Bighorn Sheep

Ovis canadensis

Original[1] prepared by R.A. Demarchi

Species Information

Taxonomy

Until recently, three species of Bighorn Sheep were recognized in North America: California Bighorn Sheep (*Ovis canadensis californiana*), Rocky Mountain Bighorn Sheep (*O. canadensis canadensis*), and Desert Bighorn Sheep (*O. canadensis nelsoni*). As a result of morphometric measurements, and protein and mtDNA analysis, Ramey (1995, 1999) recommended that only Desert Bighorn Sheep and the Sierra Nevada population of California Bighorn Sheep be recognized as separate subspecies. Currently, California and Rocky Mountain Bighorn sheep are managed as separate ecotypes in British Columbia.

Description

California Bighorn Sheep are slightly smaller than mature Rocky Mountain Bighorn Sheep (McTaggart-Cowan and Guiguet 1965). Like their Rocky Mountain counterpart, California Bighorn Sheep have a dark to medium rich brown head, neck, and dorsal body with a short black tail and a white muzzle, rump, and ventral patches. Both sexes have sturdy muscular bodies and strong necks that support horns that curve back in females and are much larger and curled around in males. The most consistent anatomical feature distinguishing the California ecotype from the Rocky Mountain ecotype is the presence of a continuous black or brown dorsal stripe dividing the white rump patch to the to the tip of the tail (Toweill 1999).

Distribution

Global

The genus *Ovis* is present in west-central Asia, Siberia, and North America (and widely introduced in Europe). Approximately 38 000 Rocky Mountain Bighorn Sheep (Wishart 1999) are distributed in scattered patches along the Rocky Mountains of North America from west of Grand Cache, Alberta, to northern New Mexico. They are more abundant and continuously distributed in the rainshadow of the eastern slopes of the Continental Divide throughout their range.

California Bighorn Sheep were extirpated from most of the United States by epizootic disease contracted from domestic sheep in the 1800s with a small number living in California until 1954 (Buechner 1960). Since 1954, Bighorn Sheep have been reintroduced from British Columbia to California, Idaho, Nevada, North Dakota, Oregon, Utah, and Washington, resulting in their re-establishment in much of their historic range. By 1998, California Bighorn Sheep were estimated to number 10 000 (Toweill 1999).

British Columbia

British Columbia's major native Rocky Mountain Bighorn Sheep population is distributed in herds in the Rocky Mountains of the East Kootenay region of southeastern British Columbia between the Kicking Horse River in the north and the U.S. border in the south, including one small herd that ranges into Montana east of Eureka during the summer months. British Columbia's population is connected at both extremes and at scattered locations along its range with sheep herds in Alberta. Separate herds winter in

1 Volume 1 account prepared by D. Spaulding.

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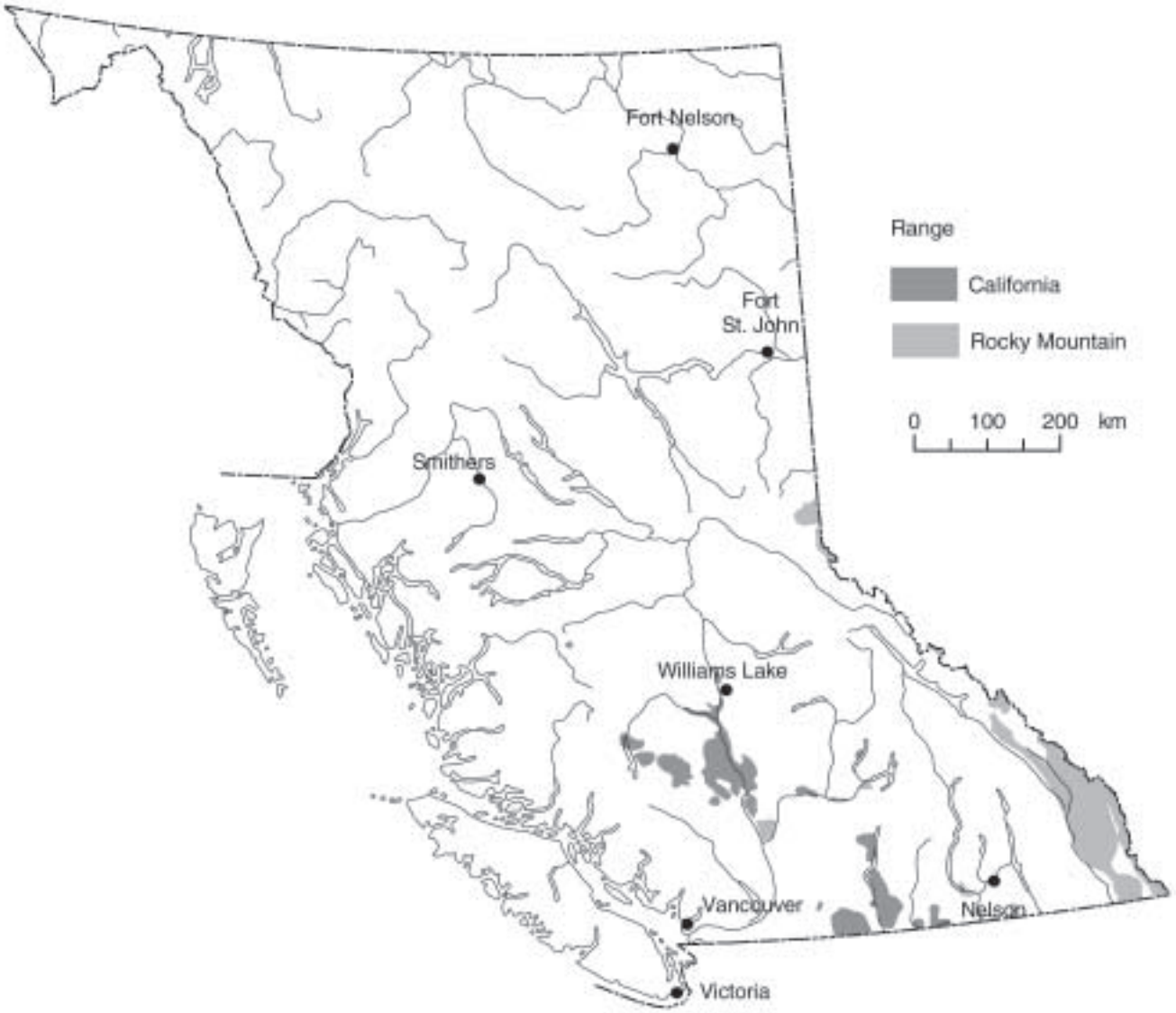
(Ovis canadensis)



Note: The map is based on current knowledge of the species' distribution.
This species may or may not occur in all areas indicated.

either province, with several small herds wintering on or immediately adjacent to the summit of the continental divide (Kakwa, Simpson River, Ewin Ridge, Sheep Mountain, Deadman Pass, and Crowsnest Pass herds). There are introduced herds of Rocky Mountain Bighorn Sheep in the Spences Bridge, Squilax, and Castlegar areas. There is a herd near Salmo as a result of a natural expansion by a transplanted herd from the Hall Mountain area of northeast Washington.

California Bighorn Sheep in British Columbia have undergone a considerable reduction in distribution and abundance since primitive times (Buechner 1960; Sugden 1961). Originally, California Bighorn Sheep were in the arid grasslands of the valleys of the Fraser, Thompson, Nicola, Lower Bonaparte, Okanagan, Ashnola and Similkameen Rivers, along the higher valleys west of the Fraser River, Bridge River, Seton Lake, Anderson Lake, Taseko Lake, Chilko Lake, Tatlayoko Lake, and Mosley Creek (Sugden 1961). California Bighorn Sheep probably disappeared in the Thompson, Nicola, and lower Bonaparte before Euro-Asian contact (Sugden 1961). Significant reductions in populations have since occurred in the Similkameen (i.e., Ashnola) and Okanagan areas.

California Bighorn Sheep were successfully reintroduced to the Thompson River watershed above Kamloops Lake in the 1960s, and to the Kettle-Granby watershed in the 1980s. Today, British Columbia's native California Bighorn Sheep population is distributed in herds in the Okanagan-Similkameen, Thompson, Fraser, and Kettle-Granby river watersheds. These populations are not continuously connected as they are fragmented into herds that have limited interchange and are considered separate metapopulations (Demarchi et al. 2000).

Ecoprovinces and ecosections

California ecotype

CEI: CAB, CCR, CHP, FRB, WCU

SOI: OKR, NOB, NOH, NTU, PAR, SCR, SOB, SOH, STU, THB

Rocky Mountain ecotype

SBI: HAF, NHR, SHR

SIM: COC, CPK, EKT, FRR, NPK, SCM, SFH, SPK

SOI: NTU, PAR, THB

Biogeoclimatic units

California ecotype

AT: p, un

BG: xh1, xh2, xh3, xw1, xw2

ESSF: dv, dvp, xc, xcp, xv

IDF: dk1, dk2, dk3, dk4, dm1, mw2, xh1, xh2, xm, xw

MS: dc1, dc2, dm1, dm2, xk, xv

PP: dh1, xh1, xh2

SBS: mh

Rocky Mountain ecotype

AT: p, un

BG: xh2, xw1

ESSF: dk, dkp, mm2, mv2, wc1, wc3, wc4, wm, xc, xcp

ICH: dw, mk1, mw2

IDF: dk1, dk2, dm2, un, xh2

MS: dk, xk

PP: dh2, xh2

SBS: dh

Forest region and districts

	Forest districts	
Forest region	**California ecotype**	**Rocky Mountain ecotype**
Southern Interior:	100 Mile House, Arrow Boundary, Cascades, Central Cariboo, Chilcotin, Kamloops, Okanagan Shuswap	Arrow Boundary, Cascades, Columbia, Headwaters, Kamloops, Kootenay Lake, Okanagan Shuswap, Rocky Mountain,
Northern Interior:		Prince George, Peace

Broad ecosystem units

AC, AB, AG, AM, AU, BS, DF, DL, DP, EF, FP, LP, MS, OV, PP, RO, SD, SG, SM, SS, TA

Elevation

The California ecotype generally occurs between 300 to 2800 m; whereas the Rocky Mountain ecotype generally occurs between 500 and 3000 m but does occur as low as 175 m at Spences Bridge where they were introduced.

Life History

Diet and foraging behaviour

Valdez and Krausman (1999) present a comprehensive review of the diets of both California and Rocky Mountain Bighorn Sheep. They state that in any given habitat, the percentages of graminoids, forbs, and shrubs in the diet of Bighorn Sheep may vary. Generally, the winter diet of Bighorn Sheep consists of mainly graminoids with lesser consumption of forbs, shrubs, and some conifers. Summer range is often alpine areas with grasses, sedges (*Carex* spp.), and a diversity of forbs used as forage. Grasslands and seral shrublands in the East Kootenay Trench Ecosection provide forage mainly from bunchgrasses such as wheatgrass (*Agropyron* spp.), fescues (*Festuca* spp.), bluegrass (*Poa* spp.), and needle grasses (*Stipa* spp.), and various forbs and shrubs (Davidson 1991).

In the Elk Valley, the diet pattern reflected the phenological plant development from spring to mid-summer. Sheep forced by deep snow to stay on high-elevation winter ranges until early summer consumed proportionately more graminoids (59%) than sheep from grasslands in the mid-elevation Montane Spruce biogeoclimatic zone (28%) (TAESCO 1982). Forbs (57%) and shrubs (14%) dominated the diet of the latter. In comparison, during spring and summer the alpine-wintering sheep used fewer shrubs (3%) but also heavily utilized forbs (36%). Conifers constituted a low percentage of the diet for both although more conifers were used in spring and summer by the alpine-wintering sheep.

In a study near Penticton, the California Bighorn Sheep studied utilized 14 grass species, 47 forbs, and 18 woody species (Wikeem and Pitt 1992). Bunchgrasses such as bluebunch wheatgrass (*Pseudoroegneria spicata*), junegrass (*Koeleria* spp.), and fescues, bluegrass, needle grasses, and various forbs and shrubs were eaten (Blood 1967; Demarchi 1968; Wikeem 1984; Wikeem and Pitt 1992). Scree slopes and cliffs are generally vegetated with shrubs that can be important to foraging such as gooseberry (*Ribes* spp.), cinquefoil (*Potentilla* spp.), sagebrush (*Artemesia* spp.), rose (*Rosa* spp.), maple *(Acer* spp.), saskatoon (*Amelanchier alnifolia*), kinnikinnick (*Arctostaphylos uva-ursi*), juniper (*Juniperus* spp.), and blueberry (*Vaccinium* spp.).

Reproduction

As with most northern ungulates, the rut is timed to optimise the availability of abundant nutritious forage at parturition (Bunnell 1982; Hebert 1973; Thompson and Turner 1982). Typically, in British Columbia rutting occurs from early November to early December with parturition occurring around 175 days after conception beginning in early June, peaking in mid-June, and ending the first week of July (Demarchi 1982; Shackleton 1999). Bighorn Sheep herds that live at high elevation all year appear to rut 1–2 weeks later.

Introduced Bighorn Sheep have the potential to double their numbers in approximately 3 years (Wishart et al. 1998). Pregnancy rates have been shown to be over 90% of adult females and bearing one young per year (Haas 1989; Jorgenson 1992). Fecundity and survival favour rapid population growth at low population density and conservative population strategies at densities approaching carrying capacity (Ricklefs 1982 in Wishart 1999). In addition, the California Bighorn Sheep ecotype occasionally produces twins thereby adding to potential productivity (Blood 1961; Spalding 1966)

Site fidelity

Generally, female Bighorn Sheep show fidelity to home range (Geist 1971; Festa-Bianchet 1986; Stevens and Goodson 1993). Both sexes have a strong home range fidelity to a particular mountain,

but generally, ewes return rate to a specific range is higher than males. Geist (1971) found that ewes returned to the same range 90% of the time while rams returned 75% of the time.

Home range

Bighorn Sheep are gregarious but live in sexually segregated groups (Geist 1971). Male Bighorn Sheep use as few as two and as many as six separate home ranges during a year. The ranges of major ram bands can include pre-rut, rutting, mid-winter, later-winter/spring, and summer ranges (Geist 1971). Some Rocky Mountain Bighorn Sheep winter and summer at high elevation but on separate mountains, such as all of the Elk Valley herds. The herds in the East Kootenay Trench, however, winter at low elevation and summer at high elevation. Generally, ewes use two to three seasonal ranges (Wishart 1978; Geist 1971; Shackleton 1973; Festa-Bianchet 1986) but Bighorn ewes can use as many as four ranges including winter, spring, lambing, and summer ranges (Geist 1971; Festa-Bianchet 1986).

Home ranges are usually part of a mountain, or a whole mountain. Of the four ungulate species studied on Premier Ridge in the East Kootenay, Bighorn Sheep were the most localized and specific in their response to environmental factors such as slope and rockiness (escape terrain) and they tended to use small, rather specific areas (Hudson et al. 1975). Home ranges can be as small as 0.8 km^2 in mid-winter or as large as 5.9 km^2 in spring and fall (Geist 1971). The high elevation winter range for the Ewin herd of approximately 150 sheep was 1.4–2 km^2 (TASECO 1982). This means that 0.47–0.50 ha would be required to support one ewe based on grazing capacity (average forage requirement of 30 kg/sheep and a grazing time of 5 months). Kopec (1982) found home ranges averaged 541 ha for ewes and 798 ha for rams in Montana. Ewes' home ranges were the smallest during lambing (47 ha) and largest during the fall, 273 ha. The rams' smallest range was in winter range (averaging 21 ha) and the largest during the spring range (averaging 305 ha). The size of lambing areas ranged from 3 to 150 ha in Idaho (Akenson and Akenson 1992). In Montana, Semmens (1996) estimated home range size for lamb-ewe groups from 6.4 to 32.9 km^2 using radio-telemetry data from three subpopulations.

Movements and dispersal

Seasonal home ranges may vary considerably between Bighorn Sheep herds, not only in size, but also in the distance to other seasonal home ranges. The separation of one seasonal range from another can be one steep gorge or it can be distances of 10–70 or more kilometres between summer and winter ranges for California Bighorn (Blood 1961; VanSpall and Dielman 1997) and 24 to >51 km for Rocky Mountain Bighorn. Ewes in central Idaho migrated 1–40 km from winter ranges to lambing ranges (Akenson and Akenson 1992). Unlike Rocky Mountain Bighorn Sheep observed by Geist (1971), the radio-collared California Bighorn Sheep studied in the Churn Creek watershed (Fraser River meta-population) did not demonstrate a difference between sexes in the timing of either spring or fall migrations. Ewes and rams migrated concurrently between the summer and the rutting/wintering areas, spending approximately 8 months on the winter range (Keystone Wildlife Research 1998). However, high water flows did delay spring migrations of ewes accompanied by lambs.

In late September or early October, large bands of rams move to a fall concentration area where they generally stay from 2 to 5 weeks. From this pre-rut range in the first week of October or the first week in November, they disperse to rutting grounds until the end of December (Geist 1971; TAESCO 1982). At this time some rams will return to pre-rut home range while others move to mid-winter home ranges where they spend 271–303 days (Geist 1971). Some young rams and the ewes will remain at the rutting grounds. By mid-March, rams return to fall concentration areas. In summer, the rams move to salt licks for a few weeks and then to summer range.

Ewes arrive later on the wintering areas and depart earlier, spending 240–268 days on wintering areas (Geist 1971). The fall concentration area or areas immediately adjacent will usually be where the ewes remain in the winter. In late March or April, separate winter/spring range may be used once the snow

hardens or is reduced enough to allow movement. Females move to lambing areas in late May or June or, infrequently, at the beginning of July. Pregnant ewes were found to move from higher quality forage to an area of lower quality to provide better protection from predation (Festa-Bianchet 1988). Lambing may take place on the winter range or in a separate lambing range. In late June or early July, barren females, juveniles, and rams move to summer ranges.

Habitat

Structural stage

Ecotype	Foraging	Security & thermal	Lambing	Rutting
California	2–3 & 6–7	4–7	1–3	1–3 & 6–7
Rocky Mountain	2–3 & 6–7	4–7	1–3	1–3 & 6–7

Important habitats and habitat features

Bighorn Sheep use a variety of habitat types within their home ranges. Habitats include open grasslands, alpine, subalpine, shrub-steppe, rock outcrops, cliffs, meadows, moist draws, stream sides, talus slopes, plateaus, deciduous forest, clearcut or burned forest, and conifer forest, all on moderately steep to steep slopes. Use of habitat varies daily and seasonally with changes in requirements for food, rest, safety, thermal cover, rutting, and lambing (Risenhoover and Bailey 1985). Table 1 summarizes coarse habitat requirements used for Bighorn Sheep. Rocky Mountain Bighorn Sheep prefer habitats with steep grasslands and broken krummholz terrain (Demarchi 1986).

California Bighorn Sheep in British Columbia exhibit three seasonal habitat use strategies. The majority of populations winter on low-elevation, southerly exposed slopes close to rocky escarpments or scree slopes, and summer in high elevation alpine and subalpine areas (Blood 1961; Sugden 1961). However, there is a population that spends both summers and winters on high-elevation, windswept alpine ridges and mountains (e.g., the Taseko, Elbow/Dash/Relay, Shulaps, and Yohetta/Tatlow herds) (P. Dielman and F. Harper, pers. comm.). Another herd spends the winters and summers at low elevations along the Fraser River canyon in the Fraser River Basin Ecosection (e.g., the entire Junction herd and part of the Churn Creek, Fraser River East, and Fraser West populations) (Demarchi and Mitchell 1973; Keystone Wildlife Research 1998; F. Harper, pers. comm.).

Table 1. Coarse feature requirements of Bighorn Sheep (after Sweanor et al. 1996)

Habitat requirement	Definition
Escape terrain	Areas with slope >27° and <85°
Escape terrain buffer	Areas within 300 m of escape terrain and areas ≤1000 m wide that are bound on ≥2 sides by escape terrain
Vegetation density	Areas must have visibility >55%, as defined by the mean percentage of squares visible on a 1 m^2 target, divided into 36 equal squares, 14 m from an observer viewing N, E, W, S from a height of 90 cm along a 10 pt, 280 m transect
Water sources	Areas must be within 3.2 km of water sources
Natural barriers	Areas that Bighorn Sheep cannot access are excluded (e.g., rivers >200 ft^3/s, areas with visibility <30% that are 100 m wide, cliffs with >85° slope)
Human use areas	Areas covered by human development are excluded
Man-made barriers	Areas that cannot be accessed due to man-made barriers are excluded (e.g., major highways, wildlife-proof fencing, aqueducts, major canals)
Domestic livestock	Areas within 16 km of domestic sheep and domestic goats are excluded

Thermal and security cover

Forests (pole/sapling to old forest) are used for security and thermal cover. Bighorn Sheep, and most commonly non-habituated groups of rams, use dense conifer forests as hiding cover when disturbed by lightening storms, motorized vehicles, and humans on foot. Mature, open forests provide Bighorn Sheep with important habitats for forage and thermal cover (Demarchi and Mitchell 1973). During a recent low temperature/deep snow event in the Ashnola watershed, California Bighorn Sheep retreated to old-growth Douglas-fir (*Pseusdotosuga menziesii*) forests, presumably to escape deep snow and to seek forage from Douglas-fir needles, twigs, and litter-fall (R. Lincoln, pers comm.). Scree slopes and rock outcrops within coniferous forests are also used as hiding cover by rams during the hunting season, and for thermal cover during hot weather. High elevation wintering Bighorn Sheep retreat to the upper margins of mature montane spruce forest during severe inclement winter weather.

Wintering

Bighorn Sheep depend on natural grasslands such as bunchgrass, ranges (especially bluebunch wheatgrass [*Pseudoroegneria spicata*] and rough fescue [*Festuca scabrella]*) and early successional forest stages: particularly as winter range for all ecotypes (Blood 1961; Sugden 1961; Demarchi and Mitchell 1973; Wikeem 1984; Demarchi 1986; Davidson 1991).

Rocky Mountain Bighorn Sheep winter on low-elevation, southerly exposed slopes close to rocky escarpments or talus slopes (Shackleton 1973; Demarchi 1986). However, two other populations in the East Kootenay winter on high-elevation, wind-swept, alpine, and subalpine ridges (TAESCO 1982; Demarchi 1986; Shackleton 1973) or winter in exposed south-facing grassland slopes at mid-elevation in the montane forest of the Fording Valley (Demarchi 1968, TAESCO 1982). Although the three populations are spatially separated, their habitat and forage requirements are similar (e.g., mineral licks, migration corridors, and proximity to escape terrain for security from predators—especially during lambing).

Use of grasslands and seral shrublands in the East Kootenay Trench ecosections by Bighorn Sheep occurs mainly during winter. Rams often use more marginal habitats on cliffs and rugged terrain (TAESCO 1982).

Lambing

Females move to lambing areas to give birth any time from early May through June, or less frequently, the beginning of July. Lambing may take place on the winter range or in a separate lambing range. Southerly and south-westerly-facing scree slopes and steep rugged terrain interspersed by rock cliffs are commonly used for lambing. Talus slopes and cliffs are commonly sparsely vegetated but provide habitat for lambing, and general security. Lambing range selection may be based on a combination of nutritional and anti-predator constraints. These sites may be sparsely vegetated but provide relatively secure habitat for birthing, nursing, and resting away from both terrestrial and aerial predators. Pregnant ewes were found to move from higher quality forage to an area of lower quality to provide better protection from predation (Festa-Bianchet 1988).

Spring/summer

Summer range is often in high elevation rocky alpine and krummholz areas (Shackleton 1973; Demarchi 1986). In Ewin Creek of the East Kootenay, ewes summered in the lower elevation forests without forming distinct nursing bands (TAESCO 1982). As with the lower elevation wintering herds, the two high elevation wintering ecotypes summer in the alpine and in subalpine forests.

Rutting

For the California ecotype, rutting ranges are often encompassed by the winter and/or lambing areas. For the Rocky Mountain ecotype, large bands of rams move to a fall concentration area or pre-rut range in late September or early October where they generally stay from 2 to 5 weeks. They disperse from this area in the first week of October or the first week in November to rutting grounds that are usually the same areas used as winter range by the ewe-juvenile component of the herd. The rams remain there until

mid- to late December. At this time, some rams will return to the pre-rut home range while others move to mid-winter home ranges where they spend 271–303 days (Geist 1971). Some young rams and the ewes and juveniles will remain at the rutting grounds. By mid-March rams return to their fall concentration areas prior to migration to summer range.

Mineral licks and watering holes

Bighorn Sheep return repeatedly to localized areas that are used as mineral licks and watering holes. These are specific to individual herds and individual herds will often use more than one mineral lick or watering hole. Access to potable water in locations secure from predation is important, particularly when ewes are accompanied by suckling lambs.

Mineral licks are an important source of essential minerals for most mountain ungulates. Certain trace minerals such as selenium and copper have been suggested as being limiting in some habitats (Schwantje 1988). This may be especially true for Bighorn Sheep herds in British Columbia because soil mineral content is low throughout their distribution (Van Dyke 1978) and this may result in some forage with low mineral content (Smith 1954). Hebert (1973) found that diets based on high altitude forages had higher levels of essential trace minerals than those at lower altitudes. Mineral content among licks varies considerably (Dormar and Walker 1996) suggesting that (1) various types of licks may serve different needs, and (2) sheep use more than one lick site. Deficiencies of trace minerals such as selenium and copper are responsible for reduced immune function in other ungulate species and may contribute to outbreaks of disease in Bighorn Sheep (Packard 1946; Schwantje 1988).

Conservation and Management

Status

Bighorn Sheep are on the provincial *Blue List* in British Columbia. Their status in Canada has not been determined (COSEWIC 2002).

Summary of ABI status in BC and adjacent jurisdictions (NatureServe Explorer 2002)

BC	AB	WA	ID	MT	Canada	Global
S2S3	S3	S3S4	S3	S4	N3	G4

Trends

Population trends

The population of California Bighorn Sheep in British Columbia includes five metapopulations, two of which—the south Okanagan and Kettle-Grandby metapopulations—encompass small isolated populations in northern Washington. The population of Rocky Mountain Bighorn Sheep in British Columbia is part of a core-satellite metapopulation of approximately 18 000 Rocky Mountain Bighorn Sheep in British Columbia, Alberta, and part of Montana, with the core situated in Alberta.

A minimum viable population of 125 has been determined for Bighorn Sheep at the subpopulation level (Berger 1990). Of the 10 subpopulations of California Bighorn Sheep in British Columbia, two are extremely small at <20 individuals, one is <125, and seven are ≥125. Of the 14 subpopulations of Rocky Mountain Bighorn Sheep in British Columbia, six are <125 individuals, and eight are ≥125.

British Columbia's California Bighorn Sheep population was estimated to be 3030–3625 in 1998, the last year of record. There was an increasing trend in both numbers and populations of California Bighorn Sheep from the early 1960s through the 1980s (Ritcey and Low 1986) and into the early 1990s (B.C. MELP 1998). The provincial population of California Bighorn Sheep increased from 1760 in 1970 to 3240 in 1985 and then to 4650 in 1990. By 1998, the population had declined to 3630 (B.C. MELP 1998; Toweill and Geist 1999). This sudden decline was largely a result of very low lamb survival amongst herds in the Fraser Basin and a die off caused by severe winter conditions in the Ashnola in 1990–1991. In 1999–2000, the central herd in the south Okanagan near Oliver, B.C., suffered a severe all age die-off, further reducing their numbers and heightening agency and public concerns for future population trends (Harper et al. 2001).

The population size of Rocky Mountain Bighorn Sheep in British Columbia was approximately 3000 in 1996, the most recent year of record. This is the largest size that inventory figures have recorded, although there may have been a larger population pre-historically when grasslands were probably more widespread. The distribution has not changed significantly from the early part of the 20th century.

Regular cyclic die-offs have dramatically affected population numbers and trends, approximately every 20 years beginning in the early 1920s (Davidson 1991). Following recovery of the last, early 1980s die-off, the population trend for Rocky Mountain Bighorn Sheep was generally upward until 1996, but there has been a subsequent decrease.

Reduced lamb survival and other contributing factors continue to be problematic for some herds. For example, a small-scale outbreak of bacterial pneumonia occurred in the Elk Valley in the fall in the late 1990s, however, this appeared to have been self-limiting as there were no further reports of sick or dead sheep following the rut (H. Schwantje, pers. comm.). Also, a significant loss of California Bighorn Sheep was caused by the translocation of mature animals from several herds between the 1950s and 1990s.

Habitat trends

An increasing amount of the traditional winter and spring habitat of Bighorn range is being alienated and/or developed for residential, agricultural, and industrial purposes. Such conflicting land uses have been and will be inevitable, because low elevation bighorn habitat is often some of the most desirable for human development. For the Rocky Mountain Bighorn Sheep, the capability of the habitat has been diminished by permanent factors such as land alienation, highways, subdivisions, and open-pit mines by <10% (Demarchi and Demarchi 1994). The suitable habitat at present is <50% of the capable habitat within the historic distribution because of forest access roads, forest succession, competition with livestock, and human disturbance. In addition to the direct loss of habitat, conifer encroachment onto native grasslands and loss of seral-shrub-grassland range have been accelerated by aggressive fire suppression practices of the provincial Ministry of Forests over the past 40 or more years. Conifer tree encroachment has occurred at a rate of 0.5–2%/yr on low-elevation winter ranges (Davidson 1991). Based on the observations of wildlife managers, the rate of winter habitat change is considered "rapid." California Bighorn Sheep managers have expressed concerns for the loss of habitat through forest fire suppression and forest succession (T. Ethier, D. Jury, D. Low, and J. Youds, pers. comm.). Critical winter range habitat has been significantly reduced throughout the Rocky Mountain Bighorn Sheep's range (≤50%) over the last 70 years. Due to their higher moisture regimes, encroachment has been even greater on spring and fall transition ranges. The loss of transition ranges forces Bighorn to arrive on winter ranges earlier and leave later (increased sedentariness). Overused winter ranges cause nutritional stress and can increase parasite (especially lungworm) infection rates leading to increased lung damage.

Threats

Population threats

Factors predisposing the south Okanagan Bighorn Sheep population to a disease die-off in 1999–2000 include probable disease transmission from domestic sheep, trace mineral deficiencies, habitat effects from urban and agricultural development, weed invasion, fire suppression, increased predation, range depletion, and forage competition with livestock and wild ungulates and harassment by humans and dogs (Harper 2001). Stressors implicated in East Kootenay Bighorn die-offs have included poor nutrition, trace mineral deficiencies, high animal density, inter-specific competition, inclement weather, harassment by humans and dogs, and high levels of parasites.

Livestock ranching is the primary threat to Bighorns through disease transmission, range depletion, and resource competition. A definite cause-and-effect relationship exists between bacteria, such as *Pasteurella* species, carried by domestic sheep and transmitted to mountain sheep. This relationship has been suspected since at least 1954 (Smith 1955)

and proven since 1982 (Foreyt and Jessup 1982). *Pasteurella* species, commonly present in domestic sheep, can induce fatal pneumonia in otherwise healthy bighorns from nose-to-nose contact (Foreyt and Jessup 1982; Onderka 1986; Onderka and Wishart 1988).

High levels of lungworm (*Protostrongylus stilesi*) infection can cause high mortality in Bighorn lambs. Although Bighorns and this species of lungworm have coevolved, the developing stages can cause significant damage to lung tissue. Any habitat factor that improves survival of lungworm larvae, their intermediate host (i.e., terrestrial snails), or their rate of ingestion will increase lungworm loads in Bighorns. Higher animal infection rates have been associated with higher soil moisture levels. Irrigated agriculture fields that attract Bighorn Sheep may exacerbate the problem since the high animal density, increased grazing pressure, and increased number of lungworm-carrying snails ingested may lead to higher infection rates (Harper 1995; P. Dielman and H. Schwantje, pers. comm.). Added to this, these sheep may prefer to live year round on such habitat and lose their normal home range movements and behaviour.

The harassment of wildlife by the presence of humans, whether in the form of wildlife viewing stands, aerial censuses, snowmobiles, helicopters, vehicles, or domestic dogs, can add undue stress to vigilant species such as Bighorn Sheep (MacArthur et al. 1982; Krausman and Hervert 1983; Stemp 1983; Legg 1998). During the third trimester and while lactating, ewes are particularly sensitive to human disturbance as they move frequently in search of high quality forage (Wagner and Peek 1999).

Predation is a possible limiting factor for Bighorn populations (Haas 1989). Eight carnivore and raptor species can prey on Bighorn, namely Grizzly Bear (*Ursus arctos*), Black Bear (*Ursus americanus*), Cougar (*Felis concolor*), Bobcat (*Lynx rufus*), Lynx (*Lynx canadensis*), Wolf (*Canis lupus*), Coyote (*Canis latrans*), and Golden Eagle (*Aquila chrysaetos*) (Kennedy 1948; Buechner 1960; Sugden 1961; McTaggart-Cowan and Guiguet 1965). Predation undoubtedly varies over space and time although coyotes, cougar, and grizzly bears are suspected to take a considerable portion of the annual production. Bighorn Sheep are less well adapted to avoiding the stalking and ambush techniques of cougars in rough terrain, particularly where there is tree or rock cover (Wishart 1999). Wehausen (1996) determined that cougar predation reduced the annual adult ewe survival to 62.5% and cougar predation accounted for 100% of all adult ewe mortalities in his study area. Hebert and Harrison (1988) studying California Bighorn Sheep in the livestock-free Junction herd concluded that coyote predation and not range condition, nutrition, stress, parasites, disease, or climate resulted in a significant loss of lambs. Harrison and Hebert (1988) also concluded that cougar predation and not habitat condition or illegal hunting reduced the number and proportion of mature rams in the Junction herd. Evidence was obtained in their study that supported the hypothesis that scavenging of cougar kills by coyotes increased the frequency of predation by cougar.

Livestock operations with inadequate methods of carcass disposal may inadvertently result in an increase or concentration of predators that in turn may lead to increased predation on adjacent Bighorn Sheep populations.

Habitat threats

A large domestic sheep industry and the free ranging of large numbers of horses on Crown range in the early to mid-1900s resulted in damage to fragile low elevation and alpine grasslands important to Bighorn Sheep in the interior in such places as the Yalakom and Ashnola valleys (Demarchi and Demarchi 1987).

Impacts from cattle grazing include reduced forage supply, abandonment of ranges, decreased distance to escape terrain, and altered habitat use patterns (Bissonette and Steinkamp 1996) in addition to depletion of range condition and trampling and fouling of watering holes and mineral licks. Plants may not support a second grazing by cattle if they are to support Bighorn Sheep the following winter and spring. While grazing lands can benefit from judicious management of cattle, they must be

carefully managed to ensure Bighorns have the appropriate forage available at the critical times of year on the critical preferred habitats.

California Bighorn Sheep habitat has been permanently lost through subdivision development on traditional sheep range, particularly in the southern Okanagan and also near Grand Forks in the Kettle-Granby, through expansion of vineyards in the southern Okanagan and expansion of alfalfa and ginseng cultivation in the Fraser River Basin. Nearly 9000 ha of native grasslands were converted to agricultural and urban development in the southern Okanagan between 1940 and 1987 with a further 4000 ha projected to be lost over the next 20 years, if present trends continue (Harper et al. 2001).

Rocky Mountain Bighorn Sheep habitat has been permanently lost through urban development at Radium Hotsprings, Fairmont Hotsprings, and Elko and the golf course at Radium. Agricultural developments along the Galton Range and Bull River have been established on traditional Bighorn Sheep range. Acreages and subdivisions between Fairmont Hotsprings and Brisco also have the potential to disrupt north–south migration of Bighorn Sheep along the western edge of the Rocky Mountains (Davidson 1991). Approximately 25% of the winter range for Bighorns in the upper Columbia area has been accessed, subdivided, and developed for housing and industry since the 1940s (Davidson 1991).

Roads and railways (e.g., Highway 97 in Vaseux, Canadian Pacific Railway, Highway #1 at Spences Bridge, Highway #3, and the highway from Radium through Kootenay National Park) occupy habitat, dissect migration routes, and result in direct mortality. Salt used for road maintenance can attract and hold sheep in highway corridors. In some cases, significant numbers of adults have been lost in single seasons.

Industrial developments such as forestry, mining, and hydro-electric developments can result in habitat loss and displacement, disturbance, interference with seasonal movements along established secure corridors, and increases in animal exposure to predation. Helicopter activity associated with seismic work, forestry, and recreation can disturb and displace sheep.

Specific developments that have impacted Bighorn Sheep include the Aberfeldie Dam and Elko Dam; open-pit mining and overburden dumping in the Elk Valley which not only altered but completely destroyed Bighorn Sheep habitat in some areas (Demarchi and Demarchi 1987); Westroc Gypsum mine at Windermere; and Line Creek's open pit coal mine.

Other examples of development that have impacted Bighorn Sheep are historic developments such as the exploration for coal with heavy equipment in the Fernie Coal Basin of the Elk Valley in the late 1960s and early 1970s (Demarchi 1968, 1977), major seismic work throughout the Southern Rockies on both sides of the Continental Divide in the 1950s, and natural gas seismic activity in the Flathead in the 1980s.

Impacts from recreation such as ski resorts, all-terrain vehicles, rock climbing, golf, heli-skiing include habitat loss, disturbance, and foraging efficiency reduction (Stockwell et al. 1991; Bleich et al. 1994). The resulting chronic stress can lead to poor health, reduced growth, and reduced reproductive fitness (Geist 1979). Chronic disturbance can work additively with other habitat and animal factors and lead to immuno-compromised individuals or populations and result in outbreaks of disease. Sheep habituated to human disturbance may be susceptible to increased highway mortality, harassment by people and dogs, and dependency on artificial food sources that may be only temporarily available.

Forest encroachment and fire suppression are reducing suitable habitat by replacing grass, forbs, and deciduous shrubs with conifers. Forest succession can interfere with seasonal movement patterns and grazing behaviour because, as the density of trees increases, the visibility decreases, increasing predation by carnivores relying on stealth. Fire suppression alters the fire ecology of grasslands.

Competition for forage from elk and mule deer on low elevation winter ranges may be substantial

(Smith and Julander 1953). Elk numbers in the East Kootenay increased from about 7000 in 1974 to about 28 000 in 1980 (Davidson 1991). When resources are scarce, Bighorn Sheep ewes may postpone first reproduction (Festa-Bianchet et al. 1995) or reduce maternal care resulting in decreased lamb survival (Festa-Bianchet and Jorgenson 1998).

The introduction and spread of invasive species on grasslands are of great concern because they replace nutritious native forage species with inedible or non nutritious plants.

Legal Protection and Habitat Conservation

Where hunting seasons are permitted, Bighorn Sheep are normally harvested under a general open season male-only with specific horn curl minimums (e.g., full or ¾ curl). Limited entry hunting (LEH) authorizations, quotas, and administrative guidelines are used to regulate hunting in some areas. Limited ewe and lamb hunting are provided where sheep numbers are approaching or have exceeded carrying capacity. Annual management unit estimates, compulsory inspection, 3- to 5-year population monitoring, population modelling, and site-specific surveys are employed by the regional and provincial wildlife managers to monitor and regulate populations. Hunting can be an important management tool for Bighorn Sheep herds due to the potential for dramatic cyclical die-offs associated with exceeding the carrying capacity of ranges. A recent survey of sheep managers in North America indicated ram hunts and ewe hunts may be a cost effective means of controlling populations at or near carrying capacity (Hacker 1999).

The ranges of some herds are protected or partially protected by provincial protected areas including:

- Junction Sheep Range Provincial Park contains the year-round range of the Junction herd
- Churn Creek Park contains the winter range of the Churn Creek herd
- Big Creek/South Chilcotin contains the year-round range of the Park Elbow/Relay herd
- Lac du Bois Grasslands contains the Kamloops Lake peripheral winter range
- Marble Range and Edge Hills Parks contain the limestone summer and winter range of the East Fraser River herd
- Cathedral Provincial Park and the newly established Snowy Mountain Provincial Park contain the Ashnola herd
- Kootenay National Park contains half of the summer, half of the winter, and all of the transitional ranges of the Radium-Stoddart Creek herd
- Yoho National Park encompasses all of the summer range for the Golden herd
- Mount Assiniboine Provincial Park and adjacent Banff National Park encompass the entire range of the Assiniboine herd
- Height of the Rockies Provincial Park encompasses the entire range of the Quarrie and Bingay Creek herds
- Akamina-Kishinena Provincial Park includes the summer range for the Waterton (Alberta) herd
- Kakwa Provincial Park protects the summer range of the Kakwa herd
- Ilgachuz Range herd is protected year round by Itcha Ilgachuz Provincial Park.

The East Columbia Lake Wildlife Management Area and the Crown property on Mount Broadwood protect important Rocky Mountain Bighorn Sheep winter ranges. In addition, private land acquisition programs have acquired the Starr Ranch at Sheep Mountain, the Neilson property at Bull River, and private property at the east side of Columbia Lake. The size of parcels varies from a few hectares of strategically situated land to over 12 000 ha of prime winter range on Mount Broadwood on the Wigwam River. However, private inholdings in the Wigwam area threaten the integrity of the winter range.

Some key California Bighorn Sheep winter and summer ranges are partially or wholly encompassed by Indian Reservations. These include Ashnola (summer range), Vaseux, North Thompson, Dog Creek, and Nemaiah. Range condition on Indian Reservations varies but as many areas are subject to year-round grazing by cattle and/or horses it is generally classed as "fair to poor" condition. In

addition, housing, commercial, recreational, and industrial developments such as the proposed 2000 lot subdivision and cable tram to the top of Mount St. Paul at the junction of the North Thomson and South Thompson rivers is expected to reduce the capability of the area to support Bighorn Sheep (F. Harper, pers. comm.). Housing and agricultural developments are among the greatest threats to maintaining the integrity of habitat in the southern Okanagan. Several non-governmental conservation organizations are actively pursuing a private land acquisition program.

A health protocol developed for domestic sheep used for vegetation management in British Columbia and Alberta was developed to ensure healthy domestic sheep access to forest lands for silvicultural purposes. Guidelines have been developed and include a review process whereby wildlife biologists are to document the presence of wild sheep and goat herds near the proposed vegetation management site. If these herds are present, the project is refused. The protocol and guidelines cannot address cattle, nor the presence of domestic sheep and goats on private land adjacent to Bighorn Sheep range. Livestock ranching and agriculture can play important roles the health of Bighorns (i.e., through disease transmission and resource competition). The recommendation of the Northern Wild Sheep and Goat Council is to provide a buffer of at least 4 km between wild and domestic sheep while others recommend 16 km (Sweanor et al. 1996). Recent guidelines used in British Columbia and Alberta are approximately 10 km, depending on natural barriers.

Access management in Bighorn Sheep habitat has centred around snowmobile and ATV uses of winter ranges and the restriction of motor vehicles for hunting. Employing the access provisions of the *Wildlife Act* to regulate road use for specific purposes provides only a partial, temporary solution to overuse of terrain resources and harassment of Bighorn Sheep. Establishing road closures for specific purposes while leaving the road open for other uses has only been a partial and often contentious solution. Critical winter range areas such as Churn Creek and the Junction range require co-ordinated access management plans which include road reclamation. However, new forest developments such as in the Churn Creek watershed threaten the integrity of movement corridors (P. Dielman, pers. comm.; Keystone Wildlife Research 1998).

The Backcountry Recreation Policy of British Columbia Crown Lands and Assets seeks to increase commercialized recreation of backcountry Crown lands. Development of backcountry lodges and helicopter-assisted skiing and hiking can threaten the integrity of Bighorn Sheep summer and winter ranges and movement corridors.

The regional wildlife program of habitat enhancement, which includes prescribed fire, selective logging, tree slashing, tree spacing, forage plant seeding, tree spacing, forage plant seeding, range fertilization, and noxious weed control, has been hampered by a lack of funding. Where they have been conducted, these efforts have been rarely evaluated post-treatment and thus the responses of the habitat to these treatments are largely unknown.

The Ministry of Forests also has an active program of weed control. Herbicide spraying of knapweed (*Centaurea* spp.) has been ongoing at Juniper Heights, Stoddart Creek, Mount Swansea Road, Canal Flats, Premier Ridge, and all range units within the former Cranbrook Forest District since the late 1970s. In 1994 a "weed control" project was undertaken on Juniper Heights to control leafy spurge (*Euphorbia esula*).

Under the results based code, specific regulations address ungulate winter range and mineral licks. Range use plans may address the needs of Bighorn Sheep provided careful planning and monitoring occur.

Identified Wildlife Provisions

A metapopulation approach should be used to strategically plan and manage for Bighorn Sheep with the ultimate goal of maintaining and enhancing Bighorn Sheep populations and habitats. This means developing a plan over a larger scale with adjacent jurisdictions in Alberta and Montana and in higher

level planning processes using historic and current geographical distribution of Bighorn Sheep ranges and movement corridors. The Okanagan-Shuswap LRMP Approved Plan provides very complete objectives and strategies for Bighorn Sheep habitat in resource management zones as a good example of higher level planning. Additional efforts will be required such as habitat acquisition, the establishment of wildlife management areas, and reintroductions, where advisable.

Sustainable resource management and planning recommendations

The following recommendations are provided for consideration within strategic level planning processes.

- ❖ Maintain and enhance the viability of Bighorn Sheep populations and habitats over their historic range.
- ❖ Reduce and eliminate where possible the contact of other livestock with Bighorn Sheep. It is recommended that, within 16 km of known Bighorn Sheep ranges, the presence of domestic sheep and goats is avoided to minimize disease transmission and competition for forage.
- ❖ Minimize disturbance during critical times and to critical habitats.
  - Develop and implement access management plans (pre- and post-development) that include deactivation recommendations and recommendations to minimize vehicle access, habitat alienation and abandonment, disturbance to Bighorns, vulnerablility to hunters, and the spread of invasive species.
  - Avoid the use of helicopters to remove timber during critical times. Maintain a helicopter no fly zone within 2 km of key habitat features such as mineral licks and watering holes, rutting and lambing areas, and narrow migration corridors.
- ❖ Miminize recreational activities in critical Bighorn Sheep habitat particularly between April and July and between October and November.
- ❖ Maintain Bighorn access to movement corridors and critical ranges.
- ❖ Maintain Bighorn movement corridors and security or resting areas. It is recommended that these areas be buffered by a minimum of 500 m up to 2000 m.
- ❖ Maintain and enhance or restore appropriate forage species and seral stages of forests and grasslands in a condition suitable for Bighorn Sheep.
  - Maintain at least 50% of each Bighorn Sheep winter range in late seral/climax condition bunchgrass dominated communities with abundant, tall grass (easily accessible above snow cover) for winter forage.
  - In areas that have been logged, reforest at reduced stocking rates that promote understorey development (herbs, grasses, and shrubs).
  - Develop and implement prescribed burn plans to enhance forage availability or improve habitat suitability on winter ranges.
  - Limit removal of browse species by livestock to 10% or less of annual browse growth on Bighorn Sheep ranges.
  - Prevent the introduction of invasive species and control spread on ranges. Revegetation of disturbed sites in sheep habitat should be done using native species mixes.
  - Consider intensive silviculture or habitat enhancement activities (spacing and commercial thinning) to enhance important habitat features in Bighorn Sheep habitat.

Wildlife habitat area

Goals

Maintain the integrity of sensitive sites that are localized and critical for specific herds on sites (portions of ranges) where landscape prescriptions are insufficient.

Feature

Establish WHAs at critical habitats: early spring range, lambing areas, late fall rutting areas, watering holes, movement corridors, resting areas, and security sites and associated escape terrain.

Size and design

The specifics of WHA location, size, exposure, and degree of protection will vary with each herd and site specific factors. The WHA should include a core area that maintains important Bighorn Sheep habitats or habitat features and a management zone to minimize disturbance, and prevent disease transmission from domestic sheep and goats.

General wildlife measures

Goals

1. Exclude domestic sheep or goats.
2. Regulate other livestock and livestock practices especially with regards to forage competition.
3. Prevent the introduction or spread of invasive species.
4. Prevent or minimize motor vehicle access to control and prevent disturbance.
5. Prevent or minimize disturbance.
6. Maintain use and access to movement corridors and critical ranges by Bighorn Sheep.
7. Maintain important habitat features.
8. Maintain riparian vegetation and adjacent range in properly functioning condition.

Measures

Access

- Do not construct roads within core area or management zone.
- Control motor vehicle access in the core area and management zone during critical periods: 1 April to 15 July with a peak during mid-June and during October and November.

Harvesting and silviculture

- Do not harvest or salvage in the corea area except for treatments designed to maintain suitable habitat features as directed by the statutory decision maker.
- Avoid silvicultural activities in the core area during lambing or rutting periods (1 April to 15 July with a peak during mid-June and during October and November).

Pesticides

- Do not use pesticides.

Range

- Plan cattle grazing to maintain desired native shrub and grass structure, stubble height, and browse utilization in the core area.
- Control cattle grazing (timing, distribution, level of use) to prevent excess soil disturbance and the introduction of invasive species in the core area.
- Restrict cattle use in the core area between 15 April and 30 June.
- Minimize cattle use of mineral licks and watering holes in the core area. Fencing may be required by the statutory decision maker.
- Do not locate salt or mineral licks, watering troughs, or other range developments in the core area.
- Exclude domestic sheep or goats in the core area and management zone.

Recreation

- Do not develop trails, roads, or recreation sites in the core area or management zone.

Additional Management Considerations

Monitor recreational activities (e.g., ice climbing, snowmobiling) in critical Bighorn Sheep habitat and plan procedures for restricting or preventing their development or expansion.

Do not locate helicopter landing sites and back-country recreation developments on or within 2 km of critical habitats for Bighorn Sheep.

Do not allow snowmobiles or ATVs or other motorized vehicles on critical Bighorn Sheep habitat.

Maintain a no fly zone for helicopter and fixed-wing air craft on critical habitats for Bighorn Sheep.

Maintain a 2 km distance from Bighorn Sheep for helicopters, fixed-wing aircraft, snowmobiles, and ATVs.

Restrict dogs on critical Bighorn Sheep habitat when occupied.

Prescribed burning may be necessary to maintain or enhance vegetation density.

Information Needs

1. Metapopulation conservation analysis over time to better understand the subpopulation dynamics and movement dynamics of the subpopulations in British Columbia.
2. Research on lamb survival, disease, predation, mineral sites, habitat use patterns and efficacy of habitat enhancement and impacts of human disturbance.
3. Impacts of helicopter activity.

Cross References

Badger, Burrowing Owl, "Columbian" Sharp-tailed Grouse, Flammulated Owl, Fringed Myotis, Gillett's Checkerspot, Grasshopper Sparrow, "Great Basin" Gopher Snake, Great Basin Spadefoot, Grizzly Bear, "Interior" Western Screech-Owl, Lewis's Woodpecker, Long-billed Curlew, Prairie Falcon, Racer, "Sagebrush" Brewer's Sparrow, Sage Thrasher, Sandhill Crane, Short-eared Owl, Sonora Skipper, Spotted Bat, Tiger Salamander, Western Rattlesnake, Westslope Cutthroat Trout, White-headed Woodpecker, Yellow-breasted Chat

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