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ENVIRONMENTAL IMPACT OF THE 1988 WINTER OLYMPICS ON BIGHORN SHEEP OF MT. ALLAN

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Abstract: For 2 years prior to the 1988 Winter Olympics on Mount Allan, data were collected on distribution, productivity, survival, lungworm output and activity budgets of bighorn sheep, (Ovis c. canadensis). During 1986/87, the ski area was first opened for public skiing and 2 pre-Olympic downhill races were held. From 1986 to 1987 the population declined by 18% due in part to an intentional increase in the non-trophy sheep hunting permits. Lower lamb survival also contributed to the decline. Lamb production in 1986 was higher (48 lambs per 100 ewes) than in 1985 (29 lambs per 100 ewes). Production in 1987 was 37 lambs per 100 ewes. Range abandonment occurred in 1986/87 on a small portion of the winter range immediately below "the ladies downhill start area". This abandonment was due to human activities on the ridge top, snowmaking, helicopter flights, and avalanche blasting. Numbers of lungworm larvae in sheep feces increased significantly in 1986/87, but they also increased at the control area and at Sheep River. During 1987-88, larval outputs had returned to pre-1986-87 levels. Steps were taken to control helicopter activity and sheep-human interaction above the ladies downhill start for the 1988 Olympics. Co-existence of this sheep population and skiers can probably be maintained provided that no further encroachment on sheep winter range occurs.

In February, 1988 the winter Olympics were held in Calgary, Alberta with the alpine events taking place on Mt. Allan. For those events, a new recreational ski development, Nakiska, was built on the same mountain that winters a large herd of Rocky Mountain bighorn sheep (Ovis c. canadensis). Considerable controversy erupted over the choice of Mt. Allan as the site with much of that concern centering on the effects this development was going to have on the well being of the bighorn herd.

A monitoring program began in spring 1985, and continued until April 1988. Construction of the facility occurred during 1985-86 and the area was first opened for public skiing during 1986-87. Several World Cup downhill races were held that first season as Olympic test races and provided the opportunity to measure sheep response to activities related to normal skiing operations as well as an Olympic equivalent. Based on the results, mitigation would be enacted and its effectiveness measured during the Olympics themselves. The objective of this paper is to report on the impact that first year of operation had on the population, what mitigation was implemented and how the bighorns responded during the Olympics.

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STUDY AREA

Mt. Allan is located approximately 90 km west of Calgary, Alberta at the northern end of the Kananaskis Range (50° 58' N, 115° 12' W). The Nakiska ski area occupies predominantly conifered northern and eastern exposures that provide limited protection from the effects of solar radiation and the strong prevailing westerly winds. These warm winds (chinooks) regularly blow during winter and have a significant modifying effect on the severity of winter. A majority of ski runs are concentrated between the base area at 1495 m and tree line at 2350 m, however, an additional lift (Platter Lift) was constructed to increase the length of the Mens Downhill ski run. This lift extended the ski area into the alpine zone to 2415 m. At 2460 m is the ridgeline above all of the ski runs. The south and southeast facing slopes below this ridge are open alpine and sub-alpine vegetation zones with tree line at about 1750 m.

While most of the upper ski runs radiate from the top of the Gold Chair Lift, 1 run (Women's Downhill) begins further east and at a point lower in elevation. The start of this run is accessed by a narrow catwalk which traverses a conifered slope for approximately 1 km before emerging from the trees onto a ridge at the top of the Women's Downhill. This ridge overlooks the Nakiska ski area to the north and an open alpine slope to the south.

METHODS

Between November and April of each year, data on population size, structure, survival and distribution were collected through direct ground observation with occasional supplementation by aerial observations. Monthly surveys were conducted over the entire Mt. Allan-Wind Ridge winter range with a helicopter being used to census the more inaccessible portions. Due to varying survey conditions, the maximum count obtained from any one monthly census for that year was used. Sheep were classified as to adult ewe, lamb, yearling ewe, yearling ram, 1/4 curl ram, 1/2 curl ram, 3/4 curl ram, and 4/5 curl ram.

Productivity estimates were obtained from ground censuses conducted during the summer. During these censuses, we attempted to travel as much of the summer range as possible in 1 to 2 days in order to reduce duplication. The maximum number of ewes, lambs and yearlings observed during these surveys was used to calculate a summer lamb/ewe ratio. Similarly, a winter ratio was obtained during the winter counts. Total spring cohort size was estimated by taking the maximum number of sheep comprising each cohort found during the previous winter and assuming no

additional mortality until spring. The number of viable lambs present was estimated using the lamb/ewe ratio for that summer and the known number of ewes which were around in late winter. The differences between the spring counts and the following winter counts provided survival estimates.

To determine range use intensity, the study area was divided into grids by vertical projection each approximately 2.5 - 3.0 hectares. Major ridges, creek drainages and cliff bands were used wherever possible as grid boundaries. The area was travelled regularly throughout winter along designated routes, however, because of weather constraints it was not possible to observe all grids with equal intensity. Area use was therefore calculated as number of sheep observed/grid/census trip. Low, medium and high use grids were arbitrarily distinguished using 0-1, 1.1-2.5, and 2.6+ sheep/grid/census respectively as criteria.

Fecal samples were collected monthly from January to April on Mt. Allan and analyzed for Protostrongylus spp. larvae (Samuel and Gray 1982). In addition, monthly samples were also collected from Wind Ridge and used as a control since these sheep were approximately 11 km from the Nakiska ski area. Because of the non normal distribution of larval counts, square root transformations were required of all counts before statistical analysis could be performed.

Additional data were collected incidentally on helicopter activity around Nakiska, snowmaking activities, recreational skiing activities and any other activity with the potential to interact with sheep.

RESULTS

Population Size

The Mt. Allan bighorn winter population increased since 1973 to a high of 297 animals in 1986 (Figure 1). Prior to 1983, estimates were based on a single census, but since 1983, estimates have been the maximum count obtained from an average of 4.4 (range 3-6) surveys per year. Following 1986, the population declined by 18% and remained at that level after the 1988 Olympics.

Survival Rates

Based on differences in cohort numbers from spring to late winter, survival of all cohorts except rams in 1986-87 was lower than that in 1987-88 (Table 1).

Hunting of both trophy rams (4/5 curl restriction) and non-trophy (ewes and lambs) sheep from the Mt. Allan herd occurred, therefore, survival rates include hunting and natural mortality. The number of rams harvested in 1986 and 1987 was 21 and 7, respectively, based on compulsory registration. In 1986, 90 permits were issued for non-trophy sheep with the harvest consisting of 47 ewes and 1 lamb. Permits were reduced to 50 in 1987 and resulted in a harvest of 14 ewes and 1 lamb. One collared ewe was killed in an avalanche and 2 lost to cougar predation. Other predators such as coyotes, bears and wolves are known to frequent the study area, but contribute an unknown level of mortality.

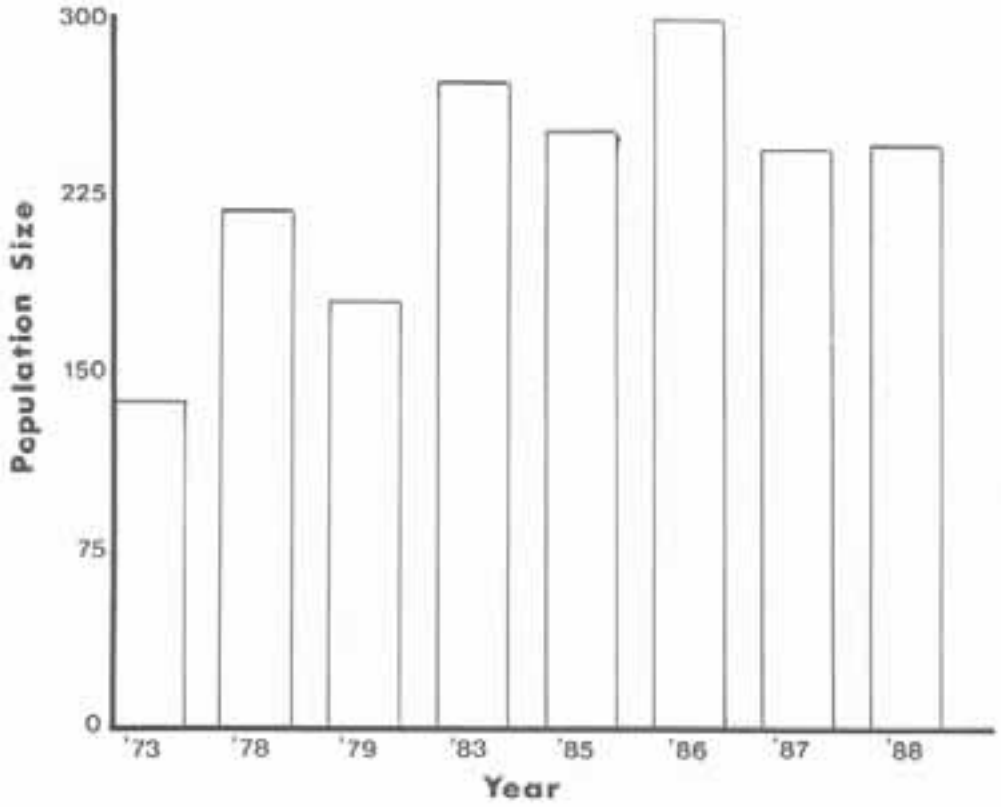

Figure 1. Winter population size of Mt. Allan herd, 1973-1988.

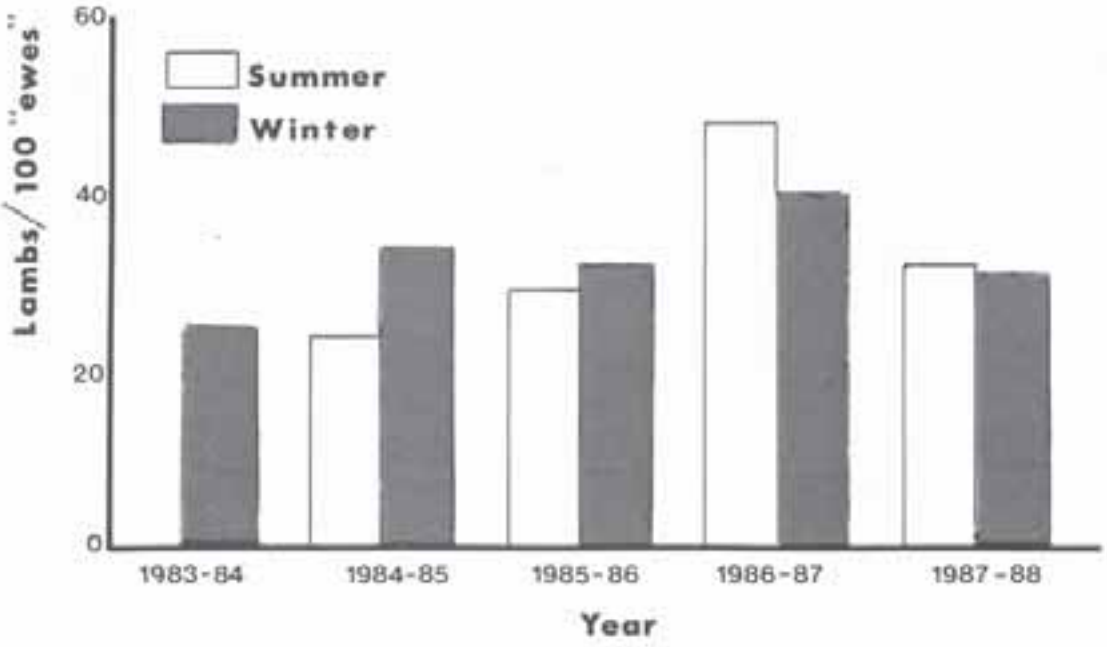

Figure 2. Summer and winter productivity on Mt Allan, 1983-1988.

Table 1. Estimated survival rates of bighorn sheep in the Mt. Allan herd from spring to late winter 1986-1988.

Year	Survival Rate			
	Adult Ewes	Lambs	Yearlings	Adult Rams
1986 to 1987	.62 (155)[a]	.58 (85)	.45 (56)	.78 (91)
1987 to 1988	.92 (112)	.79 (56)	.82 (49)	.67 (94)

[a]( ) = size of cohort in spring

Productivity

Winter lamb/"ewe" ratios (includes yearlings and 2-year old and adult ewes) averaged 32.4 (range 25 - 40) each year since 1983-84 with the highest ratio observed during summer 1986 (Figure 2). Summer values tended to be slightly lower ($\bar{x}$ = 33.2 vs. 34.2) than winter. In 1986-87 that trend was reversed indicative of the poor lamb survival previously seen. The hunting of ewes influenced the winter ratios and could explain the differences observed from summer to winter. A disproportionate number of ewes were harvested with less than 10% of the total consisting of lambs (Harvest statistics, Alberta Fish and Wildl. Div.).

Distribution

In winter, approximately half the herd concentrated on Wind Ridge while the balance extensively utilized the south and southeast facing slopes of Mt. Allan. Greatest use was made of those grids in the basin located to the southwest of the ridge above the Nakiska ski area. Sheep did however, make use of areas immediately above the Men's Downhill run and adjacent to the Ladie's Downhill run. To examine area use on a yearly basis, the study area was divided into 3 areas based on their proximity to the ski area (Figure 3) with Area 1 being on the same face or adjacent to the ski area, and Area 3 being farthest from the activity.

Area 2 received the greatest use throughout the winter and in all years with Area 1 receiving the least (Figure 4). Use of Area 1 was greatest in early winter while Area 3 was used mostly in late winter. Compared to 1985-86, Area 1 usage in 1986-87 declined to nil after December and remained negligible for the rest of the winter. In December 1986, the ski area first opened to public skiing and downhill test races were held in March. With the decline came an increase in Area 3 usage. In 1987-88, Area 1 appeared to receive similar usage to that seen in 1985-86. Also in 1987-88, the percentage of sheep using Area 3 remained high and was actually higher than Area 2 during February.

Lungworm Analysis

Compared to 1986, 1987 fecal lungworm outputs increased significantly

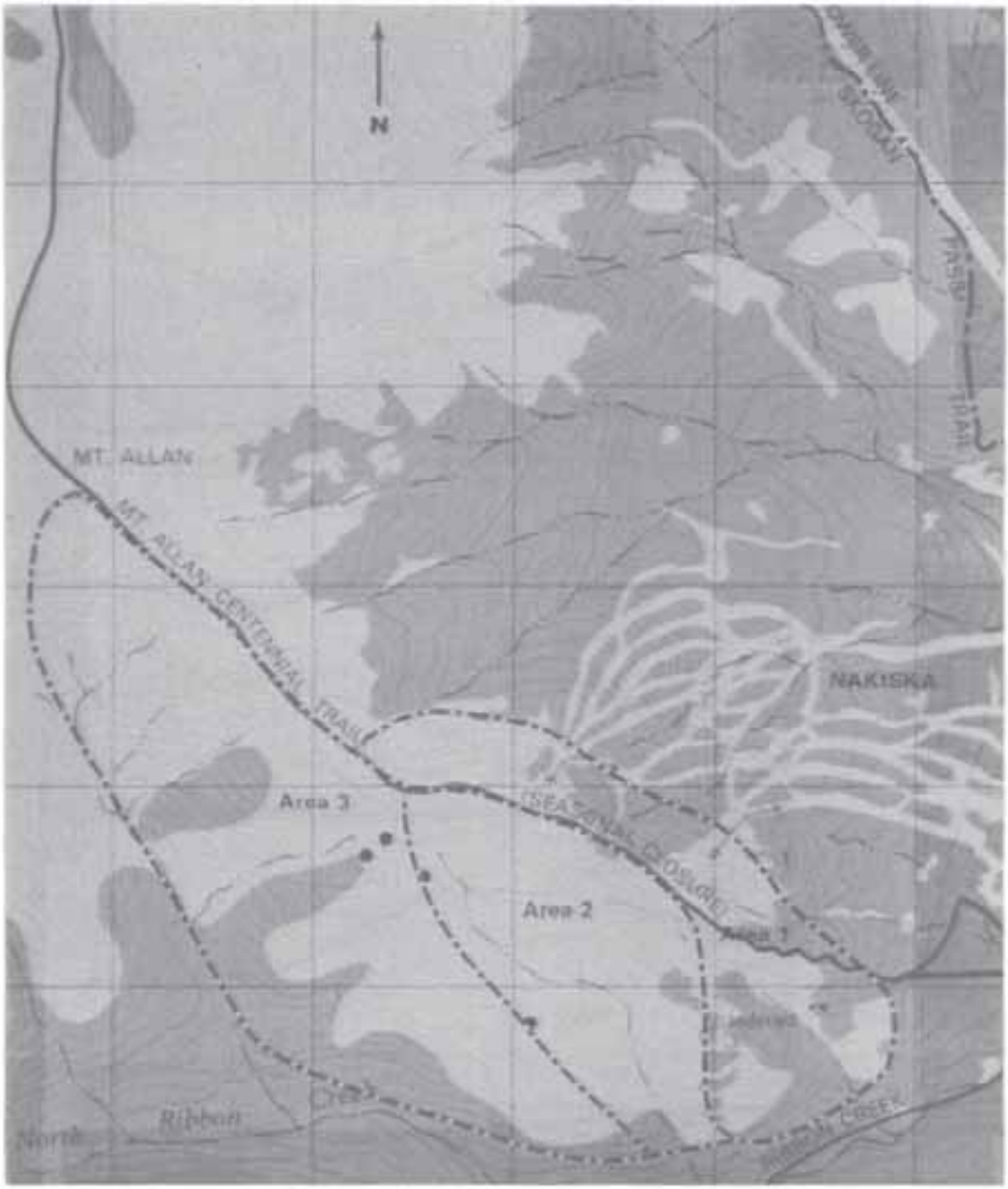

Figure 3. Locations of Area 1, Area 2, Area 3, and supplemental feeding sites (●) on the Mt. Allan winter range, 1987-88. (w→Women's downhill, w←Men's dowhill)

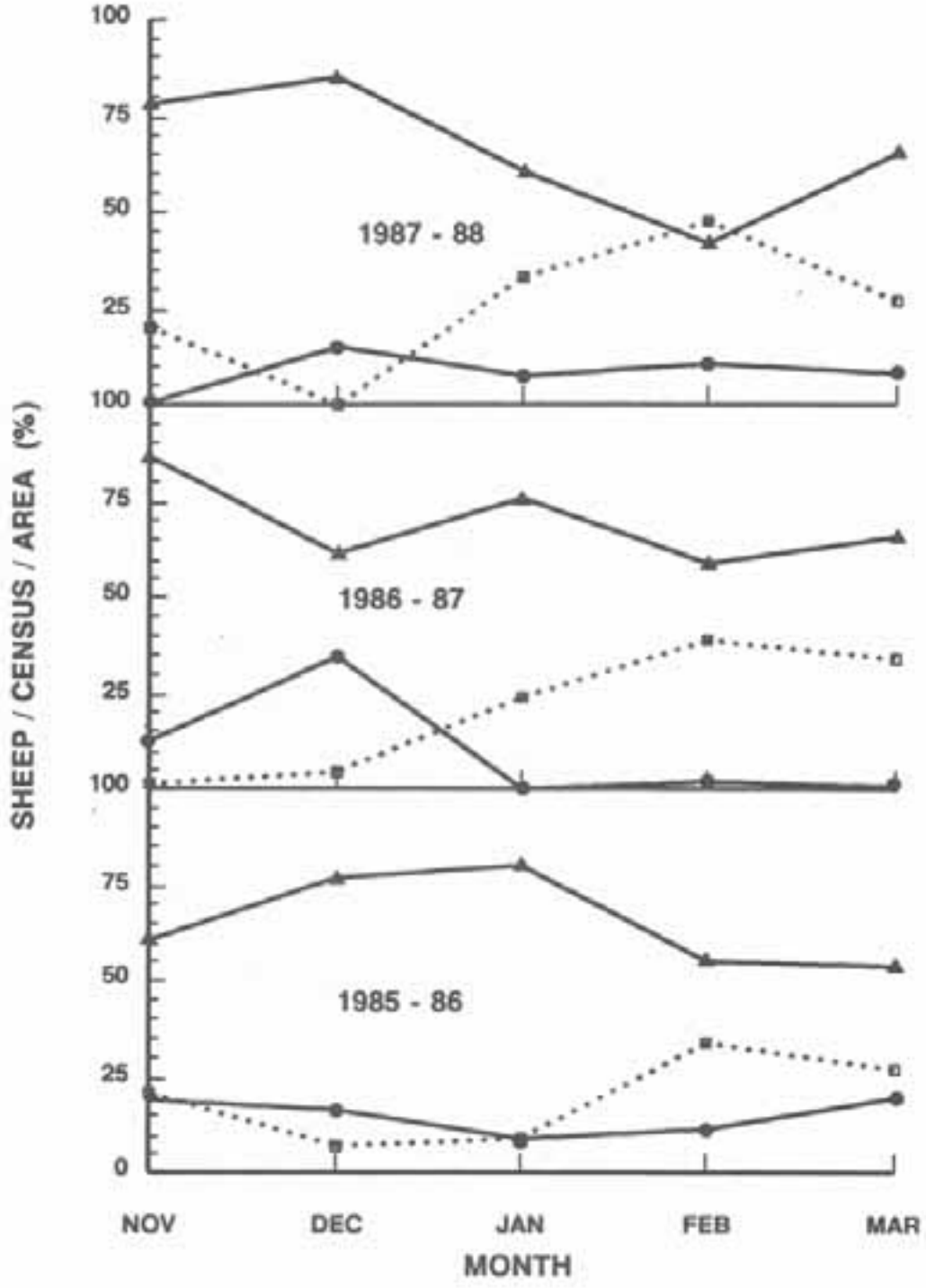

Figure 4. Area use of Mt Allan winter range 1985 to 1988. (●) area 1; (▲) area 2; (□) area 3.

($P < 0.01$). These increases occurred at both Mt. Allan and Wind Ridge (Figure 5). In 1988, larval outputs decreased to levels comparable to 1986.

Associated Activities

During the World Cup races in March 1987, helicopter activity in the Nakiska area was high. During the 2 week period, helicopters were flying above Nakiska every day except 2 bad weather days. Helicopters being used for race-related functions were not considered a problem because they stayed at or below treeline and to the northeast of the ridge. A majority of the helicopters were chartered by media groups and they did fly west of the ridge over the winter range. Film footage of bighorns taken from the air did appear on 2 television networks covering the races. Sheep predictably fled when the helicopters came overhead usually at an altitude of less than 150 m.

Snowmaking and avalanche blasting occurred during the 1986-87 and 1987-88 ski seasons. Snowmaking guns are extremely noisy and an individual cannot stand next to one for long without ear protection. While most of the snowmaking guns at Nakiska were used at lower elevation, one gun at the top of the Ladie's Downhill caused momentary disturbance to the sheep grazing on the slopes below the ridge. Their reaction upon start up of the guns was to bolt a short distance and then gradually leave the area. This reaction was noted on several consecutive days until the sheep stopped using that slope. Sheep were not seen in any area that coincided with avalanche blasting. Such blasting was done with a cannon type system and occurred on slopes near both the Men's and Ladie's Downhill courses.

People were not observed outside the ski area boundaries climbing the mountain to gain access to viewpoints. Security patrols also did not occur outside the boundaries during either the World Cup or Olympic events. Considerable human activity did occur on the ridge above the Ladie's Downhill. Such activity was related to maintenance, course preparation, officials, media, coaches and racers. During the World Cup as many as 100 people were in the vicinity of the ridge top sightseeing and picture taking. Sheep did not stay during such times. After the World Cup races, public skiing was permitted on the Ladies course with a resulting high percentage of skiers skiing onto the ridge.

Mitigation

Supplemental feeding program.-- To lessen the impacts of the Olympics and future recreational skiing activities at Nakiska, several mitigative steps were taken. A supplemental feeding program was initiated to supply sheep with a higher than normal protein diet during the Olympic winter. Its purpose was to improve body condition that theoretically would enhance an individual's ability to counter any increased stress. Additionally it would act as a lure to keep sheep in areas away from human activities. Hay bales (timothy/brome/alfalfa mix) were flown by helicopter in November to 4 sites (Figure 3). Approximately 110 bales were stacked, wrapped in plastic fencing, and covered. Beginning in November, bales were removed

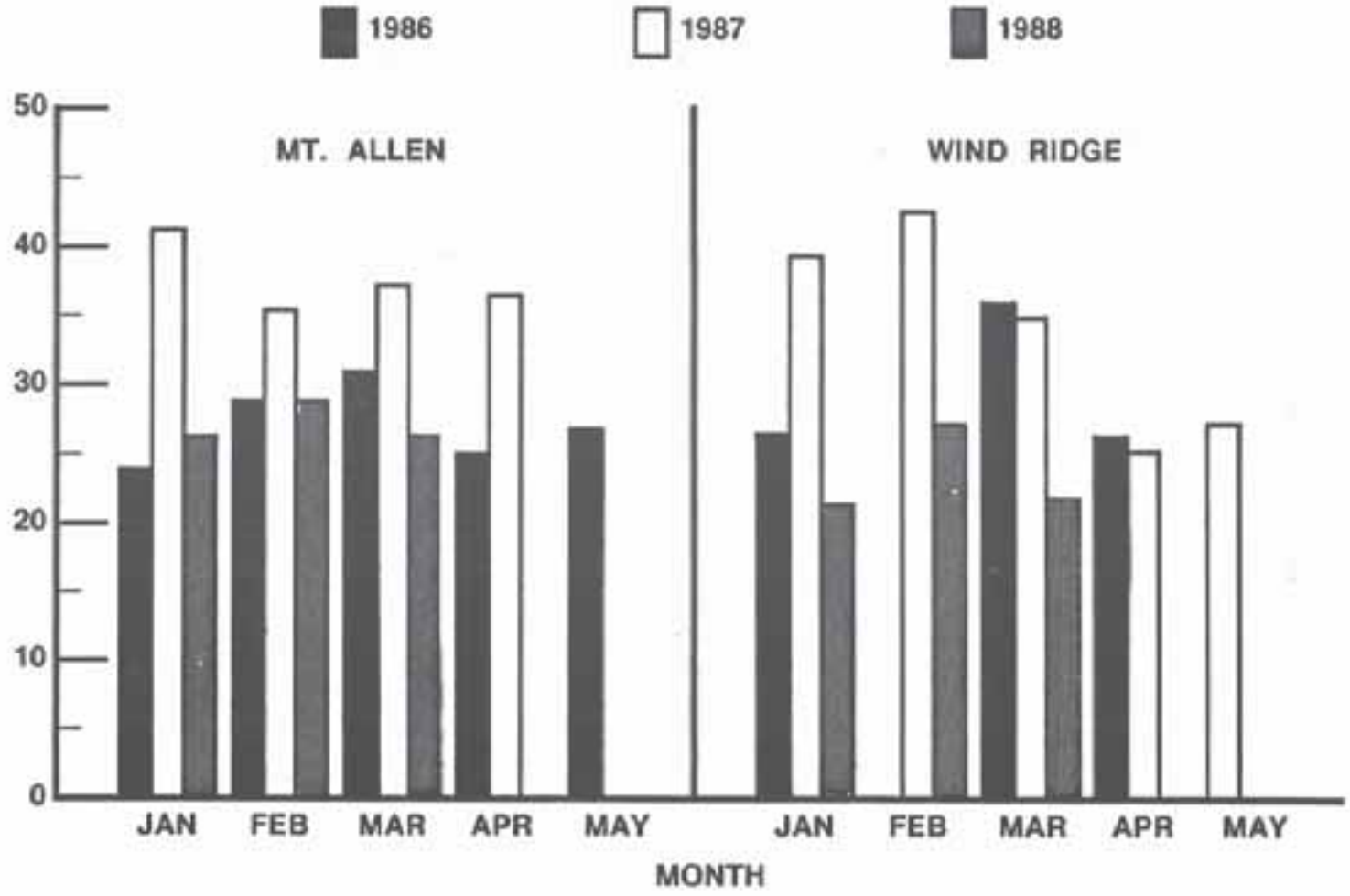

Figure 5. Mean monthly larval output from Mt Allan and Wind Ridge, 1986 to 1988.

and made available to the sheep. The amount available was slowly increased until February when hay was continually available.

Although on traditional winter range, sheep exhibited little inclination to consume the hay until the first cold temperatures (-20°C) and snowfall in January. From then until late February sheep were observed feeding at at least one of the sites whenever we were in a position to see them. During the first week of the Olympics, sheep were feeding on the hay daily often with all 4 sites receiving use. Once the weather turned mild, however, sheep only occasionally fed at the sites. By April, slightly more than half the feed had been consumed.

Helicopter restrictions.-- To alleviate helicopter harassment during World Cup events, voluntary flight guidelines were established restricting aircraft from flying west of the ridgetop above the ski area. These guidelines were distributed to all local charter companies and major media organizations. This system proved ineffective as the guidelines were ignored on several occasions. Requests to film sheep from a helicopter were received from 2 television stations and 2 stations did show film footage of bighorns prior to their broadcast of the race.

The potential for higher air traffic during the Olympics prompted the need for more effective regulations. In cooperation with the Ministry of Transportation, a NOTAM (Notice to Airmen) was put in place from January 30-March 2. Such aircraft restrictions were required for security and safety reasons anyway but were refined to accommodate our requests. Movements within the restricted airspace by accredited aircraft only, were strictly monitored and violators faced loss of licence. This regulation proved most effective. Three aircraft did fly west of the ridge during the Olympics with 2 of those being brief security flights (not required to adhere to air space restriction). The third incident involved a disoriented pilot flying from the west passing over the winter range at an altitude of about 2700 m.

Women's downhill start area.-- Attempts were undertaken to alleviate the problem of people congregating on the ridge area. Recontouring of the slope was done to prevent the funnelling of skiers onto the ridge and instead channel them downslope. In addition, a fence was erected above the start building to block access to the ridgetop. The fence proved difficult to maintain due to the high winds and proved only marginally effective. People were still able to find a way around or over the fence. Spectators were not allowed access to the upper part of the ski run, which helped in keeping the volume of people down, but there were still many officials, course workers, coaches, competitors, and media people in the area. The media were the worst offenders. During the actual competition, all attention was focused on the race and people did not have time to wander. Both before and after the Olympics the Women's course was closed to recreational skiers.

Population reduction.-- The sheep population was intentionally reduced the year before the Olympics to reduce the threat of added stress on the population due to overcrowding. This was achieved through an increase in the non-trophy sheep permits from 60 in 1985 to 90 in 1986. For 1987, permits were reduced to 50. Following the 1986 hunting season,

a reduction of 18% was observed in the winter population. This represented a decline from about 309 animals to 251. Of the difference from 1985-86 to 1986-87 in the population age and sex structure, 61% was due to a decline in adult ewes. The 48 sheep (47 ewes, 1 lamb) shot in 1986 represented a harvest rate of 16% of the 1985-86 winter population. Taking into account the recruitment of yearling ewes from the winter of 1985-86 into the 1986 summer adult ewe population, the 90 non-trophy permits issued in 1986 contributed to less than half of the observed decline in adult ewes. The previously noted low survival of yearlings and lambs contributed more to the observed population decline.

DISCUSSION

During the first year of ski area operation, the Mt. Allan herd experienced a decline in population size, low survival rates, higher than previous lungworm levels, and some range abandonment. The following spring, a drop in lamb production was evident. The decline in numbers was directly the result of poor survival of all cohorts except rams and to an intentional increase in hunting permits. Hunting could account for most of the observed declines in adult ewes and rams. The reason for poor survival of lambs and yearlings was unknown. Survival rates the following year however, were very high and comparable to the high quality population on Ram Mountain (Jorgenson and Wishart 1986). Had high mortality in 1986-87 been stress related then that same stress was no longer affecting survival in 1987-88. Sheep may have acclimatized to the new disturbances.

While low lamb:ewe ratios followed 1986-87, they were similar to those observed the 3 years prior to 1986-87. It is known that lamb:ewe ratios from Ram Mountain have ranged from 34 to 55 in a herd with pregnancy rates averaging 90% (Jorgenson and Wishart 1986). Since Mt. Allan values fall at the low end of that range, nothing can be inferred about pregnancy rates but recruitment has obviously been low for 4 of the last 5 years. Such low ratios could indicate high levels of neonatal mortality, high lamb predation or low pregnancy rates.

The increased lungworm shedding rates recorded in 1986-87 were alarming and may have indicated high stress levels, but the same high levels were also found in sheep from Wind Ridge. Outputs also increased at Sheep River, a foothills population 51 km southeast of Mt. Allan, in 1986-87 (Festa-Bianchet pers. comm.) suggesting an environmental factor unrelated to Nakiska was involved. While tempting to attribute these parameter changes to the new activities on Mt. Allan, it was not possible to establish any definite link.

It is possible, however, for increased stress levels to have caused the observed changes. In responding to stress, unnecessary energy expenditures can negatively affect production in Dall sheep (Bunnell 1978, Nichols 1978) and lower the quality of individuals in all populations of wild sheep (Shackelton 1973, Heimer and Smith 1975). Loss of range could have increased crowding, which has often been cited as contributing to disease outbreaks (Lance 1980, Festa-Bianchet 1988), increased parasite loads (Stelfox 1976), and to decreased productivity (Murphy and Whitten 1976). Initial stress of captivity and food - water deprivation together with crowding caused increased larval shedding in captive bighorns

(Fougere-Tower and Onderka, 1988). In addition, an indirect relationship between poor body condition and high fecal larval output has been demonstrated in bighorn ewes by Festa-Bianchet (1987).

That sheep on Mt. Allan were affected by certain activities on the ski area was only definitely shown in the abandonment of that portion of their winter range below the ridge above the Women's downhill run. This area was vacated after December 1986 and not used the rest of that winter. At the same time, there was a increase in sheep use of Area 3 - that farthest from the activity suggesting these new activities were forcing sheep to move as far as possible from the disturbance. People congregating on the ridge, snowmaking, avalanche blasting, and helicopter activity were all contributing factors. Except for the occasional helicopter flight, these activities did not carry over to the larger part of the winter range. Sheep seen in the vicinity of the ski area often displayed signs of being disturbance and were often displaced but would retreat to the undisturbed backside of the mountain. This abandonment was not observed the following winter. While use of the area remained little, there was not the total lack of use seen the previous year. This again suggests that there may have been some acclimatization to activities in the ridge area.

The potential for increased stress during the Olympics prompted the need for mitigation to separate skiing activities from sheep. The supplemental feeding program certainly attracted sheep and probably kept them in the vicinity of the feeding sites but whether sheep would have utilized range nearer the skiing activity without the hay is unknown. The higher than normal usage of Area 3 during January and February, 1988 was probably due to the attraction of the 2 feeding sites in that area. The other 2 sites were in Area 2 along the boundary between Areas 2 and 3. All four sites began to see heavy use in January. Sheep did not begin eating the hay until the area received snow and cold temperatures. As long as these conditions remained, the feed was consumed but once mild weather returned, sheep use dropped. Lack of snow and mild temperatures also resulted in a migration off the winter range to higher elevations. Such movements were observed during all three winters and suggests a natural response to the availability of higher quality forage at higher elevation. The additional crude protein available from the supplemental feed may not have been great enough to act as a strong lure. Timothy and brome grasses made up more than 50% of the feed. A higher alfalfa content may have been stronger incentive.

Aircraft restriction only proved effective when rigidly enforced with heavy penalties for violation. The voluntary guidelines issued for the World Cup races were ineffective and often ignored by media chartered helicopters. The NOTAM issued for the Olympic period was more effective with officials willing to amend the restrictions to consider harassment to sheep by low flying helicopters. It must be noted that our requests did not interfere or restrict the operations or running of the competitions and therefore may have aided in the ease of implementation. The major reason for the NOTAM was for security and safety and may have been more difficult to implement had the reasons been solely sheep related.

Efforts to keep people off the ridge above the Women's downhill were

generally ineffective. While closure of the area to spectators alleviated the greatest threat, there were still enough accredited people in the area that bypassed the fence to cause a problem. It was not practical to erect an effective people-proof barrier. Even with our enforcement efforts, the media and certain officials chose to ignore them. Such problems would only arise during competitions provided this ski run remains closed to the skiing public as stated in the operational guidelines of the lease with the ski area.

While the construction of the ski area and the holding of the Olympic games did not appear to have had a major impact on the bighorn herd at present, unavoidable harassment and disturbance has occurred at some locations. The current level of disturbance does not appear to have been great enough to affect their health and reproductive status. There is no question that bighorns can exist on ranges exposed to much higher levels of disturbance than that on Mt. Allan (Morgantini and Worbets 1988, MacCallum 1988) but disturbance can also combine with other factors to result in stress related die-offs (Festa-Bianchet 1988). The Mt. Allan herd does not have a history of die-offs and may not have had exposure to the pathogens isolated from dead sheep during other die-offs in North America.

That the population has not been negatively affected by the recent activities associated with Nakiska does not mean they will not be in the future. Monitoring of this herd should continue for at least 2 more years. It is currently felt that co-existence with the ski area can be maintained provided skiing activities do not encroach upon the winter range. At present, the winter range is isolated on the south side of the mountain and sheep can retreat to an undisturbed area. Mitigation currently implemented must remain to ensure that abandonment of any portion of the winter range does not occur. During future competitions, steps are required to control helicopter movements and human activities in areas likely to disturb wintering sheep.

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