WILLIAM D. WISHART - A WORKING HYPOTHESIS FOR ROCKY MOUNTAIN BIGHORN SHEEP MANAGEMENT

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Abstract: Although the genus *Ovis* enjoys a wide distribution throughout much of the mountainous regions of the northern hemisphere, the various species show very site specific responses to climate and predation. In compliance with these restrictions the Rocky Mountain bighorn is distributed along the Rocky Mountains from northern Alberta to New Mexico and presently number approximately 38,000 animals. Their restricted habitats are basically islands from which they fear to tread. As a consequence, bighorns are capable of self regulation by a number of density dependent responses. They are also capable of rapid increases when provided with suitable new or former habitats. Bighorn managers can and have responded to these population features through translocations and ewe seasons with commendable success, however, bighorn susceptibility to domestic livestock diseases continues to be a problem.

Distribution and abundance: In North America, bighorns are represented in the broomed left horn of "the great arc of the wild sheep" that spans from Sardinia (right horn) to the Baja (Clark, 1964). Forced by predators to live on rocky escarpments or cliffs near open grassy and herbaceous pastures bighorns have been confined to unique islands of habitat. These distinctive islands become more clearly defined during the winter. They are found on wind-swept or south facing slopes at both high and low elevations. For Rocky Mountain bighorns this archipelago of habitat extends throughout most of the Rocky Mountains, its foothills and associated river breaks. As of this writing there are approximately 38,000 Rocky Mountain bighorns in North America (Table 1).

Table 1. Rocky Mountain Bighorn Sheep Population Estimates in 1974* and 1999.

Province or State	Population		Parks Population		Total	
	1974	1999	1974	1999	1974	1999
Alberta	4500	6000	3400	4000	7900	10000
Arizona	0	600			0	600
British Columbia	1300	3100	100	60	1400	3160
Colorado	2200	7245	350	400	2550	7645
Idaho	2700	1640			2700	1640
Montana	2900	4900	200	200	3100	5100
Nebraska	0	70			0	70
New Mexico	400	560			400	560
Nevada	0	250			0	250
Oregon	60	560			60	560
South Dakota	150	375			150	375
Utah	200	800	150	50	350	850
Washington	20	200			20	200
Wyoming	4000	6700	800	450	4800	7150
	18430	33000	5000	5160	23430	38160

*Maximum estimates from Trefethen (1975)

This 62% increase (from approximately 23,500 bighorns since we met 25 years ago) is due largely to the translocations of about 4,000 bighorns, mostly within Colorado, Wyoming and Montana, as well as their contributions to other states (Hurley 1996). In parallel, during the same time period, Alberta harvested approximately 4,000 ewes and lambs in order to stabilize a resident bighorn population of about 6,000 animals. In other words, nursery herd management by removing ewes and lambs on productive bighorn ranges has been proceeding successfully on both sides of the Canada/U.S. border for several years by using translocations and/or hunting. Meanwhile, the overall numbers of protected park herds without management have remained static at about 5,000 animals for the last 25 years.

Population strategies: Rocky Mountain bighorns appear to respond to abundant forage sources as an "r-selected" species and to stable forage sources as a "K-selected" species. In other words, bighorn sheep fecundity and survival may either favor rapid population growth at low population density (r) or they can express conservative population strategies at densities approaching carrying capacity (K) (Ricklefs 1982).

Rationale: On new or expanding ranges bighorns have the capacity to double their numbers every three years (Buechner 1960). The doubling rate of any population can be quickly calculated using the compound interest "rule of 72", e.g., with an annual rate of increase of 24% the population will double in 3 years (72/24). In reverse, a population that takes 24 years to double has an average annual rate of increase of 3%. Following Buechner's monograph in 1960 there have been several examples of rapid increases of bighorns, particularly from transplants (McCarty and Miller 1998) and from the creation of new habitats (Wishart et al. 1998). During these expansions on new ranges there are some remarkable examples of exceptional growth rates of large rams, particularly in the chinook regions of Alberta and Montana (Gilchrist 1992, Byers and Bettas 1999).

Since bighorns are confined to unique islands of habitat, they can quickly reach carrying capacity and as a consequence, a number of density dependent events can occur (Wishart et al. 1998). Rocky Mountain bighorns have exhibited most of the population curves and all three of the age pyramids found in Odum (1971) by increasing rapidly on new range, leveling off and oscillating around K unless they contract pneumonia at which time there is usually a dramatic crash (Onderka and Wishart 1984, Semmens 1996).

The ability of bighorns to increase rapidly may be related to their history of living near new and adjoining ranges that have been created by receding glaciers, avalanches and fire. By increasing rapidly, their numbers may help to delay plant succession, thus maintaining each new range expansion, particularly in the case of avalanches or fires. In any event, bighorns can quickly exceed their food supply near suitable escape terrain. The consequences of a decreased food supply for bighorns on their confined ranges, especially during winter can result in a classic response to overpopulation, that is, decreased growth in body and horn mass, and increased age at first reproduction (Festa-Bianchet et al. 1995, Jorgenson et al. 1998).

This sequence of events was demonstrated during a long-term research study on an isolated herd of bighorns in Alberta. It was found that the herd could be held at 100 animals (with a 1:1 sex ratio) in a state of rapid growth near the inflection point of the s-shaped curve by manipulating the nursery herd and maintaining a ratio of 20 lambs/40 ewes (1+ yrs) and with no more than 30 ewes (2+ yrs) (Wishart et al. 1998). In fact, this optimum age ratio of ewes and lambs on nursery ranges is basically independent of ram numbers, since the young rams leave the nursery ranges after a few years and remain segregated from the ewes except during the rut; the rams are simply a by-product of the nursery herd (Jorgenson et al. 1993). When ewe removals ceased, the population more than doubled, aged and transformed to an inverted age pyramid. The herd has now declined to less than 100 animals.

Relevance to Management: Bighorn managers have to ask themselves whether they want managed bighorns to exhibit "r-selected" or "K-selected" population characteristics. Once this decision is made, managers must determine where, on the population curves, to maintain population sizes and what measures should be taken. Poor lamb crops and poor growth rates are usually coincident with short annual increments in ram horn growth and are considered symptomatic of low population quality (Geist 1971, Shackleton 1973, Jorgenson et al. 1998).

In general, large stable bighorn herds can be reduced to favor lamb production and ram horn growth by translocating ewes from these populations to new or historic ranges (Bailey 1990). Other populations may be reduced or stabilized through human hunter harvests of ewes. Some populations may be left to regulate themselves, as in Parks or with seasons on trophy rams only (Table 2).

Working Hypothesis of Predator Management: Insufficient space on key habitats like winter ranges or lambing grounds can result in increased vulnerability to predation (Bleich et al. 1997). Bighorns have adapted well to wolf, bear and coyote predation by dashing to cliffs and escarpments, but are less adapted to the stalking and ambush techniques of cougars in rough terrain, particularly where there is some tree cover. As a consequence, bighorn managers should not and do not recommend transplants to areas where there are escarpments with an abundance of trees and cervids. In fact, prescribed fires have been recommended in former and potential bighorn ranges to remove cover for species such as elk and deer that provide an attractive food source for cougars (this conference).

The impact of predation on bighorns is reflected on how the sheep are distributed on their ranges ("islands"). In other words, bighorn distribution

Table 2. Rocky Mountain Bighorn Harvest Management Systems used by Wildlife Agencies in 1999.*

	Province or State													
	AB	AZ	BC	CO	ID	MT	NE	NM	NV	OR	SD	UT	WA	WY
Mgmt. Method														
Transplant	X		X	X	X	X		X	X	X	X	X	X	X
Ewe season	X		X	X		X								
Any sheep														X
Any male		X		X		X			X	X	X	X	X	X
Mature male	X				X		X	X						X
Old Male	X		X											
Closed													X	X

*From Reno Conference questionnaire

and the numbers that their ranges support are dependent on the assortment of predators that confine them to those ranges. For example, during a field trip to a bighorn translocation site in Montana where there were no wolves, cougars or bears, groups of large rams were observed at a considerable distance from any visible escape terrain. In contrast, in Jasper National Park, wolves have confined and maintained a herd of close to 20 adult rams on a small winter range in close proximity to a small escarpment for the past 20 years (D. Dekker pers. commun.). Thus, the carrying capacity of these islands of bighorn habitat may wax or wane depending on the presence or absence and the composition of the bighorn predators. It should be apparent that in some situations predator management would be an option to follow for bighorn range expansion.

Disease: In recent history, the most devastating limiting factor for bighorns has been disease, mostly as a result of exposure to domestic livestock (Buechner 1960). Pneumonia (*Pasteurella* spp.) tops the list in causing dramatic declines in bighorns (McCarty and Miller 1998). Miller et al. (1991) suggest that "a comprehensive combination of habitat management and population control that maintains herds at low ecological densities may prove most effective in minimizing herd susceptibility and preventing some pneumonia epizootics in bighorns." There appears to be a decreasing threshold of susceptibility to pneumonia in mountain sheep from north to south (Foreyt et al. 1996), possibly as an adaptation to a longer exposure to domestic livestock diseases in the more southern ranges. Nevertheless, at this point in time, considerable diligence is required to prevent association of bighorns with domestic sheep. In this regard, fragmented bighorn herds that contract pneumonia are probably of less concern than a pneumonia contact with a metapopulation resulting in a large scale die-off such as the one that occurred in BC, Alberta and Montana in the 1980's (Onderka and Wishart 1986).

Parasites: For many years lungworm (*Protostrongylus* spp.) was considered an important source or contributing factor to bighorn mortality (Forrester 1971, Hibler et al. 1982). As a consequence, antihelminthic treatment programs were introduced into several bighorn herds (Schmidt et al. 1979, Foreyt et al. 1990, Jones and Worley 1997). Miller (in press) concluded that although lungworm infections may in some cases exacerbate pneumonia in bighorns, such infections are relatively benign in the absence of other respiratory pathogens and are basically a product of a complex, coevolved host-parasite relationship.

Disturbance: Bighorns can be remarkably adaptable to human caused disturbance such as roadways and tourists particularly in our national parks and other sanctuaries. In studies outside of parks, using heart rate response to measure reaction to disturbance, MacArthur et al. (1979) and Stemp (1983) found a wide range of response to people, dogs, vehicles and aircraft, depending on the level of habituation to human activities and the time of year. Low flying helicopters and free ranging dogs created the highest and longest heart rate responses. These results are not surprising in view of the long association of bighorns with eagles and wolves. Mead and Morgantini (1988) found road and gas wellsite construction on a bighorn winter range resulted in displacement of animals until construction ceased. Helicopter activity caused much stronger reaction than blasting, the use of heavy machinery, or the presence of people. Range abandonment occured on a small portion of a bighorn winter range that adjoined a new ski development for the 1988 Winter Olympics in Alberta (Jorgenson 1988). Abandonment was due to human activities on the ridge top, helicopter flights, snowmaking, and avalanche blasting. In recent years, bighorn populations have come under increasing disturbance pressure from recreational activities involving commercial helicopter activities such as heli-picnicking, heli-biking, heli-sightseeing, heli-hiking and heli-skiing. The timing of these events and other disturbance events are particularly critical during the winter months and the lambing period and there is a need for planning and strong policy directives to deal with such activities.

Conclusion: In spite of their very specific and unique habitat requirements, Rocky Mountain bighorns appear very adaptable to changes in their habitats and to various wildlife management schemes. Their response to these influences are readily observable in the individual and in the herd as a whole. After 45 years of bighorn watching my credo remains that the health of a bighorn herd is dependent on optimizing the number of young and productive animals in the nursery herd. These herds are more likely to thrive and produce more and larger bighorns.

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QUESTIONS, ANSWERS AND COMMENTS - BILL WISHART PRESENTATION

PHIL HEDRICK, ARIZONA: Is the difference in susceptibility to the disease a genetic problem or do you think it has to do with other environmental factors, or is there any evidence, for example, of transplants going south having higher or lower susceptibility, like in New Mexico?

BILL WISHART: We sent some sheep down to Oregon or Idaho a few years ago, and it reminded me of taking the canary into the coal mine, because they keeled over in pretty short order, I think.

What I'm saying is you saw that graph of the Highlands herd and there's a few survivors there and they are probably pretty valuable in a country where you have this problem and it wouldn't be smart, I don't think, to put bighorns on top of that. Mind you, depends on where you're dealing from. My feeling is that, and I'm not sure how long that resistance, if you were to call it that, lasts. It might show up in your blood work, but I still feel that the U.S. sheep have been with domestic sheep a long time and I think you've got some pretty strong sheep here in that sense. They're not all going to die bringing a sheep from like the north into situations like you have further south here. I think that may be the canary in the coal mine.

How do you interpret this? Is it genetic and is it something that they pass on? In the sense that they're resistent after die-offs, you know the survival is very poor, and eventually they get going again. I'm not sure if they retain that resistance.

UNIDENTIFIED SPEAKER: Bill, the first slide you showed, I think a herd in Montana, that didn't take off?

WISHART: Oh, yeah, the Highlands.

SPEAKER: All the bar graphs?

WISHART: Yes.

SPEAKER: I notice that herd is growing for seven, eight, nine years?

WISHART: Yes, that's right.

SPEAKER: And appears to get above some threshold, my interpretation anyway, and then it declined?

WISHART: That's right. Apparently it moved from one range to two other ranges in that low level, is that correct John McCarthy? I think they had them on one range and then it spilled over to another and then another, so you eventually had three ranges involved.

SPEAKER: So it's essentially habitat expansion?

WISHART: Yes.

SPEAKER: That shoots one of my theories in the foot.

WISHART: I hope so.

SPEAKER: I have another question. It relates to your emphasis on predation with adequate habitat and what I call visibility. In your experience, is small population size a problem with respect to predation, small size and high predators?

WISHART: In our experience, we don't consider predators a problem. Cougars get hungry, they switch from deer to mutton. Someone in Utah had an interesting comment, every time they move sheep into a new area, there're usually deer there. All they're doing is feeding the cougars. I think it's critical that you do not move them into a predominantly deer area that already has a good, high predator population.

In terms of small populations, we only average 60 sheep per winter range. They're doing fine under that system. Boy, it's an awful task for anything to get them in those open slopes. They can see predators coming a mile away. Where you see the open habitat, burn away the stuff that hides the predators.

FRANCES CASSIRER, IDAHO: It looked to me like your graph of Ram Mountain showed declining lamb survival when the population was at a high level. Looks like you still have fairly low lamb survival.

WISHART: They're back to where they were. And we have old ewes in there now and that population is going to take a while. We've got to go in and kind of freshen it up. If we can bring that population down again to a young, productive herd, I'm sure we can maintain 100 again.

The other thing that worries you with those populations, you have this K that you reach, and often you end up at a lower K, a lower capacity. In other words, it might not support 100 again. We might have to come down to 80 or something like that to get the range back to where it should be. That's worrisome when you see the big peaks and the notion is, I've got to get up there again. Don't do it; that's thin ice.

KEVIN HURLEY, WYOMING: Bill, I have a question. How are we doing 25 years later?

WISHART: The most spectacular story is what we've done with the translocation. You have problems with translocations and you'll talk about that and you'll get into what age group and how many and where and you have lots of considerations. The predators and the migratory nature, the possibilities, all that stuff. You'll have to discuss that.

You saw the GIS graphs that the DeMarchi brothers brought in. They can tell you the best places to go or not to go. I think you've done a wonderful job. The BLM people are moving domestic sheep out of the country. You're creating brand-new habitats removing domestic stock that will be outstanding for the next few years. Keep it up.