A Population Review for Elk in the Kootenay Region

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Introduction

This population review summarises Kootenay elk (*Cervus elaphus*) data, focusing on population size, composition, and adult survival. We also summarize factors that may affect the population (namely hunting, weather and predation) and assesses relationships among all data sources to broadly explain population trends over time. This population review provided a foundation for developing a Kootenay Elk Management Plan for 2010-2014 (MoE 2010) and an elk population model in progress in 2010 (similar to Cooper et al. 2003).

This report will be updated approximately every 5 years, as new information is available (e.g., results from population modelling), and based on feedback from biologists, stakeholders and others on this first version. We therefore welcome comments on this review.

The Ministry of Environment's (MoE) 2010-2014 goals for elk in the Kootenay Region are:

1. Ensure healthy elk populations over the short and long term
2. Manage elk populations to meet First Nations needs for sustenance, social and ceremonial purposes
3. Maximize sustainable hunting and wildlife viewing opportunities over the short and long term
4. Reduce elk grazing pressure where elk populations exceed allocated forage supply; determine forage supply in conjunction with the Ministry of Forests and Range (MFR) by considering range health, timing of grazing, and the forage requirements of other wildlife and livestock
5. Reduce elk crop depredation on private agricultural land (MoE 2010)

Study area

The Kootenay Region (Figure 1) covers the south-east corner of British Columbia, extending from Kinbasket Lake to the USA border, and from west of Arrow Lakes and Lake Revelstoke to the Alberta border. Four parallel mountain ranges run northwest across the region. The Monashee and Selkirk ranges define the West Kootenay sub-region, and the Purcell and Rocky Mountain ranges delineate the East Kootenay sub-region. The Kootenay River flows from the Rocky Mountains in Kootenay National Park south through the East Kootenay Trench (the valley between the Purcell and Rocky Mountain ranges) to Montana, then returns to the region near Creston in the West Kootenay. The Columbia River also originates in the East Kootenay (Columbia Lake) and flows north through the East Kootenay, then south through the West Kootenay where it eventually meets the Kootenay River. Large lakes and reservoirs are scattered throughout the region, including Revelstoke, Upper and Lower Arrow, Kootenay, Slocan, and Duncan Lakes in the West, and Koocanusa and Kinbasket Lakes in the east (Figure 1).

In general, the West Kootenay is warmer and wetter than the East Kootenay. These climatic differences are reflected by different vegetation. Both the east and west have Interior Cedar Hemlock, Englemann Spruce Subalpine Fir and Alpine Tundra Biogeoclimatic Zones, but the east also has dry forest types, including Ponderosa Pine, Interior Douglas Fir and Montane Spruce (Meidinger and Pojar 1991).

The Kootenay Region had extensive forest loss in the late 1800s and early 1900s due to large fires and land clearing for settlements and agriculture (MFR 2006). Since the 1950s, forest succession, changes in timber harvest practices, and aggressive fire suppression resulted in greater forest cover. In particular, the relative proportion of open range, open forest and closed forest in the East Kootenay Trench has changed significantly over time. In the late 1880s early explorers reported extensive areas of closed forest, but by the 1920s and 1930s, there was open range throughout most low elevation areas (Pitt 1982). This created an abundance of new forage, and in response domestic livestock and wildlife populations grew and expanded in distribution. Recent efforts have attempted to re-establish areas of open range throughout the East Kootenay Trench (East Kootenay Trench Ecosystem Restoration Steering Committee 2006).

The region supports a wide diversity of wildlife. Other ungulates include moose (*Alces alces*), mule deer (*Odocoileus hemionus*), white tailed deer (*O. virginianus*), caribou (*Rangifer tarandus*), mountain goat (*Oreamnos americanus*) and bighorn sheep (*Ovis canadensis*) (Poole 2006, Poole 2007, Mowat and Kuzyk 2009). There are a wide range of predators as well, including grizzly bears (*Ursus arctos*), black bears (*U. americanus*), wolves (*Canis lupus*) and cougar (*Puma concolor*) (Mowat 2007).

MoE manages wildlife in the region through 36 wildlife Management Units (MUs) and five Game Management Zones (GMZs) (Figure 1). The West Kootenay sub-region covers MUs 4-06 to 4-09, 4-14 to 4-19, 4-27 to 4-33, and 4-38 to 4-39, and is captured by the Revelstoke and Nelson GMZs. The East Kootenay sub-region includes MUs 4-01 to 4-05, 4-20 to 4-26, 4-34 to 4-37 and 4-40, and the Golden, Cranbrook and Fernie Game Management Zones (Figure 1). Guide outfitter territories cover most of the East Kootenay but only a small percentage of the West Kootenay.

Agriculture is scattered throughout the southern part of the region, with market and private gardens between Nelson and Castlegar; hay, grain, dairy, beef, fruit and vegetable production around Creston; vineyards, orchards and private gardens around Trail; and hay production and cattle ranching in the East Kootenay Trench and Elk Valley (Figure 1).

Methods

Population size

Population distribution

We summarised changes in elk population distribution within the Kootenay region from 1900 to 2000. A map prepared by Jamieson and Demarchi (1976) was updated to 2000 through interviews with wildlife biologists and Conservation Officers familiar with elk populations. We also referred to the history of hunting seasons over time, since new hunting seasons were opened as elk colonized new areas.

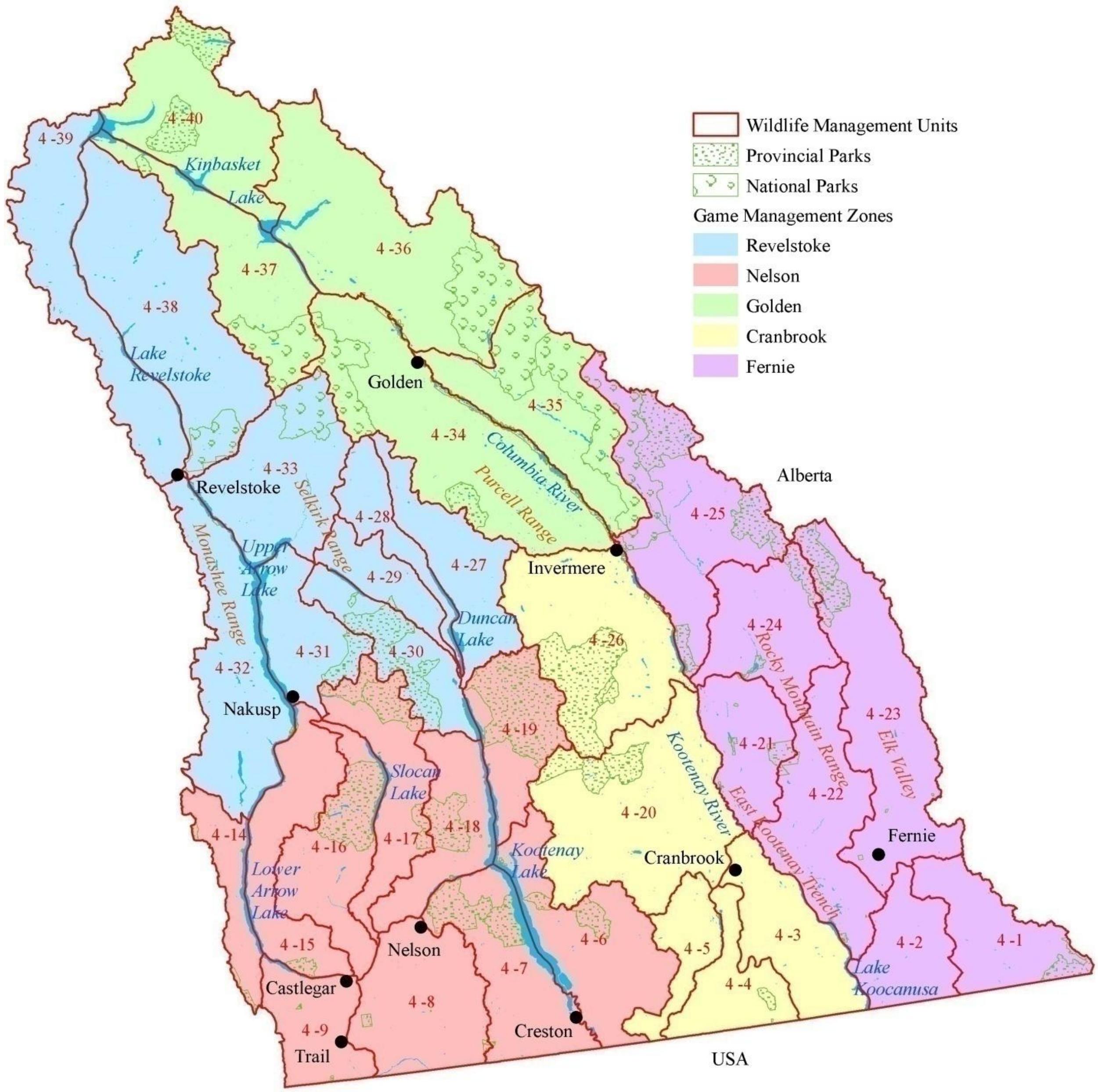

Figure 1. Kootenay Region, showing Game Management Zones (GMZ) and Wildlife Management Units (MU). The West Kootenay subregion is covered by the Revelstoke and Nelson GMZs; the East Kootenay subregion is covered by the Golden, Cranbrook and Fernie GMZs.

Population trend

We derived population trend information by summarising available elk population estimates for mid winter from 1900 to 2010. There were only a few areas with more than one historic population estimate, including the West and East Kootenay sub-regions, the South Selkirks (MUs 4-07 and 4-08, West Kootenay), the East Kootenay Trench and the Elk Valley (Figure 1).

For the West and East Kootenay sub-regions, population estimates prior to 1960 were based primarily on Annual Game Commission reports and anecdotal information. During the 1960s and 1970s, estimates were based on expert opinion, and observations during late winter aerial counts and ground based spring carry-over counts (Jamieson and Demarchi 1976). These estimates were typically expressed as minimum population estimates and were therefore likely low.

In the 1980s, MoE staff used cohort population models to estimate the size of East Kootenay elk populations. These models used harvest age composition data (e.g., from Tooth Return Programs) to reconstruct populations and estimate population abundance (Skalski et al. 2005: 522-526). Cohort model-based estimates were available for the pre-hunt period for the East Kootenay sub-region, and for early winter for the East Kootenay Trench. Since we were interested in comparing mid-winter population estimates over time, we adjusted the cohort-based estimates using the results from Bayesian population modelling over the same time period Hatter (1995a). Hatter (1995a) estimated that mid-winter populations were about 83% of the pre-hunt estimates and 94% of the early winter estimates. Error bars were subjectively set at 25% of the estimate, as recommended by Bircher and Janz (1999).

In the mid-1990s Bayesian statistical procedures (Walters and Ludwig 1994) were used to model the East Kootenay Trench elk population (Hatter 1995a). This modelling approach incorporated uncertainty in estimating population parameters, and used various data sources, including hunter success, bull and cow harvest, and population estimates from aerial surveys.

In the 1990s and 2000s, MoE and Fish and Wildlife Compensation Program (FWCP) staff used Stratified Random Block (SRB) inventories during mid-winter to estimate elk population size and change over time in the East Kootenay. This method involved dividing a study area in to subunits, assigning the subunits to strata of similar abundance levels based on the anticipated number of animals, and then intensively surveying a random selection of subunits within each stratum by helicopter (RIC 2002). A model was used to estimate the population size based on animal sightability, and extrapolation to subunits not inventoried (Unsworth et al. 1999).

During the 2000s, deer winter ranges in the South Selkirk mountains were aerially surveyed by FWCP staff three times; all ungulate sightings were recorded. Robinson and Clarke (2007) derived population estimates for elk using the aerial survey program (Unsworth et al. 1999). Since the surveys were designed to monitor deer and not elk, survey subunits were stratified post survey to derive elk population estimates. The researchers believe estimates were conservative because they assumed that subunits with no elk observed had no elk, however there were likely some elk in at least some of these subunits.

After examining estimates from various data and anecdotal sources, we plotted what we felt was the best index of the West and East Kootenay elk population trend over time. We then calculated annual percent population change in two steps. First, we calculated percent change over the total time period:

$$\left(\frac{\text{Population estimate at end of time period} - \text{Population estimate at start of time period}}{\text{Population estimate at end of time period}}\right) \times 100\%$$

Second, we calculated annual percent change by dividing the percent change over the total time period by the number of years.

Current population size

We estimated the size of the mid-winter elk population across the Kootenay Region for 2010, using the most recent inventory data whenever available, and expert opinion otherwise. Expert opinion estimates were based on discussions with knowledgeable biologists (current and former MoE, FWCP and private sector), Conservation Officers and hunters. For expert opinion estimates, we set confidence intervals at 50% of the estimate to reflect poor precision.

We re-analysed survey data collected by the FWCP during minimum count inventories. These surveys were designed to assess the impacts of hydro-electrical developments on wildlife populations, not to estimate population size. Surveyors used a helicopter to fly all suitable ungulate habitat in the study area and recorded all ungulate observations. We used an approximate sightability correction factor (1.27 for the East Kootenay, which was the average from Phillips et al. 2008) to estimate population size from the total count data.

We re-analysed SRB inventory data when study areas from separate inventories overlapped, and hence could not be simply added together to combine estimates, or when inventories did not cover all winter range within an MU. For example, to derive an elk population estimate for all of MUs 4-06 and 4-07, we combined Creston data (Stent and Mowat 2008) and South Selkirk data (Robinson and Clarke 2007). Because these study areas overlap, we used Creston data for the southern part of both MUs and 2007 South Selkirk data for the northern part of 4-07. For the northern part of 4-06, there were 5 elk blocks identified by the FWCP (Heaven et al. 1998) that were not part of the Creston study area. These blocks were included in our re-analysis, and we assumed that all blocks had moderate elk densities (P. Stent, MoE, personal communication). We used the most current inventory data available and the Elk Sightability Model for the Hiller 12-E with snow (Unsworth et al. 1999) for all re-analyses.

Population composition

We summarized data on bull to cow, and calf to cow ratios from three datasets: the Ungulate Inventory Database (UIDB), SRB inventories, and Elk Valley coal mine aerial surveys. For this population review, we focused on post-hunt winter ratios only (December 1 to March 31), as most of the data were available for this time period and bulls are more easily identified prior to early spring antler drop. Data from other seasons (e.g., spring carry over counts) will likely be analyzed for future versions of this review.

The UIDB (MoE 1997) contains data collected by MoE during structured (e.g., SRB) and reconnaissance-level aerial surveys between 1964 and 1997. Some elk data were from surveys for multiple species, or other species (e.g. deer, sheep, goats or moose) when elk were observed opportunistically. UIDB data were not corrected for sightability and therefore provide raw observed sex and age ratios. These results may be biased if different cohorts used different habitat. For each GMZ, we summed all cows, bulls and calves observed across all surveys within a winter. Then we used these totals to calculate calves per 100 cows and bulls per 100 cows. We excluded data from surveys with fewer than 25 elk classified, and highlighted data points with fewer than 100 elk classified by using a different symbol on graphs. We also removed extreme outliers (e.g., >100 calves per 100 cows) that appeared to be data errors. Data from surveys in December were merged with the subsequent calendar year; hence winter 2009 covered December 2008 to March 2009.

Data from SRB inventories were available from 1992 to 2009, and provide estimates of bull and calf to cow ratios corrected for sightability (see *Population trend* section above). Since sightability was accounted for, age and sex ratios were more accurate than those obtained from raw counts. This is particularly true for bulls, as bulls are typically in denser cover and hence have a lower sightability than cow and calf groups. In the South East Kootenay Trench, SRB inventories were conducted for the entire Trench some years, and select winter ranges in other years. For Trench-wide inventories, surveyors estimated overall age and sex ratios using the sightability model. We simply summarize these ratios in our report. However for inventories of select winter ranges, surveyors typically reported a total elk estimate, and estimated bull and calf to cow ratios for each winter range. We calculated overall Trench estimates by summing cow, calf and bull estimates across all surveyed winter ranges for each year. Then we calculated overall ratios from these totals. UIDB and SRB data overlap between 1992 and 1997; therefore some data were included in both datasets.

Elk Valley mine survey data were provided by Teck coal mines (formally Elk Valley Coal Corporation), located in MU 4-23. Post-hunt winter data were available from Elkview mine for 2007-2009, Fording River mine for 1980-2007 (a few missing years), Greenhills mine for 1982-2009 (a few missing years), and Line Creek mine for 2004-2009. There was often more than one survey per winter, particularly in the 1980s and early 1990s, and hence some of the data within a winter are likely from the same elk herds. Elk Valley mine data were not corrected for sightability. As with the UIDB data, we excluded or graphically highlighted small sample sizes. To calculate annual calf:cow and bull:cow ratios, we first summed the total cows, bulls and calves observed across all mine surveys within a winter. Then we calculated ratios based on these totals.

When available, we display 90% Confidence Intervals from SRB model outputs. When un available for SRB surveys, or for other data sets (UIDB and elk valley mine data), we calculated 95% binomial confidence intervals (Zar 1996: 525). When sufficient data were available for multiple years, we plotted approximate trend lines for each GMZ, by taking the average calf:cow or bull:cow ratio over three years (current year previous and subsequent year) across all data sources (UIDB, SRB and mine data).

Adult survival

We calculated adult cow elk survival for past radio-telemetry studies in the Slocan (DeGroot and Woods 2006) and Lardeau Valleys (Poole and Park 2003), and for past and current studies in the East Kootenay Trench (Jamieson and Hebert 1992; Jamieson and Hebert 1993; T. Szkorupa, MoE, unpublished data). We used the staggered entry design of the Kaplan-Meir non-parametric analysis (Pollock et al. 1989) to calculate natural, non-hunting and overall survival. Natural survival accounted for only non-human caused mortalities; hence hunting, poaching, and road/rail mortalities were censored. Non-hunting survival accounted for all sources of mortality except for hunting, and overall survival included all mortality sources.

There was often some uncertainty around cause of death, since most of the studies were not designed to assess this and mortalities were investigated days or even months after elk died. If the cause of death was undetermined, we typically assumed it was natural (non-human related) because human-caused deaths generally have obvious evidence, such as a cut collar or lack of a carcass (suggesting hunting or poaching), or proximity to a road or railway (suggesting collisions). In some cases we ran multiple scenarios to encompass the uncertainty around cause of death. However we only present results from the most likely cause of death assignments. Unless we had information on the timing of death (e.g., from a hunter), we assumed mortalities occurred midway between the date that the animal was last known to be alive and first detected as a mortality.

We ran analyses using monthly time intervals. All elk that were not located on the final telemetry session were censored during the last month that they were located. We also censored elk that died fewer than 30 days after collaring, since these deaths may have been capture related. We calculated 90% confidence intervals for all survival estimates.

Hunter and harvest data

We summarized hunter and harvest data from MoE's Hunter Sample Questionnaire, which was launched following the 1976 hunting season. Every January, MoE sends surveys to a large percentage of randomly selected resident hunters who purchased a hunting license the previous year. Questionnaires are species-specific; therefore a hunter may receive more than one questionnaire if they purchased a license for more than one species. In the survey, hunters are asked to provide information on the location and number of days that they hunted, and whether or not they killed an animal. If they did kill an animal, they are asked to indicate the animal's age (juvenile or adult) and sex, as well as kill date and location. Hunters that do not respond are sent a reminder and occasionally contacted by phone, which increases the response rate to about 70% (John Thornton, MoE, personal communication). Harvest by management unit is estimated with 95% confidence intervals. In addition, from 1984 onwards all hunters successfully drawn for a Limited Entry Hunt (LEH) were sent a similar questionnaire.

We compiled information on General Open Season (GOS) hunting seasons over time from MoE's Summary Statistics Database (SSDB), which covered 1984 to 1996, and archived copies of past hunting regulation synopses for earlier and later years. Information on LEH seasons was compiled and summarized from the SSDB. Questionnaire data on hunters and effort was not split out by the age or sex of the species hunted. Therefore, success and effort statistics were calculated for elk in general, and not for specific age or sex classes.

We summarized hunter and harvest data by Game Management Zone (GMZ; Figure 1). We defined resident hunter success as the percent of hunters who killed an elk, and resident hunter effort as the number of elk kills per 100 hunter days. We plotted both indices and found similar trends, thus only percent success data are presented and discussed below. At the time of data analyses, hunter numbers and hence percent success were only available to 2008.

Weather data

We acquired monthly weather data from Environment Canada (2009) for 1975 to spring 2009. Past research has identified relationships between elk population dynamics (e.g., calf survival and recruitment, adult survival, population trend) and numerous weather variables (e.g., annual and seasonal precipitation, snowfall, winter severity, summer and winter temperatures) (Coughenour and Singer 1996; Lubow et al. 2002; Wang et al. 2002; Cook et al. 2004; Lubow and Smith 2004).

Relationships varied in strength and even direction depending on the study area and time period. For this review, we chose to focus on one winter and one summer variable. For winter, we chose total annual snowfall, since this partially accounts for both temperature and precipitation (i.e., if temperatures are below zero, precipitation is likely to fall as snow), and was an important variable impacting population growth or survival elsewhere (Smith and Anderson 1998; Hebblewhite et al. 2002; Garrott et al. 2003; Vucetich et al. 2005). For summer, we selected total precipitation since this variable was correlated with calf survival and/or recruitment in other studies (Singer 1997; Lubow et al. 2002; Wang et al. 2002; Lubow and Smith 2004). Future work and population modelling will incorporate a wider range of weather statistics.

Results and Discussion

In this section, we first present results and a brief discussion on key aspects of the elk population, including population size (current and historic), composition, adult survival, and harvest. In the Conclusions section, we then discuss how these key aspects relate to each other and may explain population trends over time.

Results and discussions are generally presented at the GMZ level (Figure 1). However, for population size, data were available for only small portions of a GMZ, or for study areas that partially cover more than one GMZ (Figure 8). For example, the Southern East Kootenay Trench overlaps portions of both the Cranbrook and Fernie GMZs.

Population size

In this section, we describe 1) the Kootenay elk distribution from 1900 to 2000, 2) elk population trends from 1900 to 2010, and 3) elk population estimates for 2010, along with details on data sources used to derive these estimates.

Population distribution

Elk populations have generally expanded across the region since the early 1900s (Figure 2). Although elk were prehistorically abundant in the East Kootenay (Demarchi et al. 1992), they were rare to non-existent by the late 1880s, likely because of several severe winters with deep snow (Demarchi et al. 1992; Raedeke and Raedeke 1998). In 1900, the only remaining herds in the region were along the Rocky Mountains in the White River, Upper Bull River and Flathead River drainages (Jamieson and Demarchi 1976). There were also remnant herds in Banff and Jasper National Parks, Alberta.

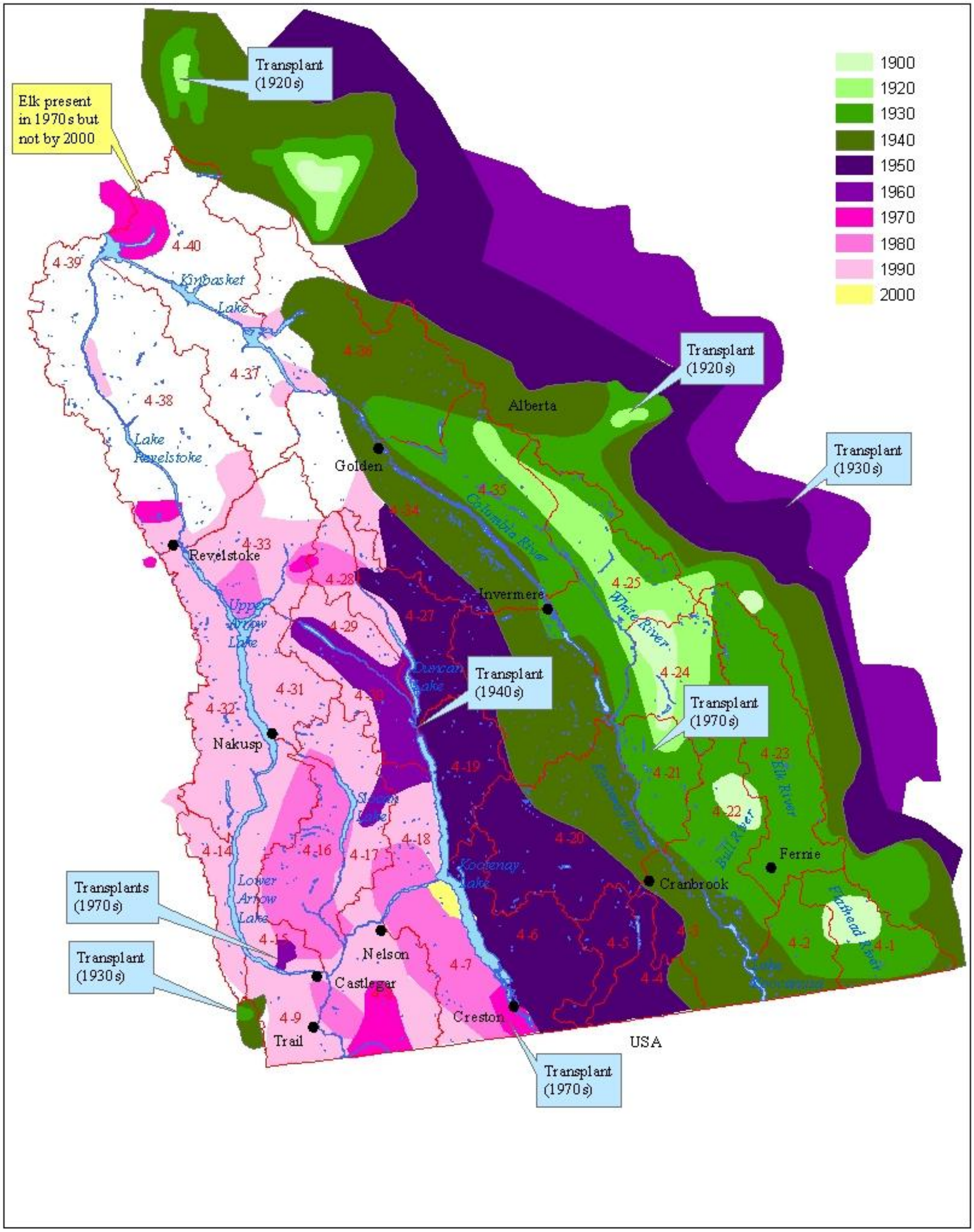

Figure 2. Approximate elk distribution in the Kootenay Region, British Columbia, from 1900 to 2000.

These remnant herds expanded, and by the 1930s elk were distributed throughout the eastern part of the region from the USA border to Golden on the east side of the East Kootenay Trench. In the 1940s, the population expanded further west and north, occupying the west side of the East Kootenay Trench. Transplants in the 1940s (Jamieson and Demarchi 1976) aided the establishment of elk in the West Kootenay. By the 1950s, elk populations extended from the Alberta border west to Kootenay Lake.

In the 1960s, elk population declines meant little change in their distribution. However in the 1970s, the expansion continued on the west side of Kootenay and Duncan Lakes, in part due to the transplant of 124 elk around Lower Arrow Lake (Hartman 1973; Demarchi 1973 cited in DeGroot and Woods 2006). Around the same time, elk were released near Creston (18 elk) and Premier Ridge (20 elk) (Ellis 1973). In the 1970s, elk populations expanded in to the region from adjacent areas in the north (Kinbasket Lake), west (near Revelstoke) and south (south of Castlegar). By 2000, elk occupied all management units in the Kootenay Region, although numbers were sparse in many parts, particularly the north where deep snow precludes year-round use.

Population trend

West Kootenay

The elk population in the West Kootenay has generally increased since the early 1900s, as the population expanded in to new areas and increased within occupied areas (Figure 3). The exact trend over time is largely speculative, given that data-based population estimates are limited. However anecdotal information suggests that the population increased through the early 1900s (aided by transplants), declined during the 1960s, and increased through the 1980s, 1990s and 2000s. Based on an analysis of hunter success data (see below), we believe that population growth may have waned in the mid 1990s, although it is unlikely that the West Kootenay population experienced substantial declines, as in the East Kootenay. Our best estimate of population trend over time (green line in Figure 3) suggests that annual growth rates may have been around 10% until the 1960s, 7% in the 1970s and 1980s, 1% in the 1990s and 7% in the 2000s. These growth rates seem reasonable given documented growth rates of colonizing elk herds (Raedeke et al. 2002: 479), and evidence of 20% annual growth for an isolated population in Washington (Eberhardt et al. 1996).

South Selkirk

In the South Selkirk, the population increased substantially from 2000 to 2007 (Robinson and Clarke 2007; Figure 4). The annual percent change in the population was 24% between 2000 and 2004, and 14% between 2004 and 2007. The primary focus of these surveys was to assess the relative densities and population trends of mule deer. Since the surveys were not designed to estimate elk population size, elk habitat may have been under-sampled, and population estimates may be low. Confidence Intervals were likely substantially underestimated because blocks were stratified post-inventory using inventory data. That said, the data were collected following standard methods each year, and provide a valuable indicator of trend.

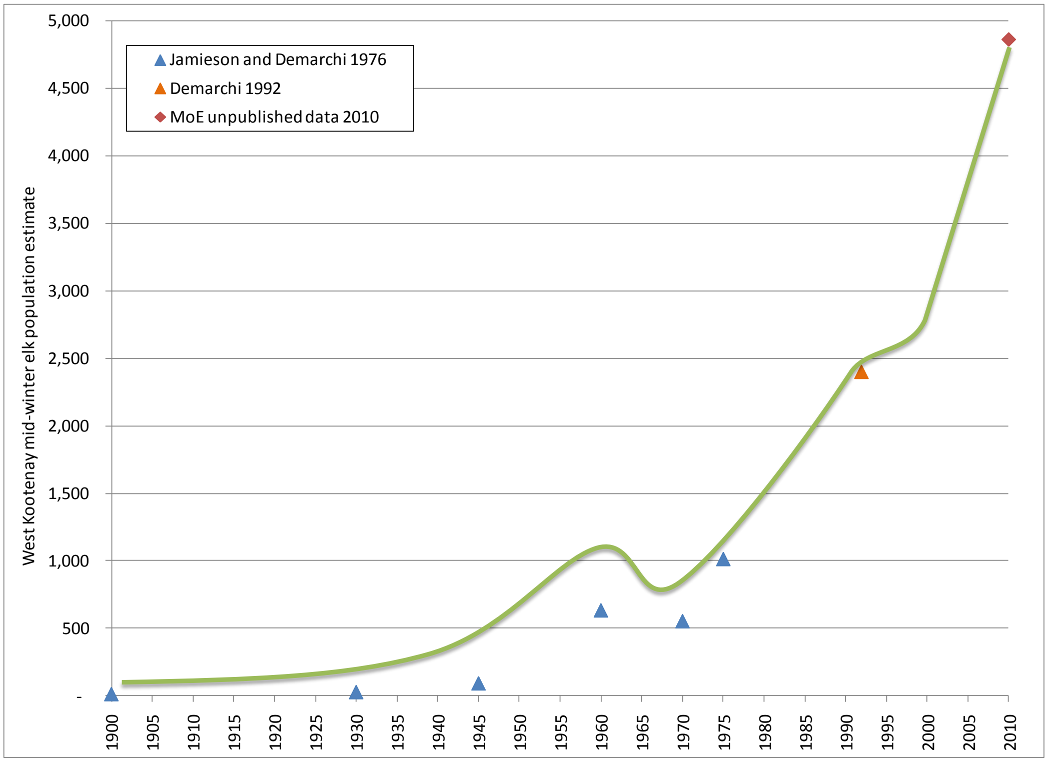

Figure 3. West Kootenay mid-winter elk population estimates, 1900 to 2010. The green line indicates our best estimate of population trend. Estimates from Jamieson and Demarchi (1976) and Demarchi (1992), were based on expert opinion, considering minimum counts from aerial surveys. MoE's 2010 estimate was based on aerial surveys and expert opinion.

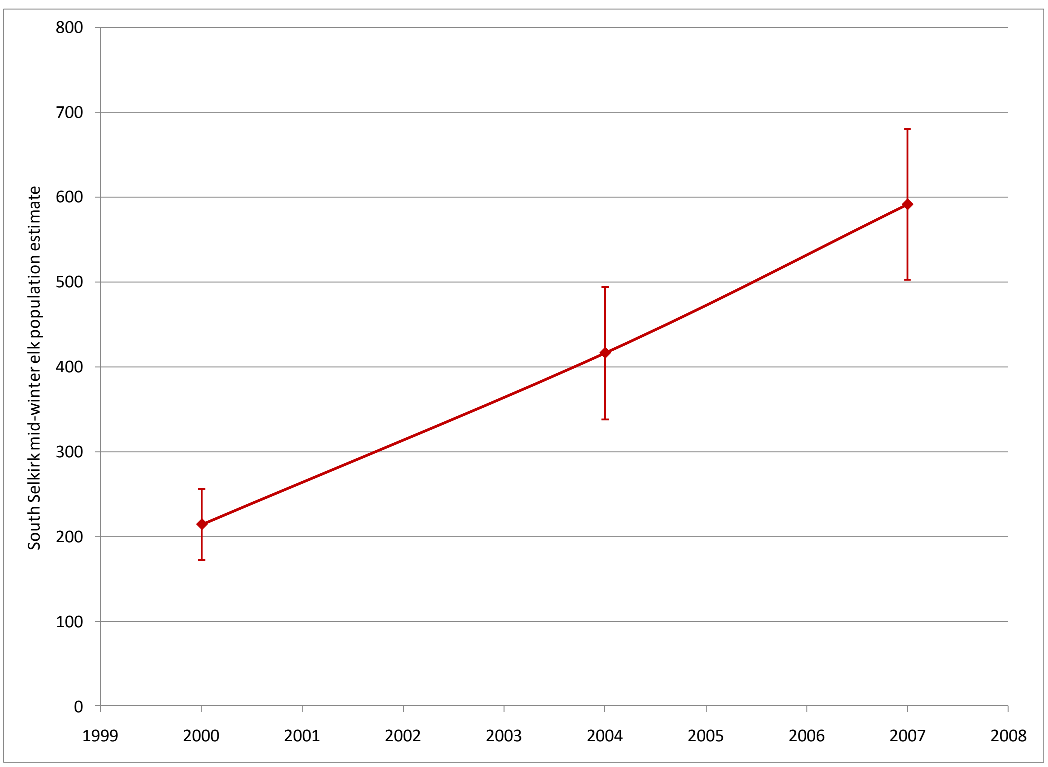

Figure 4. South Selkirk mid-winter elk population estimates from 2000 to 2007 (Robinson and Clarke 2007). Error bars indicate 90% Confidence Intervals.

East Kootenay

Population estimates for the East Kootenay suggest an increasing trend from 1900 to the early 1960s, a decline through the 1960s, an increase through the 1970s with a peak in the early 1980s, a decline through the 1980s and 1990s, and a re-bound in the 2000s (Figure 5). Estimates from 1900 to the late 1970s were based on anecdotal information and aerial/ground counts (Demarchi et al. 1975; Jamieson and Demarchi 1976; MoE unpublished data 1980). These were generally presented as minimum estimates, and hence were likely low. Expert opinion estimates in the mid to late 1970s ranged from 7,900 to 15,000 elk depending on the source, demonstrating the uncertainty around population size.

During the 1980s and 1990s, population estimates were largely based on cohort population modelling (Bircher and Janz 1999). This method is valuable for assessing population trends, and can be used to estimate population size when age data are unbiased and samples are sufficiently large (Hatter 1995b). However for the Kootenay Region, there is evidence that tooth return data (the source for age data) may have been biased, and minimum sample sizes were often not achieved, particularly for cows in the early 1990s (Simpson 1993a; Hatter 1995b). Cohort analyses are also highly sensitive to assumptions about the population, such as natural mortality rates (Hatter 1994). Subsequent modelling, assessments of input data and more recent aerial surveys suggested that the cohort analyses likely inflated population estimates in the early 1980s (Hatter 1995a).

The 2010 population estimate was a sum of estimates throughout the sub-region (Table 2; see below for details), and totalled 19,040 elk (90% CI: 16,350 to 22,930). Current elk populations are likely approaching, but not at 1980s levels. A much larger component of the East Kootenay elk population is now non-migratory (T. Szkorupa, MoE, unpublished data) so the current elk impact on grasslands and agricultural producers may be as high or higher than the 1980s, even if the population is smaller.

Southern East Kootenay Trench

Most elk in the East Kootenay inhabit the Southern East Kootenay Trench, and therefore the population trends in this area largely mirror those in the East Kootenay overall. Populations were likely stable or slightly declining in the 1980s, declining in the early and mid 1990s, and increasing in the late 1990s and 2000s (Figure 6). During the 1980s and early 1990s, cohort population modelling suggested a population decline (Hatter et al. 1994), whereas Bayesian estimates indicated the population was stable overall, but with significant declines in the bull component of the population (Hatter 1995a). The difference in results is likely because the Bayesian analyses better quantified error in the data sources and incorporated a range of data sources (hunter success, harvest data, inventory data, etc.).

In 1992, the first SRB inventory was conducted in the Southern East Kootenay Trench, covering most suitable winter range (Simpson 1992a). The original estimate of 8,941 (90% CI: 8,227-9,655) was later updated to 9,694 (90% CI: 8,948-10,440) using a revised sightability model. The estimate was revised again to account for all winter range within the Trench, resulting in approximately 11,040 elk (Figure 6; Hatter 1994).

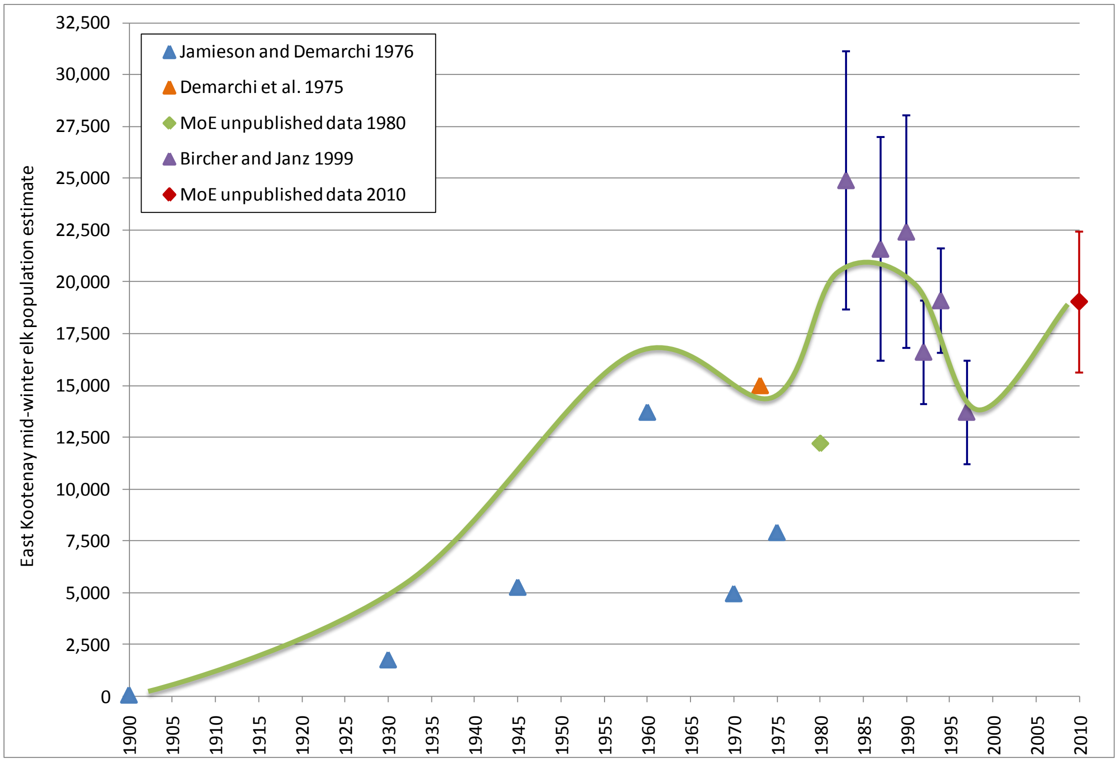

Figure 5. East Kootenay mid-winter elk population estimates from 1900 to 2010, based on various data sources. The green line indicates our best estimate of population trend over time. Estimates from Jamieson and Demarchi (1976), Demarchi et al. (1975) and MoE (unpublished data 1980) were based on expert opinion, which considered minimum counts from aerial surveys. Estimates from Bircher and Janz (1999) were based on cohort population modelling, corrected for mid-winter. MoE's (2010) estimate was based on aerial surveys and expert opinion. Error bars represent 90% Confidence Intervals.

The 1992 inventory estimate was substantially lower than government biologists and clients expected, raising questions about the accuracy of the survey, and about cohort analyses which had been used to estimate elk populations for many years (Hatter 1994; Hatter et al. 1994). Biologists in region and headquarters assessed the data and modelling approaches extensively, to determine the reason for this discrepancy. Originally, it was assumed that the SRB inventory underestimated population size, possibly because the sightability model was not applicable to south-eastern British Columbia or because the extrapolation to all winter habitat was inaccurate (Hatter 1994). However additional modelling work conducted by I. Hatter (MoE provincial ungulate specialist) in 1995 using a Bayesian framework (Walters and Ludwig 1994) produced estimates similar to the survey estimate (Hatter 1995a). Following critiques of past cohort analyses, Hatter recommended discontinuing these analyses until the accuracy of input data and assumptions could be verified. The East Kootenay Trench Agriculture Wildlife Committee officially endorsed the population estimate based on the SRB inventory, and extrapolated to the Trench (11,040 elk).

The South Trench was subsequently re-inventoried in 1997, 2001 and 2008 (Figure 6; Halko and Hebert 1997, Halko and Hebert 2001, Phillips et al. 2008). The 2008 estimate was 14,115 (90% CI: 12,761-15,469), which was significantly higher than all other estimates (Phillips et al. 2008).

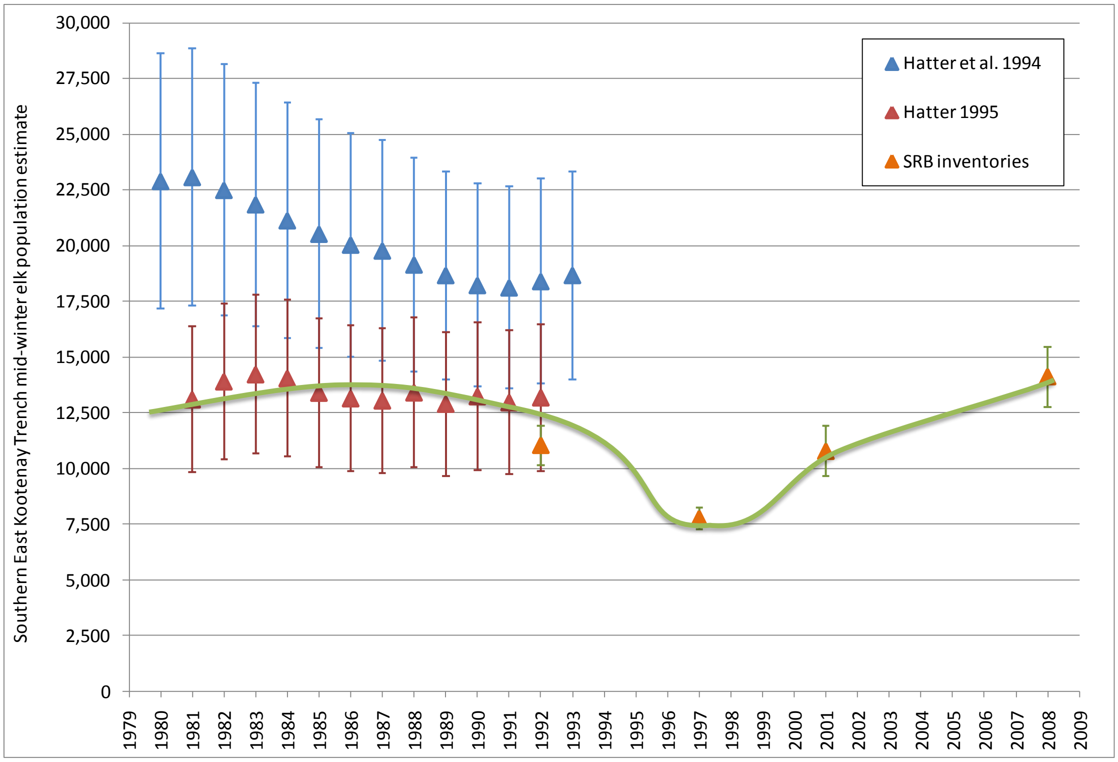

Figure 6. South East Kootenay Trench mid-winter elk population estimates, from 1980 to 2008. The green line indicates our best estimate of population trend over time. Estimates were based on cohort analyses (Hatter et al. 1994), Bayesian population modelling (Hatter 1995) and Stratified Random Block (SRB) inventories. Error bars represent 90% Confidence Intervals, and were set at 25% of the estimate for cohort and Bayesian modelling.

Elk Valley

Data are more sporadic and less accurate for the Elk Valley (MU 4-23; Figure 8) compared to the South Trench. However based on data available and anecdotal information, we believe that the Elk Valley population underwent a similar trend, with declines through the 1980s and early 1990s, and an increase during the late 1990s and 2000s. In the future, we plan to analyse aerial survey data from Teck coal mines to further assess trends.

In the mid 1980s, the estimated size of the Elk Valley elk population was over 4000 (B. Warkentin, MoE, personal communication 1984, cited in Gibson and Sheets 1997). In 1992, Simpson (1992b) conducted a SRB survey and estimated 1,418 elk (90% CI: 1,310-1,526) for the main Elk Valley and 1,500 elk for all of MU 4-23, including the Fording River drainage. However, Simpson (1992b) felt that these estimates were low because of “unusual elk behaviour” (elk did not flush in response to the helicopter as often as they did in the Trench) and the wide distribution in high elevation habitats (Simpson 1992b).

In 1993, Simpson (1993b) surveyed the Elk Valley again, but with a much expanded study area (510 km^2, compared to 198 km^2 in 1992). The new population estimate was 2,084 elk (90% CI: 1,217-2,867). Simpson (1993b) felt this estimate was high because one low strata block had many elk, and suggested that 1800 elk was a more accurate estimate. Both the 1992 and 1993 population estimates were based on the first version of the Idaho sightability model, which was later found to underestimate the East Kootenay Trench population relative to the revised sightability model (Hatter 1994).

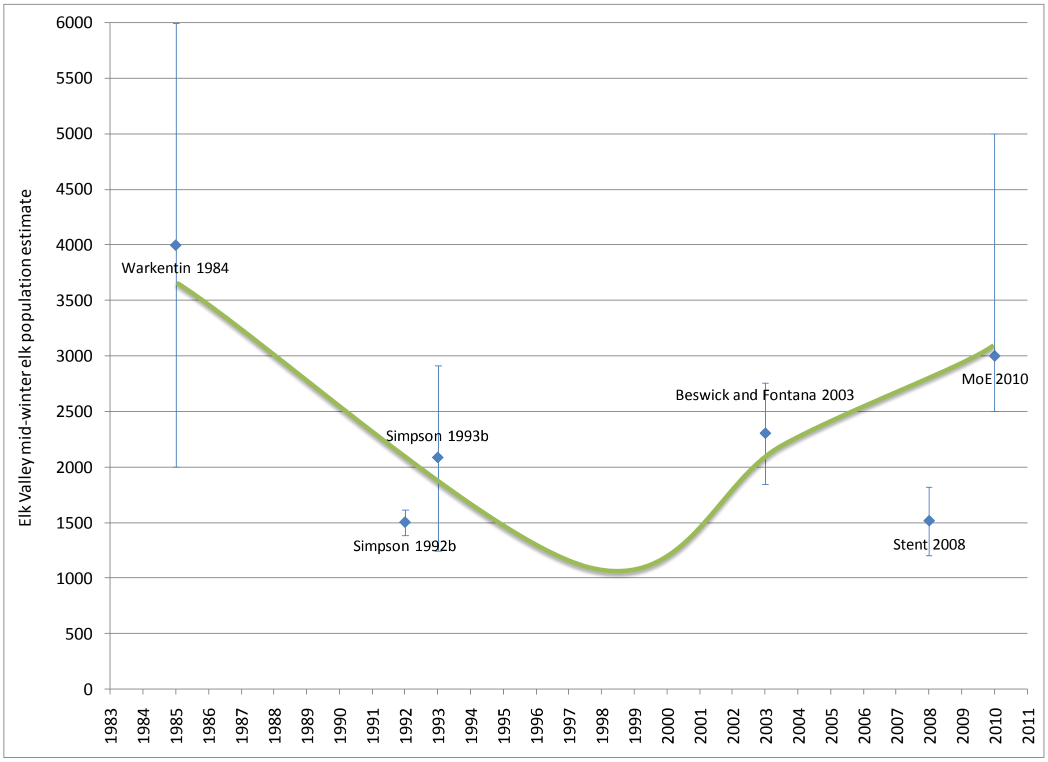

Figure 7. Elk Valley mid-winter elk population estimates, from 1984 to 2010. The green line indicates our best estimate of population trend over time. Estimates were based on expert opinion (1984 and 2010), and Stratified Random Block inventories (1992 – 2008). Error bars represent 90% Confidence Intervals.

In 2003, Beswick and Fontana (2003) surveyed the Elk Valley again and derived a population estimate of 2,303 elk (90% CI: 1,844-2,762). However accuracy and precision are questionable. There was only one sampled block in the low stratum (hence no sampling variability) and two in the medium stratum (hence very little sampling variability), which likely inflated precision for the population estimate. Variability would certainly have increased with additional surveyed blocks. Given the small sample size, the estimate may be inaccurate, however we have no way of knowing whether it is biased high or low.

In 2008, a moose inventory was completed in the southern Elk Valley (Poole et al. 2008). Elk data collected during the moose survey were combined with data collected during the 2003 Elk Valley inventory to update the estimate for MU 4-23 (Stent 2008). However the population estimate of 1,513 elk (90% CI: 1,207-1,819) is certainly low, given that coal mine surveys in the Elk Valley in 2009 observed over 2200 elk, and only covered a fraction of the suitable elk habitat in the valley. Based on the mine data, and maximum counts in recent years, we believe the population in 2010 was at least 2,500, and could be as large as 5,000.

Current population size

West Kootenay

Our mid-winter population estimate for the West Kootenay for 2010 was 4,860 elk (90% CI: 2,680-7,130) (Table 1). Inventory data were limited for this sub-region, and therefore most estimates were based on expert opinion. We discuss available inventory data and any data re-analyses for each GMZ below.

Table 1. West Kootenay elk population estimates for mid-winter 2010, rounded to the nearest 10. Estimates were based on recent aerial inventories and expert opinion. For inventories, Confidence Intervals (CIs) represent 90% probability-based intervals. For expert opinion, CIs were based on expert confidence in the estimate, or were set at 50% of the estimate.

Area	GMZ	MU	Winter estimate	Min CI	Max CI	Source
Duncan	Revelstoke	4-27 4-28	100	50	150	Expert opinion
Lardeau	Revelstoke	4-29 4-30	100	50	150	Expert opinion
Upper Arrow	Revelstoke	4-31 4-32 4-33	550	280	830	Expert opinion; Inventories had limited sightability
Lake Revelstoke	Revelstoke	4-38 4-39	90	50	150	Expert opinion
Creston	Nelson	4-06 4-07	1,230	710	1,760	Re-analysis of inventory data
South Selkirk East	Nelson	4-08	380	310	450	Re-analysis of inventory data
South Selkirk West	Nelson	4-09	160	80	240	Expert opinion
Lower Arrow (west)	Nelson	4-14	110	60	170	Expert opinion
Slocan (Lower Arrow east)	Nelson	4-15	570	290	860	Expert opinion; 2004 inventory in small portion of MU
Slocan	Nelson	4-16	970	490	1,460	Expert opinion; 2004 inventory in small portion of MU
Slocan	Nelson	4-17	250	130	380	Expert opinion; 2004 inventory in small portion of MU
Slocan (Kootenay Lake west)	Nelson	4-18	200	100	300	Expert opinion; 2004 inventory in small portion of MU
Kootenay Lake East	Nelson	4-19	150	80	230	Expert opinion
West Kootenay total			**4,860**	**2,680**	**7,130**	

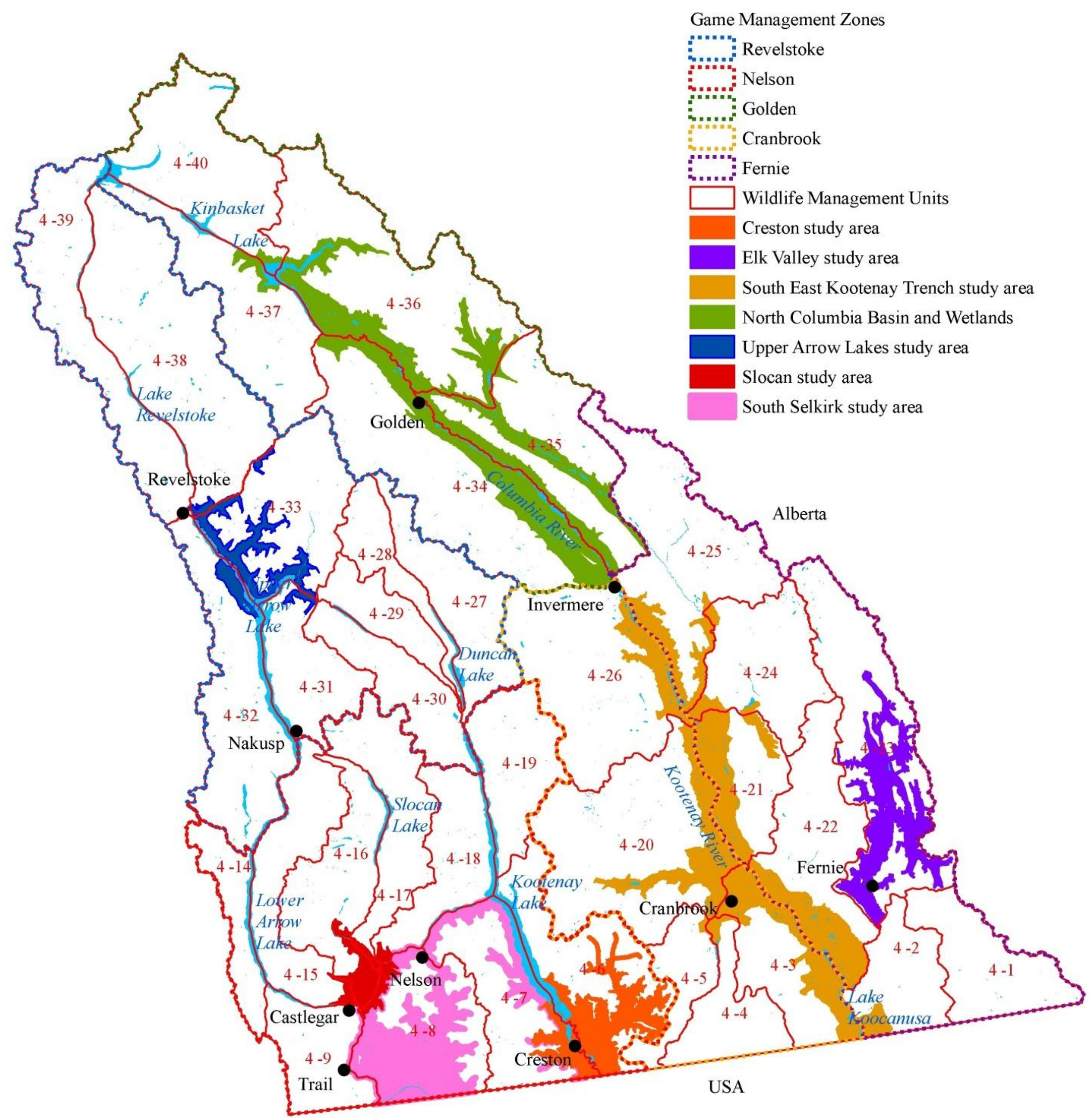

Figure 8. Map of the Kootenay Region, showing aerial survey study areas in the 1990s and 2000s.

Revelstoke GMZ

The only survey conducted in the Revelstoke GMZ was in the Upper Arrow Lakes area (MU 4-33; Figure 8). The FWCP conducted minimum count surveys in 1997 (Clarke 1997) and 1999 (Clarke 1999). In both years only 19 elk were observed. The study area has high vegetation cover and snow-free areas, which greatly limits elk sightability, and expert opinion suggests numbers are likely much larger.

Nelson GMZ

In the Creston Valley (southern portions of MUs 4-06 and 4-07), Stent and Mowat (2008) conducted a SRB inventory (Figure 8) in 2008. The population estimate was 907 elk (90% CI: 713-1,101); however a large elk herd that moves between British Columbia and Idaho was in the Idaho during the inventory. If this herd was included in the Creston estimate the population estimate was closer to 1,000 elk.

We re-analysed data from Stent and Mowat's (2008) Creston inventory, and Robinson and Clarke's (2007) South Selkirk inventory, to derive a population estimate of 1,231 elk (90% CI: 707-1,755) for all of MUs 4-06 and 4-07, and 377 elk (90% CI: 306-448) for MU 4-08 (Table 1).

DeGroot (2005) conducted a SRB survey in the southern Slocan Valley (portions of MUs 4-08, 4-15, 4-16, 4-17 and 4-18; Figure 8) in 2004. He also applied mark re-sight methods to estimate population size based on the observations of radio-collared elk. His estimate for the area was 362 elk (90% CI: 297-427) from the SRB sightability model (Unsworth et al. 1999), 923 elk from the Peterson mark re-sight method, and 1,010 from the Noremark mark re-sight program. For the mark re-sight assessments, sample sizes were small (<50 marked animals and fewer than 10 marked animals observed during the survey), collars may not have been visible during surveys, and there was no telemetry flight to confirm that collared elk were in the study area. Therefore, we believe that the aerial survey provides a more accurate population estimate for this area. The Slocan study area represented a small percentage of the winter range within the MUs surveyed and could not be extrapolated to estimate populations within the MUs. Therefore, expert opinion was used to estimate MU level population size.

East Kootenay

Our mid-winter population estimate for the East Kootenay sub-region for 2010 was 19,040 elk (90% CI: 16,350 to 22,930; Table 2). We discuss available inventory data, and any subsequent data re-analyses for each GMZ below.

Golden GMZ

The FWCP conducted minimum count inventories in portions of the North Columbia Basin and Columbia Wetlands three times between 1991 and 2006 (Bindernagel et al. 1991; Tinker et al. 1997; Klafki 2007). Data collected between 1991 and 1997 were of limited value for estimating population size because surveys spanned several MUs and other study areas (e.g., Southern East Kootenay Trench). In addition, survey intensity varied among years and was substantially lower than SRB inventories.

We derived a 2008 estimate for the North Columbia Basin (MU 4-36, 4-37 and 4-40) using data collected by the FWCP in 2005 and 2006 (Klafki 2007). During these minimum count inventories, most suitable elk winter range within the MUs was surveyed. The survey crew observed 195 elk in 4-36 and no elk in 4-37 and 4-40. Using a 1.27 correction factor (average from Phillips et al. 2008) we estimated 248 elk for MU 4-36 and assumed that this estimate remained valid for 2010. Since no elk were observed in 4-37 and 4-40, and deep snow and wolves limit elk in these areas (W. Cibulka, former Conservation Officer and L. Ingham, FWCP), we assumed the populations were very small, contributing only 20 additional elk during mid winter (Table 2).

Table 2. East Kootenay elk population for mid-winter 2010, rounded to the nearest 10. Estimates were based on recent aerial inventories and expert opinion. For inventories, Confidence Intervals (CIs) represent 90% probability-based intervals. For expert opinion, CIs were based on expert confidence in the estimate, or were set at 50% of the estimate.

Area	GMZ	MU	Winter estimate	Min CI	Max CI	Source
Columbia Wetlands West	Golden	4-34	600	400	1,030	Inventory 2009
Columbia Wetlands East	Golden	4-35	500	250	750	Expert opinion
North Columbia Basin	Golden	4-36 4-37 4-40	270	230	330	Inventory 2005
Southern East Kootenay Trench[1]	Cranbrook Fernie	4-02 4-03 4-20 4-21 4-22 4-24 4-25 4-26	14,120	12,760	15,470	Inventory 2008
Moyie	Cranbrook	4-04 4-05	400	200	600	Expert opinion
Flathead	Fernie	4-01	150	10	250	Expert opinion; Population larger during summer
Elk Valley	Fernie	4-23	3,000	2,500	5,000	Inventory (various years) and expert opinion
East Kootenay total			**19,040**	**16,350**	**22,930**	

[1]Includes a small portion of MUs 4-04 and 4-05

We used data collected during a 2009 moose inventory (Stent 2009) to update the population estimate for MU 4-34 (West Columbia Wetlands). During the moose survey, blocks were also stratified and inventoried for elk. The population estimate was 595 elk (90% CI: 161-1029). In Table 2, we increased the minimum 90% CI to 400 because 272 elk were observed during the survey, and only half of the high stratum blocks were surveyed. No recent inventory data were available for 4-35, so a 2010 estimate (Table 2) was derived using anecdotal information from individuals involved in numerous surveys in the area (W. Cibulka, former Conservation Officer and L. Ingham, FWCP).

Cranbrook and Fernie GMZs

The majority of the Cranbrook and Fernie GMZs was covered during the 2008 Trench inventory (Phillips et al. 2008; Figure 8). The population estimate was 14,115 elk (90% CI: 12,761-15,469) for the entire Trench, which is split between the GMZs. We are currently working on a population model to determine whether the elk population in the Trench may have changed since 2008. However in the interim, we assumed that the population was stable and that the 2008 inventory data reflect the 2010 mid-winter population (Table 2).

Within the Cranbrook GMZ, the only areas not captured by the South Trench study area were some winter ranges in MUs 4-04 and 4-05 (Moyie area). We used expert opinion to estimate the elk populations in the portions of these MUs not covered by the inventory (Table 2).

Within the Fernie GMZ, winter range in the Elk Valley and Flathead was not captured by the 2008 Trench inventory. The Flathead Valley supports a population of summering elk, however most elk move in to Alberta or Montana during the winter. Therefore, our mid-winter estimate was relatively small at 150 elk (Table 2). There is currently much uncertainty around the size of the Elk Valley population. However our best estimate was 3000 elk. The confidence intervals of 2,500 to 5,000 reflect our belief that the population may be substantially larger than 3000. See above (*Population trend, Elk Valley*) for details on past inventories and population estimates in the Elk Valley.

Population composition

The number of elk classified (i.e., sample size) per winter varied substantially among winters and locations in the region. In the UIDB, sample size ranged from 34 to 101 elk per winter in the West Kootenay (mean = 62 elk/winter), and 43 to 4,439 elk in the East Kootenay (mean = 908 elk/winter), after excluding samples with fewer than 25 elk classified. Between 1964 and 1997 there were sufficient data for 8 winters in the West Kootenay and 68 winters in the East Kootenay, with occasionally more than one survey per winter. However several of these winters had fewer than 100 elk classified, particularly in the West Kootenay (as indicated by small data markers on graphs below). The number of elk classified by the Elk Valley mines ranged from 43 to 1,584 per winter across all mines (mean = 491 elk/winter). The sample size increased recently, with over 1,300 elk classified per winter from 2007 to 2009. During SRB inventories, the average number of elk classified was 340 in the Nelson GMZ (range 136-521, n = 4), 3190 in the South Trench (range 731-6413, n = 10), and 1,004 in the Elk Valley (range 715-1,301, n = 3).

Calf ratios

Calf to cow ratios provide a valuable indication of calf survival and hence population growth rate, since calf survival is typically variable among years while adult cow survival remains relatively constant (Harris et al. 2008, but see Bonenfant et al. 2005). However, Harris et al. (2008) found that calf to cow ratios could not detect gradual declines in calf survival, nor provide information on fecundity or adult survival.

West Kootenay

In the West Kootenay, calf to cow ratios ranged from 19 to 83 calves per 100 cows, with an average of 59 (Figure 9). In general, calf to cow ratios from the 1980s were much less precise and accurate than ratios from the 2000s. This is because data from the 1980s were based on very small samples (less than 100 for all but one winter) and were not corrected for sightability. In the 2000s, SRB surveys did correct for sightability. Although ratios appear to fluctuate greatly from year to year, this may simply be a result of sampling error and not true differences in the parameters (Lubow et al. 2002). Overlapping error bars in the 1980s support this. More than 60 calves per 100 cows is beyond the range reported by long-term studies elsewhere, even when populations were well below carrying capacity and lacked major predators (Lubow et al. 2002). These values exceeded documented natality rates (Lubow and Smith

2004) which would mean an impossibly high calf survival rate of 100%. Therefore, these high values are likely due to error associated with small sample size.

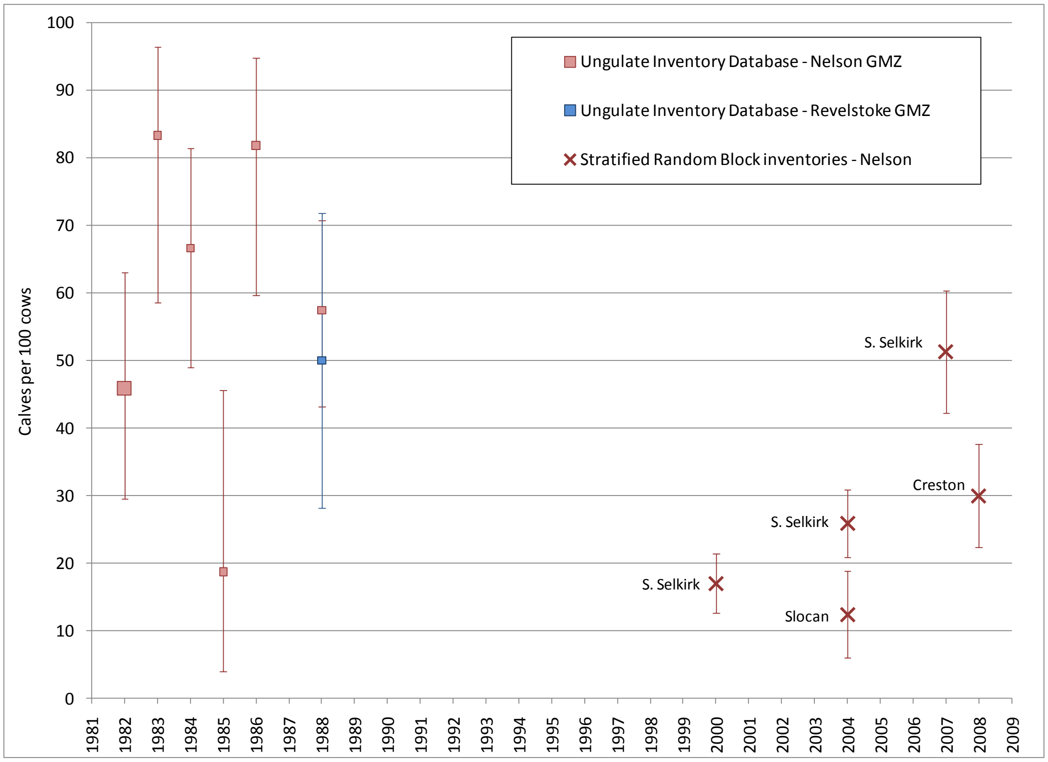

Figure 9. Calves per 100 cows estimated or observed for the Revelstoke and Nelson Game Management Zones, 1965-2009, with 90% or 95% Confidence Intervals. Small data markers indicate fewer than 100 elk classified.

East Kootenay

In the East Kootenay, calf to cow ratios ranged from 10 to over 70 calves: 100 cows, with an average of 40 calves: 100 cows across all samples and years (Figure 10, Figure 11). Although there was substantial variation among years, the prevailing trend was an increase in calf ratios from the 1960s to mid 1970s, a stable trend through the 1980s, relatively low ratios in the 1990s, and an increasing trend in the 2000s. This general trend appears to hold throughout the East Kootenay, although data are minimal for the Golden GMZ. In recent years (2008 in the Cranbrook GMZ and 2009 in the Fernie GMZ) the calf to cow ratio has dropped to under 30 calves: 100 cows. Additional years of data are required to determine whether this is due to annual variation, or a true trend. Calf ratios from the Elk Valley mines were much more variable among years than ratios from the UIDB or SRB surveys.

High annual variation in calf ratios can be attributed to annual differences in winter severity, predation, and nutrition, which may affect both calf survival and cow fecundity (see Raedeke et al. 2002 for a review). In addition, cows that successfully breed one year are less likely to breed the next year, presumably because of the nutritional stress of lactating. This may result in low calf ratios following a year with high calf ratios.

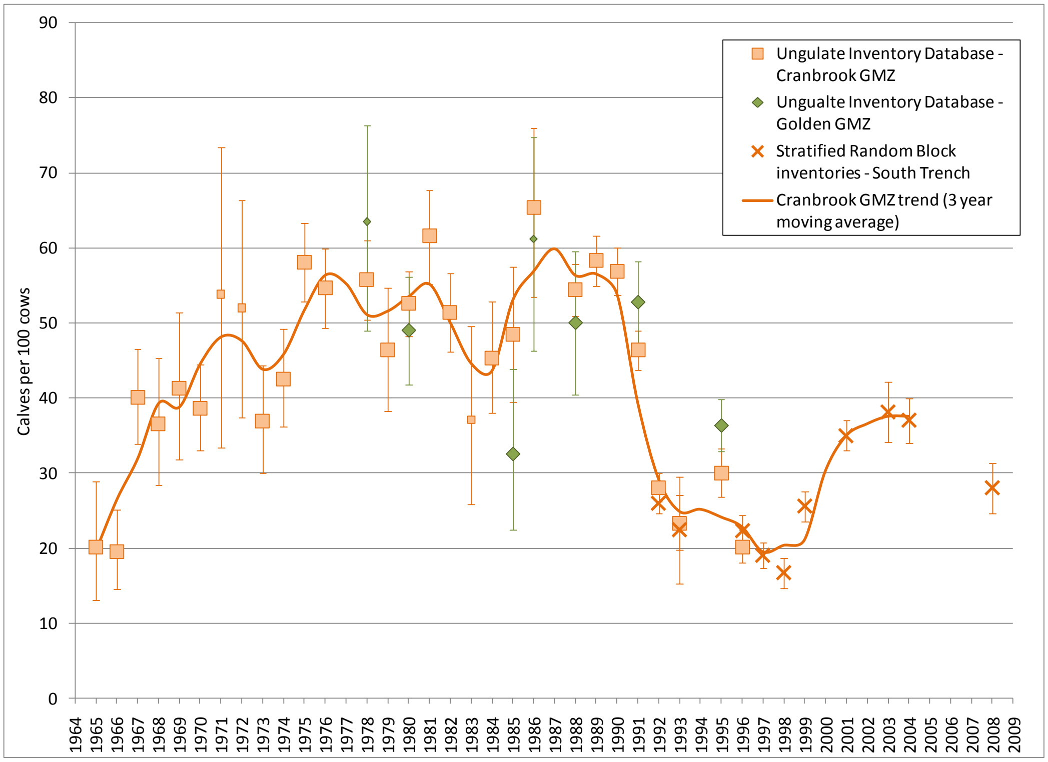

Figure 10. Calves per 100 cows estimated or observed for the Golden and Cranbrook Game Management Zones, 1965-2009, with 90% or 95% Confidence Intervals. Small data markers indicate fewer than 100 elk classified. The 3-year moving average across all data sources depicts the Cranbrook GMZ trend; data were insufficient to plot trend for the Golden GMZ.

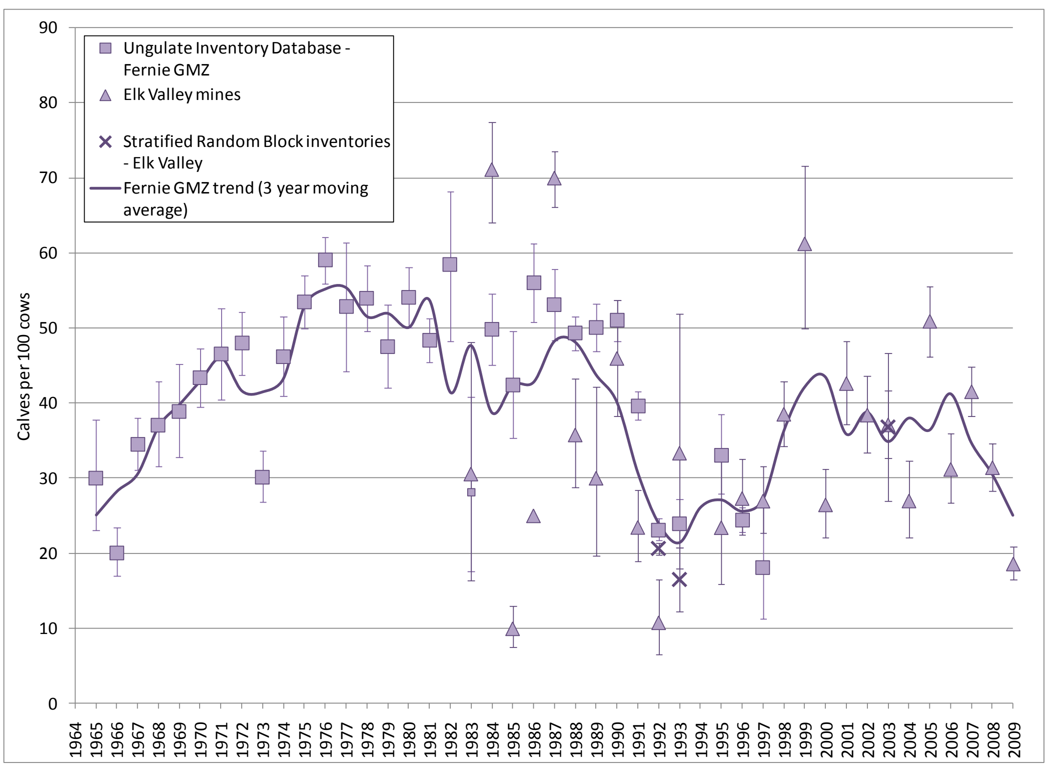

Figure 11. Calves per 100 cows estimated or observed for the Fernie Game Management Zones, 1965-2009, with 90% or 95% Confidence Intervals. Small data markers indicate fewer than 100 elk classified. The 3-year moving average across all data sources depicts trend.

Bull ratios

West Kootenay

In the West Kootenay, bull to cow ratios declined through the 1980s and data from the 2000s suggests very high bull to cow ratios (>40 bulls: 100 cows; Figure 12). Data are lacking for the 1990s, so trends during this time are unknown. Bull ratios ranged from 9 to 172 and averaged 66 bulls per 100 cows. In general, bull ratios for the West Kootenay were substantially higher than in the East Kootenay, and exceeded 20 bulls: 100 cows most years.

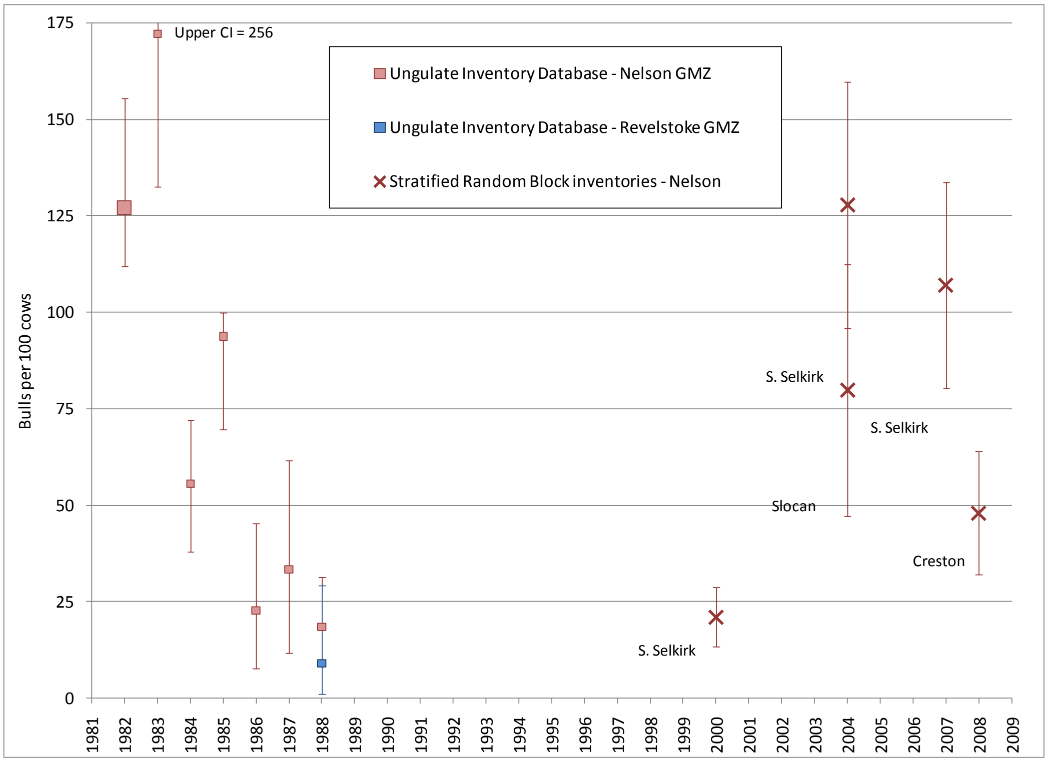

Figure 12. Bulls per 100 cows estimated or observed for Revelstoke and Nelson Game Management Zones, 1965-2009, with 90% or 95% Confidence Intervals. Small data markers indicate fewer than 100 elk classified. Points above 100 are biologically unlikely and may be caused by non-representative sampling or observer error.

East Kootenay

In the East Kootenay, bull to cow ratios also fluctuated substantially among years and study areas (Figure 13, Figure 14), ranging from 0 to 114 bulls: 100 cows and averaging 18 bulls: 100 cows across all samples. These summary statistics include likely outliers with very low (0 bulls: 100 cows in 1982 and 1983, UIDB) and very high (72 and 114 bulls: 100 cows in 1983 and 1986 respectively, Elk Valley mine data) bull ratios.

Data from the Golden GMZ are insufficient to assess trends and were unavailable for recent years. That said, most data from the 1980s suggest higher bull to cow ratios than in the mid 1990s. In the Cranbrook GMZ, bull ratios declined slightly through the 1960s and 1970s, increased and then stabilized in the 1980s, dropped in the early 1990s and then rose through the late 1990s and 2000s. In the Fernie GMZ, bull ratios rose then declined in the 1960s, declined slightly through the 1970s, stabilized at a higher level in the 1980s and 1990s, and then increased through the 2000s. The apparent increase in bull ratios during the late 1980s is likely because mine data were incorporated at this time. Mines presumably had higher bull ratios because of limited hunting on their properties. In both GMZs, bull ratios were generally below 20 bulls: 100 cows from 1965 to 2000, and above 20 bulls: 100 cows in the 2000s.

Although there has undoubtedly been an increase in bull to cow ratios, part of the apparent increase in recent years is likely due to differences in data. In 1992, the first SRB inventory was conducted, providing more accurate bull to cow ratio estimates than available from raw observations. Bull to cow ratios are typically underestimated when sightability of different sexes is not accounted for, because bulls are inhabit denser cover, are sexually segregated, and winter in smaller groups (McCorquodale 2001). This is demonstrated by data from years with both corrected and uncorrected data. For example, in 1993, ratios estimated from SRB inventories were roughly double those observed and recorded in the UIDB. However this bias is not consistent among years or locations and hence a standard correction factor cannot be applied.

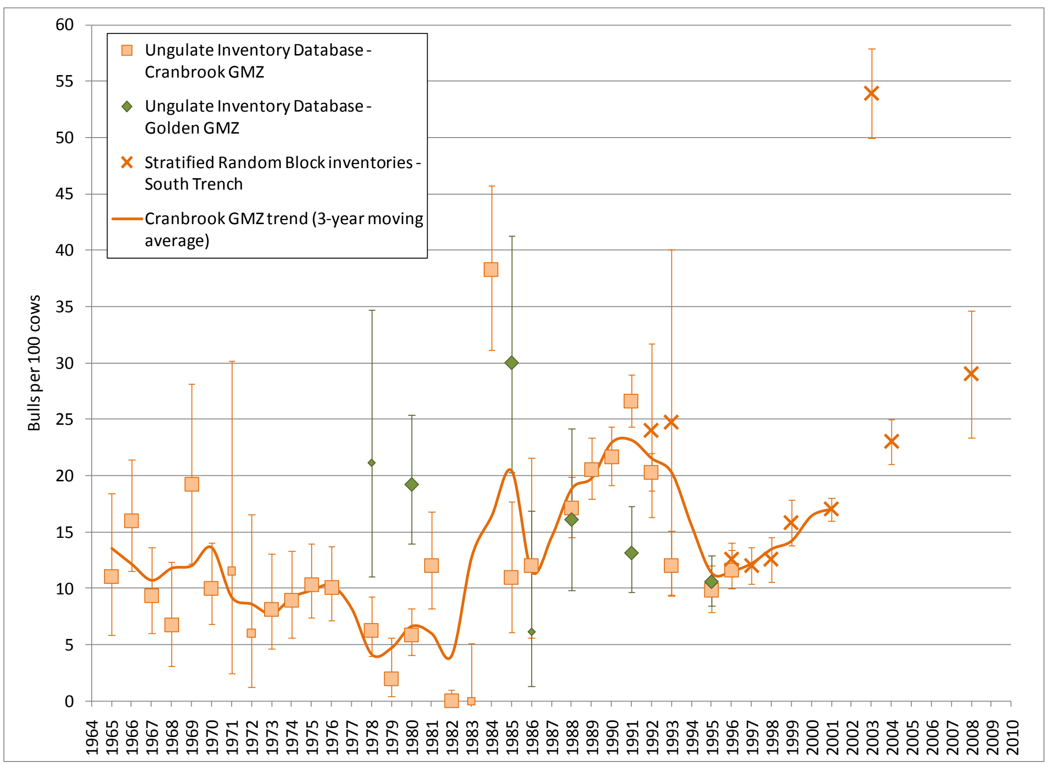

Figure 13. Bulls per 100 cows estimated or observed for Cranbrook and Golden Game Management Zones, 1965-2009, with 90% or 95% Confidence Intervals. Small data markers indicate fewer than 100 elk classified. The 3-year moving average across all data sources depicts the Cranbrook GMZ trend; data were insufficient to plot trend for the Golden GMZ.

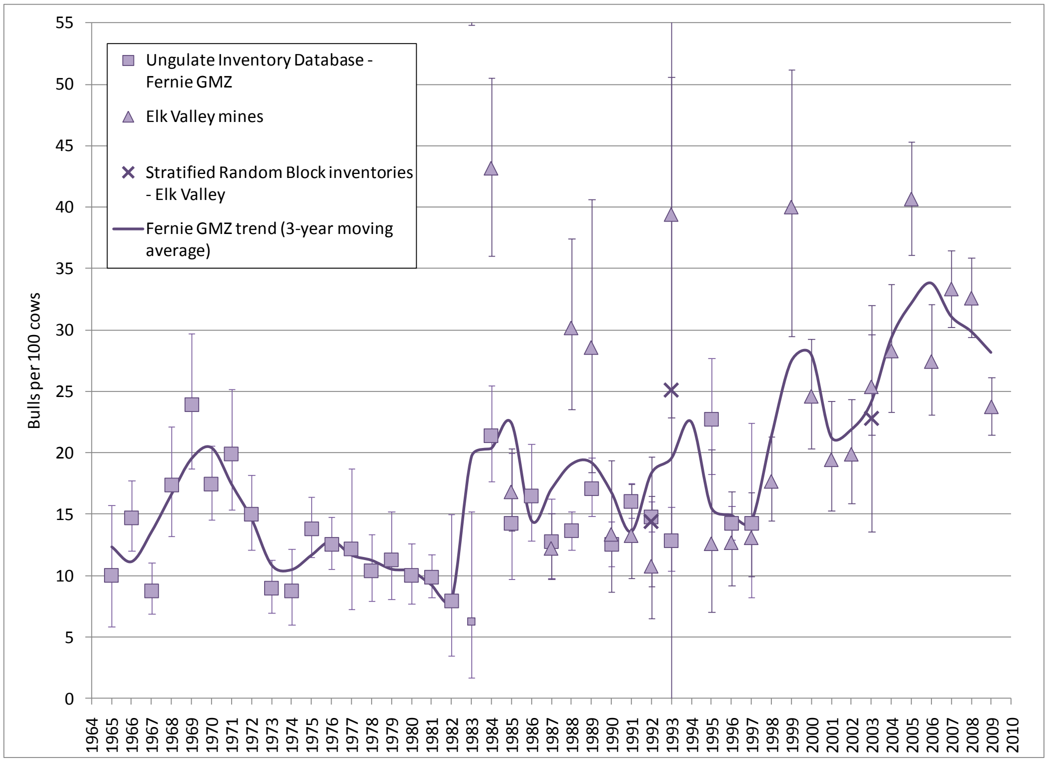

Figure 14. Bulls per 100 cows estimated or observed for the Fernie Game Management Zone, 1965-2009, with 90% or 95% Confidence Intervals. Small data markers indicate fewer than 100 elk classified. Suspected outliers were excluded from the dataset for the Elk Valley mines (72 bulls: 100 cows in 1983 and 114 bulls: 100 cows in 1986). The 3-year moving average across all data sources depicts trend.

Adult survival

In the Lardeau area (Revelstoke GMZ, West Kootenay) Poole and Park (2003) collared 6 cow elk in both 1999 and 2001, for a total of 12 collared elk. Each group was monitored for one year; one animal died 6 weeks after capture. There were no cow hunts during the study, but there were resident wolves. The estimated natural, non-hunting and overall annual survival was 91% (Table 3). However Poole and Park (2003) suggested that the one mortality may have been capture related. If this was the case, survival would be 100%.

Table 3. Annual elk survival for radio-telemetry studies in the Kootenay Region, 1986 to 2010, with 90% Confidence Intervals in parenthesis. The natural survival rate accounted for non-human caused mortalities, the non-hunting survival rate accounted for all mortality causes except for hunting, and the overall survival rate accounted for all sources of mortality (including hunting). All analyses were conducted using the staggered entry Kaplan-Meier analysis.

Study area	Years	Total months	Sample size	Natural survival	Non-hunting survival	Overall survival
Lardeau	99, 01	12	12	91% (64-100%)	91% (64-100%)	91% (64-100%)
Slocan	03-05	28	24	100% (86-100%)	100% (86-100%)	100% (86-100%)
Slocan	03-09	77	24	97% (93-100%)	-	91% (84-96%)
EK Trench	86-93	83	64	99% (97-100%)	97% (95-99%)	92% (84-98%)
EK Trench	07-10	41	82	91% (87-95%)	86% (80-90%)	81% (75-86%)

In the Slocan Valley (Nelson GMZ, West Kootenay), DeGroot and Woods (2006) collared and monitored 22 cow elk over 2 years (2003-2004) with no natural or non-hunting human-caused mortalities. Hence natural and non-hunting annual survival rates were 100% (Table 3). One cow was killed during the legal hunting period, but despite this estimated overall survival remained at 100% (after rounding). The Kaplan-Meir non-parametric analysis does not calculate confidence intervals when survival is 100%, so we calculated binomial confidence intervals instead (Zar 1996:525). Age at collaring varied from 8 months to 8 years, with a mean age of about 5 years during both years of study. These ages may be conservative because teeth from older animals are more difficult to age. There were no resident wolves in the area.

Monitoring of collared elk in the Slocan stopped in early 2005, but 14 elk still had functioning Very High Frequency (VHF) collars. In spring 2009, these collars were relocated (G. Mowat, MoE, unpublished data). Two collars were found near carcasses suggesting natural mortalities. One collar was found in a local yard and another had been cut, suggesting human-caused mortality. Based on these data, the annual natural survival rate was 97%, and the overall survival rate was 91%, including hunting mortalities (Table 3). We could not differentiate between hunter-kills and other human-caused mortality, so we did not estimate non-hunting survival. It is important to note that the mean age of collared animals was at least 10 years by 2009, which is likely much higher than average for the population. Although elk can live 20 or more years, the average life expectancy in the wild is 10-12 years (Blood 2000). Therefore, the estimated survival rate for 2003 to 2009 is certainly biased low, and at 97% suggests a very high natural survival rate for the population.

In the East Kootenay Trench, 69 elk were radio-collared between 1986 and 1992, including 4 bulls, 1 calf, 7 female yearlings, and 57 older cows (Jamieson and Hebert 1992; Jamieson and Hebert 1993). More elk were collared during the second phase of the project (1991-93) than during the earlier phase (1986-98). Collared elk were monitored until 1993. The average age of collared elk was 4.5 years, however about a third of elk were not aged and simply identified as “adults”. A portion of the elk stayed in the valley bottom year round while the majority migrated to summer ranges in the mountains. Wolves occurred in the mountains but were likely scarce in the Trench. We removed bulls and calves from the data, leaving a sample size of 64 cow elk (including yearling cows). The natural survival rate was nearly 100% (Table 3), and did not vary among study years (≥99% each year). Survival rates remained over 90% when we accounted for non-hunting and all sources of mortality.

Elk were again radio-collared in the southern East Kootenay Trench in 2007 and 2008. Each year, 41 female elk were collared for a total of 82 elk (T. Szkorupa, MoE, unpublished data). None of the elk were calves, and 1-2 were likely yearlings. The average age was about 4.5 years, although age was not determined for about a third of the collared elk. Nearly half of the collared elk did not migrate away from the Trench during summer. Elk survival rates for 2007 to the first half of 2010 were 91% annually when considering only natural mortalities, 86% when all non-hunting mortalities were considered, and 81% when all mortality sources were accounted for (Table 3). Natural and non-hunting survival rates were similar among years (<3% difference between min and max), but overall survival was lower for the first year of the study (75% compared to 80-81% in other years).

Overall, cow elk survival rates were high in the West Kootenay and in the East Kootenay during the late 1980s and early 1990s. Causes of elk mortality include malnutrition, predation, hunting, poaching, and highway and railway accidents (Raedeke and Raedeke 1998, Cook 2002). Although elk harbour several parasites, bacteria and viruses, these typically cause disease or death only when elk are severely malnourished (Blood 2000). When we consider the causes of mortality, high survival rates during these studies make sense. Forage was abundant in the West Kootenay study areas (Poole and Mowat 2002) and apparently sufficient in the East Kootenay to avert malnutrition-related deaths. Predators were absent or at low densities, and human-caused mortalities were minimal.

In the East Kootenay Trench, survival rates were about 10% lower in the late 2000s compared to the late 1980s/early 1990s. Confidence intervals do not overlap for natural or non-hunting survival, and only overlap slightly for overall survival, which suggests survival has dropped significantly. This appears to deviate from other studies in North America, which have documented high survival for large herbivores and very low annual variation (Gaillard et al. 1998; Garrot et al. 2003).

For both the past and current Trench studies, we subtracted the overall survival rate from the non-hunting survival rate to determine the percent of mortalities attributable to human causes other than hunting. We also subtracted the overall survival rate from the non-hunting survival rate to determine the percent of mortalities attributable to hunting. These calculations indicated that hunting mortalities were similar for both studies (about 5%), but human-caused mortalities other than hunting were much higher in the late 2000s (5%) compared to the late 1980s/early 1990s (1%). This aligns with vehicle-elk collision data, which indicate that mortality rates on East Kootenay highways were 2-3 times higher in the 2000s compared to the 1980s. Documented vehicle-elk mortalities peaked at nearly 140 in 2002, the last year that data were reported (Sielecki 2004). There were also several suspected poaching mortalities in the late 2000s, compared to very few in the late 1980s/early 1990s. This may in part be due to incorrect classification of mortalities, since it seems unlikely that poaching has increased significantly. Several radio-collars were found cut, during or after the hunting season. Researchers assumed that the elk were killed illegally, and that hunters would return collars from legally killed elk to the Ministry of Environment. However some hunters may have been reluctant to return collars, perhaps because they thought it was unlawful to kill collared elk. If these mortalities were classified as hunting mortalities, the non-hunting survival rate would go up.

Natural causes of mortality also appeared to be higher in the late 2000s compared to the late 1980s/early 1990s in the Trench. Unfortunately, researchers could not determine the cause of death for many natural mortalities, so it is difficult to explain the difference. Even if mortalities had been investigated soon after death, determining the cause can be very difficult (e.g., an animal that dies of malnutrition may be scavenged, which could appear to be a predator-related death). Predator numbers are certainly higher in the Trench and surrounding mountains currently, compared to the late 1980s/early 1990s. Research in Glacier National Park, immediately south of our region, demonstrated that elk populations declined as wolves re-colonized the area, and survival rates in GNP were similar to the EK Trench during the 2000s (83%; Kunkel and Pletscher 1999). It is also possible that malnutrition is a greater factor now, given that the elk population is large and growing, while forage resources are stable or declining, because of forest in-growth, historic and current over-grazing, increases in invasive plants and human use/development (Stewart et al. 2006). However bone marrow samples collected during the late 2000s studies have not shown any evidence of malnutrition to date (T. Szkorupa, MoE, unpublished data).

The only other study to assess survival in the Kootenay Region was conducted on Natal Ridge, in the Elk Valley (Gibson and Sheets 1997). During this study, 51 cow elk were radio-collared between 1982 and 1992. Collared elk were 6.5 years old on average and were monitored for up to 13 years. The overall survival rate was 93% (SE = 2.1%). There was very little natural mortality, and most elk died from hunting, poaching or road/rail collisions. The overall survival rate was similar to the early East Kootenay Trench study (92%) during roughly the same time period. This is reasonable given that both populations had low predator densities, and similar elk hunting seasons.

Gibson and Sheets (1997) also found a higher overall survival rate for non-migratory elk (98%, SE = 1.5%) compared to migratory elk (90%; SE = 3.5%). Most resident cow elk died of natural causes, whereas most migratory cow elk died from hunting and poaching. Survival rates for migratory versus non-migratory elk have not yet been analysed for the current East Kootenay Trench study, however an initial assessment of the data suggests that the reverse may be true, with a higher mortality rate for non-migratory elk. The higher mortality rate appears to be primarily due to human causes, which is expected given that hunting seasons were designed to focus harvest on non-migratory elk.

For bulls, Gibson and Sheets (1997) reported an average survival of 77% between 1985 and 1995. The sample size was small (1-5 per year and 9 across all years) and the average lower and upper 95% confidence intervals were 47-100%. All mortality was due to hunting. The kill rate for 2-3 year old bulls was at least 10% of the standing population, whereas older age classes were harvested at about 3% (minimum estimate). During the study there were General Open Seasons that restricted the harvest to 3 point or better bulls for part of the season, and 6 point or better bulls for the remainder of the season. Out of 65 marked cows and bulls, the rate of poaching was estimated at 12 for every 100 legally killed elk. However this is likely an underestimate since only confirmed poaching incidents were included in the analysis.

Hunter and harvest data

General Open Hunting Seasons 1976-2009

General open hunting seasons changed many times between 1976 and 2009. In the West Kootenay, these seasons were restricted to south and central parts of the sub-region (MUs 4-06, 4-07, 4-18, and 4-19 to 4-30). In 1976, bull seasons were very liberal, with a 65 day any bull open season. Any bull seasons continued until 1989 and ran for 52 to 67 days, depending on the year and MU. In 1990, the GOS harvest was restricted to 3-point bulls (bulls with at least 3 point/tines on at least one antler), and in 1992 a 6-point season (bulls with at least 6 points/tines on at least one antler) was introduced in advance of the 3-point season. The West Kootenay general open seasons became more restrictive through the 1990s and 2000s, with increasingly longer 6-point seasons and shorter 3-point seasons until there was only a 6-point season by 1998.

The West Kootenay also had general open seasons for cow and calf elk from 1976 to 1986. These seasons ran for 6 to 17 days in select MUs and were generally held in October. There was then a 20 year span with no cow/calf GOS until 2007, when a youth/senior season was opened for 11 days in the Creston area only (portions of 4-06/4-07). Archery seasons began in the West Kootenay with a 9-day any bull hunt in 2000. Starting in 2005, bow-hunters were also permitted to harvest a cow or calf elk in the Creston area during the same 9-day period.

In the East Kootenay (Golden, Cranbrook and Fernie GMZs), there were long (51-58 day) 3-point bull seasons from 1976 to 1981. From 1982 to 1991, there were long (41 day) 3-point bull seasons followed by short 6-point seasons. Over time, the 6-point season was reduced from 16 to 5 days. In 1992, the order of the 6-point and 3-point seasons was reversed, with the 6-point season opening first. Through the 1990s the length of the 6-point season was lengthened from 11 days to 30 days, as the 3-point season was reduced from 30 days to 11 days. In 1998, the 3-point season was cancelled, and the 6-point season was lengthened to 41 days. This September 10th to October 20th season was still in place in 2009.

In the East Kootenay, the first GOS for cow/calf elk was instituted in 2007. This September 10th to 20th season was restricted to youth and senior hunters in low elevation areas of the East Kootenay Trench (Zone X). MoE opened archery seasons in 1988, beginning with a 5 day 3-point or better bull season which was expanded to 9 days in 1990. The 9-day archery season was expanded to include any bull in 2000, and any elk in 2005 (although cow/calf elk could only be hunted in Zone X).

Limited Entry Hunt Opportunities 1984-2009

As with general open seasons, LEH seasons and numbers of permits varied significantly over time and among MUs within the Kootenay Region. Between the mid 1980s and mid 1990s, there were large numbers of calf only and cow/calf (where either a cow or calf may be hunted) permits throughout the region. Seasons ran from October to November or December. In the Nelson GMZ, calf only and cow/calf permits were issued in different MUs depending on the year and in the Revelstoke GMZ, calf and cow seasons were restricted to MUs 4-27 to 4-30. In the Fernie GMZ, MU 4-23 (Elk Valley) had no LEH season between 1998 and 2006, and MU 4-01 (Flathead) had no LEH season after 1997. Over this time period, MoE increased calf-only permits in the Revelstoke GMZ (Figure 15), decreased permits in the Golden GMZ (Figure 17), and increased then decreased permits in the Nelson (Figure 16), Cranbrook (Figure 18) and Fernie (Figure 19) GMZs. Calf-only seasons were cancelled by 1994 in the Golden, Cranbrook and Fernie GMZs, by 1997 in the Revelstoke GMZ, and by 1999 in the Nelson GMZ. Cow/calf permits were generally stable between the mid 1980s and mid 1990s, until 1998 when every cow/calf season was closed except for the Creston area.

Since the late 1990s, cow and calf seasons remained closed in the Revelstoke and Golden GMZs. In the Nelson, Cranbrook and Fernie GMZs, cow/calf permits increased through the 2000s. In the Nelson GMZ, recent cow/calf hunts focused on agricultural areas in the Slocan Valley and Creston area, and ran from September to January. In the Cranbrook and Fernie GMZs recent cow/calf hunts were restricted to low elevation agricultural areas and closed in mid-October to focus the harvest on non-migratory (i.e., resident or homesteader) elk.

Limited entry hunting for bulls only occurred in the West Kootenay (Revelstoke and Nelson GMZs), and ran from September 10th to October 31st. These hunts were restricted to bulls with at least 3 points. MoE issued an increasing number of permits over time since 1984, because of rising population estimates, and because new MUs were opened to LEH hunting. In the Nelson GMZ, bull LEH seasons began in MU 4-08, 4-09 and 4-15, and were expanded to include MUs 4-17 in 1989, 4-16 in 1996 and 4-14 in 2007. In the Revelstoke GMZ, the first bull LEH season was opened in MU 4-33 and was expanded to include MUs 4-32 in 1993, 4-38 in 2002, and 4-31 in 2007.

Any sex/age permits were issued for MU 4-06 only, and ran from November to January in the 1980s and 1990s and from September to December in the early 2000s. From the mid 1980s to mid 1990s the number of any age/sex permits declined slightly. MoE closed the any age/sex season in the late 1990s, and then issued a small number of permits in the early 2000s until the season was again closed in 2004.

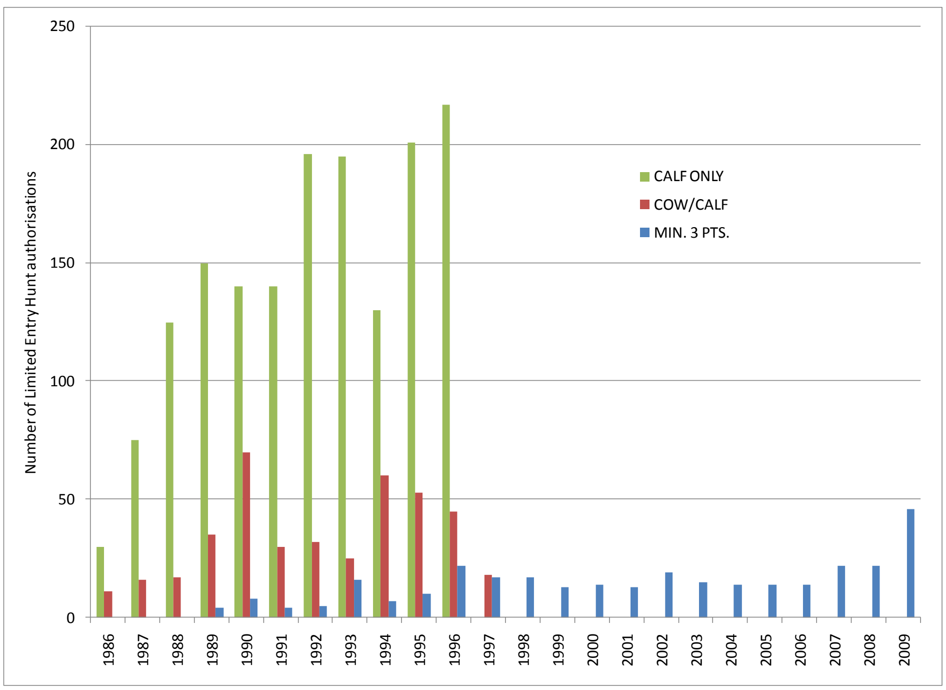

Figure 15. Number of Limited Entry Hunt authorizations issued in the Revelstoke Game Management Zone from 1984 to 2009. Cow/calf authorizations permit hunters to harvest a cow or a calf. Bull authorizations restrict harvest to bulls with at least 3 points (or tines) on at least one antler.

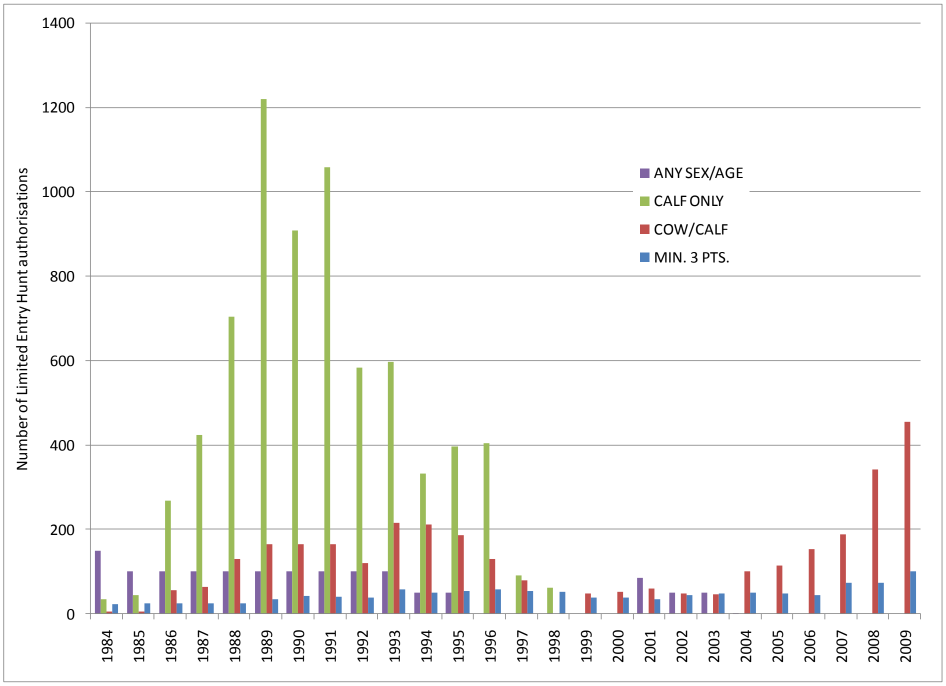

Figure 16. Number of Limited Entry Hunt authorizations issued in the Nelson Game Management Zone, 1984 to 2009. Cow/calf authorizations permit hunters to harvest a cow or a calf. Bull authorizations restrict harvest to bulls with at least 3 points (or tines) on at least one antler.

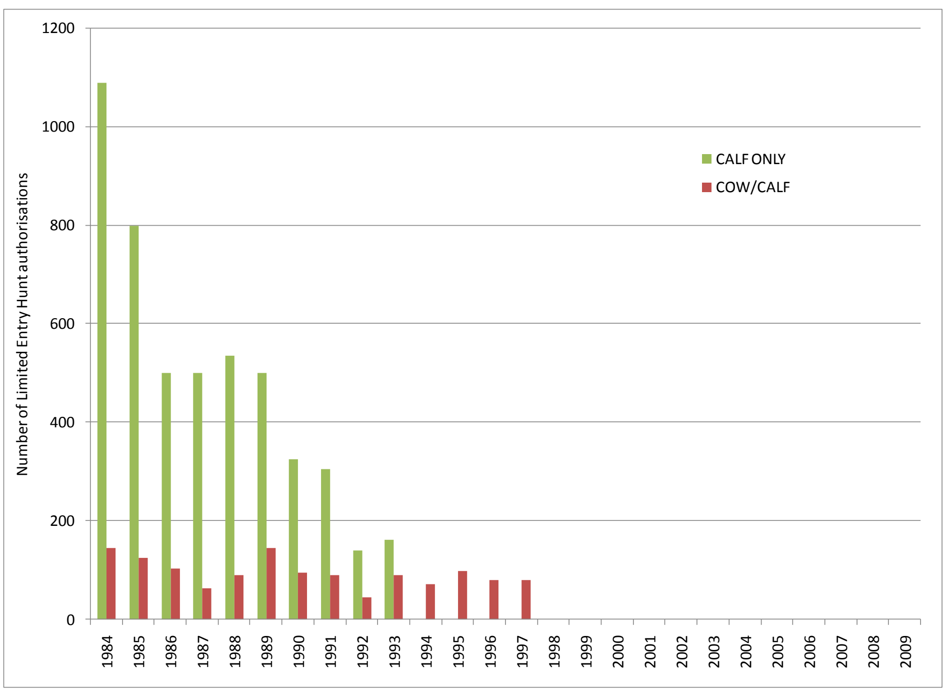

Figure 17. Number of Limited Entry Hunt authorizations issued in the Golden Game Management Zone from 1984 to 2009. Cow/calf authorizations permit hunters to harvest a cow or a calf.

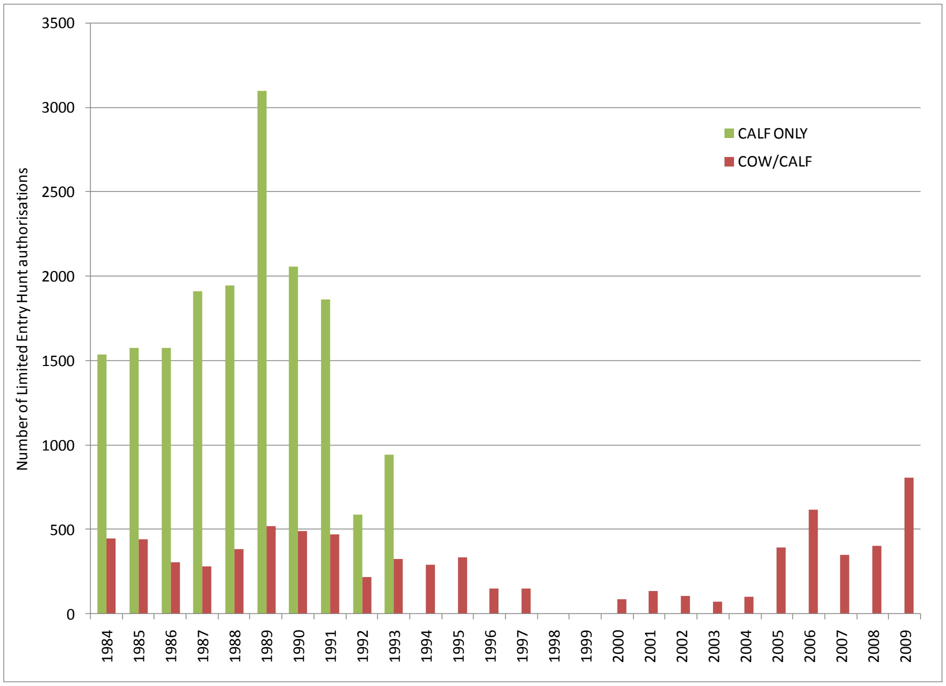

Figure 18. Number of Limited Entry Hunt authorizations issued in the Cranbrook Game Management Zone from 1984 to 2009. Cow/calf authorizations permit hunters to harvest a cow or a calf.

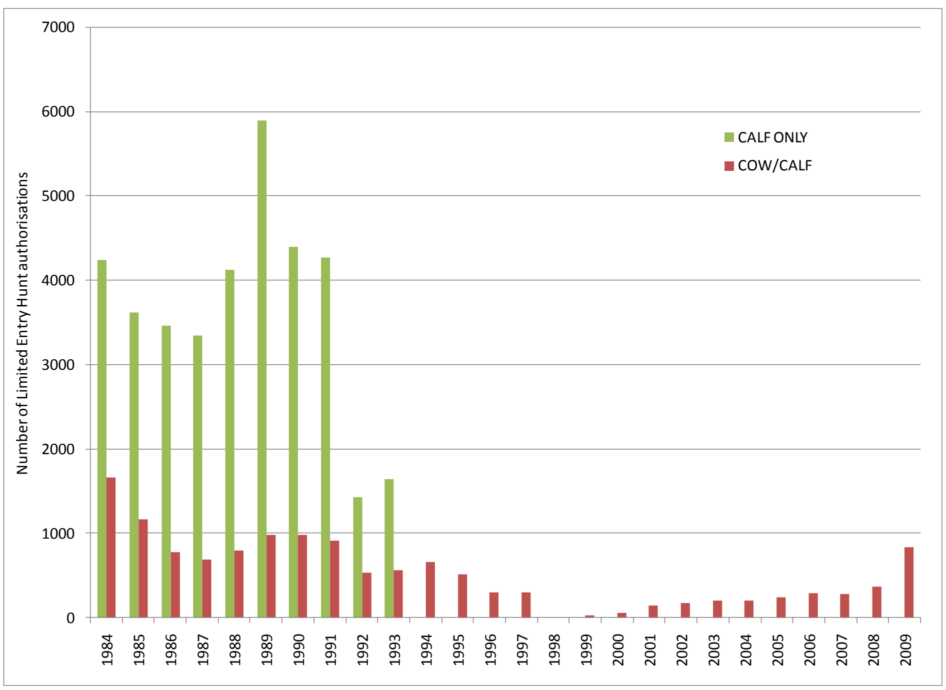

Figure 19. Number of Limited Entry Hunt authorizations issued in the Fernie Game Management Zone from 1984 to 2009. Cow/calf authorizations permit hunters to harvest a cow or a calf.

Number of Resident Elk Hunters 1976-2008

The number of elk hunters in the Kootenay Region peaked in the mid 1980s at over 14,000 hunters, declined through the 1990s to under 5,000 hunters, and increased in the 2000s up to nearly 10,000 hunters (Figure 20). The majority of hunters were in the Fernie GMZ, followed by the Cranbrook GMZ, then the Nelson and Golden GMZs. There were relatively few elk hunters in the Revelstoke GMZ.

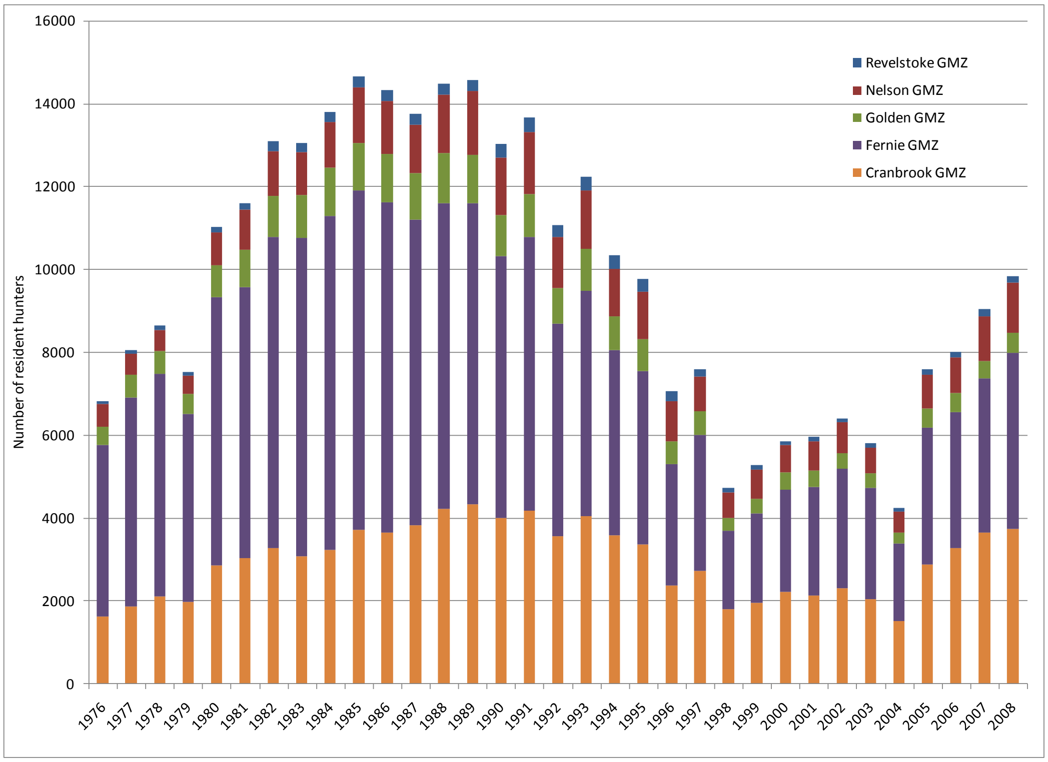

Figure 20. Number of resident elk hunters in the Kootenay Region, by Game Management Zone (GMZ) from 1976 to 2008. Data are from the BC Ministry of Environment's Hunter Sample Questionnaire.

In the Revelstoke GMZ, the long-term average was approximately 200 hunters per year and peaked at over 350 hunters in the early 1990s. The number of hunters in recent years (2007 and 2008) was about 80% of the long term average. Hunter numbers in the Nelson GMZ were close to 1,000 on average with over 1,500 during the late 1980s peak. In 2008, there were over 1,200 hunters, which exceeded the long term average.

In the Golden GMZ, there were over 700 hunters per year on average with a peak of over 1,200 hunters in the late 1980s. Recently, hunter numbers were approximately 65% of the average. Hunters in the Cranbrook GMZ peaked in the late 1980s and exceeded 4000 for several years. The long term average of approximately 3,000 hunters per year was approached in 2005 and exceeded by 2006. In the Fernie GMZ, there was an average of about 5,000 hunters per year. During the 1980s, there were consistently over 7,000 hunters and over 8,000 hunters in a couple of years. Recent hunter numbers were about 80% of the long term average.

The overall decline in the number of elk hunters has several potential explanations. First, hunting has declined in British Columbia and across North America for a variety of social reasons (Thornton 2007). Second, many hunting seasons have become more restrictive over time which has likely deterred some hunters. For example, the number of cow/calf hunting opportunities dropped substantially in the late 1990s. The trend in hunter number largely mirrors the trend in LEH opportunities over time and in different parts of the region. In some areas, such as the Flathead (MU 4-01), Golden GMZ and Revelstoke GMZ, LEH hunts for cow or calf elk closed in the late 1990s and have remained closed. The Elk Valley (MU 4-23), a very popular elk hunting area, had LEH seasons in the 2000s, but for a very small area that was restricted to youth and seniors only. Bull seasons became increasingly restrictive over time, with limited opportunities to hunt smaller bulls (e.g., 3 point or better). Third, the number of hunters likely declined as the elk population declined through the 1990s. Survey data suggest that the elk population dropped in the late 1990s, so there were simply fewer elk to hunt and hence fewer hunters. In the 2000s the elk population recovered in most parts of the region and the number of hunters increased correspondingly.

Elk Harvest 1976-2008

In the Kootenay Region, the elk harvest peaked in the mid 1980s, declined through the 1990s, and then increased through the 2000s (Figure 21). The bull and cow harvest in recent years (2005-2008) approached mid 1980 levels, however the calf harvest remained substantially lower. This trend largely holds for the individual GMZs, with a few exceptions as discussed below.

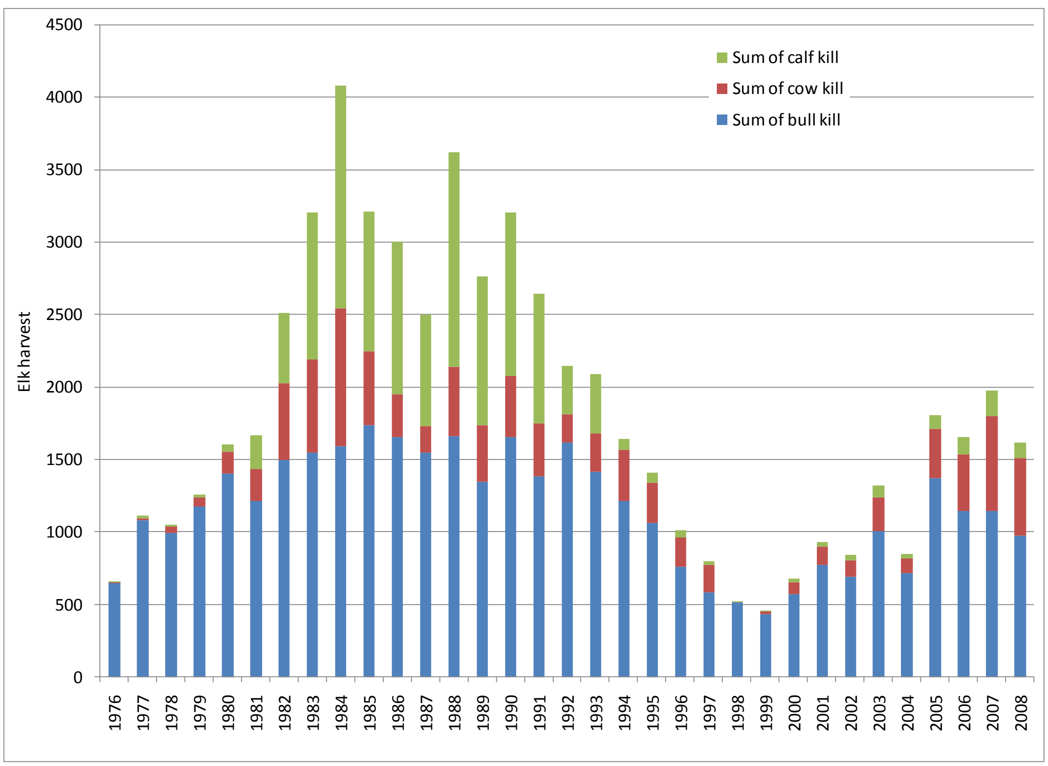

Figure 21. Estimated elk harvest by sex and age in the Kootenay Region from 1976 to 2008. Data are from the BC Ministry of Environment's Hunter Sample Questionnaire.

In the Revelstoke GMZ, the annual bull harvest was typically below 30 (Figure 22), with the highest recorded harvest in 2007. The recent increase in bull harvest was likely because MoE opened new units to hunting (e.g., MU 4-31), and increased the number of permits across this GMZ. This was in response to elk population increases and expansions in distribution over the past three decades. In addition, elk populations have likely increased in the MUs with GOS, providing additional opportunities for 6-point bull harvest. We are uncertain why the bull kill dropped in 2008, since the number of LEH permits was similar to 2007. Given the small sample size (i.e., number of permits), random annual effects (e.g., poor weather) can have major impacts on success rates and hence kill. Cow/calf seasons were halted in this GMZ in 1996. However when cow/calf seasons were in place, the harvest was minimal, with fewer than 10 cows and 10 calves harvested in most years.

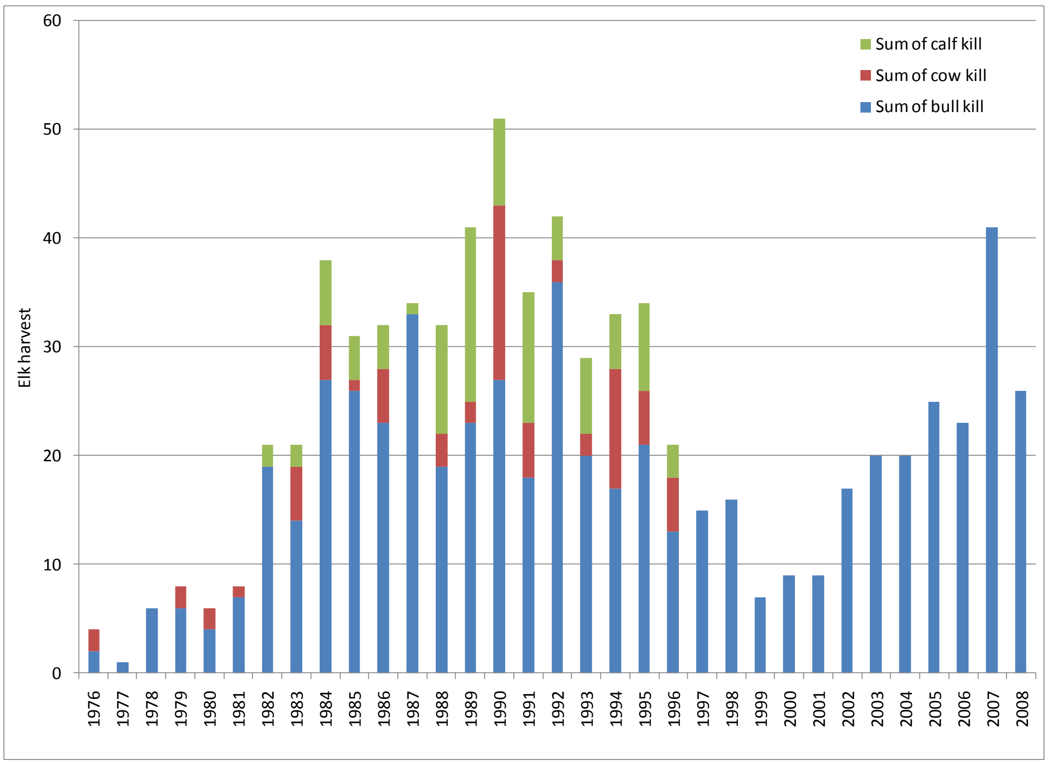

Figure 22. Estimated elk harvest by sex and age in the Revelstoke Game Management Zone (MU 4-27 to 4-33, 4-38 and 4-39) from 1976 to 2008. Data are from the BC Ministry of Environment's Hunter Sample Questionnaire.

In the Nelson GMZ, the bull harvest increased through the late 1970s until the late 1980s, when the harvest averaged around 150 bulls per year (Figure 23). The bull harvest then declined through the 1990s to a low of 65 in 2000, and has subsequently increased to a peak of over 200 bulls in 2007. The bull harvest in the mid 2000s was similar to the late 1980s despite more restrictive general open seasons (6-point or better bulls only) and only slight increases in bull LEH permits. The cow/calf harvest varied substantially among years in the 1980s, with an average of 30 cows and 30 calves harvested per year. The cow/calf harvest declined in the early 1990s and increased again in the 2000s. The estimated 2008 cow harvest was the highest recorded since 1976.

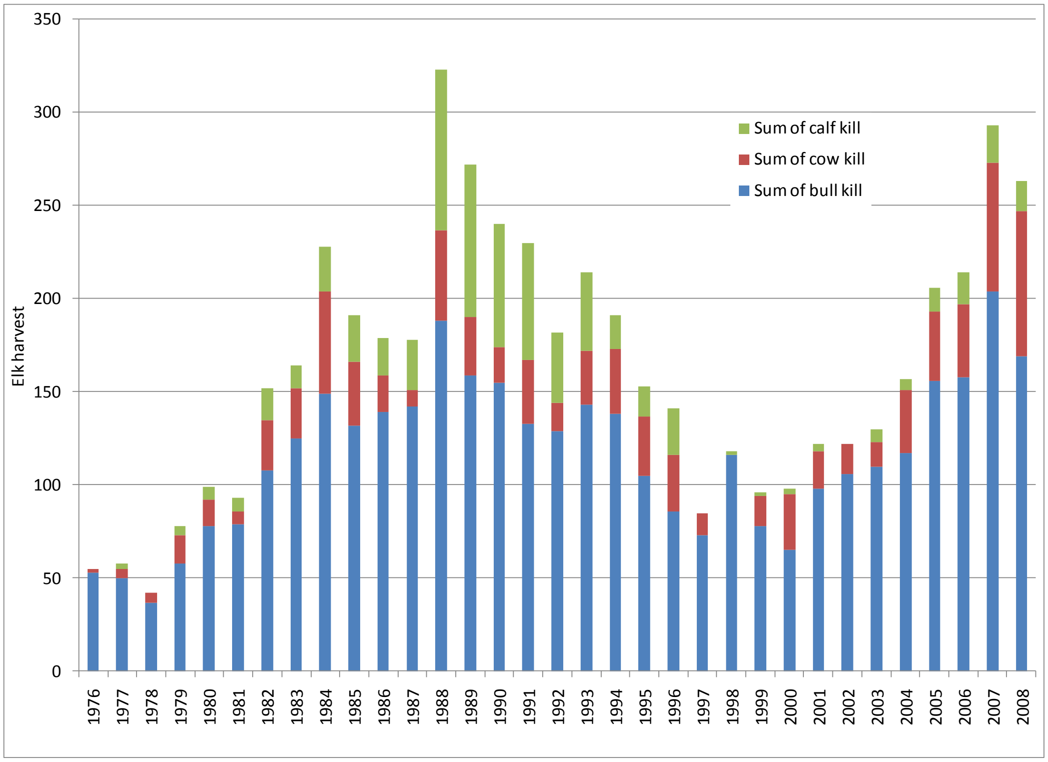

Figure 23. Estimated elk harvest by sex and age in the Nelson Game Management Zone (MUs 4-06 to 4-09, 4-14 to 4-19) from 1976 to 2008. Data are from the BC Ministry of Environment's Hunter Sample Questionnaire.

In the Golden GMZ, bull harvest in the 1980s and early 1990s fluctuated around 100 and peaked at just under 130 in 1992 (Figure 24). Bull harvest dropped dramatically in the late 1990s and hit a low of 20 in 2000. In the 2000s bull harvest has increased slightly, but still remains at half the 1980s levels. This may in part be attributed to relatively few hunters in recent years, with just over half of the long term average (see below). Cow and calf harvest in the 1980s varied annually, ranging from similar numbers to the bull harvest to half of the bull harvest.

In the Cranbrook GMZ, bull harvest fluctuated around 380 in the 1980s, increased in the early 1990s, declined through the mid 1990s and increased again in the 2000s (Figure 25). Between 2005 and 2007 an average of 400 bulls were harvested per year, which surpassed average 1980s levels and approached early 1990s levels. This is despite significantly more restrictive seasons (no 3-point or better opportunities) and a fraction of the hunters, which suggests a growing, and perhaps historically high population in this GMZ. The cow elk harvest peaked in 2005-2008; the 2007 harvest was more than double 1980s levels. This was notwithstanding similar number of permits as in the 1980s and significantly shorter cow/calf seasons; hence success for cows in particular must be up. In 2007, there was also a GOS for youth and senior hunters which increased the cow and calf harvest, but only slightly compared to 2005 and 2006 levels. Calf harvest was highest in the early 1980s to early 1990s with an average of more than 350 calves harvested per year. The recent calf harvest is much lower than historic levels because MoE currently issues cow/calf (antlerless) permits and not calf-only permits. Hunters apparently select cows over calves when given the choice. In the 1980s, MoE issued thousands of calf only permits. This was thought to have minimal impact on the elk population since it was assumed that hunting mortality was compensated for by an increase in survival for the remaining population (i.e., compensatory mortality).

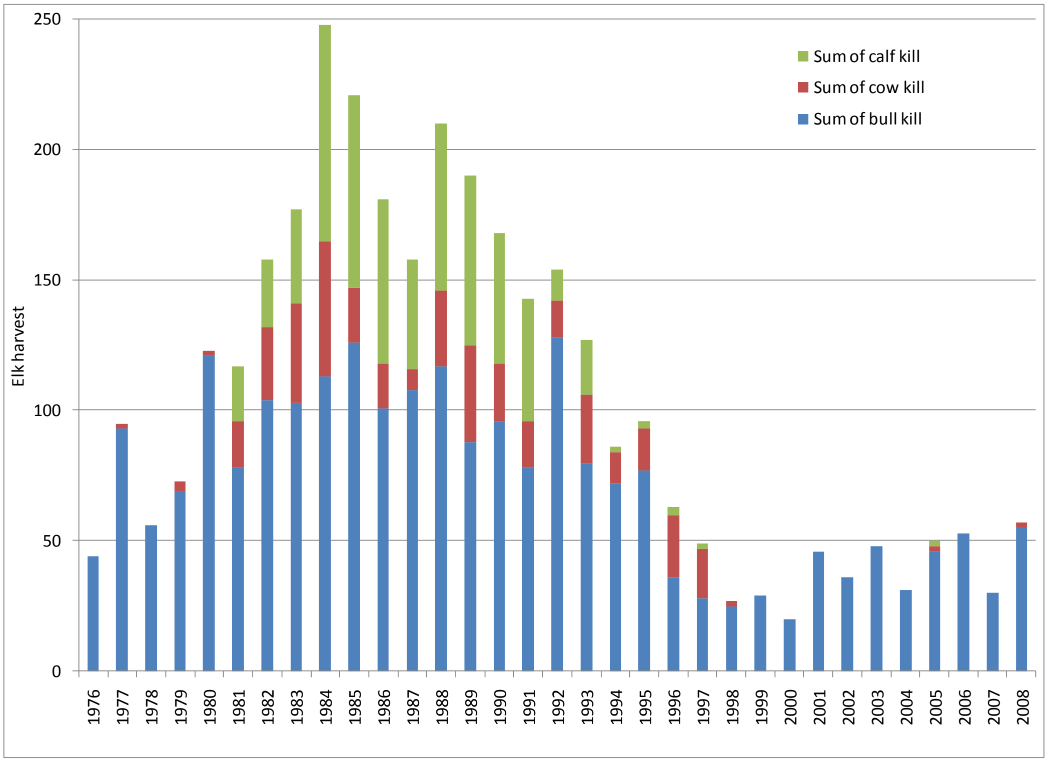

Figure 24. Estimated elk harvest by sex and age in the Golden Game Management Zone (MUs 4-34 to 4-37 and 4-40) from 1976 to 2008. Data are from the BC Ministry of Environment's Hunter Sample Questionnaire.

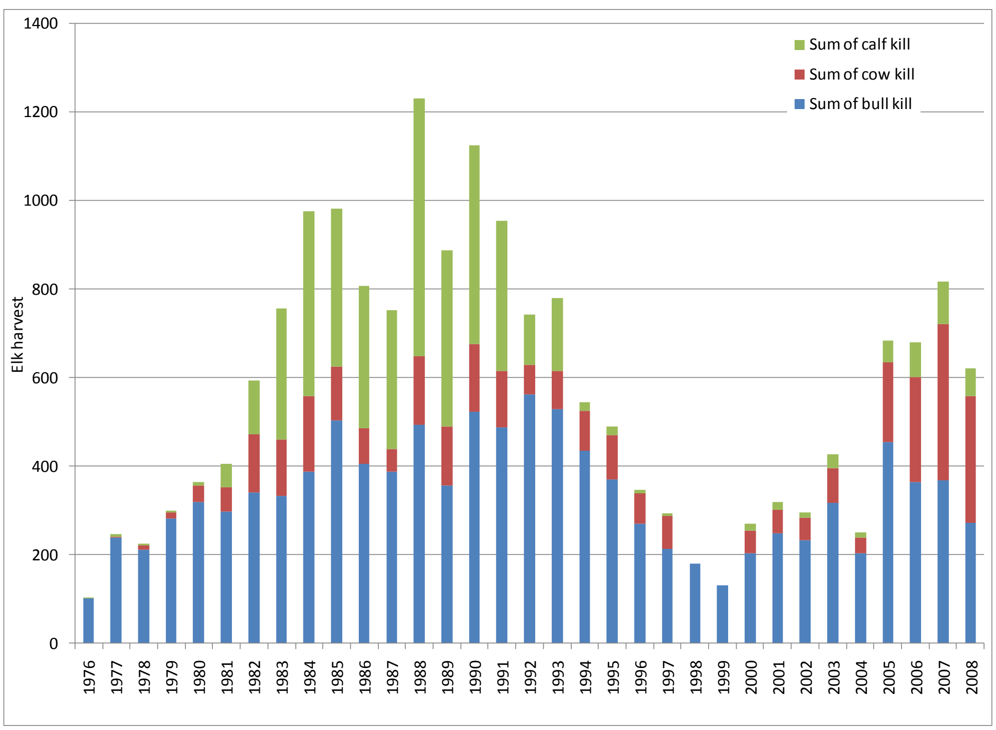

Figure 25. Estimated elk harvest by sex and age in the Cranbrook Game Management Zone (MUs 4-03 to 4-05, 4-20 and 4-26) from 1976 to 2008. Data are from the BC Ministry of Environment's Hunter Sample Questionnaire.

In the Fernie GMZ almost 900 bulls were harvested per year in the 1980s. This number declined through the 1990s to a low of 180 bulls (Figure 26). The bull harvest increased in the 2000s but remained well below 1980s levels. There are currently more restrictive bull seasons (6 point only), but this is also the case for the Cranbrook GMZ. A steady decline in hunter numbers may explain the relatively low bull harvest recently in the Fernie GMZ. In recent years, the number of hunters was still below the historic average in this GMZ, in contrast to the Cranbrook GMZ, where recent hunter numbers were on par with the historic average. The harvest data suggest that the elk population in the Fernie GMZ may be approaching or at levels in the 1980s and early 1990s, however the kill may be down because of fewer hunters.

The cow/calf harvest in the Fernie GMZ varied substantially among years through the 1980s, with an average of 270 cows and close to 500 calves harvested each year. By 2007, the cow harvest approached 1980s levels but the calf harvest remained well below. As in other GMZs, harvest levels were down in 2008 largely because of relatively low hunter success that year. Although LEH opportunities have increased in the Trench portion of the GMZ (MUs 4-02, 4-22 and 4-21), recent cow/calf hunts were very restrictive in the Elk Valley (few permits for youth and seniors only, and a small area) and there was no cow/calf season in MUs 4-01, 4-24 or 4-25.

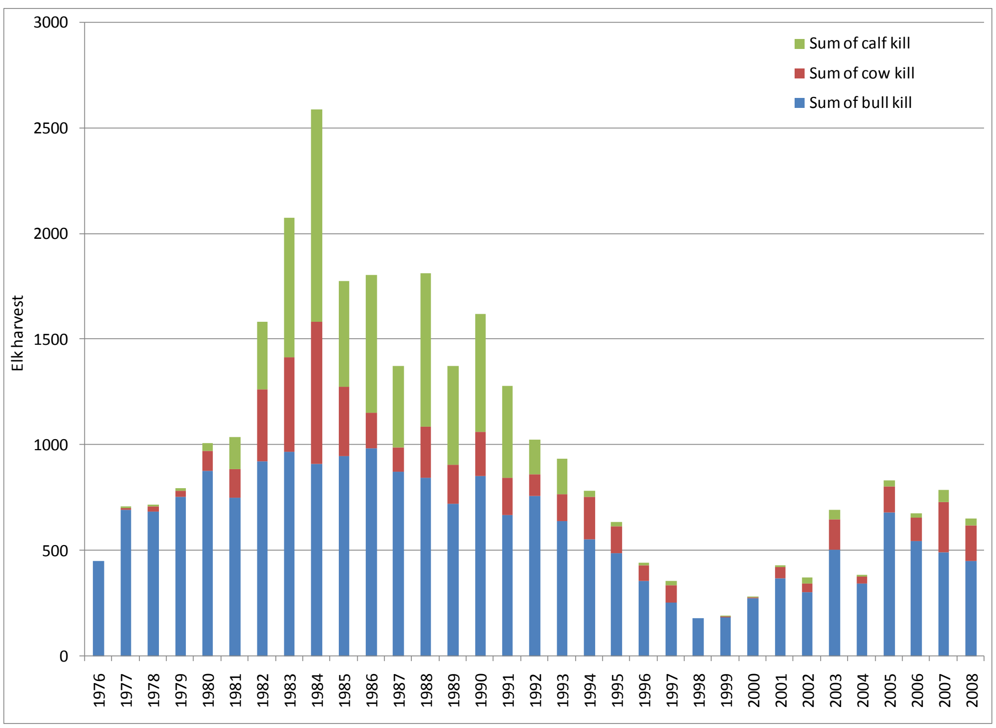

Figure 26. Estimated elk harvest by sex and age in the Fernie Game Management Zone (MUs 4-01, 4-02, 4-21 to 4-25) from 1976 to 2008. Data are from the BC Ministry of Environment's Hunter Sample Questionnaire.

Hunter Success 1976-2008

Many factors can influence hunter success, such as hunter opportunity (e.g., number of LEH permits), access, seasons (e.g., length of season and antler restrictions), weather, and hunter interest. Hatter (2001) found that for deer, hunter success data underestimated the rate of population decline, and overestimated the rate of population increase.

In the West Kootenay, hunter success increased through the late 1970s and 1980s, declined in the early 1990s, increased in the early 2000s and then fluctuated annually around a relatively high average (Figure 27). In the Revelstoke GMZ, success was generally between 5 and 15% except during the 2000s, when success climbed to 15-23%. The recent high success was despite a lack of cow/calf hunts, which typically provide for higher success. The number of hunters in this GMZ was lower in the mid 2000s compared to the 1980s, which may be attributed to a lack of cow/calf opportunities, the closure of several MUs to elk hunting until recently, and 6-point antler restrictions in the MUs with GOS.

Success was higher in the Nelson GMZ, ranging from 10 to 20% in most years and peaking at 30% in 2004. The high kill and hunter success in the 2000s compared to historic levels suggest that the population has increased significantly in recent years, and is likely at a historic high. The cow elk harvest also peaked in 2007, notwithstanding fewer permits than in the mid 1990s. This is attributable to high hunter success that year.

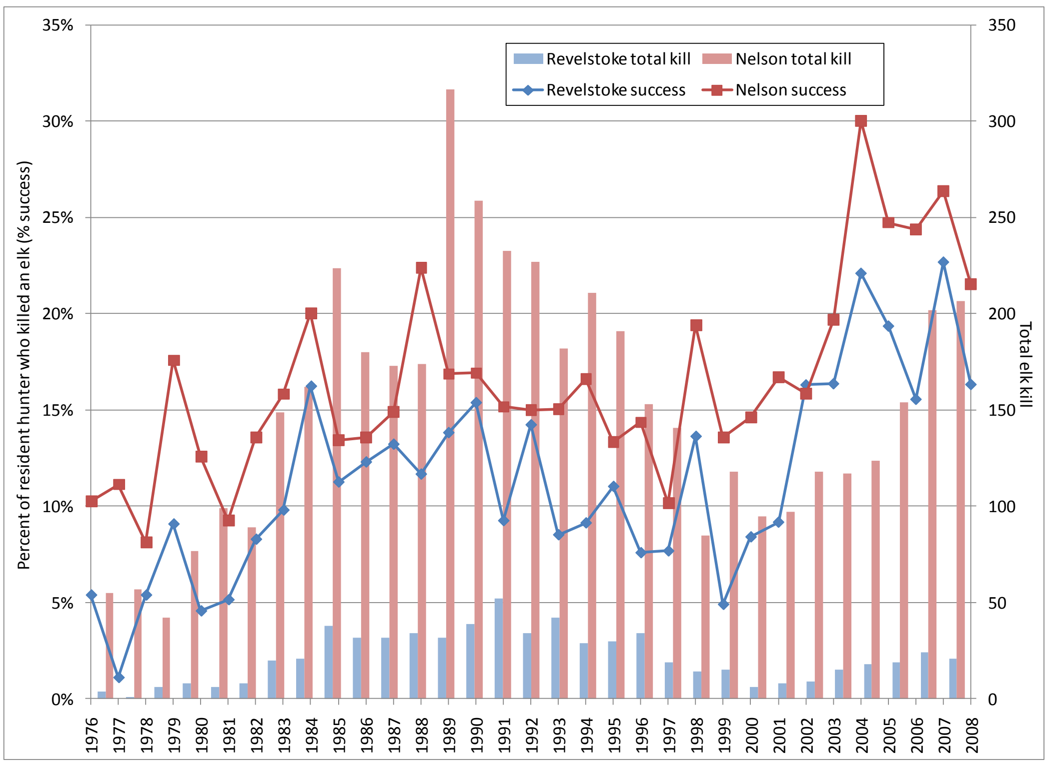

Figure 27. Resident hunter percent success (percent of elk hunters who killed an elk) from 1976 to 2008 for West Kootenay Game Management Zones (Revelstoke and Nelson).

In the East Kootenay, success peaked in the 1980s, declined steeply through the 1990s and has generally increased in the 2000s (Figure 28). Success in the southern part of the East Kootenay (Cranbrook and Fernie GMZs) was generally higher than in the north (Golden GMZ). The variation in success among years was substantial, ranging from less than 5% to over 30%, depending on the year and location. Success during any one year is therefore relatively uninformative, yet trends over time may point to changes in population size.

In the Golden GMZ, success increased in the 2000s relative to the late 1990s, but was much lower than in the mid 1980s. This is in contrast to all other GMZs, which had significant increases in success in the 2000s. The recent low success may be due to changes in hunting seasons over time. In the 1980s, hunters could harvest 3-point or better bulls and there were hundreds of cow/calf LEH permits with seasons that ran until November or December. In the 2000s, the bull general open season was restricted to 6-point or better bulls and there were no cow/calf seasons. However other GMZs also had more restrictive seasons in the 2000s compared to the 1980s and early 1990s, yet bull harvest and hunter success was high. This suggests that the elk population in the Golden GMZ may currently be lower than 1980s/1990s levels.

In the Fernie and Cranbrook GMZs, success rose in the early 2000s when the hunting seasons were primarily for bulls only, suggesting an increasing population. In the 1980s, average hunter success was 20% for both GMZs. Recent (2005 to 2008) success was at this level for the Cranbrook GMZ (20%) and close for the Fernie GMZ (18%). The hunting seasons differed between these periods, so a direct comparison is tenuous. In the 1980s, bull seasons were more liberal, with 3 point or better seasons, and many cow/calf LEH permits were issued for late fall, when hunting is generally more successful. In the 2000s, general open seasons for youth/senior hunters were introduced. We might expect these seasons to have lower success than seasons open to all hunters since youth are less experienced, and some seniors are less mobile. Overall, the high recent success under comparatively restrictive seasons suggests the elk populations in the Cranbrook and Fernie GMZs may be close to 1980s levels.

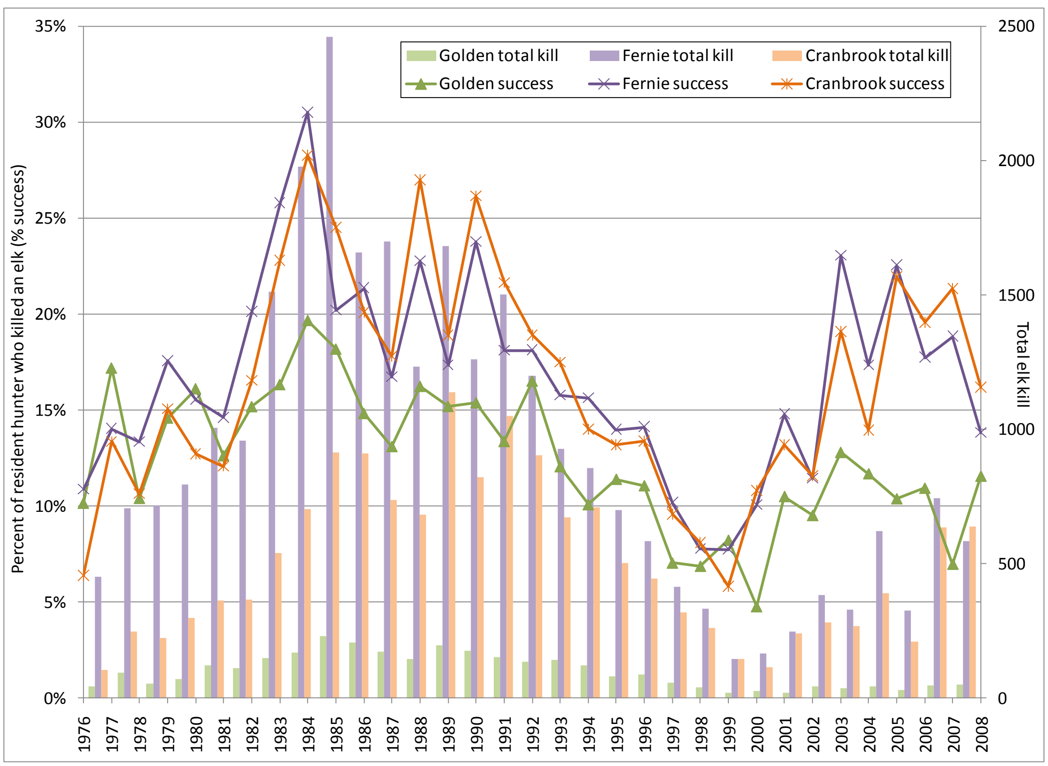

Figure 28. Resident hunter percent success (percent of elk hunters who killed an elk) from 1976 to 2008 for East Kootenay Game Management Zones (Golden, Cranbrook and Fernie).

Weather data

Summer (April to September) precipitation averaged 229 mm (95% CI: 205-252 mm) at the Cranbrook airport and 319 mm (95% CI: 291-346 mm) at the Castlegar airport (Figure 29). As indicated by the 3-year running average, summer precipitation peaked in the early 1980s, mid 1990s and mid 2000s, and hit historic lows in the early 2000s. In Cranbrook, very dry years (less than 176 mm, the lower quartile) were more common in the 2000s, and to a lesser extent in the 1990s, than in the 1970s and 1980s. In Castlegar, all 3 very dry summers (less than 264 mm, the lower quartile) occurred in the 2000s.

Total snowfall was about 60% higher in Castlegar compared to Cranbrook (Figure 30). The Cranbrook average was 127 cm/year (95% CI: 111-143 cm) and the Castlegar average was 202 cm/year (95% CI: 180-223 cm). Over this 30-year span, the maximum snowfall at both locations occurred in 1996-97.

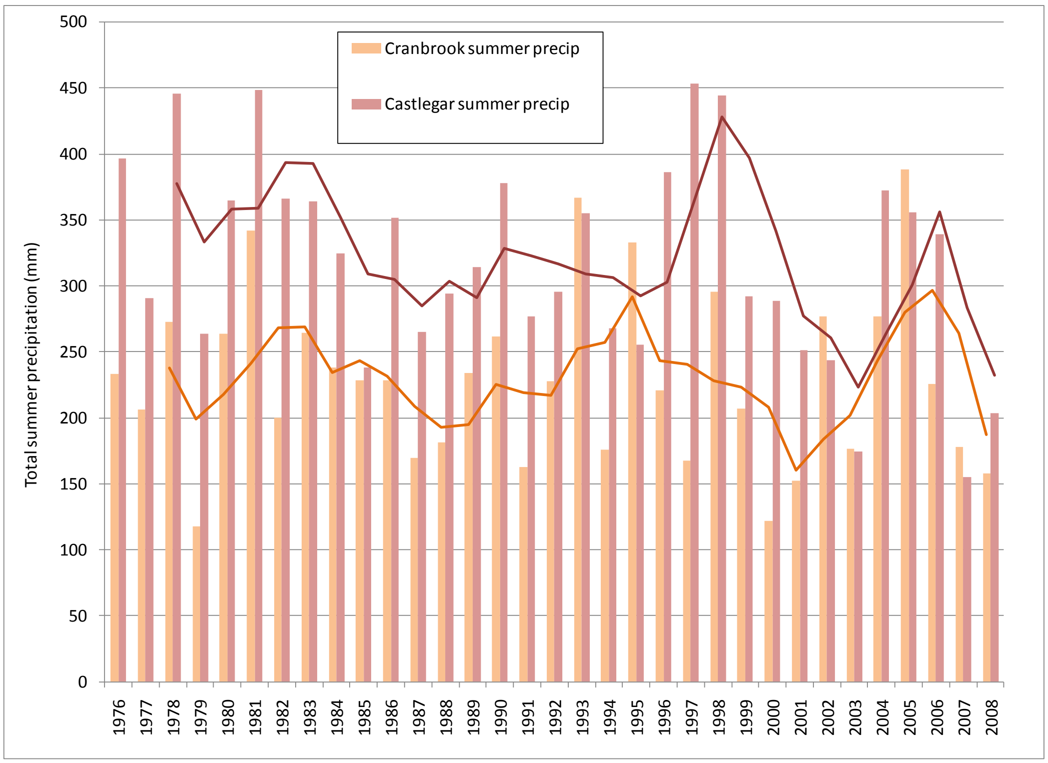

Figure 29. Total summer precipitation (mm) at the Cranbrook and Castlegar airports, from 1975 to 2008. Lines represent the 3-year running average.

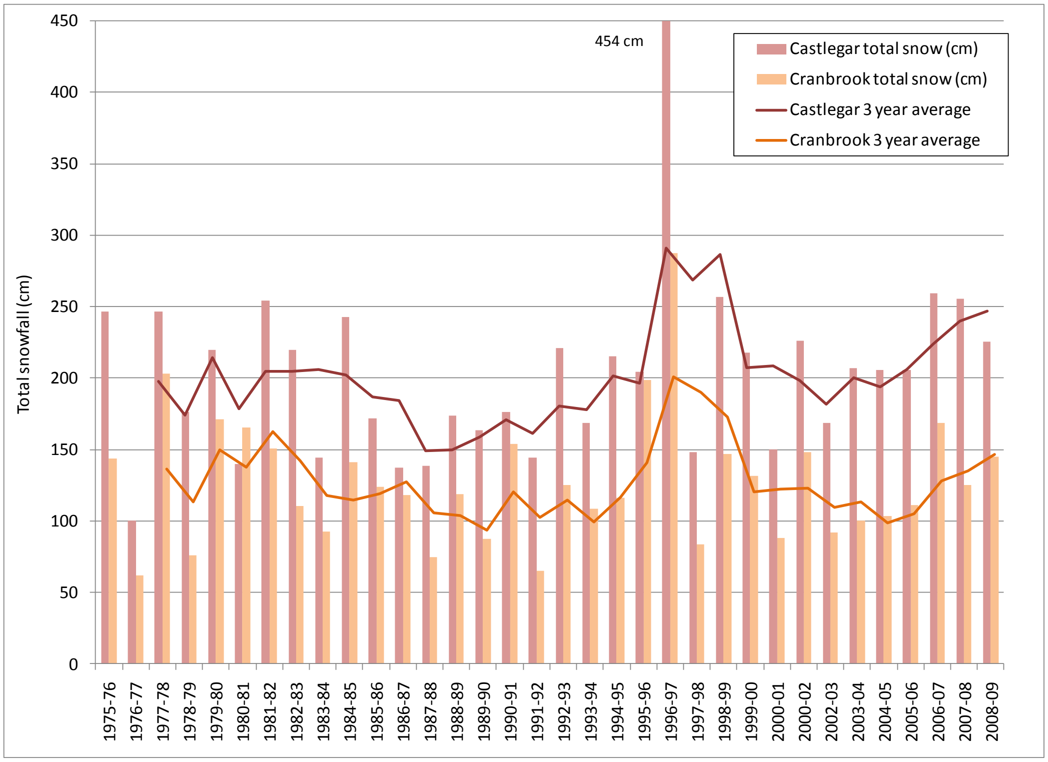

Figure 30. Total snowfall (cm) at the Cranbrook and Castlegar airports, from 1975 to 2009. Lines represent the 3-year running average.

Conclusions

For this population review, we chose to broadly assess the most likely factors that may affect calf ratios, bull ratios and population trends over time. These were simply visual assessments that will be used to guide future, more thorough analyses. We will also investigate relationships among variables through concurrent population modelling (Cooper et al. 2003). For calf and bull ratios, we assessed the potential effect of harvest, weather and predation. We then assessed whether calf ratios, adult female survival and harvest rates affected population trends. We focused on the West Kootenay and East Kootenay sub-regions, because data at finer scales (e.g., individual GMZs) were often not available. Although other factors, such as available forage, may also affect elk populations, data were unavailable to assess relationships graphically. However we discuss relationships in general terms whenever possible.

West Kootenay

Calf ratios

Calf ratio data for the West Kootenay were sporadic and hence data interpretation is tenuous. However higher ratios in the 1980s compared to the 2000s may be due to smaller predator populations in the past (Figure 31). Cougar kill data suggest that the cougar population may have declined since the late 1990s, which may explain higher calf ratios in the late 2000s compared to the early 2000s. Wolf populations have expanded across the West Kootenay and have likely increased in numbers (Mowat 2007). Mowat (2007) also suggests that grizzly bears increased in many parts of the region over the past 30 years; bears can kill significant numbers of calf elk (Cole 1972; Barber-Meyer et al. 2008; Murrow et al. 2009). Hence calf ratios in the West Kootenay may remain below 1980s levels if predator populations stay high.

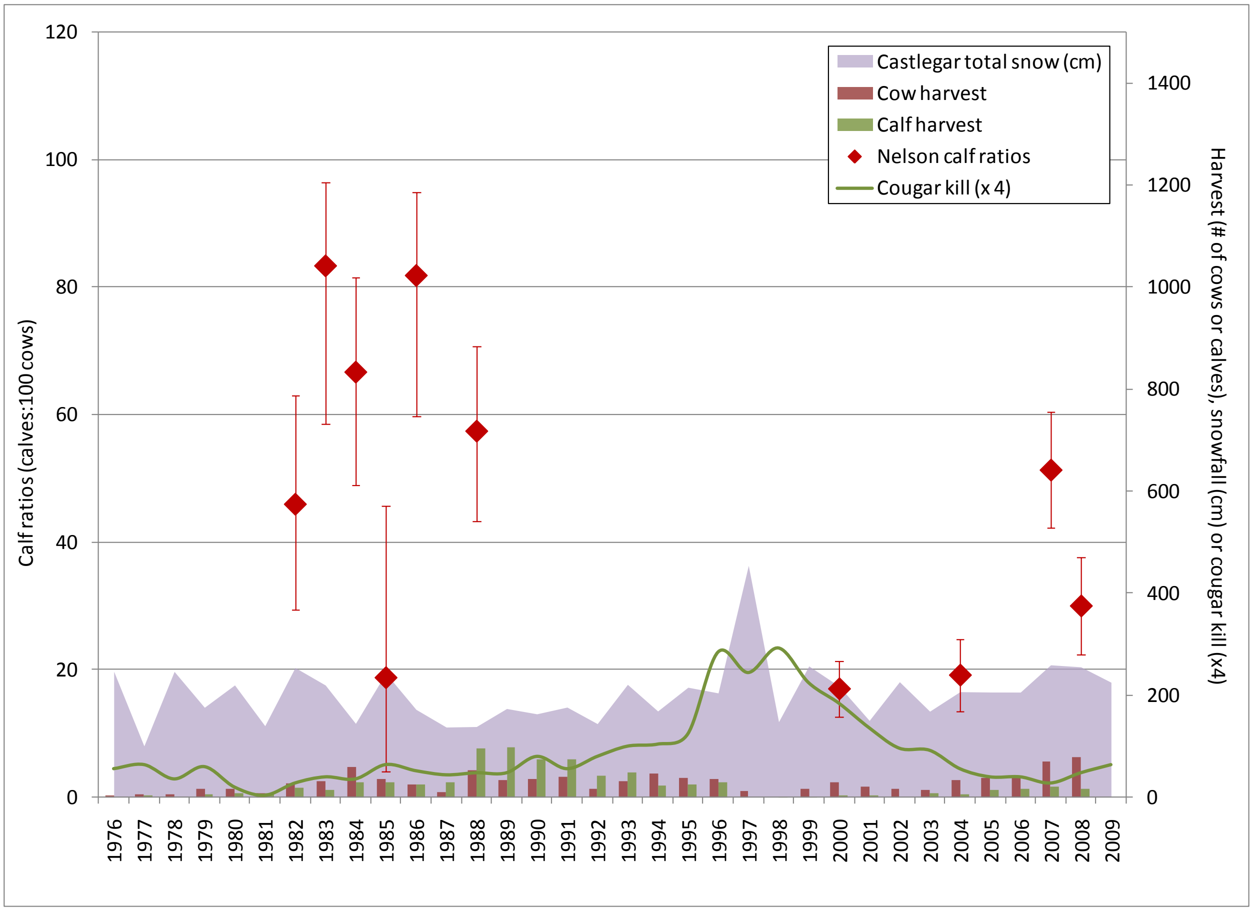

Figure 31. West Kootenay calf ratio trends, 1976-2009, relative to harvest, snowfall and an index of cougar predation. Calf ratios for 2004 represent the average from 2 studies. Cow and calf harvest is for Revelstoke and Nelson Game Management Zones. Snowfall was from the Castlegar Airport. Annual hunter kill of cougars was multiplied by 4 to facilitate viewing on the secondary y-axis.

The West Kootenay calf harvest was high in the 1980s, but this did not appear to impact calf ratios, perhaps because there was substantive cow harvest at the same time. The only winter with fewer than 40 calves: 100 cows (1985) did have a relatively high calf harvest the preceding fall (1984), which could have been a factor. However sample sizes for calf ratios were small, particularly for the 1980s (reflected by large error), and there is hence much uncertainty about true calf ratios.

We did not detect observe a relationship between snowfall and calf ratios. However exceptionally dry summers in the 2000s may have negatively impacted calf survival and recruitment. Other studies have documented relationships between summer or spring precipitation and calf survival or recruitment (Singer 1997; Lubow et al. 2002; Lubow and Smith 2004).

Bull ratios

As with calf ratios, assessing bull ratios in the West Kootenay is difficult because of few studies, data from different study areas and small sample sizes (hence large error). That said, the data point to declining bull ratios through the 1980s (Figure 32). One data point suggests ratios were still low in the early 2000s, but increased in the mid to late 2000s. The most recent data (2008) suggest a recent drop in bull ratio, yet it was still higher than the late 1980s and early 2000s.

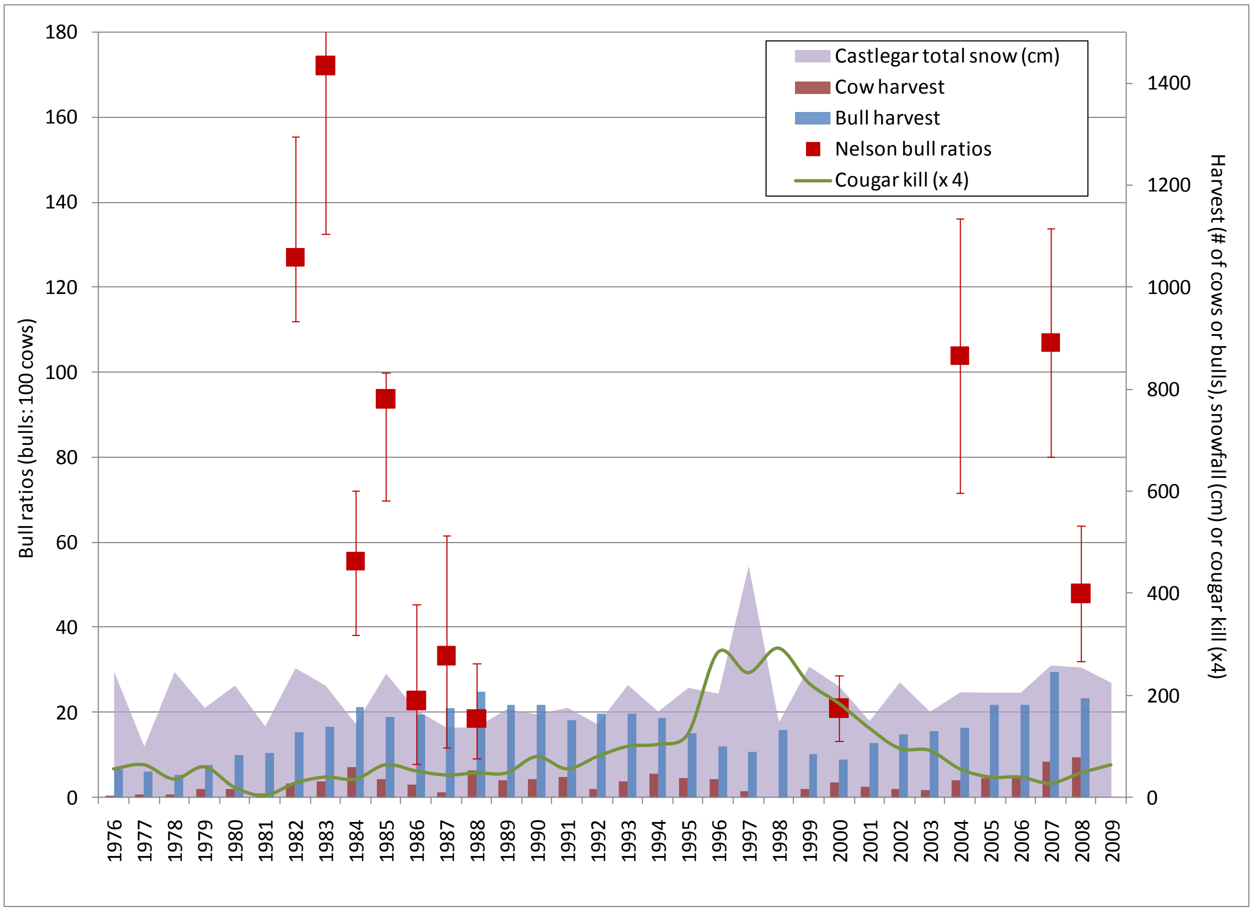

Figure 32. West Kootenay bull ratio trends, 1976-2009, relative to harvest, snowfall and an index of cougar predation. Bull ratios for 2004 represent the average from 2 studies. Bull and cow harvest is for Revelstoke and Nelson Game Management Zones. Snowfall was from the Castlegar Airport. Annual hunter kill of cougars was multiplied by 4 to facilitate viewing on the secondary y-axis.

The West Kootenay had long any bull hunting season in parts of the sub-region in the 1970s and 1980s, which corresponds with declining bull ratios through the 1980s. Seasons became more restrictive over time, which likely explains the increase in bull ratios in the 2000s. Over the same time period (1980 to 2010) bull to cow ratios were substantially higher in the West Kootenay (mean = 66 bulls: 100 cows across all surveys) than in the East Kootenay (mean = 21 bulls: 100 cows across all surveys). This may be because the West Kootenay had highly restrictive hunting seasons (some MUs closed to hunting and others with a small number of LEH permits), and relatively difficult hunting (dense forest and limited access). The low bull ratio in 2000 may be explained by higher predation and a couple of relatively severe winters in the mid 1990s. Bull elk are generally more susceptible to wolf predation (Winnie and Creel 2007) and hard winters (Raedeke et al. 2002: 469) than cow elk, because of depleted energy reserves post-rut.

Population trend

We suspect the elk population increased at a high rate (~7% per year) through the 1970s and 1980s, stabilized during the 1990s, and then increased again in the 2000s (~7% per year; Figure 33). Calf ratio data support this with high ratios during rapid population increases and lower ratios during slower population increases. Data on calf ratios were not available during the 1990s, when we suspect the population may have been stable. Adult survival data for the West Kootenay were only available during the 2000s and were consistently very high, which supports the estimated population trend during this time. Given limited data on population trends, we simply assumed a linear trajectory.

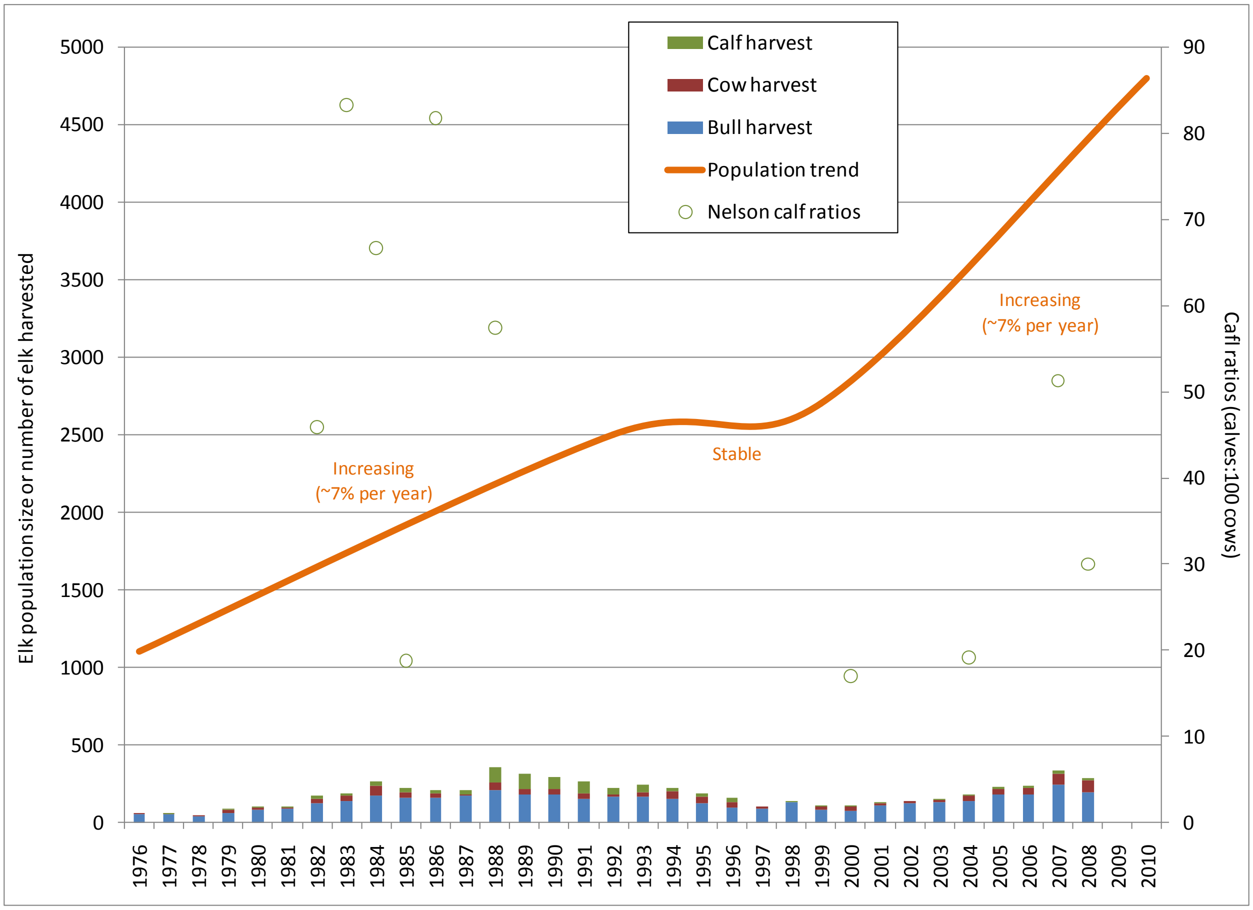

Figure 33. Approximate elk population trend in the West Kootenay, 1976 to 2010, relative to harvest and calf ratio trends. Bull, cow and calf harvest is for Revelstoke and Nelson Game Management Zones. Calf ratios are from the Nelson GMZ.

Elk harvest in the West Kootenay was minimal in the 1970s and early 1980s, and increased during the mid 1980s and early 1990s. It is possible that this contributed to population stability in the 1990s, but data are insufficient to assess this. Calf ratios and potentially adult survival may also have declined during the 1990s because of a couple winters with heavy snowfall (Figure 31) and relatively high cougar numbers. Harvest levels increased during the 2000s, however since the population was likely much larger at this time, population effects were probably minimal. That said, local populations with targeted hunting (e.g., Slocan Valley and Creston) may have experienced human-caused population declines.

East Kootenay

Calf ratios

In the East Kootenay, calf ratios were roughly stable from the 1970s to mid 1980s, but with high annual variability (Figure 34). The 3-year moving average ranged from 40 to 60 calves: 100 cows, which is surprisingly high given that hundreds of calves were harvested each year during the 1980s. However Lubow and Smith (2004) found that 89% of calf harvest was compensated for by reduced natural morality for the Jackson elk herd in Wyoming. It is also possible that some of the reported calves killed were actually yearling cows. Predator populations were low, as suggested by hunter kill of cougar (Figure 34), and hence likely had little impact on calf survival and recruitment. In the early 1980s, a couple winters with higher than average snowfall did not appear to affect calf ratios.

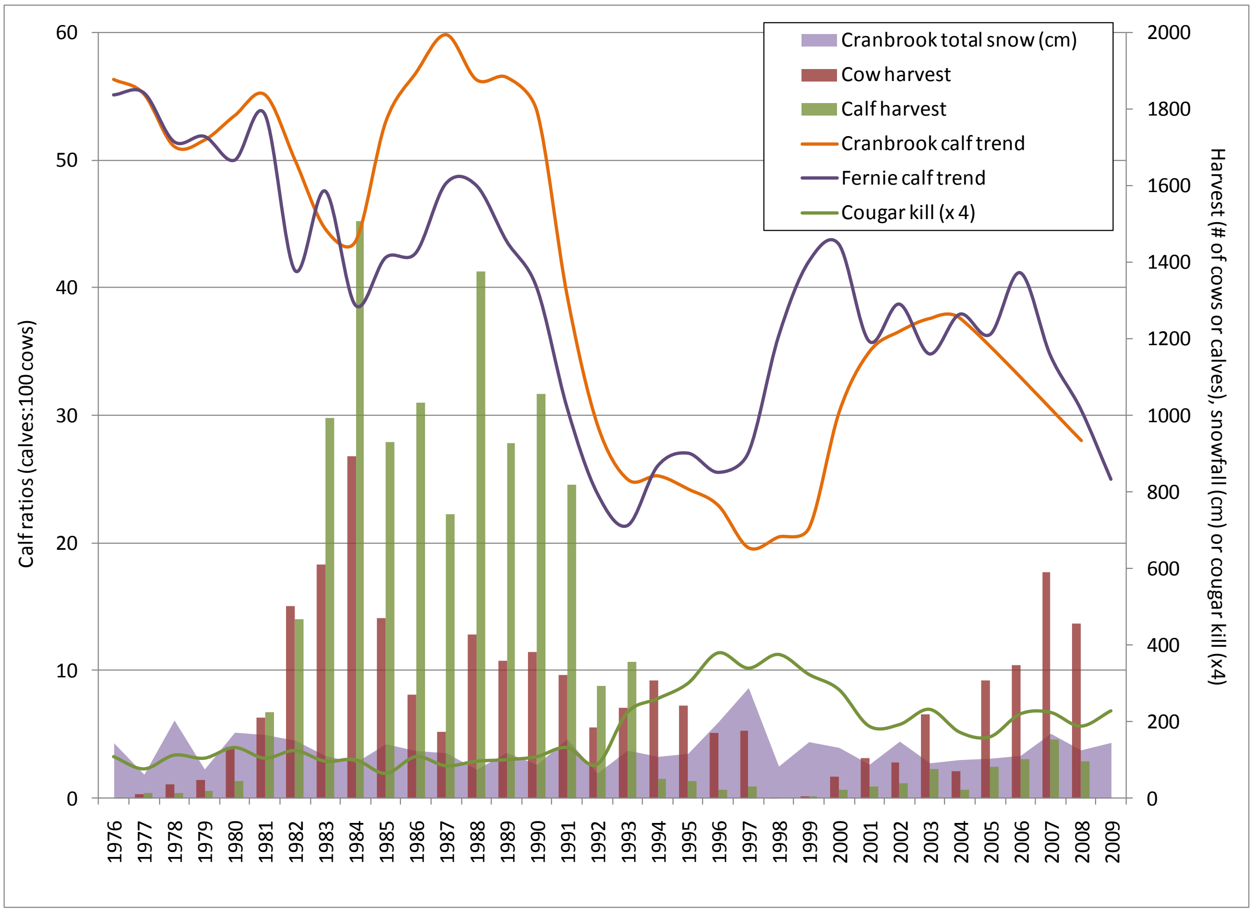

Figure 34. East Kootenay calf ratio trends, 1976 to 2009, relative to harvest, snowfall and an index of cougar predation. Calf ratio trends represent the 3-year moving average. Cow and calf harvest is for Golden, Cranbrook and Fernie Game Management Zones. Snowfall was from the Cranbrook Airport. Annual hunter kill of cougars was multiplied by 4 to facilitate viewing on the secondary y-axis.

In the late 1980s, calf ratios began to drop, and continued to decline to the mid 1990s. The drop appears to precede increases in cougar populations (as estimated by hunter kill of cougar), however wolf and grizzly populations were likely increasing around this time (Mowat 2007). Although wolves kill adult and calf elk (Mech et al. 2001; Wright et al. 2006), grizzly bears typically focus on calves (Cole 1972; Singer et al. 1997; Barber-Meyer 2008). The harvest rate (% of calves harvested) may also have increased in the late 1980s if the population declined during this time. The combination of high calf harvest and snowfall may have affected calf ratios in the late 1980s, whereas these factors *on their own* did not appear to affect calves in the early 1980s (high snowfall) or mid 1980s (high calf harvest).

Calf ratios were much lower during the 1990s, hovering around 25 calves: 100 cows. During their assessment of the East Kootenay elk population, Raedeke and Raedeke (1998) proposed that calf survival and recruitment was primarily driven by habitat, predation and potentially severe winters in the mid 1990s. There were two high snow winters in the 1990s, with close to or more than 200 cm (1995-96 and 1996-97). Hard winters can affect calf numbers by increasing calf mortality during the winter, and by reducing cow reproductive success during the subsequent fall (Singer et al. 1997; review in Raedeke et al. 2002: 452). There was also a jump in hunter kill of cougar in the 1990s, pointing to higher cougar numbers and hence predation rates. Mowat (2007) suggests that wolf populations followed a similar trend, with increasing and high numbers in the 1990s. Although weather and predation can affect calf survival and recruitment alone, the interaction is often more significant (Hebblewhite et al. 2002). It is interesting to note that many elk populations in western North America experienced low calf: cow ratios in the mid 1990s (Raedeke and Raedeke 1998; Eberhardt et al. 2007). This may be attributed to large-scale climate patterns, which have been linked to elk population trends (Hebblewhite 2005).

In the 2000s, calf ratios increased to around 30-40 calves: 100 cows, which was above 1990s levels but well below 1970s and 1980s levels. This may have been driven by predation, since cougar populations were likely lower in the 2000s than the 1990s, but higher than the 1970s and 1980s (Mowat 2007). Wilson and Morley (2005) suggest that a series of mild winters in the early 2000s was the primary reason for population increases. Snowfall data support this, with below average levels for 2001 to 2005. As discussed above, the interaction between weather and predation is often significant as well. Calf harvest and relatively high snowfall in the late 2000s may explain declines in calf ratios in the late 2000s. However calf ratios generally fluctuate substantially from year to year, so additional years of data are required to determine whether this is a trend, or simply annual variation.

Another factor that may affect calf ratios is the availability of forage (Raedeke 1998), through density-dependent reductions in calf survival and recruitment (Sauer and Boyce 1983; Lubow et al. 2002), and/or adult female reproduction (Stewart et al. 2005). Although we have limited data on forage availability over time, forage has likely declined since the 1970s due to forest in-growth, over-grazing (wildlife and/or livestock), competition with livestock, invasive plants, off-road vehicle use, and human developments (Ross 1997; Stewart et al. 2002; Wilson and Morley 2005). In addition, wide-spread wildlife exclusion fencing in the East Kootenay Trench has reduced the availability of irrigated, fertilized crops that elk frequently depredated. Wilson and Morley (2005) suggest that there is little support for an elk population response to habitat since there were higher calf ratios in the early 2000s when range condition and forage had likely declined. However the population was recovering from a low in the mid 1990s, so per capita forage, which drives density dependence (Lubow et al. 2002), may have been higher in the early 2000s compared to the 1980s and early 1990s. It is possible that declines in calf to cow ratios in the early 1990s were due to a large elk population, and a density-dependent response (Raedeke et al. 2002), however, as previously discussed, predation, weather and perhaps hunting may explain the trend as well. Often populations limited by predators and/or hunting do not show evidence of density-dependence (review in Lubow et al. 2002).

Although data on forage availability overall are lacking, summer precipitation may provide an indication of annual forage production. Vucetich et al. (2005) reported evidence of elk starvation during a mild Yellowstone winter that followed several dry years in the early 2000s. The East Kootenay also had low summer precipitation at this time, which may have contributed to a drop in calf survival in the later 2000s.

Finally, low bull ratios and a lack of mature breeding bulls are often raised as a potential cause of reduced breeding success and/or calf survival (Noyes et al. 1996; Raedeke and Raedeke 1998: 8). There is some evidence that these factors may impact breeding success, but only when bull ratios were very low (fewer than 5 to 10 bulls per 100 cows *prior* to the hunting season). However evidence that bull ratios negatively impact calf survival or recruitment is lacking (Raedeke et al. 2002: 458). Our data suggest that pre-season bull ratios were above 10 bulls per 100 cows most years, given that ratios were generally higher than this *after* the hunting season. Furthermore, when bull ratios were low (fewer than 10 bulls: 100 cows post-season; Figure 35), calf ratios were at historic highs.

Overall it appears that the interactive or additive effect of variables (snowfall, harvest and predation) may have affected calf ratios in the East Kootenay over time, but none of the individual variables explained ratios alone. We ran several linear regressions to test for relationships and none was significant (T. Szkorupa, MoE, unpublished data). This makes sense given that predators generally kill calves or adults weakened by malnutrition, harsh weather or injuries (Cole 1972; Blood 2000; Mech et al. 2001; Hebblewhite et al. 2002). Modelling work by Vucetich et al. (2005) also suggested that climate and harvest alone had little impact on the Yellowstone elk population, but these factors together likely caused population declines in the mid 1990s. Concurrent population modelling will analyse the interaction among variables and affect on past elk population trends.

Bull ratios

In the East Kootenay, periods of relatively low bull to cow ratios (1970s and 1980s) correspond with periods of high bull harvest (Figure 35). During the 1970s and 1980s long 3-point or better bull seasons resulted in a high kill. The 3-point season was shortened over time and eventually closed in 1998; the 6-point or better season was lengthened over time, and completely replaced the 3-point season in 1998. There has been a substantial rise in bull to cow ratios since harvest was restricted to 6-point bulls throughout the hunting season, as predicted by Bircher et al. (2001) and documented by Wilson and Morley (2005). Prior to 1998, ratios were below 15 bulls: 100 cows; since 2003 ratios exceeded 20 bulls: 100 cows. Other factors (weather and predation) likely had relatively insignificant impact on bull ratios compared to hunting. One exception may be for the Cranbrook GMZ, where declining bull ratios in the early 1990s were associated with increasing predator populations (Mowat 2007). Since bull harvest was declining during this time, predation may have contributed to bull population declines. As previously discussed, bulls are often disproportionately affected by predation (Winnie and Creel 2007).

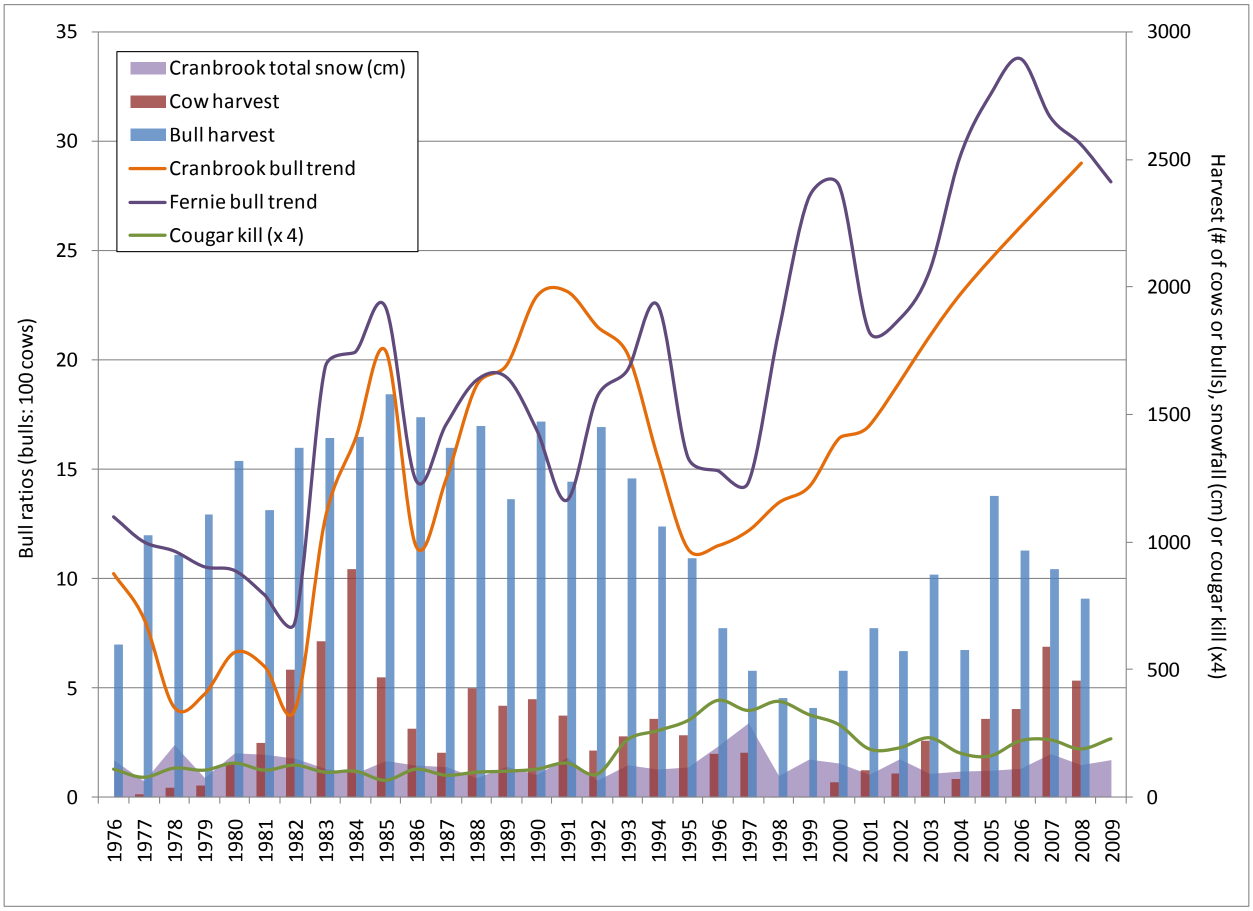

Figure 35. East Kootenay bull ratio trends, 1976 to 2009, relative to harvest, snowfall and an index of cougar predation. Bull ratio trends represent the 3-year moving average. Suspected outliers were excluded for the Cranbrook Game Management Zone (54 bulls: 100 cows in 2003), and the Fernie GMZ (72 bulls: 100 cows in 1983 and 114 bulls: 100 cows in 1986). Bull and cow harvest is for Golden, Cranbrook and Fernie GMZs. Snowfall was from the Cranbrook Airport. Annual hunter kill of cougars was multiplied by 4 to facilitate viewing on the secondary y-axis.

Population trend

Our analysis indicates that the East Kootenay elk population increased during the 1970s, remained stable through the 1980s, declined in the early to mid 1990s and increased in the 2000s (Figure 36). Calf ratio trends support the population trend data: ratios were high in the 1970s (>50 calves: 100 cows), high but variable in the 1980s (40-60 calves: 100 cows), low in the 1990s (around 20-30 calves: 100 cows), and higher in the 2000s (around 30-40 calves: 100 cows).

High harvest levels in the 1980s did not appear to negatively affect the population in the early 1980s, but may have in the late 1980s. However absolute harvest levels are less informative than harvest rates (i.e., percent of the population harvested). If the elk population was declining in the mid 1980s and absolute harvest stayed the same, this would mean an increase in the harvest rate, which could drive the population down. For example, the absolute cow harvest in the early 1990s was only slightly lower than in the 1980s. If the population was smaller in the early 1990s, this higher harvest rate could have contributed to population declines. The absolute harvest in the mid to late 2000s was similar to the 1980s. Given the population was likely smaller in the 2000s, the harvest rate would have been higher. This is supported by the lower adult cow survival rates in the 2000s compared to the 1980s/1990s.

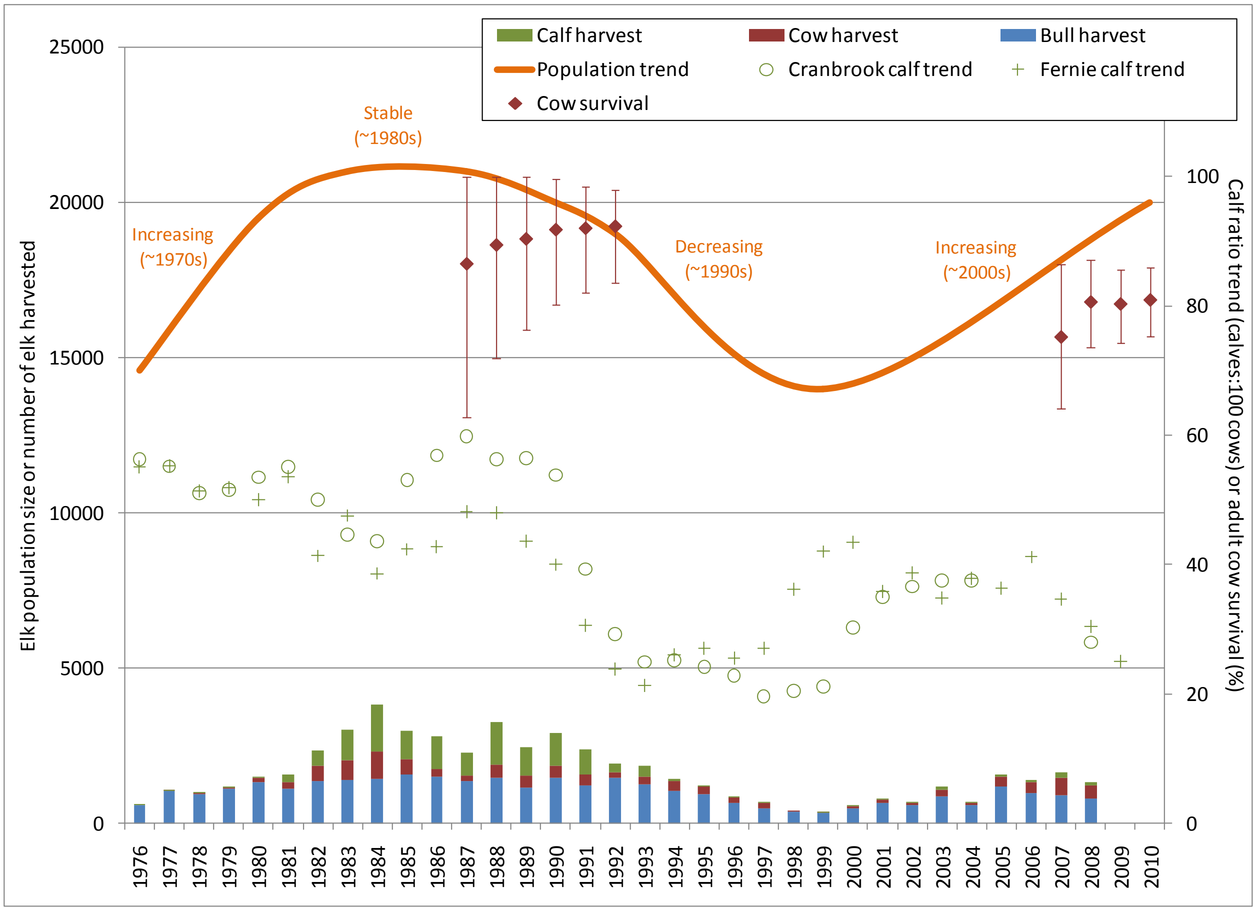

Figure 36. Approximate elk population trend in the East Kootenay, 1976 to 2010, relative to harvest, calf ratio trends and adult cow survival. Bull, cow and calf harvest is for Golden, Cranbrook and Fernie Game Management Zones. Calf ratio trends represent the 3-year moving average. Adult cow survival includes all mortality sources.

Adult female survival was high in the late 1980s and early 1990s (about 92% accounting for all mortality sources) and lower in the late 2000s (about 81% accounting for all mortality sources). Survival during both studies appeared to increase slightly over time, but largely overlapping error bars indicate no significant differences among years. Estimates were less precise during the early years of both studies because of smaller sample sizes. Adult female survival estimates were high in the early 1990s, and therefore do not explain population declines during this period. This suggests that low calf recruitment or survival (as indicated by calf to cow ratios) was largely driving the population decline. Raithel et al. (2005) analysed elk population trend data from across highly variable study areas and found that calf survival due to weather and other stochastic events generally had a greater impact on elk population trends than survival of adult females. This was primarily due to relatively constant adult female survival. In the East Kootenay, adult female elk survival was not monitored during the extremely harsh winter of 1996-97. In Yellowstone, where that winter was similarly harsh, adult survival was negatively impacted, despite not being impacted by weather in other years (Garrott et al. 2003).

Survival rates during the late 2000s put in to question our population trend estimate for that period. We suggest that the population increased, but cow survival and calf ratios may be too low for population growth. In both northern Yellowstone and Glacier National Park, elk populations declined when adult female survival was around 83% (Kunkel and Pletscher 1999; Evans et al. 2006). Although we are uncertain about the primary cause for lower adult survival, hunting is likely a factor. Since hunters are more likely to kill prime-aged cow elk, their impact on population dynamics can be significant (Vucetich et al. 2005; Eberhardt et al. 2007).

In conclusion, it appears that both calf recruitment and adult survival may have affected past East Kootenay elk population trend. In the late 1980s/early 1990s, calf recruitment was likely more important since adult survival remained high. However lower adult survival in the late 2000s along with moderate to low calf recruitment may stabilize or drive the population down. Updated information on elk population size is required to adequately assess this. Calf recruitment appears to be primarily driven by a combination of winter weather, harvest of calves and predation. Higher adult mortality was primarily influenced by human-caused mortality, although adult survival data were unavailable for the particularly harsh winter of 1996-97.

Recommendations

For future versions of this population review, we recommend the following:

- Analyse data based on newly defined Population Management Units (PMU) instead of GMZs. In the 2010-2014 Kootenay Elk Management Plan, PMUs were defined by grouping management units to capture summer and winter range for elk populations (MoE 2010). Game Management Zones split some elk populations, and group other discrete populations, and are hence less appropriate for assessing population dynamics.
- Analyse and incorporate additional data sources, such as spring carry over counts (conducted by volunteer groups and MoE), and Elk Valley mine data to look at population trends. For the first version of the review, we primarily analysed data available in digital form. However we are in the process of entering historic data in to databases, and intend on analysing these in the future.
- Incorporate results from population modelling, currently underway for the South East Kootenay Trench. The modelling will estimate past population trend, current population size, and test the influence of various limiting factors (e.g., weather and predation) and the potential impact of various harvest strategies (Cooper et al. 2003).
- Use the above population model in a sensitivity analysis to examine which data are most important when estimating population growth and other management targets. Use the model to test the risk associated with various harvest strategies.

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Environment biologists and technicians, including Ray Demarchi, Bob Jamieson, Bill Warkentin, Anna Fontana, Bob Forbes, and Guy Woods, for collecting and storing data on elk over many decades, and for the numerous reports that summarized the history of elk and their management in the region. Gerry Kuzyk (provincial ungulate biologist, MoE) provided an in-depth and highly constructive review of an earlier draft of this document. Staff from Teck coal mines generously provided wildlife observation data from their annual surveys.

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