POPULATION AND HARVEST TRENDS OF MOUNTAIN SHEEP AND MOUNTAIN GOATS IN BRITISH COLUMBIA

GERALD KUZYK[1], Ministry of Forests, Lands and Natural Resource Operations, PO Box 9391Stn. Prov. Govt., Victoria, BC, V8W 9M8, Canada
PATRICK DIELMAN, Ministry of Forests, Lands and Natural Resource Operations, Suite 400 - 640 Borland Street, Williams Lake, BC, V2G 4T1, Canada
BILL JEX, Ministry of Forests, Lands and Natural Resource Operations, Bag 5000, 3726 Alfred Avenue, Smithers, BC, V0J 2N0, Canada
CHRIS PROCTER, Ministry of Forests, Lands and Natural Resource Operations, 1259 Dalhousie Drive, Kamloops, BC, V2C 5Z5, Canada
AARON REID, Ministry of Forests, Lands and Natural Resource Operations, Suite 401 - 333 Victoria Street, Nelson, BC, V1L 4K3, Canada
HELEN SCHWANTJE, Ministry of Forests, Lands and Natural Resource Operations, PO Box 9391Stn. Prov. Govt., Victoria, BC, V8W 9M8, Canada
IRENE TESKE, Ministry of Forests, Lands and Natural Resource Operations, 205 Industrial Road, Cranbrook, BC V1C 7G5, Canada
CONRAD THIESSEN, Ministry of Forests, Lands and Natural Resource Operations, Suite 400 - 10003 110th Avenue, Fort St. John, BC, V1J 6M7, Canada

Abstract: We present provincial population and harvest trends for mountain sheep and mountain goats in British Columbia (BC). Population size was estimated every 3–5 years from 1987–2011 by regional biologists and compiled for provincial totals. Over this time, Stone's Sheep (*Ovis dalli stonei*) numbers in northern BC were generally consistent at between 9,900–15,000 animals ($\bar{x}$ = 12,250). The estimated number of Dall's sheep (*O. d. dalli*) was 400–600 in the extreme northwest of the province. All bighorn sheep in BC are classified as *Ovis canadensis* but are separated into Rocky Mountain and California bighorn sheep ecotypes for management purposes. Total bighorn sheep numbers peaked in the early to mid-1990s with estimates of 2,750–3,250 Rocky Mountain bighorn sheep and 3,100–3,900 California bighorn sheep. The estimated number of mountain goats (*Oreamnos americanus*) appeared stable over time ($\bar{x}$= 52,200) but this may be due to a lack of inventory data that would enable detection of population change. Mountain sheep and mountain goats have high value to both resident and non-resident hunters as well as for wildlife viewing. Annual hunting licence sales for the 23 years 1989–2011 for mountain sheep and mountain goat ranged from 2,024–3,091 ($\bar{x}$ = 2,564) and 2,404–3,415 ($\bar{x}$ = 2,946), respectively. Compulsory inspection and reporting of horns from harvested mountain sheep and mountain goats was initiated in 1976. This information was used to determine trends in resident and non-resident harvest over 36 years (1976–2011). Annual harvest of Stone's sheep ranged from 254–515 ($\bar{x}$ = 357) and from 0–16 ($\bar{x}$ = 9) for Dall's sheep. Bighorn sheep harvest peaked in the mid-1990's with Rocky Mountain bighorn sheep harvest from 21–106 ($\bar{x}$ = 57) and 31–145 ($\bar{x}$ = 74) for California bighorn sheep. Annual harvest of mountain goats ranged between 599 and 1,163 ($\bar{x}$ = 846). Key concerns are discussed to outline the need for increased inventory and applied research dedicated to mountain sheep and mountain goats.

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Key words: bighorn sheep, British Columbia, harvest, Dall's sheep, mountain goat, Stone's sheep, thinhorn sheep.

[1] Email: Gerald.Kuzyk@gov.bc.ca

Mountain sheep and mountain goats are important species in BC for a variety of reasons that include food, culture, visual appreciation and trophy values. They are considered iconic both regionally and provincially. There are four types of mountain sheep in the province (Fig. 1); two subspecies of thinhorn sheep, and two ecotypes of bighorn sheep. Approximately 80% of the global population of Stone's sheep (*Ovis dalli stonei*) occurs in northern British Columbia and a small population of Dall's sheep (*O. d. dalli*) is found in the extreme northwest corner of the province. Rocky Mountain bighorn sheep are native in the mountain ranges of east-central and southeast BC and there are two introduced populations in the southern interior. California bighorn sheep are primarily at lower elevation in drier habitats along river drainages in the southern interior part of the province (Blood 1961). Rocky Mountain and California bighorn sheep were originally considered separate subspecies (Shackleton 1999) but in 2001 they were classified as one species (*Ovis canadensis*) following Wehausen and Ramey (2000; BC Conservation Data Centre, 2012). Since then, bighorn sheep have been managed as two separate ecotypes and California bighorns are further divided into four metapopulations (Demarchi et al 2000b; Fig. 1). There is likely some low degree of mixing between the ecotypes on adjacent ranges. There is no overall management plan for mountain sheep in BC but in the Thompson Okanagan Region three regional plans have been developed for California and Rocky Mountain Bighorn Sheep (Harper et al. 2002, Fraser River Bighorn Sheep Advisory Committee 2004, South Thompson Bighorn Sheep Management Committee 2005). Status Reports have been developed for Rocky Mountain bighorn sheep (Demarchi et al. 2000a), California bighorn sheep (Demarchi et al. 2000b) and thinhorn sheep (Demarchi and Hartwig 2004).

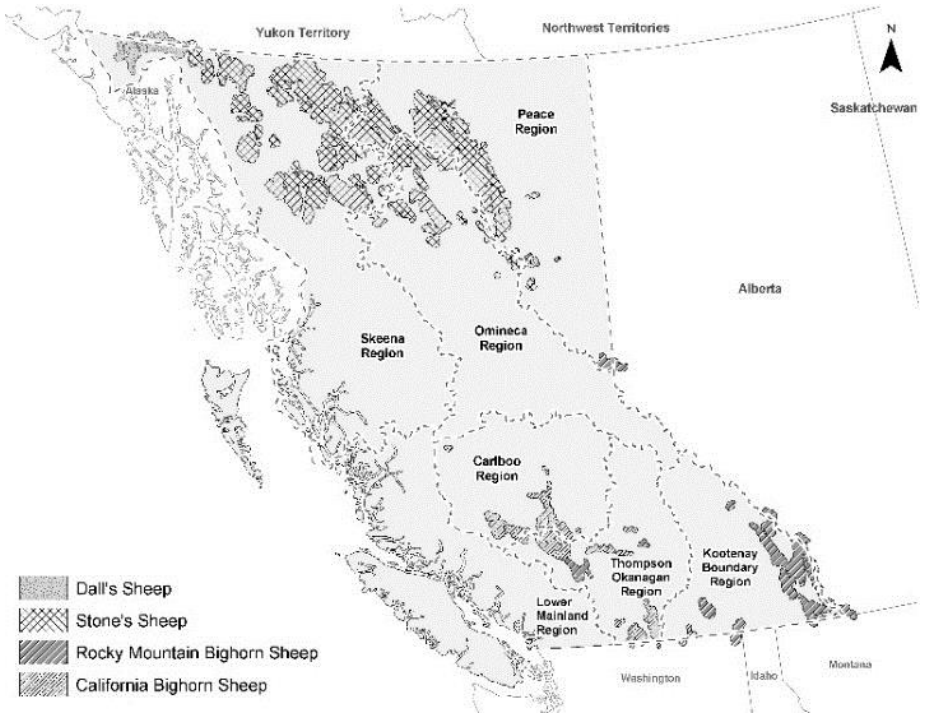

Fig. 1. Distribution of mountain sheep in British Columbia.

British Columbia is home to approximately half of the world's mountain goats (Fig. 2); therefore, the province has a global responsibility for mountain goat conservation and management. Relative to other ungulate species, mountain goats have low reproductive rates and can be sensitive to human disturbance, so conservative management is advised (Festa-Bianchet and Côté 2008). In 2010, the BC Ministry of Environment released the *Management Plan for the Mountain Goat* (*Oreamnos americanus*) *in British Columbia* which contains detailed population and harvest information and provides recommendations for improved population monitoring and maintaining sustainable harvest (Mountain Goat Management Team 2010). This paper provides a long-term assessment of population and harvest trends of mountain sheep and mountain goats in BC.

METHODS

Population estimates were determined by regional biologists every 3 to 5 years from 1987 to 2011 using aerial survey data in combination with expert opinion. These regional estimates were then compiled for provincial totals. Rocky Mountain

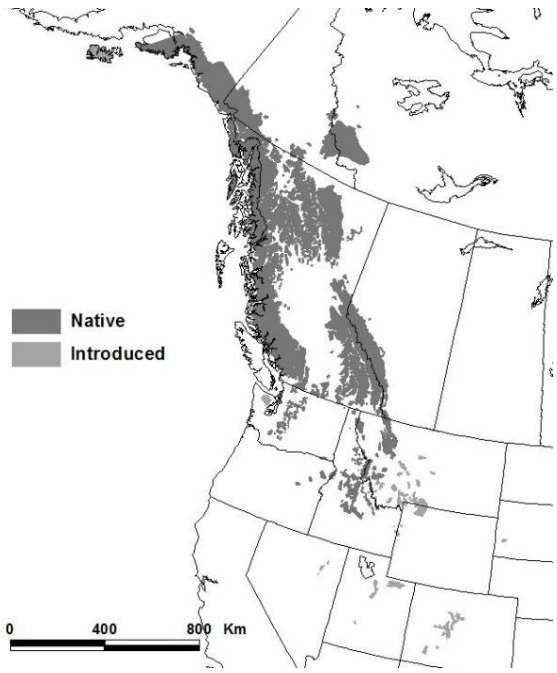

Fig. 2. Distribution of mountain goats in North America depicting the large range encompassed within British Columbia (map courtesy BC Ministry of Environment 2010).

and California bighorn sheep data were pooled from 1987 to 1994 but have been recorded separately since 1997. To better reflect uncertainty of estimates, ranges were produced from 2000 to 2011

Harvest data were gathered for 36 consecutive years (1976–2011) through the Ministry's Compulsory Inspection and Reporting (CI) program which requires that all successful licensed hunters submit horns and heads from harvested mountain sheep and mountain goats in order to legally possess and transport them. Inspection and reporting process is standardized to include: estimation of age using horn growth annuli, recording inter-annulus length measurements, total horn lengths, estimated horn broomed length, and horn base circumferences. Because reporting is mandatory, these data are not presented with estimates of error. As a specific regional project, CI data for thinhorn sheep from the Skeena Region were screened for reporting bias for 1996–2011 and these data were incorporated into this analysis (Jex 2011).

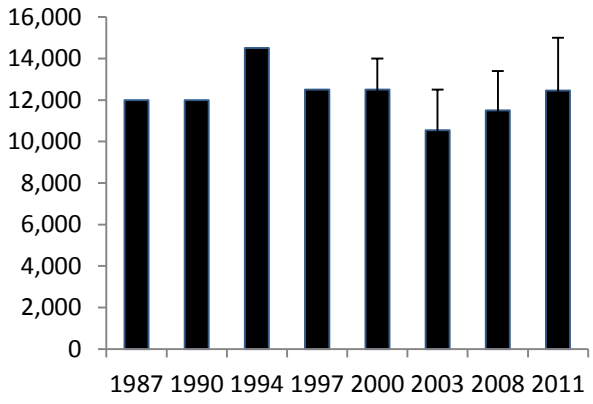

Fig. 3. Population estimates of thinhorn sheep in BC.

RESULTS AND DISCUSSION

Thinhorn Sheep

Skeena-Omineca-Peace Regions

Populations of the two subspecies of thinhorn sheep, Stone's sheep and Dall's sheep (Fig. 1), in British Columbia appear to be generally stable at between 9,900 and 15,000 animals since 1987 ($\bar{x}$= 12,250). Early estimates were primarily informed by expert opinion and limited fixed-wing aircraft survey data. Since 2000, population estimates were produced as ranges and are more refined as helicopter-based inventories were used (Fig. 3). Licensed harvest of Stone's sheep has ranged from 254 to 515 ($\bar{x}$ = 357) annually since 1976, with fluctuations occurring in the mid-1980s and early 1990s (Fig. 4) that are consistent with population abundance patterns in other thinhorn populations (Hik and Carey 2000, Alaska Department of Fish and Game 2008). Possible causes of fluctuations in harvest include: changes in weather patterns that affect winter and spring severity subsequently resulting in a negative effect on lamb survival and abundance; anthropogenic disturbances and increased levels of access that alienate habitats and alter habitat use; as well as economic drivers and hunting conditions that affect the numbers and timing and success of hunters. Harvest of Dall's sheep during this time ranged from 0 to 16 ($\bar{x}$ = 9) annually and is recently trending down (Fig. 5), most likely due to the small portion of the province that Dall's sheep occupy and the amplified effect

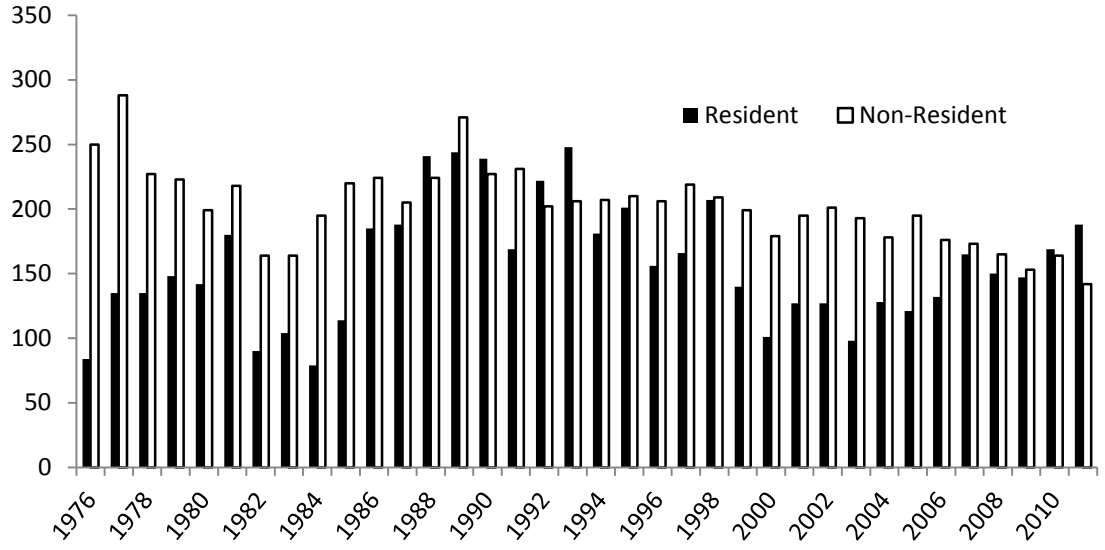

Fig. 4. Annual harvest of Stone's sheep in BC from 1976-2011.

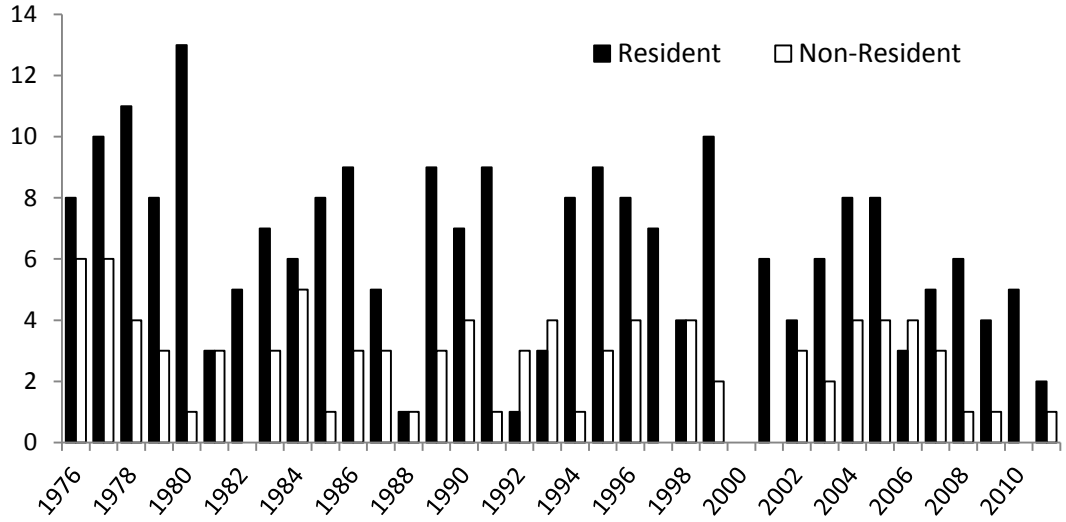

Fig. 5. Annual harvest of Dall's sheep in BC from 1976-2011.

that the previously noted impacts have on the low annual harvest. Increases in exploration activities, resource development and anthropogenic disturbances since 2005 may have affected the availability of Dall's sheep to licensed hunters as some rams may move into the Yukon when disturbed (Jack Goodwin[2] pers. comm.). Anecdotal information on the level of success in the resident and non-resident harvest (Fig. 5) supports the disturbance proposition.

Rocky Mountain Bighorn Sheep

Kootenay/Boundary Region

Fluctuations in provincial numbers of Rocky Mountain bighorn sheep (Figs. 6 and 7) and harvest (Fig. 8) are best explained by examining factors affecting the bighorns within the Kootenay/Boundary Region (Fig. 1). Population estimates have been between 1900 and 2400 sheep since the mid-1980s (Fig. 6) and herds are

[2] Jack Goodwin is a guide outfitter based in Atlin, BC. His operating area covers Wildlife Management Units 6-29 & 6-28, and is the only area where Dall's sheep occurs in BC.

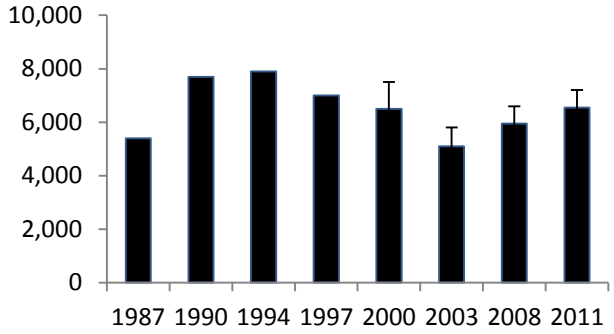

Fig. 6. Population estimates of bighorn sheep (Rocky Mountain and California bighorns combined) in BC.

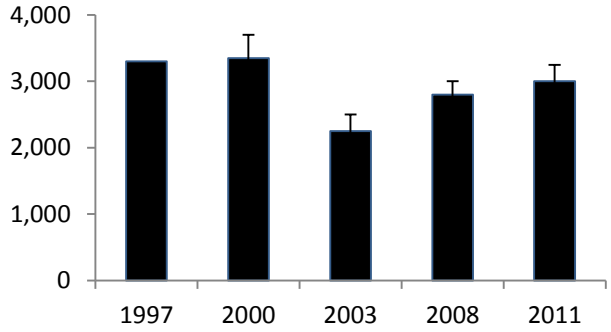

Fig. 7. Population estimates of Rocky Mountain bighorn sheep in BC.

generally divided into those that use lower elevation winter ranges within the Rocky Mountain Trench and those that use higher-elevation winter ranges. Some seasonal movement occurs between BC and Alberta. An all-age respiratory disease die-off occurred in the early 1980s in some herds in the region while other herds were not affected. This occurrence of disease followed a pattern seen at least twice before with reports of similar die-offs in the 1940s and 1960s (Schwantje 1988). Since the 1980s, most herds have either increased or remained stable; however, there are some smaller herds whose numbers have either never recovered or have declined. Predation, reduced access to quality habitat including conifer in-growth, and site specific adverse weather conditions (e.g. high snowfall winters in 1996/97 and 1997/98) may be factors associated with the reduced survival in these herds. No disease outbreaks have been reported since the 1980s die-off.

Annual harvest of Rocky Mountain Bighorn sheep has ranged from 21 to 106 ($\bar{x}$ = 57) from 1976 to 2011. Prior to 1977, harvest strategies in the eastern part of the region included a 7/8 curl or minimum 8-year-old ram season which was changed to a full curl regulation in 1978. Between 1985 and 2002 there was a resident Limited Entry Hunt (LEH) ewe season to reduce specific herd densities. Currently, only full-curl ram seasons are available. Harvest peaked in the late 1980s and early 1990s with an average of 55 rams and 42 ewes annually (Fig. 8). Harvest levels declined after the two severe winters to a low of 20 rams in 2000, increasing since 2005 with an average of 41 rams per year (Fig. 8).

Peace Region

The Narraway herd, in the southern reaches of the Peace Region is North America's most northerly bighorn sheep population. Currently this herd is estimated to be less than 200 individuals. Surveys have been sporadic and it is only recently that Alberta and BC have collaborated on surveys so trend information is lacking. Seasonal migrations to the east occur in winter, with movements back to the west in summer. The extent (spatial and numerical) of seasonal migration is unknown and likely dependent on winter severity. The most recent survey (2009) enumerated 177 sheep, of which 54 were in BC. The herd appears to be stable, as there is no indication from previous surveys of large fluctuations in population size.

Harvest of this herd is managed with a full curl regulation in BC and trophy sheep regulation in Alberta. From 1983 to 2009 the average annual combined harvest from BC and Alberta was 5 sheep (range 1–11). BC harvest during that time period averaged 2 rams/year (range 0–9) and Alberta harvest was 3 rams/year (range 0–9). There were no apparent trends in harvest through time. BC and Alberta will continue to collaborate on management of this herd.

Thompson/Okanagan Region

Two introduced herds (Spences Bridge and Chase herds) of non-migratory Rocky Mountain bighorn sheep exist in the Thompson/Okanagan Region. Populations are thought to be stable and number approximately 500 and 40 sheep respectively. Only the Spences Bridge herd is currently hunted. Harvest in the last 5 years

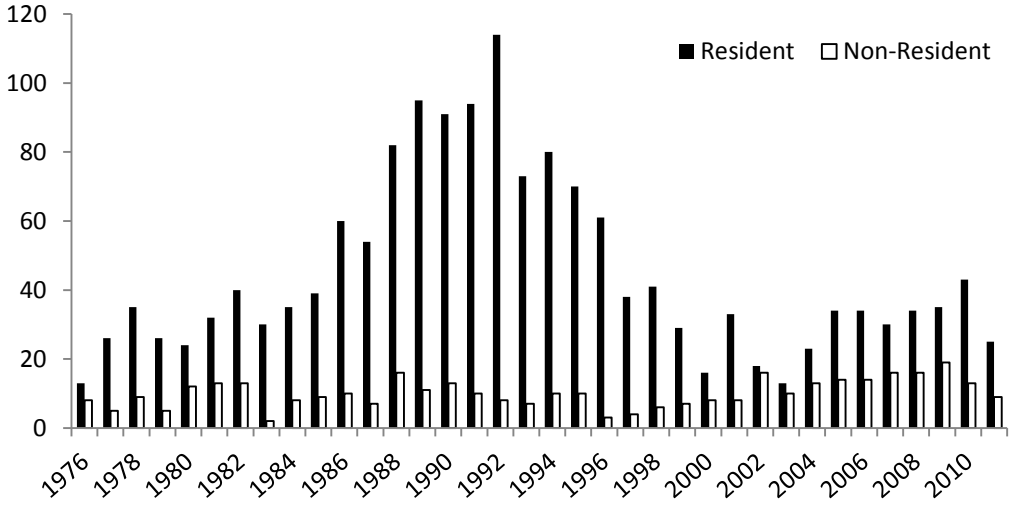

Fig. 8. Annual harvest of Rocky Mountain bighorn sheep in BC from 1976-2011.

averaged approximately 7 rams per year (range 5–10) under a horn curl restricted General Open Season (GOS). Harvest regulation changes in 1999 were designed to reduce ram harvest and focus on older sheep resulting in lower harvest. In years prior to 1999, harvest was managed under a full curl regulation and the number of rams taken was high, averaging 17 per year (range 11–22). Due to rapid horn growth, most of these were young rams. In 1999, a more restrictive horn curl regulation was implemented and harvest has since averaged 5 rams per year (range 0–10).

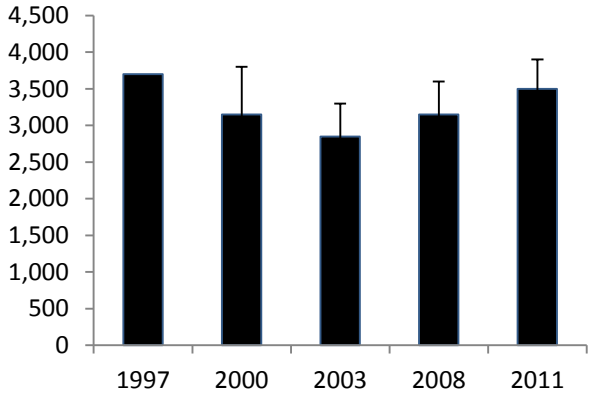

Fig. 9. Population estimates of California bighorn sheep in BC.

California Bighorn Sheep

Total numbers of California bighorns in BC peaked in the early to mid-1990s and then declined through 2003 (Figs. 6 and 9). Since 2003 there has been recovery provincially however some populations remain depressed. Some herds have recently expanded into previously unoccupied habitats and these contribute to the more recent increase in 2008 and 2011 estimates.

Annual harvest ranged from 31-145 ($\bar{x}$ = 74). Harvest increased from 1980 through 1995, declined through to 2000 and has been stable to slightly increasing since (Fig. 10). The harvest decline since the mid-1990s was largely due to the decline in the Fraser River metapopulation and associated changes to hunting regulations during that time which are detailed below.

Fraser Metapopulation

The current population estimate for the Fraser metapopulation is approximately 1,600 California bighorn sheep. The highest density and largest of these herds have historically been the low-elevation resident and migratory herds along major river basins. Through the 1980's and early 1990's, the Fraser metapopulation was estimated at between 2,800 and 2,900 sheep. Beginning in 1995, many herds experienced substantial declines, dropping to an estimated low of approximately 1,200 by 2005–2007 (Fig. 9).

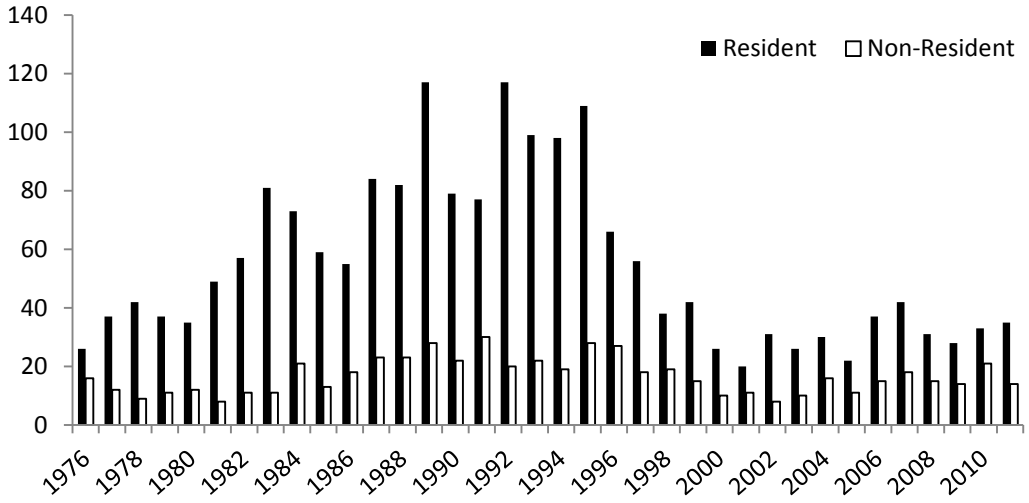

Fig. 10. Annual harvest of California bighorn sheep in BC from 1976-2011.

Extremely low lamb recruitment in some herds over long periods combined with high predation rates by coyotes and cougars are believed to be primary factors (Hebert and Harrison 1988, Harrison and Hebert 1988). In addition, a significant number of ewes were removed from specific herds for translocation to the United States for conservation purposes over several decades (Table 1), and range quality has suffered from livestock use and conifer in-growth. Since 2005, a few herds have increased; however, the majority of herds remain at relatively low numbers with several herds with chronic low lamb recruitment (<10% in two cases). A recently-initiated research project has identified *Mycoplasma ovipneumoniae* in clinically ill young lambs in one of these herds.

Prior to 1996, harvest for this metapopulation was managed under ¾ and full curl GOS regulations. In 1996, a LEH for ¾ curl rams in combination with a GOS for full curl rams was implemented in much of the area to significantly reduce ram harvest. Ram harvests since 1996 have averaged 14 per year. The declines in harvest are attributed to an overall population decline which resulted in more restrictive regulation regimes (such as conversion to full curl) and closure of some GOS hunting seasons (Fig. 10).

Thompson Metapopulation

The current population estimate for the Thompson metapopulation is approximately 1,000 California bighorn sheep. There are five herds of California bighorn sheep within this metapopulation and all but one have increased significantly since the late 1980s. Two herds (Battle Creek and Chasm Creek) are new and naturally established, and combined have increased to approximately 180 animals since the early 1990s and early 2000s, respectively. Overall numbers in the South Thompson and Kamloops Lake herds increased from approximately 175 in the late 1980s to approximately 750. One herd (Skwaam Bay) introduced to suboptimal habitat in the early 1990s has not fared as well and has been stable at approximately 30 animals.

The Thompson metapopulation of sheep has one herd (Kamloops Lake) that has had consistent hunting regulations; only a portion of the herd is hunted and harvest has been minimal, averaging 2 rams per year. A hunt was established for the South Thompson herd from 2006–10 and a total of 11 rams were harvested. Because a significant portion of this herd ranges on private lands, the hunt was instituted as part of a pilot landowner enfranchisement project. This program is now in review therefore the season is currently closed pending outcomes of the review. A LEH hunt has been established for the Chasm Creek herd

beginning in the 2012 season and if current trends observed in the other expanding herd (Battle Creek) continue, a hunt on that herd may be expected in the near future.

Okanagan-Similkameen Metapopulation

The current population estimate for the Okanagan–Similkameen metapopulation totals approximately 1,015 sheep with about 615 in the Okanagan herd and 400 in the Similkameen herd. The Okanagan herd suffered an all-age respiratory disease-related die-off in 1999–2000, where approximately 65% of an estimated 430+ bighorns died. There was a significant reduction in lamb recruitment post die-off, a typical pattern following all-age die-offs in bighorn sheep (University of California-Davis 2007, Wehausen et al. 2011). However, within two years the recruitment had returned to pre-die-off levels and by 2011, the Okanagan bighorns recovered to pre-die-off numbers. As part of a recovery plan (Harper et al. 2002), California bighorn sheep were translocated into vacant habitat at the northern extent of this sheep range in 2007 and 2009 (Table 1). The translocation has contributed approximately 100 additional bighorns to this metapopulation. Harvest for the Okanagan and Similkameen herds are under any ram and ¾ curl LEH seasons, respectively. Since 2004, the average annual harvest has been 21.

Kettle-Granby Metapopulation

This is the easternmost metapopulation of California bighorn sheep in BC and occurs in the Kootenay/Boundary Region (Fig. 1). This herd was translocated into the area in the 1980s from the south Okanagan (Table 1) and has grown to approximately 200 animals. These sheep are limited to mid- to low-elevation slopes due to high crown closure forest on the upper slopes. The majority of the population occur along the south and east aspects of major river drainages within the area. Currently, this metapopulation has hunting seasons for any ram under an LEH, with an average annual harvest of 4.

Mountain Goats

The estimated provincial population of mountain goats has remained relatively stable from 1987 to 2011 at about 50,000 animals (Fig. 11). There is a lack of current and repeated inventories such that while a large portion of the province has been surveyed for mountain goats, many surveys have occurred only once, resulting in a poor understanding of population trends (Mountain Goat Management Team 2010). Visibility bias during mountain goat surveys has been a confounding factor in determining population estimates in BC (Cichowski et al. 1994, Poole 2007), especially for coastal populations living largely in or near forested habitats (Mountain Goat Management Team 2010). A new technique for estimating mountain goat abundance using fecal DNA shows promise for addressing this visibility bias (Poole et al. 2011).

Mountain goats are managed under both either sex GOS and LEH seasons. In 2010, a provincial regulation was implemented to minimise harvest of females and an outreach program was initiated to train hunters online. The annual harvest of mountain goats has ranged from 599 to 1,163 ($\bar{x}$ = 846; Fig. 12). There were some years in the late 1980s and early 1990s where harvest exceeded 1000 mountain goats per year yet there was no associated increase in licence sales. In some years non-resident harvest exceeded resident harvest highlighting the importance of mountain goats to the guide/outfitting industry (Fig. 11).

The northern portion of the province (Omineca, Peace and Skeena Regions) contains approximately 65% of the provincial mountain goat population. The number appears stable; however, in recent years resource development projects and backcountry recreation expansion

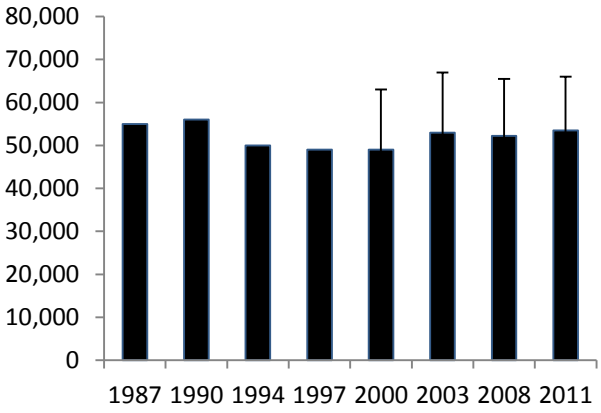

Fig. 11. Population estimates of mountain goats in BC.

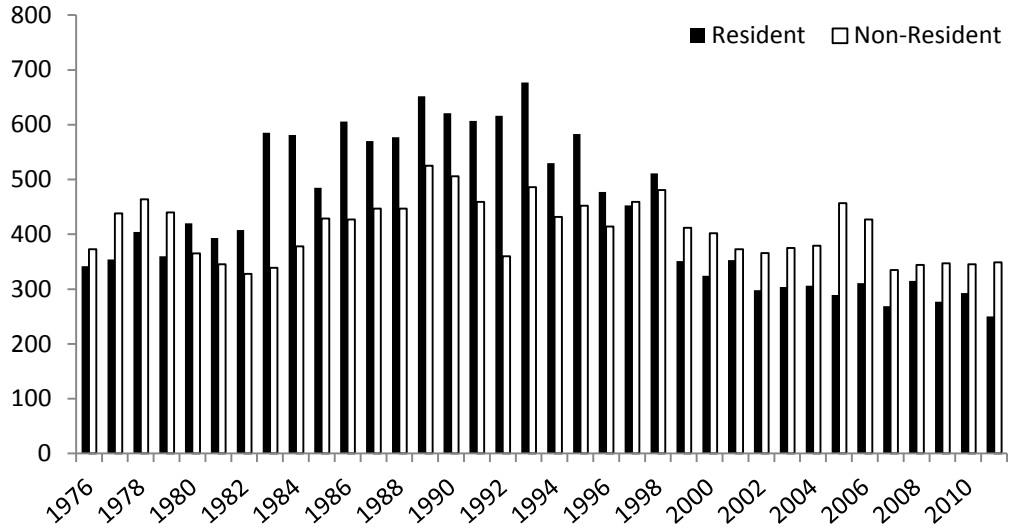

Fig. 12. Annual harvest of mountain goats in BC from 1976-2011.

have been associated with habitat alienation and habitat loss. Large-scale mountain goat population declines resulting from disease and parasites have not been identified in BC (Jenkins et al. 2004), although it is suggested anecdotally that the occurrence of contagious ecthyma in a herd in the extreme northwest of the province has affected its viability. Within the last decade, observations and reports of animals affected by the virus in this herd have declined (Jack Goodwin, pers. comm.). In the north, mountain goats are predominantly managed through a combination of GOS and LEH opportunities where high levels of easy access could increase the risk of localized overharvest. The main harvest management concern is the proportion of female mountain goats taken. For example, resident hunters usually harvest a higher proportion of female mountain goats than do non-resident hunters. Since 1976, the average composition of the harvest for resident hunters in the north is 34% female versus 66% male; for non-resident hunters the composition is 22% female versus 78% male. Since 2000, average composition of harvest for resident hunters in the north is 25% female versus 75% male; for non-resident hunters the composition is 16% female compared to 84% male. This change is assumed to be the result of the hunter education program aimed specifically at improving gender identification of mountain goats.

In the southern portion of the province, the Kootenay/Boundary region has the highest numbers of mountain goats and numbers there are currently stable. In other areas, particularly the Coast mountain ranges and some interior mountain ranges, mountain goat population trends have been variable. Some populations appeared to peak in the mid-1990s and have since declined by as much as 50%, while other interior and south coastal populations appear to have slowly declined over the last 2 decades. In contrast to these more widespread declines, some populations have been stable and other populations have re-established themselves in a number of mountain complexes formerly extirpated of mountain goats. Some stable populations have also shifted range use and changed distribution within ranges (Mountain Goat Management Team 2010). The reduction in mountain goat harvest (Fig. 12) likely reflects some of the broader population declines in the central interior portion of the province and subsequent regulation changes. About 30% of the provincial harvest of mountain goats occurs in the Kootenay/Boundary region (Mountain Goat Management Team 2010) where there have been changes in hunter opportunity from 1979–1984 when LEH authorizations were increased from

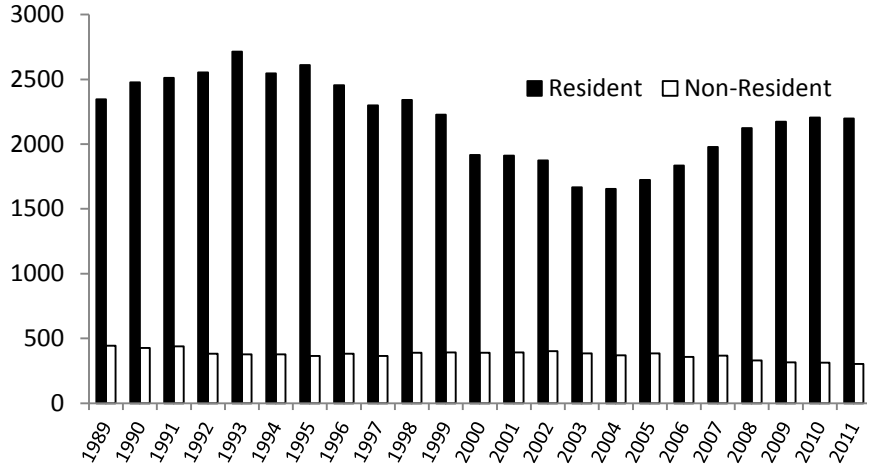

Fig. 13. Licence sales for mountain sheep in BC.

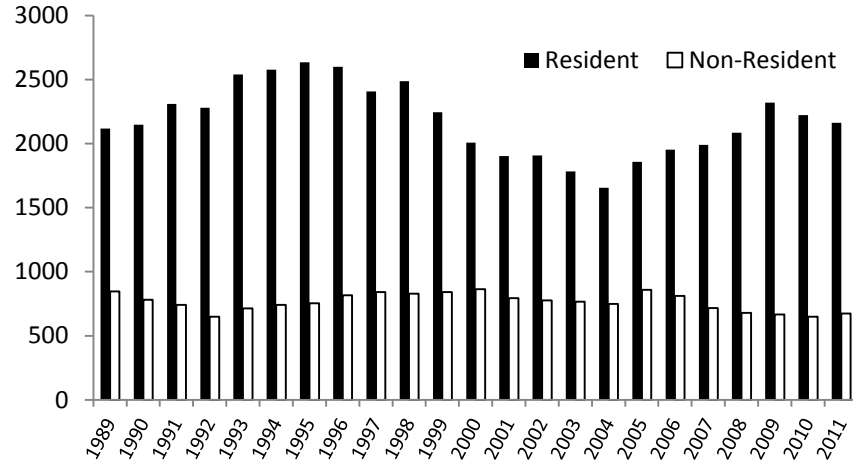

Fig. 14. Licence sales for mountain goats in BC.

about 100 to over 1,100 authorizations per year. Annual resident harvest increased during this time from about 75 to 450 mountain goats. There was another increase in LEH authorizations between the mid-1990s and mid-2000s yet harvest declined, probably due to reduced hunter interest as hunter numbers also declined from 700–850 to 400–500 during this time (Mountain Goat Management Team 2010).

Licence Sales for Mountain Sheep and Mountain Goats

Mountain sheep and mountain goats are valued by both resident and non-resident hunters. Annual hunting licence sales for 23 years (1989 to 2011) ranged from 2,024 to 3,091 ($\bar{x}$ = 2,564) for mountain sheep and 2,404 to 3,415 ($\bar{x}$ = 2,946) for mountain goat (Figs. 13 and 14). Resident hunter licence sales for both mountain sheep and goats peaked in the early to mid-1990s and fell to a low in 2004 and then showed a steady increase to 2010. This same trend is reflected in the provincial general resident hunter licence sales for all species. Annual non-resident harvest for both mountain sheep and mountain goats is limited by guide outfitter quotas, however licence sales are not. Non-resident license sales in BC during this same timeframe have remained relatively stable, and on average made up 18% of the total mountain sheep licence sales and 36% of the total mountain goat licence sales.

Translocations

Translocations can reflect population trends of mountain sheep (Tables 1 and 2). The luxury of robust bighorn populations with few recognized conflicts and good quality range in previous decades resulted in BC providing bighorn stock for many successful recovery programs in the United States, particularly from 1954 to 2000. After the identification of Bovine Spongiform Encephalopathy in Canadian cattle in the late 1990s, the US closed the border to ruminant imports and has allowed only one importation of bighorn sheep from Alberta in the winter of 2011.

BC has provided a total of 568 animals (primarily reproductive age females) to the western US for reintroductions or herd augmentations (Table 2). In addition, a total of 850 animals were moved between herds within BC (Table 1). In early years in BC the purpose of

Table 1. Translocation of bighorn sheep within BC (1933-2012).

Year	Source	Region[a]	Destination	Region	No. Translocated	Ecotype
1933	Squilax	TOR	Skwaam Bay (Adams Lk.)	TOR	20	Rocky Mountain
1955	Junction	CR	Bluff Lake	CR	9	California
1955	Junction	CR	Vaseux	KBR	4	California
1955	Junction	CR	Whitewater	CR	2	California
1956	Junction	CR	U.B.C.	LMR	4	California
1956	Junction	CR	Dog Creek	CR	8	California
1956	Junction	CR	Gang Ranch	CR	6	California
1957	Junction	CR	U.B.C.	LMR	4	California
1957	Junction	CR	Vaseux	TOR	10	California
1966	Junction	CR	Kamloops Lake	TOR	11	California
1977	Vaseux	TOR	Okanagan Game Farm	TOR	20	California
1981	Kamloops	TOR	Harper Ranch	TOR	1	California
1982	Wigwam Flats	KBR	Bull River	KBR	16	Rocky Mountain
1984	Columbia Lake	KBR	Lizard Range	KBR	28	Rocky Mountain
1984	Columbia Lake	KBR	McGuire Creek	KBR	7	Rocky Mountain
1984	Vaseux	TOR	Grand Forks	TOR	20	California
1985	Columbia Lake	KBR	Tulip Creek	KBR	20	Rocky Mountain
1985	Columbia Lake	KBR	McGuire Creek	KBR	10	Rocky Mountain
1985	Junction	CR	Harper Ranch	TOR	6	California
1985	Junction	CR	Dog Creek	CR	12	California
1985	Vaseux	TOR	Grand Forks	TOR	12	California
1986	Columbia Lake	KBR	Lizard Range	KBR	11	Rocky Mountain
1986	Stoddart Creek	KBR	Wigwam Flats	KBR	47	Rocky Mountain
1986	Columbia Lake	KBR	Wildhorse R.	KBR	5	Rocky Mountain
1986	Junction	CR	Dog Creek	CR	13	California
1986	Vaseux	TOR	Grand Forks	TOR	13	California
1987	Stoddart Creek	KBR	Arrow Lakes	KBR	18	Rocky Mountain
1987	Columbia Lake	KBR	Wildhorse R.	KBR	12	Rocky Mountain
1987	Columbia Lake	KBR	Lakit Lake	KBR	11	Rocky Mountain
1987	Columbia Lake	KBR	Mause Creek	KBR	17	Rocky Mountain
1987	Junction	CR	Word Creek	CR	7	California
1987	Deer Park Ranch	CR	Skwaam Bay	TOR	1	California
1988	Deer Park Ranch	CR	Skwaam Bay	TOR	12	California
1989	Radium	KBR	Wigwam Flats	KBR	20	Rocky Mountain
1988	Deer Park Ranch	CR	Word Creek	CR	12	California
1989	Stoddart Creek	KBR	McGuire Creek	KBR	19	Rocky Mountain
1990	Spences Bridge	TOR	Squilax Creek (Chase)	TOR	4	Rocky Mountain
1990	Junction	CR	Chilko Lake	CR	11	California
1992	Stoddart Creek	KBR	Ram Creek	KBR	22	Rocky Mountain
1993	Ewin Ridge	KBR	Bingay Creek	KBR	7	Rocky Mountain
1993	Thomas Ranch (South OK)	TOR	Penticton Creek	TOR	12	California
1994	Big Bar	TOR	Seton Lake	TOR	23	California
1993	Radium	KBR	Ram Creek	KBR	27	Rocky Mountain
1994	Radium	KBR	Ewin Ridge	KBR	10	Rocky Mountain
1994	Junction	CR	Taseko Mtn.& Tosh Creek	CR	32	California
1998	S. Thompson (Harper Ranch)	TOR	Penticton Creek	TOR	14	California
1997	S. Thompson (Harper Ranch)	TOR	Seton Lake	TOR	2	California
1997	Kamloops Lake (Tranquille)	TOR	Seton Lake	TOR	1	California
2004	Harper Ranch	TOR	Shorts Creek	TOR	12	California
2005	Radium	KBR	Wasa Creek	KBR	25	Rocky Mountain
2007	Keremeos	TOR	Ok Mtn.	TOR	34	California
2007	Golden	KBR	Whiteswan Lake area	KBR	19	Rocky Mountain
2008	S. Thompson (Mt. Paul/Sun River	TOR	Alkali Ranch	CR	26	California
2009	Golden	KBR	Grundy Creek	KBR	13	Rocky Mountain
2009	Kamloops Lake (Tranquille)	TOR	Ok Mtn.	TOR	15	California
2009	Kamloops Lake (Tranquille)	TOR	Big Bar (OK Ranch)	TOR	42	California
2012	S. Thompson (Mt. Paul/Sun River	TOR	Fraser River (Mackay Creek)	TOR	36	California
2012	S. Thompson (Mt. Paul/Sun River	TOR	Fraser River (Mackay Creek)	TOR	15	California
Total translocations within BC						**850**

[a] CR - Cariboo Region, TOR - Thompson/Okanagan Region, KBR - Kootenay/Boundary Region, LMR - Lower Mainland Region

translocations was primarily to establish new herds, but since 1980 the purpose was mostly as a management tool to reduce herd density as a disease mitigation measure. There have been 58 translocations, ranging from 1 to 47 individuals, within BC from 1933–2012. Two translocations (Spences Bridge and Chase), totalling 99 bighorn sheep, moved bighorns into BC from Banff

Table 2. Translocation of bighorn sheep into BC (1927) and translocation of bighorn sheep from BC (1954-2000).

Year	Source	Region[a]	Destination	Region	No. Translocated	Ecotype
1927	Alberta (Banff)	-	Spences Bridge	TOR	49	Rocky Mountain
1927	Alberta (Banff)	-	Squilax (Chase)	TOR	50	Rocky Mountain
Total translocations into BC						**99**
1954	Junction	CR	Oregon	-	20	California
1956	Junction	CR	N. Dakota	-	18	California
1957	Junction	CR	Washington	-	18	California
1963	Junction	CR	Idaho	-	19	California
1965	Junction	CR	Idaho	-	9	California
1966	Junction	CR	Idaho	-	10	California
1967	Junction	CR	Idaho	-	12	California
1971	Junction	CR	California	-	10	California
1978	Vaseux	TOR	Nevada	-	12	California
1983	Junction	CR	Nevada	-	19	California
1984	Junction	CR	Nevada	-	12	California
1985	Junction	CR	Nevada	-	20	California
1988	Junction	CR	Idaho	-	14	California
1989	Junction	CR	N. Dakota	-	10	California
1989	Junction	CR	Nevada	-	33	California
1989	Keremeos	TOR	Nevada	-	20	California
1990	Junction	CR	Nevada	-	15	California
1990	Columbia Lake	KBR	Colorado	-	34	Rocky Mountain
1990	Junction	CR	Oregon	-	15	California
1993	Keremeos	TOR	Nevada	-	26	California
1995	Big Bar	TOR	Nevada	-	42	California
1996	Kamloops Lake [Tranquille]	TOR	Washington	-	25	California
1996	South Thompson [Harper Ranch]	TOR	Washington	-	7	California
1996	Big Bar	TOR	N. Dakota	-	21	California
1996	Big Bar	TOR	Nevada	-	20	California
1997	South Thompson [Harper Ranch]	TOR	Utah	-	11	California
1997	Kamloops Lake	TOR	Utah	-	12	California
1997	Spences Bridge	TOR	Snake River/Oregon, Idaho, WA	-	40	Rocky Mountain
1999	South Thompson [Harper Ranch]	TOR	Nevada	-	18	California
1999	Kamloops Lake [Tranquille]	TOR	Nevada	-	5	California
2000	South Thompson [Harper] (11)	TOR	Washington/Lake Chalan	-	11	California
2000	South Thompson [Mt. Paul] (10)	TOR	Washington/Lake Chalan	-	10	California
Total translocations out of BC						**568**

[*] CR - Cariboo Region, TOR - Thompson/Okanagan Region, KBR - Kootenay/Boundary Region, LMR - Lower Mainland Region

National Park, Alberta in 1927. These animals were released into traditional California bighorn habitat and herds have persisted and expanded their range. There have been 32 translocations during 1954–2000, totalling 568 bighorn sheep (range 5–42), where sheep were moved out of BC. Sixty Stone's sheep were moved in 2 translocations from 1990–1996 within BC (Hatter and Blower 1996). From 1924–1999 there were 151 mountain goats moved within the province and 93 animals from the province (Hatter and Blower 1996; Mountain Goat Management Team 2010).

CONCLUSION

Most populations of mountain sheep and mountain goats in BC are considered relatively stable with some localised declines in bighorns and interior and coastal populations of mountain goats. Large-scale population declines in bighorn mountain sheep in BC have historically been related to respiratory disease outbreaks that occurred after contact with domestic sheep. This issue continues to be a priority concern on privately owned land in BC (Appendix 1). In general, harvest trends do follow population levels and this is especially apparent in Rocky Mountain and California bighorn sheep. Harvest appears to be proportional to population size, where Stone's sheep have a greater population size (9,900–15,000) and average annual harvest ($\bar{x}$ = 357) relative to Rocky Mountain bighorn sheep population size (2,750–3,250) and harvest ($\bar{x}$ = 57) and California bighorn sheep (3,100–3,900) ($\bar{x}$ = 74).

A better understanding of the basic ecology of mountain goats is needed in BC, especially in coastal habitats where limited inventory and

anecdotal reports suggest numbers may be declining (Mountain Goat Management Team 2010). Mountain goats are sensitive to helicopter disturbance (Côté 1996, Festa-Bianchet and Côté 2008) and there are real challenges managing both mountain goats and mountain sheep in balance with socio-economic pressures of industrial and recreational development. Some research has recently been published on the impacts on mountain goats (Cadsand et al. 2012) but further investigation is warranted with the increase in resource extraction and recreational industries working in mountain goat and mountain sheep habitat.

Research on mountain sheep has largely focused on the habitat use of California bighorn sheep (Blood, 1961, Demarchi 1965, Demarchi and Mitchell 1973, Wikeem 1984), Rocky Mountain bighorn sheep (Hebert 1973, Poole 2012) and Stone's sheep (Seip and Bunnell 1985, Walker et al. 2007, Churchill and Glaholt 2012) with only limited work on factors that may affect populations (Harper 1984, Milakovic and Parker 2011) including disease (Schwantje 1988). Recent research on harvest management examining bighorn horn growth data in relation to age of harvest determined that rams which grew horns at a faster rate were harvested at a younger age (Hengeveld and Festa-Bianchet 2011), but there is still a lack of research focused on linking harvest and populations. A new collaborative project with Dr. Marco Festa-Bianchet (University of Sherbrooke) is using Stone's sheep CI horn data to analyse ecological variables that may affect survival, growth, and vulnerability of Stone's Sheep to harvest. Additional work is required focussing on the factors involved in poor bighorn lamb recruitment and other health-related issues of mountain sheep and mountain goats. New research should be focused wherever possible on applied population and harvest management issues and produce recommendations to enhance and maintain sustainable populations and harvest of mountain sheep and mountain goats in BC.

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Appendix 1. Matrix of issues/topics for mountain sheep in British Columbia originally developed for the Western Association of Fish and Wildlife Agencies Wild Sheep Working Group. Ranked 1 (highest) to 10 (lowest) priority.

ISSUE/ MANAGEMENT TOPIC	Thompson[a]/ Okanagan	Kootenay/ Boundary	Cariboo	Skeena	Omineca	Peace	Thompson/ Okanagan[a]
WS Habitat Quality	5	2	5	7	3	8	4
WS Habitat Quantity	8	2	8	8	8	7	4
Habitat Fragmentation	5	4	7	4	7	7	7
Vegetative Succession	4	2	8	8	5	4	3
Water Availability	8	5	8	10	2	10	6
Wilderness Designations	10	7	7	8	3	5	8
Restrictions due to Wilderness Designation	10	7	9	10	8	10	9
WS Habitat on Private/Deeded Lands	3	5	3	10	1	10	3
Recreational Impacts	7	3	3	5	3	7	6
ATV/OHV	3	2	2	5	8	9	5
Human Expansion	4	3	8	10	8	10	2
Energy Development	3	1	3	10	9	2	6
Livestock Grazing	2	2	2	7	9	9	2
Restrictive Fences	9	5	9	10	9	10	7
Wild Horses	5	10	10	7	9	9	3
Forage Competition	9	3	4	9	7	5	7
Poaching/Illegal Take	5	8	5	3	9	5	9
Anti-Hunting NGOs	None	8	9	8	8	9	9
P/A of Advocacy NGO	Y	Y	Y	Y	Y	Y	Y
Adequacy of Funding	1	4	6	3	8	3	4
Dedicated Personnel for WS Management	3	4	7	7	9	1	5
Lack of Management Plan	8	7	5	5	None	3	5
Too Little Access for Hunting/Management	7	5	10	8	5	5	9
Too Much Access	7	5	7	5	5	6	2
Shared WS Management with Tribal/First Nation	No	5	5	5	No	1	5
Predation – wolves	5	5	6	7	5	2	9
Predation – cougars	3	5	10	10	9	10	3
Predation – coyotes	5	6	7	8	7	6	3
Predation on WS (avian)	5	?	5	7	?	8	?
Predation on WS	4	4	8	7	5	4	5
Ability to Influence Predation Levels on WS	5	6	8	8	No	5	5
Disease Issues with WS	1	2	1	7	No	4	2
Disease Issues (other than w/ Domestics)	4	6	7	7	No	9	4
Viability of Populations	4	7	7	7	8	6	7
T&E Listing Status	10		10	10	No	9	7
Connectivity between WS Meta-Population	9	5	5	7	8	8	5
Impediments/Barriers	5	5	10	8	8	8	7
Mining Developments	5	6	6	3		1	5
Helicopter Disturbance	8	6	7	3		7	9

[a] Indicates subregion