Extension Note

BC Journal of Ecosystems and Management

Relationship between winter severity and survival of mule deer fawns in the Peace Region of British Columbia

Dominic (Nick) Baccante[1] and Rob Woods[2]

Abstract

This extension note summarizes results of an ongoing study to measure the survival of mule deer (*Odocoileus hemionus*) fawns through their first winter in the Peace Region of British Columbia. Each spring since 1991, mule deer were counted and classified by sex and age by driving along roads that go through areas known for providing good winter range. Seven transects were driven for a total distance of 205.3 km. The number of fawns observed is expressed as a ratio of fawns per 100 does. Average monthly air temperature and total monthly snowfall data from November to the following April from 1991 through 2008 were obtained from Environment Canada's website. A winter severity index (WSI) integrating temperature and snowfall data was calculated and correlated to the observed fawn-to-doe ratio. A statistically significant relationship between this ratio and the WSI was obtained through regression analysis. Resulting data confirms previous research that showed survival of fawns through their first winter is higher in milder winters. For the same time period, we also compared WSI values for the Peace Region with those from three other areas in British Columbia. Results indicate that, on average, the Peace Region experienced harsher winter conditions than the other regions. The variation of the WSI was also much greater in the Peace Region. These results have implications for mule deer management in this region.

KEYWORDS: *fawn mortality, mule deer,* Odocoileus hemionus*, winter severity.*

Contact Information

1 Section Head, BC Ministry of the Environment, Fish and Wildlife Section, 10003–110th Avenue, Room 400, Fort St. John, BC V1J 6M7. Email: Nick.Baccante@gov.bc.ca

2 Wildlife Biologist, BC Ministry of the Environment, Fish and Wildlife Section, 10003–110th Avenue, Room 400, Fort St. John, BC V1J 6M7. Email: Rob.Woods@gov.bc.ca

JEM* — *Volume 10, Number 3 *Published by Forrex Forum for Research and Extension in Natural Resources*

Baccante, D. and R. Woods. 2010. Relationship between winter severity and survival of mule deer fawns in the Peace Region of British Columbia. *BC Journal of Ecosystems and Management* 10(3):145–153. *www.forrex.org/publications/jem/ISS52/vol10_no3_art12.pdf*

Introduction

Mule deer (*Odocoileus hemionus*) are relatively abundant in the large agricultural area surrounding the Peace River valley in northeastern British Columbia. These animals are important economically as a game species and ecologically as part of the richly diverse ecosystems in this area. Like other cervids, mule deer rut during the fall and in this area of British Columbia fawns are born in June. Fawn survival is significantly affected by the snow and temperature conditions during their first winter.

Low survival of mule deer fawns has been correlated to low population recruitment throughout the western United States (Unsworth et al. 1999). Consequently, the fawn-to-doe ratio is a population parameter commonly measured by wildlife managers to determine reproductive output and recruitment in a population (Roseberry and Woolf 1991). Bender et al. (2008) suggested that the rate of population increase is driven by adult doe survival and fawn survival expressed as fawn-to-doe ratios in the spring. Because the does are not as affected by weather conditions, their survival is relatively stable from year to year (i.e., 85–90% survival). Conversely, fawn-to-doe ratios can vary widely. Thus, fawn survival can have a greater impact on a population's rate of increase. Although mule deer fawns are susceptible to various predators, weather is a significant influence on their survival and is documented in several studies. In arid areas of the central and southwestern United States, where winters are relatively mild but moisture can be a limiting factor, fawn survival has been correlated to the amount of precipitation as it provides moisture for forage plants (Picton 1979; Wakeling 2001). Wasley (2004), in a comprehensive report on the status of mule deer in Nevada, reported a highly significant relationship between estimated population size and average monthly precipitation for the years 1976–2000. Despite all other possible influences that can affect mule deer survival in Nevada, precipitation was the single most influential factor.

In cooler climates, mule deer fawns are more likely to be affected by harsh winters. Bartmann and Bowden (1984) found that early winter (November–December) snow depth was a good predictor of deer mortality. Bartmann et al. (1992) reported that temperature and snow affected fawn survival, with February snow depth the best predictor within their Colorado study area. Bishop et al. (2005) concluded that winter severity was a major cause of increased mortality of both fawns and adults. The direct cause of mortality from harsh winters was malnutrition, which indirectly increased predation of deer in poor condition. Pojar and Bowden (2004) also found increased mortality of fawns as a result of cool and damp weather in Colorado. Several studies measured fawn survival through their first winter using recapture data collected by collaring animals (Pojar and Bowden 2004; Bishop et al. 2005; Lomas and Bender 2007). Other studies document impacts on whole mule deer populations from thermal conditions, such as temperature, snow, wind, and solar radiation, as well as the role of thermal habitat availability (Parker and Robbins 1984; Leckenby and Adams 1986; Parker and Gillingham 1990; Poole and Mowat 2005).

The fawn-to-doe ratio is a population parameter commonly measured by wildlife managers to determine reproductive output and recruitment in a population.

In our study, we have not measured survival directly or tracked survival of fawns over time; rather, we report annual counts of fawns, expressed as the number of fawns per 100 does, as a relative measure of survival at the juvenile stage after their first winter season. We correlated these counts to winter severity, expressed as an index that combines temperature and snow measurements.

Methods

We have conducted annual spring counts of mule deer in the Peace Region since 1991. Counts are done by driving a vehicle along selected transects (Figure 1). These roads have good vantage points and cover known areas of high use by mule deer. Most of these transects cover south-facing slopes of the Peace River valley, which provide abundant forage earlier than other areas because of microclimate effects along these slopes. Timing of the survey usually ranges from about mid-April to the first week in May. An effort is made to conduct these surveys in favourable and similar weather conditions each year. The vehicle is stopped whenever deer are observed and observers (1–2 people) use spotting scopes to count and classify deer by sex and age class. From 1991 to 2003, five transects were sampled that varied in length between

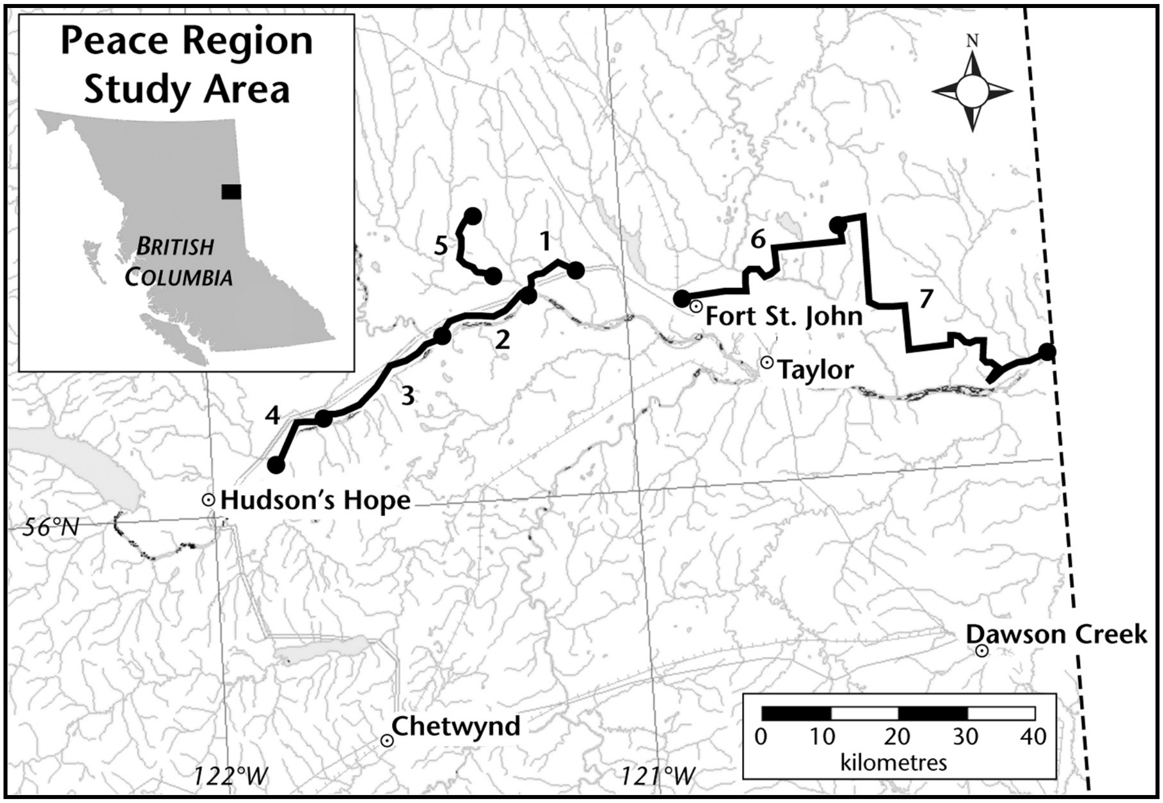

FIGURE 1. Map showing the transect numbers and their location within the study area near Fort St. John, BC, where the spring deer counts took place from 1991 to 2008. The black dots represent the transect end and start points.

12 and 16 km. In 2004, an additional transect 31 km long was added and, in 2005, a 100 km long transect was added. The number of transects has remained unchanged since 2005, and we do not anticipate adding any more. The total length of all seven transects is 205.3 km.

Weather data consisting of monthly summaries of mean, maximum, and minimum air temperatures and snow precipitation were obtained from the Environment Canada website (*http://climate.weatheroffice.ec.gc.ca/climateData/canada_e.html*). These data were collected at the closest station to the study area (airport at Fort St. John, BC).

Following a methodology used by Ian Hatter (BC Ministry of Environment, pers. comm., December 2008), we calculated a winter severity index (WSI) using monthly snowfall in centimetres (SNOW) and mean monthly air temperatures in degrees Celsius (TEMP) in the following manner:

- if TEMP ≤ –25°C, then WSI = 4 × SNOW
- if TEMP > –25°C and ≤ –15°C, then WSI = 3 × SNOW
- if TEMP > –15°C and ≤ –5°C, then WSI = 2 × SNOW
- if TEMP > –5°C, then WSI = 1 × SNOW

As shown in the formulas above, a temperature-dependent multiplier is used to scale the effect of snowfall. We chose this WSI because of its simplicity. We feel it adequately integrates snow and temperature data in a way that reflects weather impacts on deer in our region. Temperature and snowfall data were used to calculate WSI values for the November 1 to April 30 period for each year for the duration of our study. We then summed the WSI values for each of the six months from November through April to determine the total WSI for each year. The WSI represents the integration of weather data starting in November of one calendar year to the end of April in the following year. For example, the year 1997 would represent the winter of 1996–1997, but in the figures and tables it would be represented as 1997. Lower WSI values represent milder winters with lower snow precipitation and/or milder temperatures.

As a relative annual measure of fawn abundance, the number of fawns observed is expressed as a ratio of number of fawns per 100 does. We regressed this ratio against the WSI to quantify the effect of WSI on fawns. All analysis was done using JMP software (SAS Institute Inc., Cary, NC, USA).

Results

Table 1 summarizes data showing the total number of mule deer counted each spring along with WSI values. These data indicate that, between 1991 and 2008, the fawns per 100 does varied 10-fold from a low of 5 to a high of 54, and WSI values ranged from 129 during the mildest winter to 717 in the most severe winter. Averaged over the study period, the adult females were four times more abundant than adult males (275 females to 69 males), and the average number of unclassified deer was only 5.

Figure 2 shows the fawn-to-doe ratio regressed against WSI. This figure also shows the fitted regression line and its 95% confidence limits. The plot illustrates a significant relationship with a negative slope of the fitted line, indicating higher fawn numbers in milder winters. The resulting equation of the fitted line is:

$$\textit{Number of fawns per 100 does} = 60.784 - 0.0788 \times WSI$$

Approximately 59% ($R^2 = 0.59$) of the variation in fawn-to-doe ratios is explained by variations in the WSI. Categories are shown on the graph with dotted lines to indicate values of good fawn survival (≥ 30 fawns per 100 does) and mild, moderate, and severe winters based on the WSI. Fawn-to-doe ratios greater than 30 are associated with increasing population sizes, as suggested by Bender et al. (2008). During mild winters (WSI ≤ 350), the average ratio of fawns per 100 does is 43. During moderate winters (WSI between 351 and 700), the average ratio is 18; in severe winters (WSI above 701), the average ratio is 14.

Comparisons of plotted values of fawn-to-doe ratios over time indicate that trends are fairly similar for transects 1 through 4 as shown in Figure 3.

TABLE 1. Summary of observed mule deer counted and classified during the spring of each year from 1991–2008. No counts were done in 1995.

Year	No. transects	Total transect length (km)	Total males	Total females	Total fawns	Total unclassified	Total no. deer	Total fawns per 100 females	Winter severity index
1991	5	74.1	59	201	86	30	376	43	330
1992	5	74.1	79	240	99	6	424	41	350
1993	5	74.1	74	355	192	9	630	54	186
1994	5	74.1	45	202	71	0	318	35	534
1995					*No Surveys Done*				
1996	5	74.1	49	339	25	3	416	7	486
1997	5	74.1	48	265	37	0	350	14	717
1998	5	74.1	45	240	82	0	367	34	204
1999	5	74.1	18	235	31	0	281	13	400
2000	5	74.1	27	218	86	0	331	39	206
2001	5	74.1	27	231	124	0	382	54	129
2002	5	74.1	73	320	66	2	461	21	408
2003	5	74.1	78	262	78	2	420	30	394
2004	6	105.3	87	248	104	0	439	42	349
2005	7	205.3	125	395	170	0	690	43	303
2006	7	205.3	141	359	181	12	693	50	207
2007	7	205.3	89	277	15	11	392	5	544
2008	7	205.3	105	285	87	13	490	31	302

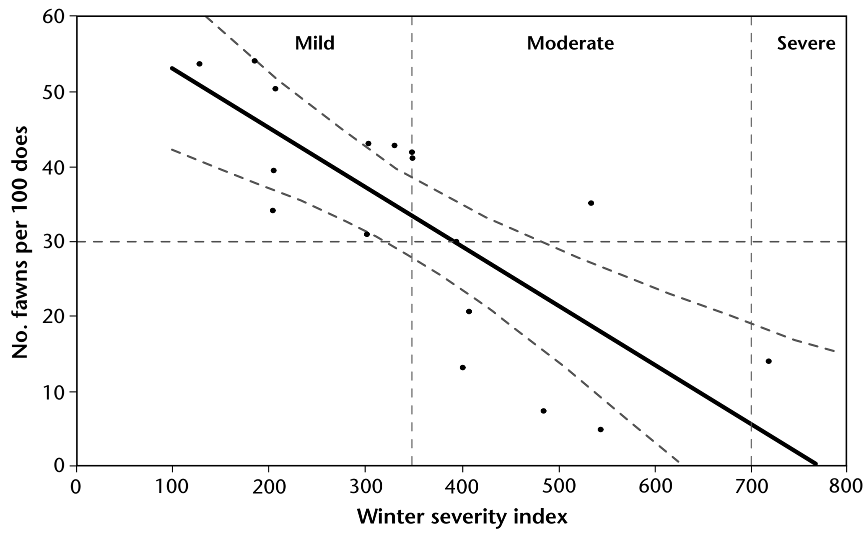

FIGURE 2. Number of mule deer fawns per 100 does plotted against winter severity index. Also shown are 95% confidence limits for the predicted line. Vertical dashed lines separate winters into mild, moderate, and severe. The horizontal dashed line distinguishes populations that are potentially increasing from those that are not, as indexed by fawn-to-doe ratios in other studies.

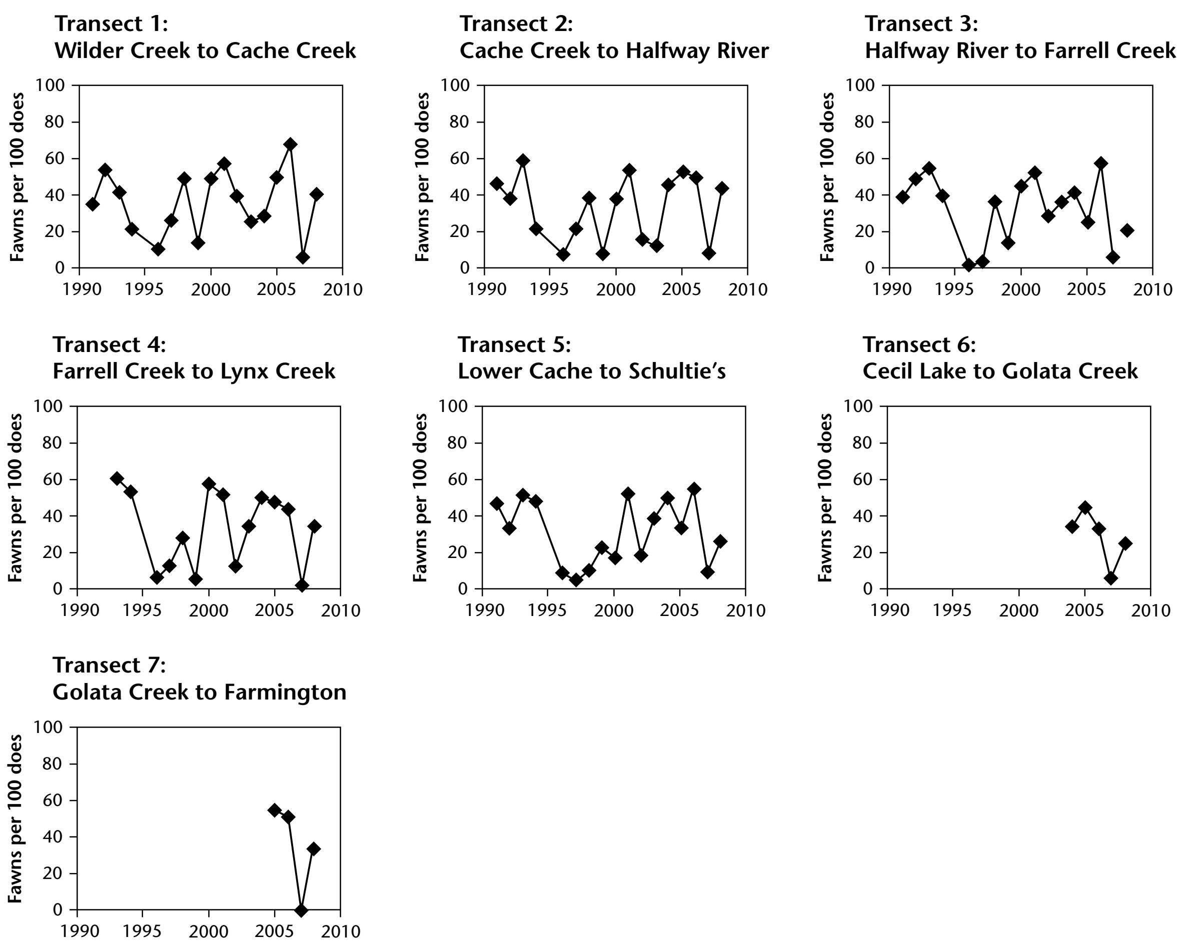

FIGURE 3. Plots of observed fawn-to-doe ratios by year for each transect.

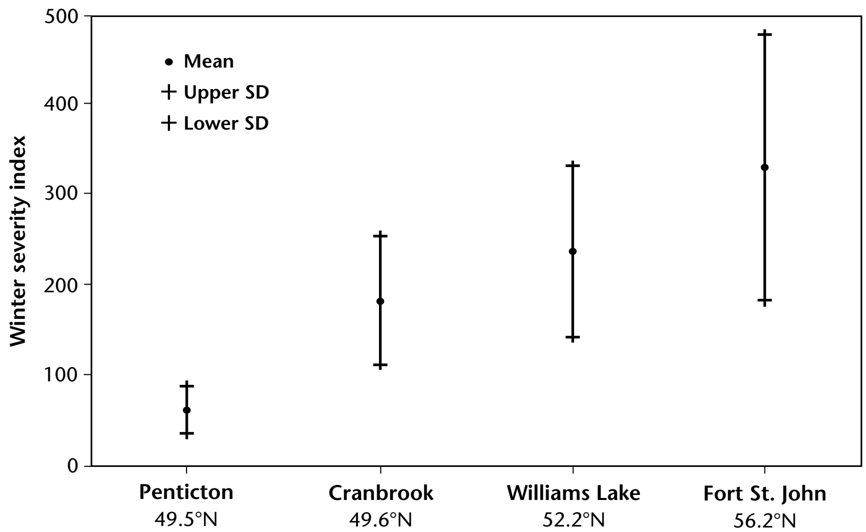

FIGURE 4. Plot of mean (±1 standard deviation) winter severity index values for Penticton, Cranbrook, Williams Lake, and Fort St. John, BC.

All of these transects are located along the Peace River and therefore have very similar habitats and weather conditions. Transect 5, located away from the river valley, shows some different trends from the others, probably due to differing habitats. Transects 6 and 7 do not yet have sufficient long-term data to identify trends, but despite the small sample size, the patterns are similar to the other transects over the same time period.

To gain a provincial perspective on the relative effects of winter on mule deer, we compared WSI values from our region with other areas in British Columbia that support mule deer populations. We calculated WSI values using weather data for the period 1977–2009 for Penticton, Cranbrook, and Williams Lake. Figure 4 shows the mean (±1 standard deviation) WSI values for each location, and also the latitude. The mean WSI values (±1 standard deviation) for each location are: 63 (±26.6) for Penticton, 185 (±71.6) for Cranbrook, 238 (±94.6) for Williams Lake, and 330 (±146.8) for Fort St. John. These values show that winter in Fort St. John is 1.4, 1.8, and 5.2 times more severe for mule deer than in Williams Lake, Cranbrook, and Penticton, respectively. Perhaps of more importance is the relative difference in variation as measured by the standard deviation. The severity of Fort St. John winters is 1.6, 2.1, and 5.5 times more variable compared to the same locations.

Discussion

Other researchers have used indices of winter severity to correlate low fawn survival to high snow depths and low air temperatures (Verme 1968; Bartmann 1984; Bartmann and Bowden 1984). Our study supports their conclusions by showing higher fawn-to-doe ratios in springs following mild winters. Despite the strong correlation coefficient ($r = 0.77$) between fawn-to-doe ratios and winter severity, the effects of weather on fawn survival are more intricate than can be explained by one simple statistical relationship. Further analysis should also partition some of these effects based on a finer scale and interpretation of the data.

For example, we looked at four observations with the highest variance from the fitted line and attempted to explain these differences through a more detailed analysis of the weather data. These observations correspond to data from 1994, 1996, 1999, and 2007. In 1994, the fawn-to-doe ratio was higher than expected for the corresponding WSI. For the other three years, the ratios were lower than expected. This would imply milder winter conditions during 1994 and harsher ones for 1996, 1999, and 2007. More detailed examination of the available weather data showed that 1994 had the least amount of snowfall during March and April (total for both months = 7.5 cm) compared to all other years (average = 39.8 cm). It also had the third-warmest temperatures for March and April (average = +2.8°C) compared to all other years (average = −0.3°C). However, January 1994 had the highest snowfall (98.7 cm) and one of the coldest temperatures (−18.1°C) compared to other years, which had averages of 31.1 cm of snow and −13.1°C. Based on these observations, it appears that favourable conditions in early spring can result in higher fawn-to-doe ratios in the spring, despite cold temperatures and high snowfall in January.

The other three years (1996, 1999, and 2007) ranked in the top 23% of all years for total snowfall from November to April. Also, January 1996 and 1999 were colder (averages of −24°C and −16.4°C, respectively) and slightly snowier (34.8 cm and 31.1 cm, respectively) than average (31 cm). For 2007, March and April were colder (average −3.5°C) than the overall average (−0.3°C). Additionally, 1999 had above-average snowfall in March and April (42.8 cm) than the overall average (39.8 cm). These results suggest that the WSI can be refined by using different combinations of weather data rather than calculating the WSI for the entire winter period. This will require more detailed analysis, which was beyond the scope of our study, but will be a worthwhile investigation for future analysis.

Comparing WSI values for the Peace Region with those of other areas in the province provided insights into the significance of weather factors for over-winter survival of mule deer fawns. The results indicate harsher and more variable winter conditions in the Peace Region than other parts of British Columbia. Clearly, these differences have implications for the management of mule deer in the Peace Region. When proposing new hunting regulations for mule deer, biologists need to recognize the highly variable and unpredictable effects of weather on deer over-winter survival. To do this effectively, it is important to capitalize on opportunities for obtaining precise and accurate data on relative or absolute abundance estimates of mule deer. Without this information, the risks of making detrimental management decisions increase.

Although winters in the Peace Region can be severe and highly variable, the probability of severe winters (i.e., as defined by the categories we use here) is relatively low over the long term. Using the available weather data, the predicted occurrences of mild, moderate, and severe winters over a 100-year period are 60, 37, and 3 years, respectively. This implies that mule deer in this region of British Columbia have a high potential to recover from periodic natural population declines. This will not only depend on the stability of observed weather trends so far, but also on the frequency and magnitude of other natural or anthropogenic factors, such as hunting pressure, predation, and unforeseen impacts to their habitats. The Peace Region is currently experiencing high rates of industrial activity from oil and gas, mineral, and other energy exploration and development. These activities can have individual and cumulative impacts on the habitat of mule deer and other wildlife that are very difficult to predict and quantify.

We can only speculate about how inclement weather affects fawn mortality in the Peace Region. Verme (1968) suggested that heat loss from the body due to low temperatures must be quite significant and is intensified if the animal has to struggle through deep snow, thus expending large amounts of energy. Although quantifying heat loss from an animal is a very complicated process (Kleiber 1961), the role of factors that affect heat loss (e.g., temperature, snow, wind, solar radiation, and thermal habitat) has been well documented in several studies (Parker and Robbins 1984; Leckenby and Adams 1986; Parker and Gillingham 1990; Poole and Mowat 2005). Deep snow can also negatively affect the deer's ability to avoid predators and find food.

Other factors may possibly mitigate the negative effects of weather. Moen (1968) concluded that deer will tolerate significant radiant heat loss if highly nutritious foods are available (e.g., forage farm crops). This may be happening in part of our study area because it includes large tracts of prime farmland. In addition, during late winter and early spring, many of the deer were observed on the south-facing slopes of river breaks where snow disappears earlier, thermal input is greater, and vegetation sprouts earlier. Nevertheless, very low temperatures over an extended period of time may have a negative effect on survival even though good food supplies are present. Ransom (1967) found that extremely cold weather negatively affected the physical condition of white-tailed deer in Manitoba, despite abundant browse and light snowfall. Long stretches of cold weather also increase deer mortality in spite of the animal's ability of coping with inclement weather (Verme and Ozoga 1971).

Hobbs (1989) developed a simulation model linking energy balance to survival of mule deer. One component of this model tested the influence of snow and temperature on fawn survival. He found that mortality remained virtually unchanged when simulated snow depth was increased during mild winters. He concluded that because snow would not persist in the presence of milder temperatures, the negative impacts from snow were negligible. Conversely, reducing simulated snow depths during severe cold winters, reduced fawn mortality by almost 50%. This model provides valuable insights for planning future refinements of our WSI to account for within-season variations of snow and temperatures. This will result in a better understanding of factors affecting fawn mortality within our study area.

Conclusions and recommendations

Although many factors certainly influence fawn-to-doe ratios, weather appears to play a significant role. Winter severity is an important factor in fawn survival, but weather conditions in March and April are likely more important than overall winter conditions in determining survival. Ratios equal to, or greater than, 30 fawns per 100 does are indicative of mild winters with higher fawn survival. Regional differences in winter severity are thus important factors to consider in the management of mule deer. The winter survival index is a good integrator of snow and temperature conditions and is a statistically reliable predictor of fawn survival.

We encourage others to carry out similar surveys in their regions. These surveys can be undertaken at very low cost and provide valuable information on the effects of regional or local weather conditions on fawn survival. Understanding the impacts of weather on recruitment of mule deer can help managers assess the importance of weather relative to other more manageable factors, such as hunting and non-hunting mortality, predation, and disease. It is important to continue monitoring over-winter survival of deer fawns in light of the current anticipated changes to temperatures at a global and regional scale. If predicted future warming trends occur, then survival of mule deer fawns may also increase, resulting in higher population recruitment that will affect management prescriptions.

To further the understanding of fawn survival, we recommend:

- continuing this project indefinitely;
- looking for opportunities to obtain reliable relative or absolute abundance data on mule deer population; and
- using these data for mule deer management.

We also recommend that future analyses combine these data with information on trends in other mule deer age and sex classes, relationships between fawn survival and hunting success, and changes in climate.

Winter severity is an important factor in fawn survival, but weather conditions in March and April are likely more important than overall winter conditions in determining survival.

Acknowledgements

Thanks to Ian Hatter (BC Ministry of Environment, Victoria, BC) for putting together the Peace Mule Deer Harvest Management Strategy, which includes some of the weather and survival analysis. Also thanks to Conrad Thiessen, Rod Backmeyer, and others who have participated in the surveys over the years; Jessica Baccante for entry and analysis of weather data; Heather Hopkins for maintaining our wildlife library and data entry; and Roxanne Smith and other staff at our library in Victoria for helping with the literature search. Also thanks to anonymous reviewers for greatly improving this manuscript.

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ARTICLE RECEIVED: **March 31, 2009**
ARTICLE ACCEPTED: **June 30, 2010**

FIA Forest Investment Account Forest Science Program

Production of this article was funded, in part, by the British Columbia Ministry of Forests and Range through the Forest Investment Account–Forest Science Program.

Test Your Knowledge . . .

Relationship between winter severity and survival of mule deer fawns in the Peace Region of British Columbia

How well can you recall some of the main messages in the preceding Extension Note?
Test your knowledge by answering the following questions. Answers are at the bottom of the page.

1. What are the two parameters used to calculate the winter severity index in this study?
   - A) Wind speed and air temperature
   - B) Air temperature and solar radiation
   - C) Air temperature and snow depth
   - D) Wind speed and solar radiation

2. Why is the fawn-to-doe ratio a common measurement in deer population studies?
   - A) Is easy to collect
   - B) Does not vary over time
   - C) Is indicative of the rate of increase of a population
   - D) All of the above

3. How does the winter severity index for the Peace Region compare to other parts of British Columbia?
   - A) It is a larger value
   - B) It is more variable
   - C) All of the above

ANSWERS

1. C 2. C 3. C