
| *Mahonia nervosa* (Pursh) Nutt. | dull Oregon-grape |
| *Mahonia repens* (Lindl.) G. Don | creeping Oregon-grape |
| *Pachistima myrsinites* (Pursh) Raf. | falsebox |
| *Penstemon fruticosus* (Pursh) Greene | shrubby penstemon |
| *Penstemon procerus* Dougl. ex Graham | small-flowered penstemon |
| *Phleum alpinum* L. | alpine timothy |
| *Phleum pratense* L. | timothy |
| *Picea glauca x engelmannii* Parry ex Engelm. | hybrid white spruce |
| *Pinus contorta var. latifolia* Dougl. ex Loud. | lodgepole pine |
| *Pinus ponderosa* Dougl. ex P. Lawson & C. Lawson | ponderosa pine |
| *Poa* spp. L. | bluegrass |
| *Poa pratensis* L. | Kentucky bluegrass |
| *Populus balsamifera* L. | poplar |
| *Populus tremuloides* Michx. | trembling aspen |
| *Prunus pensylvanica* L.f. | pin cherry |
| *Prunus virginiana* L. | choke cherry |
| *Pseudotsuga menziesii var. glauca* (Beissn.) Franco | interior Douglas-fir |
| *Pyrola* spp. L. | wintergreen |
| *Ribes* spp. L. | gooseberry |
| *Rosa acicularis* Lindl. | prickly rose |
| *Rosa woodsii* Lindl. | prairie rose |
| *Rubus idaeus* L. | red raspberry |
| *Rubus parviflorus* Nutt. | thimbleberry |
| *Rubus pubescens* Raf. | trailing raspberry |
| *Salix* spp. L. | willow |
| *Sedum lanceolatum* Torr. | lance-leaved stonecrop |
| *Selaginella densa* Rydb. | compact selaginella |
| *Shepherdia canadensis* (L.) Nutt. | soopolallie |
| *Spiraea betulifolia* Pall. | birch-leaved spirea |
| *Stipa comata* Trin. & Rupr. | needle-and-thread grass |
| *Stipa richardsonii* Link | spreading needlegrass |
| *Symphoricarpos albus* (L.) Blake | common snowberry |
| *Symphoricarpos occidentalis* Hook. | western snowberry |
| *Thuja plicata* Donn ex D. Don in Lamb. | western redcedar |
| *Trifolium* spp. L. | clover |
| *Tsuga heterophylla* (Raf.) Sarg. | western hemlock |
| *Vaccinium* spp. L. | blueberry/huckleberry |
| *Viburnum edule* (Michx.) Raf. | highbush cranberry |

Sources:

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APPENDIX 3. *Percent of plant species found in diets of mule deer on the Beaver Valley winter range, 1984 – 1989*

| | Year | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1984 Jan** | **1984 Feb** | **1985 Feb** | **1986 Dec** | **1987 Jan** | **1987 Feb** | **1988 Jan** | **1988 Dec** | **1989 Jan** | **1989 Feb** | **1989 Mar** |
| **Coniferous trees** | | | | | | | | | | | |
| Open snow depth (cm) | 45 | 25 | 67 | 25 | 25 | 20 | 10 | 5 | 47 | 42 | 49 |
| *Abies lasiocarpa* | + | + | – | 13 | 6 | + | 13 | 6 | 1 | + | 11 |
| *Pinus contorta* | + | + | – | + | – | + | – | – | – | – | – |
| *Pseudotsuga menziesii* | 76 | 42 | 82 | 36 | 22 | + | 15 | 35 | 43 | 71 | 61 |
| Conifer bark | – | – | – | – | – | + | – | 10 | 4 | 2 | 2 |
| Other | 3 | 4 | – | 2 | + | 5 | – | – | – | – | – |
| **Subtotal** | **79** | **46** | **82** | **51** | **28** | **5** | **28** | **51** | **48** | **73** | **74** |
| **Shrubs and deciduous trees** | | | | | | | | | | | |
| *Acer glabrum* | – | + | – | + | – | + | – | + | + | + | – |
| *Alnus spp* | – | – | – | – | – | + | – | – | – | – | – |
| *Amelanchier alnifolia* | 4 | 5 | – | 5 | + | 28 | 5 | + | 25 | 2 | 5 |
| *Betula papyrifera* | – | – | – | – | – | – | + | – | – | – | – |
| *Ceanothus sanguineus* | – | – | – | – | – | – | – | – | 4 | 1 | – |
| *cornus stolonifera* | 6 | + | – | – | 10 | 16 | 4 | 1 | – | + | + |
| *Lonicera involucrata* | – | – | – | – | – | + | – | – | – | – | – |
| *Mahonia aquifolium* | 4 | 21 | – | 29 | 34 | 32 | 28 | 26 | 1 | – | 5 |
| *Populus* spp. | – | – | – | – | – | – | – | – | – | 1 | – |
| *Ribes* spp. | – | – | – | – | – | – | + | – | 1 | – | 2 |
| *Rosa acicularis* | – | – | – | – | – | + | + | – | – | – | – |
| *Rubus* spp. | – | – | 5 | – | – | – | – | + | 3 | 1 | – |
| *Salix* spp. | – | – | 3 | + | – | – | 5 | – | 8 | 6 | 2 |
| *Shepherdia canadensis* | – | – | – | – | – | – | 4 | 1 | 2 | 7 | 2 |
| *Spirea betulifolia* | – | – | – | – | – | – | – | 1 | – | – | 1 |
| *Symphoricarpos albus* | – | – | – | – | – | – | – | + | 1 | – | – |

| | **1984 Jan** | **1984 Feb** | **1985 Feb** | **1986 Dec** | **1987 Jan** | **1987 Feb** | **1988 Jan** | **1988 Dec** | **1989 Jan** | **1989 Feb** | **1989 Mar** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Vaccinium* spp. | – | – | – | – | – | – | 4 | 3 | 2 | 1 | + |
| Other | 5 | 12 | 8 | 7 | 11 | 8 | 2 | – | – | – | 4 |
| **Subtotal** | **19** | **38** | **16** | **41** | **55** | **84** | **52** | **32** | **47** | **19** | **21** |
| **Forbs** | | | | | | | | | | | |
| *Achillea milefolium* | – | – | – | + | – | – | – | – | – | – | – |
| *Arctostaphylos uva-ursi* | – | – | – | – | – | – | – | 1 | – | – | |
| *Linnaea borealis* | – | – | – | – | – | + | + | – | – | – | – |
| Other | 1 | + | + | 2 | 1 | + | 7 | 6 | – | – | + |
| **Subtotal** | **1** | **+** | **+** | **2** | **1** | **+** | **7** | **7** | **–** | **–** | **+** |
| **Grasses and grass–like** | | | | | | | | | | | |
| Grasses | 1 | 16 | 1 | 3 | 15 | 11 | 1 | 5 | – | + | 2 |
| Sedges | + | – | – | – | – | – | – | 3 | – | – | – |
| **Subtotal** | **1** | **16** | **1** | **3** | **15** | **11** | **1** | **8** | **–** | **+** | **2** |
| **Ferns and fern allies** | | | | | | | | | | | |
| Lichens | + | + | 1 | 1 | + | + | 12 | 1 | 3 | 1 | 3 |
| Mosses | + | + | – | 1 | + | + | + | – | + | + | 1 |

+= <1%, – = 0.

APPENDIX 4. *Percent of plant species found in diets of mule deer on the Big Lake winter range, 1985 – 1988*

| | Year | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1985 Dec** | **1986 Jan** | **1986 Feb** | **1986 Mar** | **1986 Dec** | **1987 Jan** | **1987 Feb** | **1987 Mar** | **1987 Dec** | **1988 Jan** | **1988 Feb** |
| Open snow depth (cm) | 45 | 25 | 67 | 25 | 25 | 20 | 10 | 5 | 47 | 42 | 49 |
| **Coniferous trees** | | | | | | | | | | | |
| *Abies lasiocarpa* | – | – | – | – | – | + | – | – | – | – | – |
| *Pinus contorta* | – | – | – | – | + | 5 | + | – | – | 2 | 1 |
| *Pseudotsuga menziesii* | 74 | 61 | 79 | 56 | 60 | 61 | 58 | 6 | 28 | 36 | 55 |
| Conifer bark | – | – | – | – | – | 6 | – | – | 6 | 4 | 4 |
| Other | – | 2 | 2 | 4 | 3 | 1 | 3 | + | – | – | – |
| **Subtotal** | **74** | **63** | **81** | **60** | **63** | **73** | **61** | **6** | **34** | **42** | **60** |
| **Shrubs and deciduous trees** | | | | | | | | | | | |
| *Acer glabrum* | – | – | – | – | – | – | + | – | 4 | – | – |
| *Alnus* spp. | – | – | – | – | – | – | – | – | – | – | + |
| *Amelanchier alnifolia* | – | – | – | – | + | + | + | 9 | 14 | 5 | + |
| *Betula papyrifera* | – | – | – | – | – | – | – | – | + | – | – |
| *Cornus stolonifera* | – | – | – | 4 | – | – | – | 5 | – | + | – |
| *Mahonia aquifolium* | 11 | 5 | – | 15 | + | + | 9 | 56 | 21 | 16 | 8 |
| *Populus* spp. | – | – | – | – | – | + | – | – | – | – | – |
| *Ribes* spp. | – | – | – | – | – | – | + | – | + | – | – |
| *Salix* spp. | – | – | 8 | – | – | + | 4 | – | – | 3 | + |
| *Shepherdia canadensis* | – | 4 | – | – | 5 | + | + | – | + | + | 5 |
| *Vaccinium* spp. | – | – | – | – | – | – | – | – | 4 | – | – |
| Other | 4 | 18 | 7 | 7 | 13 | 17 | 12 | 5 | 9 | 12 | 14 |
| **Subtotal** | **15** | **27** | **15** | **26** | **18** | **17** | **25** | **75** | **52** | **36** | **27** |
| **Forbs** | | | | | | | | | | | |
| *Achillea milefolium* | – | – | – | – | + | + | + | – | – | – | – |
| *Composite* spp. | – | – | – | – | + | – | – | – | – | – | – |
| *Linnaea borealis* | – | – | – | – | – | – | + | 8 | 4 | – | + |

| | 1985 Dec | 1986 Jan | 1986 Feb | 1986 Mar | 1986 Dec | 1987 Jan | 1987 Feb | 1987 Mar | 1987 Dec | 1988 Jan | 1988 Feb |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Other | 5 | 7 | 1 | 1 | 9 | 5 | 4 | 1 | 4 | 5 | 7 |
| **Subtotal** | **5** | **7** | **1** | **1** | **9** | **5** | **4** | **9** | **8** | **5** | **7** |
| **Grasses and grass–like** | | | | | | | | | | | |
| Grasses | 3 | 3 | 4 | 6 | 6 | 3 | 6 | 7 | 6 | 9 | 2 |
| Sedges | – | – | – | 4 | 1 | 1 | 1 | 1 | – | – | 2 |
| **Subtotal** | **3** | **3** | **4** | **10** | **7** | **4** | **7** | **8** | **6** | **9** | **4** |
| Lichens | 3 | 0 | 0 | 3 | 4 | 1 | 1 | 2 | + | 6 | 2 |
| Mosses | 0 | 1 | 0 | 0 | 1 | 1 | 2 | 2 | + | + | – |

+= <1%, – = 0.

APPENDIX 5. *Percent of plant species found in diets of mule deer on the Bonaparte River winter range, 1986 – 1987*

| | **Year** | | |
|---|---|---|---|
| | **1986** | **1987** | **1987** |
| | **Dec** | **Jan** | **Feb** |
| Open snow depth (cm) | 23 | 29 | 29 |
| Coniferous trees | | | |
| *Pinus ponderosa* | 6 | + | 6 |
| *Pseudotsuga menziesii* | 57 | 50 | 66 |
| Conifer bark | + | – | – |
| Other | 4 | 3 | – |
| **Subtotal** | **67** | **53** | **72** |
| **Shrubs and deciduous trees** | | | |
| *Acer glabrum* | – | + | – |
| *Amelanchier alnifolia* | 8 | + | 4 |
| *Artemisia frigida* | – | + | + |
| *Cornus stolonifera* | – | + | 5 |
| *Salix* spp. | – | 5 | – |
| *Shepherdia canadensis* | 9 | + | + |
| Other | 5 | 19 | 12 |
| **Subtotal** | **22** | **24** | **21** |
| **Forbs** | | | |
| *Cerastium* spp. | – | + | – |
| *Composite* spp. | – | + | – |
| *Penstemon fruticosus* | – | 9 | + |
| Other | 2 | 4 | 3 |
| **Subtotal** | **2** | **13** | **3** |
| **Grasses and grass–like** | | | |
| Grasses | 2 | 1 | 3 |
| Sedges | + | – | – |
| **Subtotal** | **2** | **1** | **3** |
| Lichens | 7 | 9 | 1 |
| Mosses | + | + | + |

+= <1%, – = 0.

APPENDIX 6. *Percent of plant species found in diets of mule deer on the Churn Creek winter range, 1983 – 1988*

| | | | | | **Year** | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **1983** | **1983** | **1983** | **1983** | **1983** | **1984** | **1984** | **1984** | **1988** |
| | **Jan** | **Feb** | **Mar** | **Nov** | **Dec** | **Jan** | **Feb** | **Dec** | **Jan** |
| **Open snow depth (cm)** | **2** | **0** | **0** | **0** | **0** | **10** | **0** | **0** | **0** |
| **Coniferous trees** | | | | | | | | | |
| *Pinus contorta* | – | – | – | – | 1 | 2 | 1 | – | – |
| *Pseudotsuga menziesii* | 60 | 82 | 82 | 71 | 89 | 86 | 86 | 43 | 29 |
| Other | – | – | – | – | – | – | – | 2 | 5 |
| **Subtotal** | **60** | **82** | **82** | **71** | **90** | **88** | **87** | **45** | **34** |
| **Shrubs and deciduous trees** | | | | | | | | | |
| *Amelanchier alnifolia* | – | – | – | + | – | – | + | – | 3 |
| *Artemisia* spp. | 37 | 17 | 6 | 23 | 2 | 7 | 8 | – | 17 |
| *Chyrsothamnus nauseosus* | – | – | – | – | + | – | – | – | – |
| *Juniperus* spp. | – | – | – | – | 1 | 1 | 3 | – | – |
| *Mahonia* spp. | – | – | – | + | – | – | – | – | – |
| *Salix* spp. | + | – | 4 | – | + | – | – | – | – |
| *Shepherdia canadensis* | – | – | 2 | 1 | 1 | 1 | + | 5 | – |
| *Symphoricarpos* spp. | – | – | – | + | + | – | – | – | – |
| Other [a] | – | – | – | – | – | – | – | 9 | 7 |
| **Subtotal** | **37** | **17** | **12** | **24** | **4** | **9** | **11** | **14** | **27** |
| **Forbs** | | | | | | | | | |
| *Antennaria* spp. | – | – | 2 | 1 | – | – | – | – | – |
| *Arctostaphylos uva–ursi* | – | – | 1 | – | – | – | – | – | – |
| *Astragalus* spp. | – | + | – | – | – | – | – | – | – |
| *Composite* spp. | + | + | 2 | 1 | 1 | – | + | – | – |
| *Galium* spp. | + | – | – | – | – | 1 | 1 | – | – |
| *Geum* spp. | – | – | – | – | + | – | – | – | – |
| *Rubus pubescens* | – | + | – | – | – | – | – | – | – |
| Other[b] | – | – | + | – | – | – | – | 2 | 17 |
| **Subtotal** | **+** | **+** | **5** | **2** | **1** | **1** | **1** | **2** | **17** |
| **Grasses and grass–like** | | | | | | | | | |
| *Agropyron spicatum* | – | – | + | – | + | – | – | – | – |
| *Carex* spp. | + | – | – | + | *3* | + | – | *11* | + |
| *Festuca* spp. | – | – | – | *1* | – | – | – | – | – |
| *Juncus* spp. | – | – | – | – | + | – | – | – | – |
| *Poa* spp. | *1* | + | *1* | – | + | *2* | *1* | – | – |
| Grasses | + | – | – | – | – | – | – | 27 | 18 |
| Other | + | – | – | – | – | – | – | – | – |
| **Subtotal** | **1** | **+** | **1** | **1** | **3** | **2** | **1** | **38** | **18** |
| Lichen | – | – | – | – | – | – | – | + | 2 |
| Mosses | – | – | – | – | – | – | – | – | 1 |

[a] "Other" includes Ribes, Shepherdia, Chyrsothamnus, Salix, and Mahonia.

[b] "Other" includes Aster and Balsamorhiza.

+ = <1%, – = 0.

APPENDIX 7. *Percent of plant species found in diets of mule deer on the Knife Creek winter range, 1982 – 1985*

| | | | | | | **Year** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1982 Dec** | **1983 Jan** | **1983 Feb** | **1983 Nov** | **1983 Dec** | **1984 Jan** | **1984 Feb** | **1984 Dec** | **1985 Jan** | **1985 Feb** | **1985 Mar** |
| Open snow depth (cm) | 0 | 6 | 0 | 0 | 30 | 45 | 25 | 37 | 47 | 58 | 45 |
| **Coniferous trees** | | | | | | | | | | | |
| *Pinus contorta* | – | – | – | 1 | 2 | 1 | 3 | | | | |
| *Pseudotsuga menziesii* | 73 | 89 | 69 | 75 | 70 | 68 | 62 | 76 | 81 | 72 | 70 |
| Conifer bark | – | – | – | – | 4 | 2 | 5 | – | 3 | 7 | – |
| Other | – | – | – | – | – | – | – | – | – | + | – |
| **Subtotal** | **73** | **89** | **69** | **76** | **76** | **71** | **70** | **76** | **84** | **79** | **70** |
| **Shrubs and deciduous trees** | | | | | | | | | | | |
| *Alnus* spp. | – | – | – | – | – | 1 | – | – | + | + | – |
| *Amelanchier alnifolia* | – | 2 | – | + | 10 | 7 | 5 | 4 | 2 | + | + |
| *Artemisia frigida* | – | – | – | + | – | – | – | + | – | – | + |
| *Betula* spp. | – | – | – | – | 1 | 1 | – | + | – | + | – |
| *cornus stolonifera* | 1 | – | – | 8 | – | – | – | – | – | – | – |
| *Juniperus Communis* | – | – | – | – | – | + | – | – | – | – | – |
| *Ledum groenlandicum* | – | – | – | – | + | – | – | – | – | – | – |
| *Mahonia aquifolium* | 16 | 4 | 21 | 12 | 4 | 1 | 1 | + | – | – | 3 |
| *Pachistima myrsinites* | – | 1 | – | – | – | – | – | – | – | – | – |
| *Populus* spp. | – | – | – | – | – | 1 | – | – | + | – | – |
| *Prunus virginiana* | – | – | – | – | + | 1 | 1 | – | – | – | – |
| *Ribes* spp. | – | – | – | – | – | 1 | 1 | – | – | – | + |
| *Rosa* spp. | – | – | – | – | + | – | + | – | – | – | – |
| *Rubus* spp. | – | – | – | – | – | – | – | – | – | + | + |
| *Salix* spp. | + | 2 | 3 | + | 1 | 1 | + | + | + | – | + |
| *Shepherdia canadensis* | + | + | – | – | + | 1 | 1 | + | + | – | + |
| *Spiraea betulifolia* | – | – | – | – | 1 | 5 | 1 | – | – | – | – |
| *Symphoricarpos* spp. | – | – | – | + | – | – | + | – | + | – | – |

| | 1982 Dec | 1983 Jan | 1983 Feb | 1983 Nov | 1983 Dec | 1984 Jan | 1984 Feb | 1984 Dec | 1985 Jan | 1985 Feb | 1985 Mar |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Vaccinium* spp. | 1 | – | – | – | + | 2 | – | + | + | – | + |
| *Viburnum edule* | – | – | 1 | – | – | – | – | – | – | – | – |
| Other[a] | – | – | – | – | – | – | 2 | 9 | 5 | 5 | 7 |
| **Subtotal** | **18** | **9** | **25** | **20** | **17** | **22** | **12** | **13** | **7** | **5** | **10** |
| **Forbs** | | | | | | | | | | | |
| *Achillea millefolium* | – | – | – | – | – | + | – | + | – | – | – |
| *Antennaria* spp. | 2 | – | – | – | – | 1 | + | – | – | – | – |
| *Aralia nudicaulis* | – | – | – | – | – | – | – | – | – | – | – |
| *Arctostaphylos uva–ursi* | – | + | – | – | 1 | + | 1 | – | – | – | – |
| *Arnica cordifolia* | – | – | – | – | – | – | – | + | – | – | – |
| *Astragalus miser* | – | – | – | + | – | – | – | + | – | – | – |
| *Balsamorhiza sagittata* | – | – | – | – | + | – | + | – | – | – | – |
| *Cornus canadensis* | – | – | – | + | – | – | – | – | – | – | – |
| *Composite* spp. | 3 | + | 1 | – | – | – | – | + | – | – | – |
| *Galium* spp. | – | – | – | + | – | – | – | – | – | – | – |
| *Geranium* spp. | – | – | – | – | – | – | – | + | – | – | – |
| *Geum* spp. | 1 | – | – | – | – | – | – | – | – | – | – |
| *Linnaea borealis* | – | – | – | – | + | – | 1 | + | – | – | – |
| *Pyrola* spp. | – | – | 1 | – | – | – | – | – | – | – | – |
| *Sedum lanceolatum* | – | – | – | – | – | – | – | + | – | – | – |
| *Trifolium* spp. | 1 | – | – | – | – | – | – | – | – | – | – |
| Othera | + | – | 2 | – | 2 | 1 | 1 | 8 | + | + | 1 |
| Subtotal | 7 | + | 4 | 1 | 3 | 2 | 3 | 8 | + | + | 1 |
| **Grasses and grass–like** | | | | | | | | | | | |
| *Agropyron spicatum* | – | – | – | – | – | + | + | – | – | + | + |
| *Bromus* spp. | + | – | – | – | – | – | – | – | – | – | + |
| *Calamagrostis* spp. | – | – | – | – | 1 | 2 | 2 | – | – | + | + |
| *Carex* spp. | – | – | – | + | – | 1 | 2 | – | – | + | + |

| | 1982 Dec | 1983 Jan | 1983 Feb | 1983 Nov | 1983 Dec | 1984 Jan | 1984 Feb | 1984 Dec | 1985 Jan | 1985 Feb | 1985 Mar |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Festuca occidentalis* | – | – | – | – | + | – | – | – | – | + | – |
| *Poa* spp. | 1 | 1 | 1 | – | – | 1 | 1 | – | – | + | – |
| *Stipa* spp. | – | – | – | + | – | – | – | – | – | – | – |
| Other | – | – | 1 | – | – | + | + | 1 | 2 | 10 | 14 |
| Subtotal | | 1 | 1 | 2 | + | 1 | 4 | 5 | 1 | 2 | 10 |
| **Ferns and fern allies** | | | | | | | | | | | |
| Ferns | 1 | + | + | – | + | – | – | – | – | – | – |
| *Selaginella densa* | – | + | + | – | – | – | – | – | – | – | – |
| Lichens | – | – | – | 1 | 2 | 3 | 7 | 3 | 8 | 2 | 3 |
| Mosses | – | – | – | – | – | – | 1 | – | – | – | – |

[a] "Other" includes unspecified amounts of previously listed species.

+ =<1%, – = 0.

APPENDIX 8. *Percent of plant species found in diets of mule deer on the Middle Lake winter range, 1986 – 1988*

| | Year | | | | |
|---|---|---|---|---|---|
| | **1986 Nov** | **1986 Dec** | **1987 Mar** | **1988 Jan** | **1988 Feb** |
| **Open snow depth (cm)** | **25** | **60** | **0** | **35** | **27** |
| **Coniferous trees** | | | | | |
| *Abies* spp. | 1 | 2 | 1 | 2 | – |
| *Picea glauca x engelmannii* | – | 1 | – | 3 | – |
| *Pinus contorta* | 4 | 2 | + | 3 | – |
| *Pseudotsuga menziesii* | 43 | 61 | 39 | 50 | 33 |
| *Thuja plicata* | – | 2 | 3 | 3 | + |
| *Tsuga heterophylla* | – | 8 | 11 | 9 | 8 |
| Conifer bark | – | 3 | 2 | – | 5 |
| **Subtotal** | **48** | **79** | **56** | **70** | **46** |
| **Shrubs and deciduous trees** | | | | | |
| *Acer glabrum* | – | 1 | – | + | – |
| *Amelanchier alnifolia* | 5 | 1 | 7 | 5 | 1 |
| *Betula papyrifera* | 1 | + | 1 | 1 | 2 |
| *Ceanothus velutinus* | 9 | 4 | 4 | 3 | 22 |
| *Cornus stolonifera* | – | + | + | + | 1 |
| *Crataegus* spp. | 1 | – | – | – | – |
| *Mahonia* spp. | – | + | + | – | – |
| *Populus* spp. | 1 | 1 | + | + | – |
| *Prunus pensylvanica* | 1 | – | – | – | – |
| *Prunus virginiana* | – | 1 | – | – | – |
| *Ribes* spp. | – | + | 1 | 1 | 1 |
| *Rosa acicularis* | + | 1 | 1 | 2 | 3 |
| *Rubus* spp. | – | + | – | 1 | – |
| *Salix* spp. | 3 | 1 | 1 | 2 | 8 |
| *Shepherdia canadensis* | 9 | 6 | 7 | 5 | 3 |
| *Symphoricarpos* spp. | – | – | – | – | – |
| *Vaccinium* spp. | 13 | 1 | + | 1 | 1 |
| Other | – | – | 3 | 2 | + |
| **Subtotal** | **43** | **17** | **25** | **23** | **42** |
| **Forbs** | | | | | |
| *Achillea millefolium* | 1 | – | – | – | – |
| *Arctostaphylos uva–ursi* | 3 | 1 | + | + | – |
| *Aster ciliolatus* | 1 | – | + | – | – |
| *Aster* spp. | – | – | – | + | 4 |
| *Crucifer* spp. | – | – | + | – | – |
| *Cornus canadensis* | – | – | – | – | – |
| *Fragaria* spp. | – | – | – | – | – |
| *Penstemon* spp. | + | – | – | 7 | – |
| Other | – | + | 1 | + | 3 |
| **Subtotal** | **5** | **1** | **1** | **+** | **7** |
| **Grasses and grass–like** | | | | | |
| *Agropyron spicatum* | – | – | + | + | – |
| *Bromus anomolus* | – | + | 3 | + | – |
| *Calamagrostis rubescens* | 2 | 1 | 2 | 1 | – |
| *Carex* spp. | – | + | 4 | – | – |
| *Festuca occidentalis* | – | 1 | – | – | – |
| *Festuca rubra* | 1 | – | – | – | – |

| | 1986 Nov | 1986 Dec | 1987 Mar | 1988 Jan | 1988 Feb |
|---|---|---|---|---|---|
| *Phleum* spp. | – | – | 1 | 1 | 2 |
| *Poa pratensis* | 1 | – | – | – | – |
| *Poa* spp. | – | 1 | 3 | 1 | + |
| *Stipa* spp. | – | + | + | + | – |
| Other | – | + | 2 | 1 | – |
| Subtotal | 4 | 3 | 15 | 4 | 2 |
| **Ferns and fern allies** | | | | | |
| *Equisetum arvense* | – | 1 | 1 | 1 | 1 |
| Lichens | – | + | + | 1 | 1 |
| Mosses | – | + | + | – | – |

+ = <1%, – = 0.

APPENDIX 9. *Percent of plant species found in diets of mule deer on the Tree Farm Licence 5 winter range, 1985 – 1988*

| | | | | | | **Year** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1985 Nov** | **1985 Dec** | **1986 Jan** | **1986 Feb** | **1986 Mar** | **1986 Dec** | **1987 Jan** | **1987 Feb** | **1987 Dec** | **1988 Jan** | **1988 Feb** |
| | 0 | 21 | 18 | 26 | 0 | 25 | 10 | 0 | 0 | 9 | 32 |
| **Coniferous trees** | | | | | | | | | | | |
| *Abieslasiocarpa* | 25 | 26 | 14 | 14 | – | 53 | 29 | + | 10 | 12 | 13 |
| *Pinus contorta* | – | – | – | – | – | 7 | – | – | – | – | – |
| *Pseudotsuga menziesii* | 34 | 43 | 12 | 15 | 10 | 28 | 19 | 12 | 12 | 27 | 53 |
| Conifer bark | – | – | 6 | – | – | – | – | – | – | 1 | 8 |
| Other | – | – | – | – | 2 | – | + | 3 | – | – | – |
| **Subtotal** | **9** | **69** | **32** | **29** | **12** | **88** | **48** | **15** | **22** | **40** | **74** |
| **Shrubs and deciduous trees** | | | | | | | | | | | |
| *Acer glabrum* | 5 | – | – | – | – | – | – | – | – | – | + |
| *Alnus* spp. | – | – | – | – | – | – | – | – | + | – | + |
| *Amelanchier alnifolia* | – | – | – | – | – | + | + | + | + | 3 | + |
| *Betula papyrifera* | – | – | – | – | – | – | – | – | – | + | 3 |
| *Cornus stolonifera* | 7 | 5 | 12 | 28 | 52 | – | + | 11 | 17 | 7 | – |
| *Mahonia aquifolium* | 18 | 19 | 45 | 33 | 21 | – | 33 | 60 | 42 | 31 | – |
| *Populus* spp. | – | – | – | – | – | – | – | – | + | – | – |
| *Ribes* spp. – | – | – | – | – | – | – | + | – | – | – | |
| *Rubus* spp. | – | – | – | – | – | + | – | – | – | – | + |
| *Salix* spp. | – | – | – | – | – | 4 | + | – | – | + | 6 |
| *Shepherdia canadensis* | – | – | – | – | – | – | + | – | + | + | + |
| Other | 8 | 3 | 7 | 6 | 6 | 6 | 10 | 4 | 13 | 7 | 7 |
| **Subtotal** | **38** | **27** | **64** | **67** | **79** | **10** | **43** | **75** | **72** | **48** | **16** |
| **Forbs** | | | | | | | | | | | |
| *Linnaea borealis* | – | – | – | – | – | – | – | 6 | + | – | – |
| Other | 2 | + | – | 1 | 2 | 1 | 2 | 6 | 3 | 3 | 1 |
| Grasses and grass–like | – | 3 | 1 | 3 | 1 | + | 2 | 2 | – | 3 | + |
| Ferns and fern allies | + | 1 | + | – | + | – | – | – | – | – | – |
| Lichens | 1 | + | 1 | – | 5 | 1 | 3 | + | 2 | 5 | 8 |
| Mosses | – | + | 2 | 2 | 1 | 2 | 1 | – | – | – | |

+ = <1%, – = 0.

APPENDIX 10. *DAPA and faecal nitrogen (FN) levels found in mule deer pellets for each winter range in different years*

| Year | Month | Beaver Valley | | Big Lake | | Bonaparte River | | Churn Creek | | Knife Creek | | Middle Lake | | Tree Farm Lic. 5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DAPA | FN | DAPA | FN | DAPA | FN | DAPA | FN | DAPA | FN | DAPA | FN | DAPA | FN |
| 1982-1983 | Dec | – | – | – | – | – | – | – | – | – | 1.28 | – | – | – | – |
| | Jan | – | – | – | – | – | – | – | 0.90 | – | 1.13 | – | – | – | – |
| | Feb | – | – | – | – | – | – | – | 1.17 | – | 1.16 | – | – | – | – |
| | Mar | – | – | – | – | – | – | – | 1.29 | – | – | – | – | – | – |
| 1983-1984 | Dec | – | – | – | – | – | – | – | 1.79 | – | 2.06 | – | – | – | – |
| | Jan | – | 1.90 | – | – | – | – | – | 1.31 | 0.44 | 1.36 | – | – | – | – |
| | Feb | – | 2.06 | – | – | – | – | – | 1.31 | 0.47 | 1.41 | – | – | – | – |
| | Mar | – | – | – | – | – | – | – | 1.41 | 0.57 | 1.47 | – | – | – | – |
| 1984-1985 | Dec | – | – | – | – | 0.52 | – | – | 1.49 | 0.56 | 1.52 | – | – | – | – |
| | Jan | – | – | – | – | – | – | – | – | 0.47 | 1.41 | – | – | – | – |
| | Feb | 0.51 | 2.58 | – | – | – | – | – | – | 0.43 | 1.26 | – | – | – | – |
| | Mar | – | – | – | – | – | – | – | – | 0.47 | 1.35 | – | – | – | – |
| 1985-1986 | Nov | – | – | – | – | – | – | – | – | – | – | – | – | 0.82 | 1.81 |
| | Dec | – | – | 049 | 1.54 | – | – | – | – | – | – | – | – | 0.76 | 1.61 |
| | Jan | – | – | 0.48 | 1.60 | – | – | – | – | – | – | – | – | 064 | 1.85 |
| | Feb | – | – | 0.50 | 1.29 | – | – | – | – | – | – | – | – | 0.61 | 1.85 |
| | Mar | – | – | 0.40 | 1.53 | – | – | – | – | – | – | – | – | 0.91 | 2.56 |
| 1986-1987 | Nov | – | – | – | – | – | – | – | – | – | – | – | 1.47 | – | – |
| | Dec | – | 2.00 | 0.56 | 2.24 | – | 2.13 | – | – | – | – | – | 1.44 | 0.69 | 1.92 |
| | Jan | – | 2.06 | 0.59 | 1.98 | – | 1.98 | – | – | – | – | – | – | 0.69 | 1.78 |
| | Feb | 0.63 | 2.13 | 0.52 | 1.95 | – | 1.87 | – | – | – | – | – | – | 0.72 | 1.90 |
| | Mar | – | – | 0.62 | 1.97 | – | – | – | – | – | – | – | 1.79 | – | – |
| 1987-1988 | Dec | – | – | 0.54 | 1.65 | – | – | – | – | – | – | – | – | 0.77 | 2.17 |
| | Jan | 0.41 | 1.66 | 0.48 | 1.58 | – | – | 0.42 | 1.32 | – | – | – | 1.46 | 0.73 | 1.78 |
| | Feb | – | – | 0.48 | 1.56 | – | – | – | – | – | – | – | 1.58 | 0.61 | 1.75 |
| 1988-1989 | Dec | 0.38 | 1.52 | – | – | – | – | – | – | – | – | – | – | – | – |
| | Jan | 0.44 | 1.38 | – | – | – | – | – | – | – | – | – | – | – | – |
| | Feb | 0.46 | 1.25 | – | – | – | – | – | – | – | – | – | – | – | – |
| | Mar | 039 | 1.30 | – | – | – | – | – | – | – | – | – | – | – | – |
| All Years | x | 0.46 | 1.80 | 0.51 | 1.71 | – | 2.00 | 0.47 | 1.33 | 0.48 | 1.43 | – | 1.55 | 0.72 | 1.90 |
| | SD | 0.09 | 0.42 | 0.06 | 0.27 | – | 0.32 | 0.07 | 0.24 | 0.06 | 0.27 | – | 0.14 | 0.09 | 0.26 |
| | N | 7 | 11 | 11 | 11 | – | 3 | 2 | 9 | 7 | 11 | – | 5 | 11 | 11 |

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