DALL RAM HORN GROWTH AND POPULATION QUALITY: MANAGEMENT SIGNIFICANCE

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INTRODUCTION

Population quality is indicated by horn growth characteristics in Dall rams. Heimer and Smith (1974) presented criteria for determination of population quality based on horn size and growth rate. The management significance of Dall sheep population quality in Alaska has been recognized and refined in subsequent work (Heimer and Smith 1975). The purpose of this paper is to review methods of determining population quality, briefly define the relative quality of sheep populations in Alaska, and relate these findings to long range management planning. In addition, the impact of the often proposed full curl rule on the Dall ram harvest in Alaska will be predicted.

MATERIALS AND METHODS

Horn volume at age 7 years, growth rate, diameter, and average attainable volume were determined for defined areas of Alaska as described by Heimer and Smith (1974). These parameters were then summed to give quality index scores based on horn size and growth rate. Areas producing rams with high quality index scores were regarded as areas of high quality, and those producing sheep with low quality index scores the areas of low quality.

Measurements of tip to tip spread and degrees of curl were used to calculate the expected horn length at 3/4 curl (the present legal definition) and full curl. These lengths were calculated for rams in each area of Alaska by assuming that every ram horn was a perfect spiral describing a right, circular cylinder (Fig. 1). If this cylinder was unrolled, the horn would be theoretically unrolled and the base of the right triangle formed (Fig. 1) would be equal to the diameter of the horn coil multiplied by π. The height of the triangle would be equal to the pitch of the spiral (mm of divergence from the midline of the skull to the horn tip per revolution) multiplied by the number of revolutions, in this case either 1.0 for a full curl or 0.75 for a 3/4 curl. The hypotenuse of the triangle (calculated by a theorum of Phythagorus) would equal the length of the orbital horn surface from its base to tip.

Once these standard (3/4 curl and full curl) lengths had been calculated, the mean annual segment lengths of horns from each area were added until the lengths for 3/4 and full curl were reached. Because the cumulative segment lengths did not always equal the standard lengths,

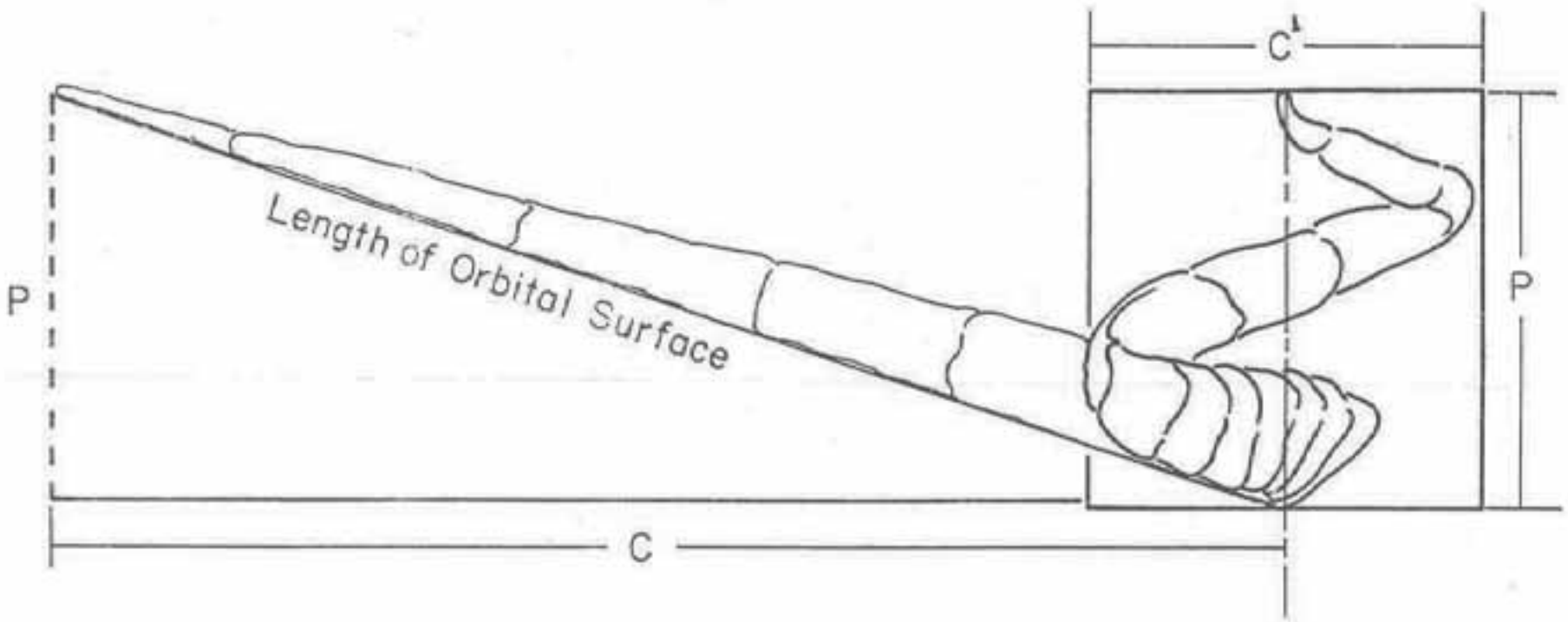

Figure 1. Calculation of orbital surface lengths of 3/4 and full curl ram horns. P= pitch of horn soiral (half of tip to tip spread), C' = diameter of horn curl, C = circumfrence of horn (π X C') projected onto a plane. Length of orbital surface = $(C^2 + P^2)^{.5}$.

the year in which the ram horn was closest to the standard length was used to calculate the mean age at 3/4 curl and full curl for rams of each study area.

When average lengths and ages of 3/4 curl and full curl ram horns were known, it was possible to calculate their volumes. Horn volumes were calculated using the formula, $V = \frac{h}{3} r^2$. Horn length is "h", "r" is the radius of the base and "V" is volume of the entire horn. A correction factor relating entire horn volume to calculated volume was derived by calculating volumes for 25 horns and then determining their volume by water displacement. The correction factor was 0.717. This correction factor was then multiplied by the calculated volume to estimate actual volume.

RESULTS

Dall sheep habitat in Alaska's seven mountain ranges is indicated in Fig. 2. The defined subunits within each mountain range are detailed in Fig. 3. Quality index scores and values for the parameters which define them for each subunit are given in Table 1.

Values for lengths at 3/4 and full curl for each subunit as well as the volumes for these lengths and the percentage of maximum attainable volume are given in Table 2. It can be seen that rams generally achieve about 60 percent of their maximum expected volume at 3/4 curl and about 90 percent at full curl.

The average ages at 3/4 and full curl and the average age of rams harvested in 1974 are given by mountain range in Table 3.

Insufficient data precluded calculation of the age at 3/4 and full curl for each subunit. Determination of these ages for entire mountain ranges ignores the effects of differing quality on the age at which a ram might reach these lengths but scanty data did not allow finer resolution at this time.

Statewide harvest and numbers of hunters were determined from sheep harvest ticket returns.

DISCUSSION

Areas of Alaska's mountain ranges are ranked according to quality index score in Table 4. It can be seen that several distinct groupings of quality are apparent. It was initially recommended that only those areas ranked down through fourth position be managed as trophy production areas. Recommended management schemes in these areas included restriction of hunter numbers, possible regulation of access and transportation type and legal ram definition at full curl and/or a minimum age. This would allow taking of old broomed rams and prohibit harvest of precocious rams at minimal full curl. It was also recommended that harvest levels be

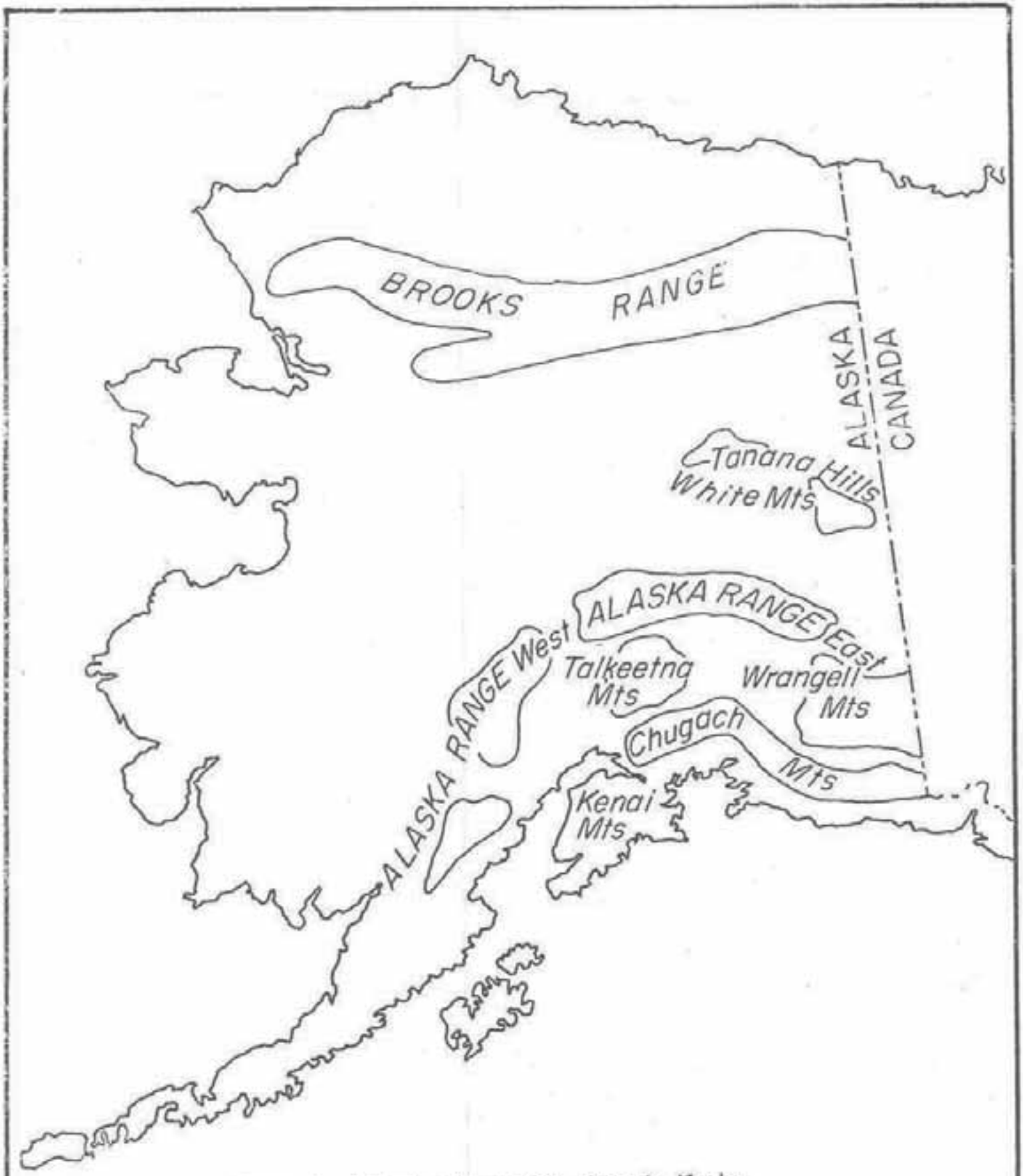

Figure 2. Distribution of Dall sheep in Alaska.

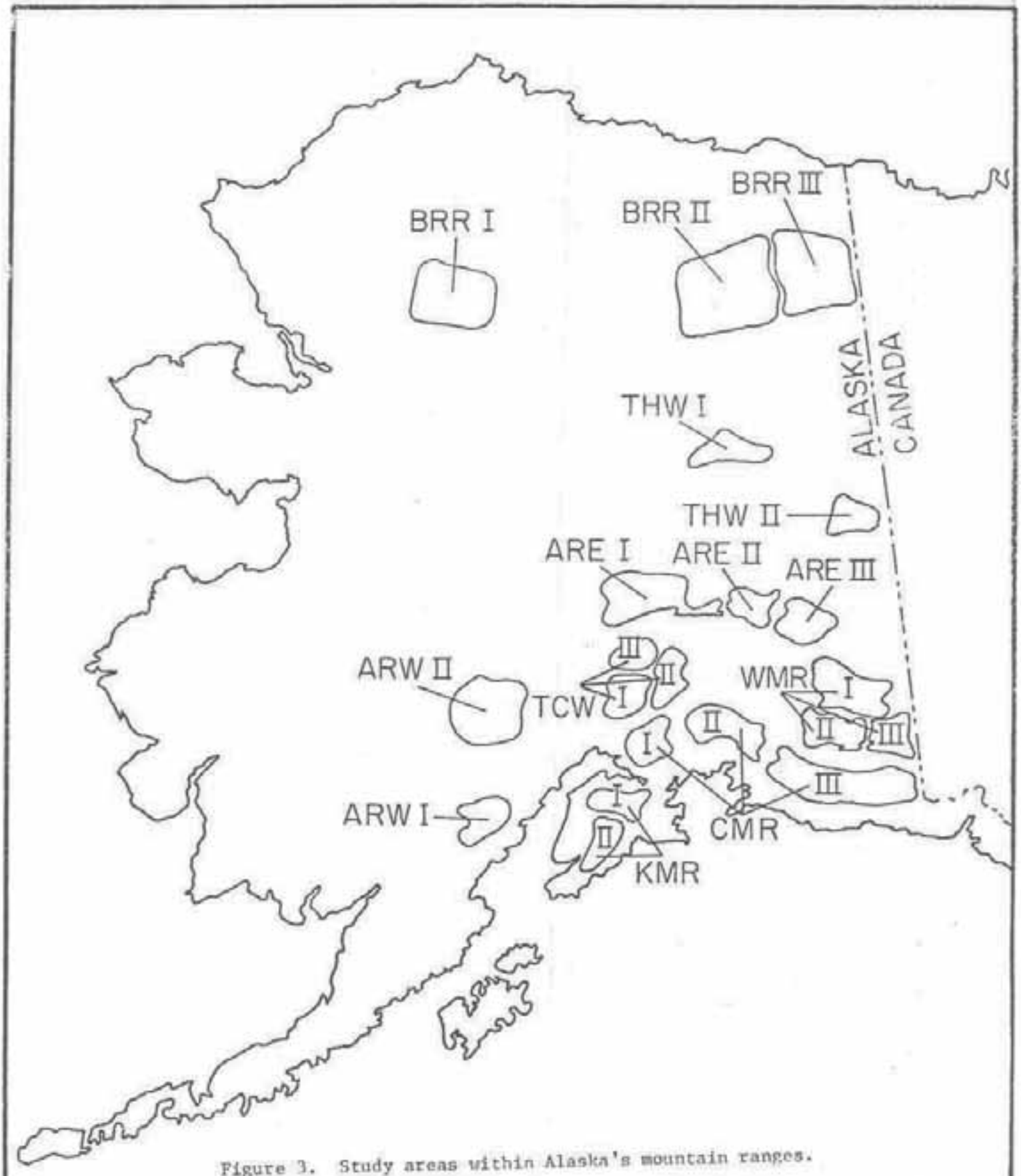

Figure 3. Study areas within Alaska's mountain ranges.

Table 1. Quality index of rams by area within each mountain range.

Range and Area	7 year volume (cc)	Maximum expected volume (cc)	Maximum sustained growth (cc/yr)	Diameter of curl (cm)	Quality Index
Alaska Range East					
ARE I	1282	1841	282	26.7	3432
ARE II	1549	2153	351	28.1	4081
ARE III	1796	2301	402	29.0	4528
Alaska Range West					
ARW I	1100	1628	303	24.3	3055
ARW II	1355	1793	293	26.1	3467
Brooks Range					
BRR II	1316	2151	295	27.9	3790
BRR III	1272	2071	332	29.0	3704
Chugach Mountains					
CMR I	1215	2042	330	26.6	3614
CMR II	1509	2691	410	27.4	4637
Kenai Mountains					
KMR I	1219	1868	322	26.5	3436
KMR II	1519	2131	382	28.6	4061
Talkeetna Mountains					
TCW I	1566	2616	392	27.0	4601
TCW II	1089	2274	301	25.6	3690
Tanana Hills-White Mts.					
THW I	1584	2297	361	26.7	4269
THW II	1474	2221	363	27.8	4086
Wrangell Mountains					
WMR I	1332	1809	326	27.1	3494
WMR II	1495	2333	338	23.9	4190
WMR III	1921	2503	426	30.4	4880

Table 2. Average calculated lengths, average volumes and percentages of maximum attainable volumes of 3/4 and full curl ram horns by area within each mountain range.

Range/area	Average length at full curl		Average length at 3/4 curl		Max vol	3/4 curl			
	mm	inches	mm	inches	in cc	vol in cc	% of max	vol in cc	% of max
Alaska Range East									
ARE I	897	35.3	673	26.5	1841	1171	63.6	1855	100.8
ARE II	940	37.0	725	28.5	2153	1438	66.8	2170	100.8
ARE III	956	37.6	716	28.2	2301	1412	61.4	2161	93.6
Alaska Range West									
ARW I	821	32.3	617	24.3	1628	935	57.4	1585	97.4
ARW II	869	34.2	652	25.7	1793	1128	62.9	1807	100.8
Brooks Range									
BRR II	936	36.8	702	27.6	2151	1369	63.6	2179	101.3
BRR III	937	36.9	703	27.7	2071	1247	60.2	1775	85.7
Chugach Mountains									
CMR I	885	34.8	662	26.1	2092	1215	59.5	1979	96.9
CMR II	912	35.9	686	27.0	2691	1343	49.9	2344	87.1
Kenai Mountains									
KMR I	874	34.4	656	25.8	1868	1201	64.3	1795	96.1
KMR II	938	36.9	704	27.7	2131	1416	66.5	2084	97.8
Talkeetna Mountains									
TCW I	904	35.6	678	26.7	2616	1303	49.8	2134	81.6
TCW II	871	34.3	653	25.7	2274	1095	48.2	1999	87.9
Tanana Hills-White Mts.									
THW I	879	34.6	659	26.0	2297	1198	52.2	2077	90.4
THW II	913	35.9	685	27.0	2221	1373	61.8	2099	94.5
Wrangell Mountains									
WMR I	908	35.8	682	26.8	1809	1192	65.9	1954	108.2
WMR II	804	31.7	604	23.8	2333	936	40.2	1726	74.0
WMR III	983	38.7	737	29.0	2503	1497	59.8	2406	96.1

Table 3. Average ages at 3/4 and full curl and average age of rams harvested in 1974 by mountain range.

Mountain range	Age at 3/4 curl (yrs.)	Age at full curl (yrs.)	Average age in 1974 harvest
Alaska Range East	5.5	8.6	6.8
Alaska Range West	5.4	8.1	9.3
Brooks Range	6.7	9.7	8.9
Chugach Mountains	5.1	7.9	6.6
Kenai Mountains	5.2	7.9	6.1
Talkeetna Mountains	5.3	7.8	5.5
Tanana Hills-White Mountains	5.7	8.8	---
Wrangell Mountains	4.9	7.3	6.6

Table 4. Areas ranked according to quality index values provided in Table 3.

Area	Rank	Quality Index Score	Difference from next higher index score
WMR III	1	4880	--
CMR II	2	4637	243
TCW I	3	4601	36
ARE III	4	4528	73
THW I	5	4269	259
WMR II	6	4190	79
THW II	7	4086	104
ARE II	8	4081	5
KMR II	9	4061	20
BRR II	10	3790	271
BRR III	11	3704	86
TCW II	12	3690	14
CMR I	13	3614	76
WMR I	14	3494	120
ARW II	15	3467	27
KMR I	16	3436	31
ARE I	17	3432	4
ARW I	18	3055	377

established at less than the annual increment to the full curl population. This may seem wasteful to some managers, but will assure a balanced sheep society and insure that hunters always have a reasonable probability of finding a truly outstanding ram. One of these areas, ARE III, has been managed like this for two harvest seasons.

Those areas ranked in positions 5 through 9 were recommended to be managed by full curl regulation with hunters to have free access and no harvest quotas established. This would be management just as it presently exists in Alaska except the legal definition would be changed to full curl.

The remaining areas (10-18) were recommended for management under the current 3/4 curl regulation with some consideration given to either sex harvest in areas of high population densities. It was stressed that this either sex harvest should be closely supervised and eveniy distributed to affect either minimum impact or maximum benefit depending on the rationale of the area managers.

These were recommendations: they were made to area managers after the process of long range management planning had begun. Up to this point the response to these recommendations has been disappointing because of two reasons. First, there is an extreme reluctance on the part of many managers to take actions which may depress what is an apparently safe harvest level (down to 3/4 curl).

Secondly, the planning process was well along before this report was completed and many area managers were not advised of the result in time to implement them. Still, the public will have the opportunity to comment on these long range plans and if they desire management on the basis of population capability and quality it may result. Resistance to changes in management of Dall sheep populations are based in part on tradition.

For the last 25 years, sheep hunting in Alaska has been regulated by allowing only the harvest of rams with horns greater than or equal to 3/4 of a curl. In recent years, however, there have been many requests to change to a "full curl rule". These proposals are generally justified on the basis that taking a full curl ram is more satisfying than taking a 3/4 curl ram. Objections to this line of thinking are: 1) a full curl regulation would unnecessarily result in fewer harvestable rams and a lower success ratio; 2) there is little biological justification for going to a full curl regulation; and 3) sheep hunters are not required to take sheep of less than their personal standards, whatever they happen to be.

The harvest of Dall rams in Alaska averaged a little over 1,000 animals per year for the last 8 years (1967-1974), and during this time the number of hunters has averaged about 3,000. There is little reason to anticipate that the statewide harvest will decrease in the immediate future. That is, it may be expected that the annual harvest will continue to be about 1,000 rams or more under 3/4 curl regulations currently in affect.

The impact of harvesting only full curl rams can be estimated using data on average ages at which rams attain 3/4 and full curl in each mountain range and data reflecting average ages of sheep actually harvested in each mountain range (Table 3). In the Alaska Range East, Kenai Mountains and Talkeetna Mountains the average ram taken during 1974 was nearly 2 years younger than the age at which it would have attained full curl (Table 3). In the other mountain ranges (except Alaska Range West) hunters are taking animals which average about 1 year younger than full curl. It is evident, therefore, that imposition of a statewide full curl regulation would result in a substantial reduction in Alaska's statewide ram harvest.

The projected magnitude of this theoretical reduction can be computed using the following information: (1) the percentage of harvested rams which had not reached the age of full curl by mountain range during 1972-1974 (Table 5), and (2) total numbers of rams taken in each mountain range during this 3-year period (Table 6). The mean harvest for these years minus the portion of the harvest which was less than full curl equals the theoretical harvest under a full curl regulation (Table 7).

It can be seen that the immediate result of implementing a statewide full curl regulation would be a 67 percent reduction in the harvest (a decrease from an expected harvest of 1,153 rams to 382 rams). If the number of hunters (average 3,945 during 1972-1974), hunter effort and distribution of hunting activity were similar to those of the last 3 years, implementation of a full curl regulation would result in a decrease in hunter success from 39 percent to about 13 percent.

Long-term reductions in harvest and success may not be as severe as those immediately following implementation of a full curl regulation. Many rams harvested before they reach full curl under the present regulation would be available for harvest as full curl rams. In most mountain ranges it takes 2.5 to 3 years for a 3/4 curl ram to reach full curl status. The extent of natural mortality during these years is unknown, but Geist (1971) and Murphy (1974) have suggested that attainment of dominance status and attendant energy expenditures in rutting increase natural mortality significantly during this period of a ram's life. Determination of natural mortality rates in rams between the ages of 3/4 curl and full curl will require additional field study.

Despite the paucity of knowledge regarding total sheep populations and natural mortality in adult rams, it is possible to compute the theoretically sustainable harvest of full curl rams in Alaska. Numbers of Dall sheep observed on systematic surveys of several mountain ranges in Alaska are presented in Table 8 and, although minimum numbers of sheep in the remaining mountain ranges are not known, conservative estimates based on available data are as follows: Chugach Mountains, 3,000 sheep; Alaska Range West, 2,000 sheep; and Brooks Range, 15,000 sheep.

During systematic surveys rams were classified according to relative horn size. Results of these surveys indicate that the percentage of rams 3/4 curl or greater ranges from 5.7 percent in the heavily hunted ARE I

Table 5. Numbers and ages of Dall rams in subsamples of the harvest from 1972-1974 by mountain range and the percentage of rams which had not attained full curl.

Age in years	ARE	ARW	BRR	CMR	KMR	TCW	WMR
4	19	4	2	7	6	9	19
5	23	3	9	19	12	15	30
6	24	10	16	12	14	7	33
7	21	5	20	9*	5*	6*	31*
8	19*	8*	26	8	4	3	29
9	19	5	42*	3	-	1	13
10	13	8	41	3	-	1	12
11	5	8	26	2	-	1	5
12	4	1	13	-	-	-	2
13	1	1	7	2	-	-	-
14	1	-	5	-	-	-	-
% less than full curl	71	57	56	72	90	86	65

*age at full curl

Table 6. Actual numbers of rams killed by mountain range during 1972, 1973 and 1974 and mean statewide harvest during this period.

Year	ARE	ARW	BRR	CMR	KMR	TCW	WMR
1972	241	69	236	112	36	80	349
1973	187	119	242	81	59	61	363
1974	194	119	236	137	73	114	352
Mean	207	102	238	110	56	85	355

Mean total rams = 1,153

Table 7. Theoretical harvest by mountain range under full curl regulation.

	Mountain Range						
	ARE	ARW	BRR	CMR	KMR	TCW	WMR
mean three year harvest	207	102	238	110	56	85	355
percent decrease under full curl regulation	71	57	56	72	90	86	65
expected harvest reduction under full curl regulation	147	58	133	79	50	73	231
expected harvest under full curl regulation	60	44	105	31	6	12	124

Total rams = 382

Table 8. Observed sheep populations and percent legal rams by specific survey by area within mountain range.

Mountain range area	Total observed sheep population	Specific survey year	Sample size	% 3/4 curl
Alaska Range East				
ARE I	4142	1970-73	5103	5.7
ARE II	1103	1974	550	16.7
ARE III	1140	1974	742	14.2
McKinley Park	----	1973	298	11.1
Alaska Range West	----	----	----	----
Brooks Range				
BRR I	----	----	----	----
BRR II	----	1974	1741	12.6
BRR III	----	1973	1125	12.9
Chugach Mountains	----	----	----	----
Kenai Mountains				
KMR I	1203	----	----	----
KMR II	992	----	----	----
Talkeetna Mountains				
TCW I	423	1974	423	8.2
TCW II	1759	1974	1759	8.2
Sheep Mountain closed area	----	1974	201	19.9
Tanana Hills-White Mountains				
THW I	286	----	----	----
THW II	285	----	----	----
Wrangell Mountains				
WMR I	6069	1973	[8331	10.1]
WMR II	1060	----		
WMR III	1212	----		

to 19.9 percent on Sheep Mountain which is not hunted. In unhunted areas (McKinley Park and Sheep Mountain) the proportion of legal (3/4 curl) rams averages 15 percent; we shall assume that if Alaska were unhunted 15 percent of the population estimated earlier would be legal rams (3/4 curl or greater). That is, there would be 15 percent of about 40,000 sheep or 6,000 legal, 3/4 curl rams.

Data published by Murie (1944) suggests that 12 years is the maximum average age for Dall rams in McKinley Park. Only 2 percent of the rams in our sample were older than 12 years indicating that Murie's estimate of the maximum age of Dall rams was reliable. It takes more than 5 years (5.4 years) for the average ram in Alaska to reach 3/4 curl and if we assume that all rams will die by age 12, it follows that any ram which dies of old age will have lived 6 years after having attained 3/4 curl status.

By assuming survivorship is linear for the 6,000 3/4 curl rams (ages 6 through 12) calculated to exist in a theoretically unhunted Alaska, the number of full curl rams entering the population can be estimated by constructing a triangle with a base distance representing 6 years, an area of 6,000 units (representing 6,000 rams) and a calculated height which should approximate the number of rams entering the population at any age from 5 to 12 years (Fig. 4). Estimated recruitment to a population of about 40,000 sheep would be 2,000 3/4 curl rams per year or 1,150 full curl rams per year.

This estimate is considered to be conservative for several reasons. First, the total sheep population numbers used were numbers actually observed during systematic surveys in four of Alaska's seven mountain ranges. It is very unlikely that all sheep were seen on these surveys. Also, conservative estimates of numbers for Chugach Mountains, Brooks Range and Alaska Range West populations were used. In addition, our estimate that rams with 3/4 curl or larger horns comprise only 15 percent of this hypothetical unhunted population is probably conservative as well. The two unhunted populations providing the basis for this figure (McKinley Park and Sheep Mountain) are of low or average quality. In fact, the proportion of 3/4 curl rams in McKinley Park, which is unhunted, is lower than that observed in many hunted areas. Finally, use of linear survivorship curve appears justified for full curl rams (Deevey 1947) but the curve from 3/4 curl to death is not linear. Instead, it is an expotential function which, if used in our model, would predict greater numbers of full curl rams than the linear model we used. Consequently, it appears that Alaska could support a sustainable harvest of greater than 1,150 full curl rams. We must emphasize here that this theoretical level of harvest could be sustained only with a perfectly homogenous distribution of hunters. This is not the case at present.

It should be noted that this conservative estimate of the full curl increment is about equal to the present 3/4 curl regulated harvest. Whether there will be significant changes in management of Dall sheep in Alaska in the foreseeable future is not known. The decision to base management on population quality will probably be slow in coming and in

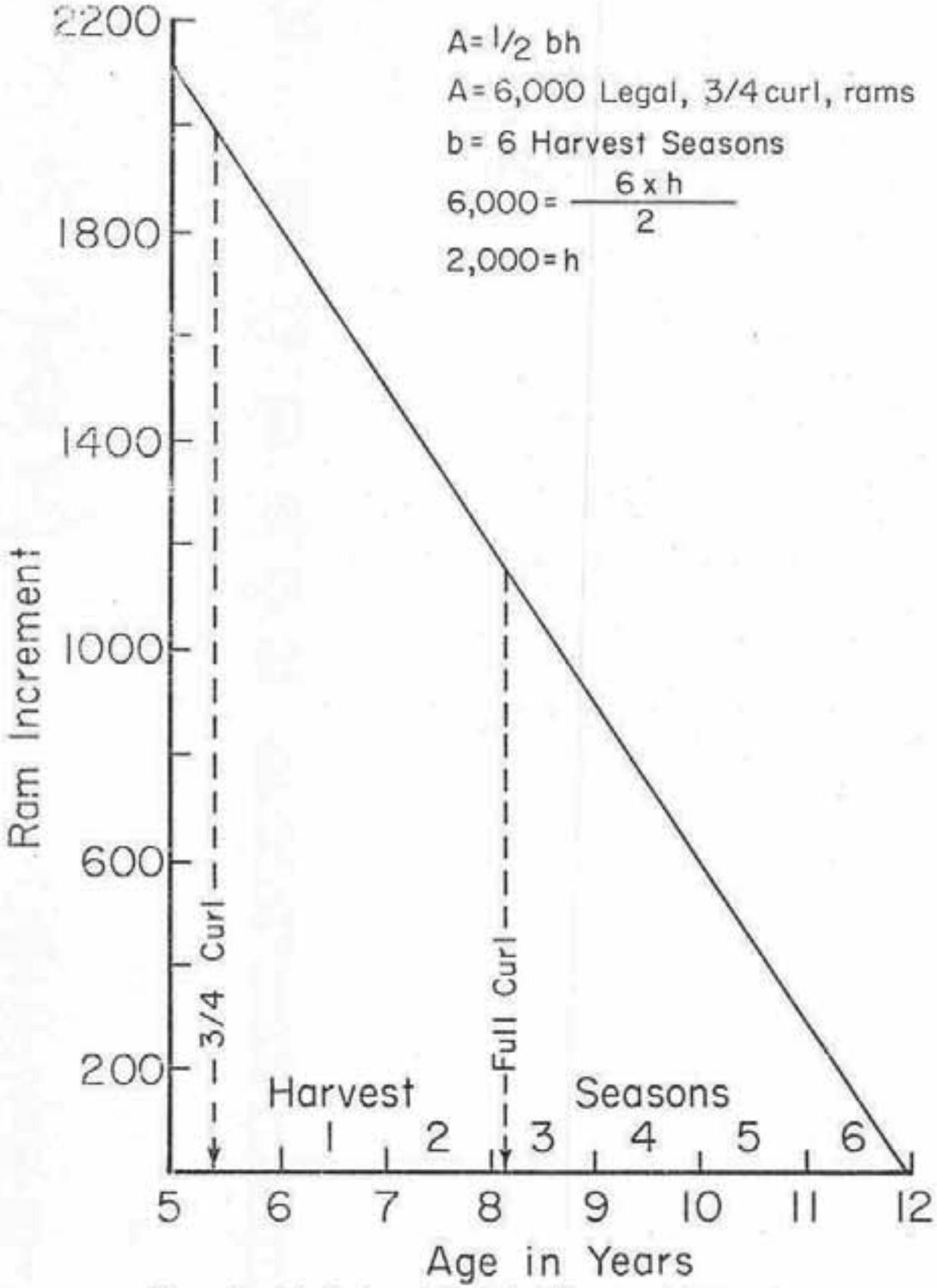

Figure 4. Calculation of Alaska's 3/4 curl and full curl ram increment assuming 15 percent legal rams and total population of 40,000 sheep. Also assuming linear survivorship from 3/4 curl to death at 12 years.

fact rests on aesthetic more than biological grounds. The current thinking of the Alaska Department of Fish and Game is that decisions of aesthetics should originate from the public and reflect the feeling of most Alaskans. It is our opinion that a piecemeal approach to changes in management which is not based on population quality would be less than the ideal situation.

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