RESEARCH NEEDS FOR MOUNTAIN GOAT MANAGEMENT

D. S. Eastman

British Columbia Fish and Wildlife Branch

Parliament Buildings, Victoria, B.C. V8W 2Z1

Abstract: Three aspects of mountain goat research were examined: the amount of information available, research priorities, and the relevance of current research to perceived research needs. Examination of a comprehensive goat bibliography revealed that approximately 60 - 70 scientific papers have been published since 1910. The rate of publication is increasing rapidly so that more information is becoming available to assist wildlife managers. Research priorities were assessed through a questionnaire survey that listed potential topics. Based on a sample of 28 replies, the top three research needs were development of inventory techniques, assessment of the impact of hunting on population dynamics, and development of methods to predict carrying capacity. Studies on economic valuation, and user attitudes and preferences were ranked the lowest. Twelve other topics received intermediate rankings. Statistical analysis showed that the questionnaire respondents applied essentially similar criteria ($P<0.001$) in ranking the research topics. However, this set of ranks was not similar to the priorities assessed from the subject matter of papers presented at this symposium ($P>0.05$). Recommendations for future research included: directing research effort to priority topics, emphasizing experimental versus descriptive projects, improving communications between researchers and managers, holding bi-annual mountain goat workshops, and defining management objectives clearly so that the role of research becomes clarified and more effective.

The concerns of this paper are: 1. How much technical information on mountain goat is available to assist wildlife managers? 2. What are research priorities for mountain goat as seen by researchers and managers? 3. Is present research related to these research priorities? Based on consideration of these concerns, recommendations will be offered that hopefully will aid future research and management.

Mountain goats (Oreamnos americanus) are probably the least understood of all the North American ungulates. Several reasons are responsible for this dearth of knowledge: the species typically inhabits terrain that is precipitous and inaccessible, thus posing logistical problems for researchers and managers; it is widely dispersed, making study difficult; and, other big game species have usually had a higher priority than mountain goats. Consequently, little time or money remained for mountain goats after the needs of higher priority species were met. Also, mountain goats were possibly thought safe from over-hunting due to their inaccessible habitat (Foster 1976).

Given the lack of information on mountain goats, it is not surprising that the species was managed by principles based on experience and knowledge derived from other ungulates. This limited management options prematurely and may prove to be biologically unsound. The following possibilities were largely overlooked: that goats have very low productivity; that they have a social structure that is particularly sensitive to hunting; and that hunting mortality is additive rather than compensatory.

This symposium is a tangible manifestation of growing concern about the adequacy of mountain goat management. It is the first such meeting. (Mountain goats are probably the last of the big game species to have this distinction.) Presumably, the symposium's objective is to encourage better management of mountain goat. It is a laudable target, but the key question about this goal is "better management for what?". Obviously, goals will vary according to geography and organization, but it is my impression that most agencies lack explicit management goals for mountain goat. Lacking these goals, it is difficult to clearly define what research needs to be done for better mountain goat management. Thus in the management process of formulating policies and defining objectives, gaps and problems can be identified that prevent or restrict successful attainment of these objectives. Bridging gaps and solving problems often requires a variety of actions that involves research, administration, public education, etc. The key point is to clearly identify what aspects are best suited to the abilities and skills of research.

Meeting future needs is a difficult challenge. Predicting the future is dodgy at best, but prediction becomes more difficult without a framework of objectives. Without a framework, evaluation is problematic and progress hard to realize. This symposium will probably succeed in identifying research needs for present management but will fare less successfully in identifying future needs.

METHODS

Availability of Information

To be available, information should be published in recognized journals or obtainable as theses from university libraries. To assess the ease-of-access to these types of documents I used a bibliography compiled by Foster (1977) as my data base. From it, I noted the date of publication only of journal articles or theses with the words mountain goat appearing in the title. The numbers of articles were plotted by ten-year intervals to indicate the numbers of articles as well as the rate of publication.

Research Needs for Future Management

My approach to define research needs was through a questionnaire survey. A form letter was mailed to all persons presenting papers in this symposium, to most regional wildlife biologists in Alaska and British Columbia, and to a few other individuals involved in wildlife research, protection and management of mountain goats. The letter requested information regarding affiliation, nature of job responsibility, and asked respondents to priorize 17 research topics that covered a broad range of subject matter (Fig. 1). General remarks and comments were also solicited.

Methods of completing the list of topics varied. In some cases, all were priorized while in other cases only some of the topics were ranked. In some cases, topics were numbered sequentially from 1 - 17 but in other cases, all topics were ranked using an abbreviated scale such as 1 - 7. Many ties resulted. Such a variable data base would be difficult to analyze without some transformation. I made the following alterations for the subsequent analysis. Where all topics were priorized with a scale of less than 1 - 17, and therefore had tied evaluations, each tied score was assigned the average of the ranks they would have been assigned had no ties occurred (Siegal 1956). Where ranking of topics was incomplete, I assumed all unranked subjects were tied at a rank one lower than the lowest one listed. These "tied" ranks were then treated as described above. For example, if only seven topics were ranked from 1 - 7, then I assigned all the unranked topics with a value of $(8 + 9 + ... + 16 + 17)/10$ or 12.5. Having done this, I was able to examine the concordance of rankings between agencies, between job categories and between organizational levels.

It is important to recognize the limitations of this approach to assessing research priorities. First, most topics were inter-related and thus tied rankings were likely encouraged. I tried to reduce this problem by stressing that the emphasis of the topic should be ranked. Second, my list defined the universe for ranking. Omission of important topics could seriously reduce the value of a ranking exercise. I avoided this difficulty by asking for other topics to be listed, and by emphasizing in the results that they were applicable only to the list circulated. Third, working of the topics may have caused confusion, misunderstanding or both. Semantic problems of this nature are a fact of life. Ideally, such a ranking should be followed up with personal interviews for perception checks but this was impractical.

The Kendall coefficient of concordance (W) was the statistical technique used to assess the degree of association between ranks provided by the respondents. The procedure is summarized briefly by Siegal (1956: 237):
1. Let N = number of topics to be ranked, and let k = number of judges (biologists) assigning ranks. Arrange observed ranks in a k x N table.
2. For each topic, determine the sum of ranks assigned by the k judges (R_j).
3. Determine the mean of R_j. Express each R_j as a deviation from that mean. Square these deviations, and sum them to obtain S.
4. Compute the value of W using the formula: $W = S/ 0.083 \ k^2 \ (N^3 - N)$
5. To determine if W is significantly different from zero, calculate a value of chi-squared using the formula: $X^2 = k \ (N - 1) \ W$, and test for significance with $df = N - 1$.

This coefficient tests the degree of agreement amongst biologists in ranking the topics.

1. Work area: University _____ state/province/territory _____
   federal _____ private _____ park _____
   other (specify) _____

2. Job responsibility is mainly: Research _____ management _____
   administration _____ I & E _____ enforcement _____
   other (specify) _____

3. Rank the following topic areas in order of your perceived priority

   for research on goats:

   To some extent, some of these topics are inter-related - they

   represent different emphasis on common phonemena. Thus it is these

   type of emphases that should be priorized.

   Topic   Rank

   1. Impact of hunting on population dynamics   _____
   2. Impact of access on goats   _____
   3. Habitat utilization (descriptive)   _____
   4. Social behaviour   _____
   5. Impact of forestry/mining/settlement/hydro   _____
   6. Importance of parasites and disease on productivity   _____
   7. Resource partitioning: niche characterization   _____
   8. Resource partitioning: habitat selection   _____
   9. Home range (role of tradition), migration, and movements   _____
   10. General ecological studies   _____
   11. Methods for predicting carrying capacity   _____
   12. Economic value (hunting and other uses)   _____
   13. User attitudes and preferences   _____
   14. Nutrition   _____
   15. Significance of mineral licks   _____
   16. Developments of inventory techniques   _____
   17. Development of population/habitat simulation models   _____
   18. Other topics _____
       Enough research already, application needed _____

   Do you have other remarks related to research needs?

   _____

   _____

Figure 1. The questionnaire used to assess priorities for mountain
            goat research.

Once this list of priorities was prepared, I compared it with the frequency of occurrence of topics at this symposium. The most frequent topics were assumed to have the highest rank. The agreement between both tests was examined using the Spearman rank correlation coefficient, r_s, with the null hypothesis that the two sets of ranking were not positively associated (Siegal 1956: 202-213).

RESULTS AND DISCUSSION

Availability of Information

Little published information is available on mountain goats, assuming the data-base was complete (Fig. 2). Since 1910, only 64 papers and theses have been published on mountain goats. This represents approximately 20% of all articles listed by Foster (1977). The number is somewhat inflated as many articles were derived from theses. Both were included in my tally. Conversely, many useful articles did not have the words "mountain goat" in the title and so were omitted in my search of Foster's bibliography. On balance, while the number of publications dealing with goats is probably more than 64, the fact remains that the published literature on mountain goats is scanty.

The rate of publication is increasing rapidly (Fig. 2). During the 1910-1919 decade only one paper was published on goats. By 1960 - 69, this figure was 16, and the projected number for 1980 - 89 is about 45 publications.

Priorities of Research Topics

The data base from the mailed questionnaire was 31 replies. The responses were widely distributed with respect to geographic area, strongly weighted to state and provincial agencies, and evenly divided between researchers and managers (Table 1). To have a better balance of opinions, it would have been desirable to have larger samples from managers in Idaho, Montana and Washington.

Table 1. Source of replies to research questionnaire, by geographic area, job function, and organizational affiliation.

Geographic area	Distribution by function and affiliation						Total by geographic area (%)
	by function			by affiliation			
	mgmt.	res.	admin.	state	fed.	univ.	
Alaska	5	3	2	9	1	-	10 (32%)
Alberta	2	3	-	3	1	1	5 (13%)
British Columbia	7	1	-	7	-	1	8 (26%)
Idaho	-	1	-	1	-	-	1 (3%)
Montana	1	3	-	3	-	1	4 (13%)
Washington	1	3	-	1	1	2	4 (10%)
Yukon	1	-	-	1	-	-	1 (3%)
TOTAL	17	14	2	25	3	5	33 (100%)
	(52%	42%	6%)	(76%	9%	15%)	

Analysis of priorities showed a highly significant (P<0.001) degree of concordance (five respondents did not rank topics, so N = 28). This can be interpreted as meaning that the respondents were applying essentially the same set of criteria in ranking the research topics (Siegal 1956). As Siegal (1956: 238) emphasizes, however, this does not mean that the rankings recorded are correct. For example, the biologists could be using the "wrong" set of ordering criteria. In the absence of a "more objective" set of priorities, the rankings based on the sum of individual ranks is probably the best estimate of the "true" order. The test of the correctness of these
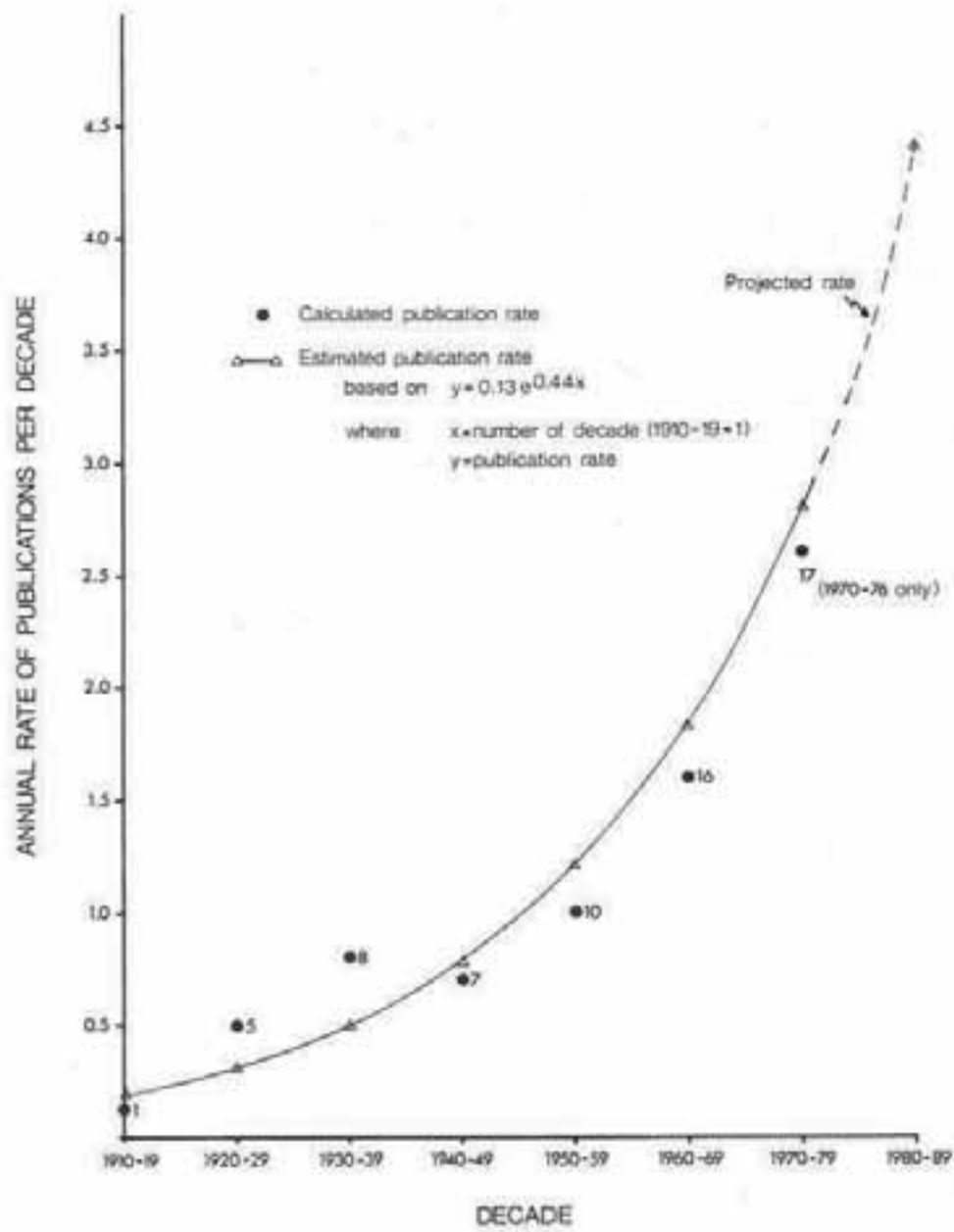
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Figure 2. Trend in annual rate of publication of scientific articles on mountain goats, 1910-1989.

- Developments of inventory techniques

150 —

- Impact of hunting on population dynamics

- Methods for predicting carrying capacity

175 —

- Home range (role of tradition), migration, and movements
200 — Impact of forestry/mining/settlement/hydro
- Habitat utilization (descriptive)
- Impact of access on goats

225 —

250 —

General ecological studies
Resource partitioning: habitat selection
- Development of population/habitat simulation models
- Social behavior
275 — Nutrition
- Resource partitioning: niche characterization

300 —

- Importance of parasites and disease on productivity

- Significance of mineral licks

325 —

- User attitudes and preferences
350 — Economic value (hunting and other uses)
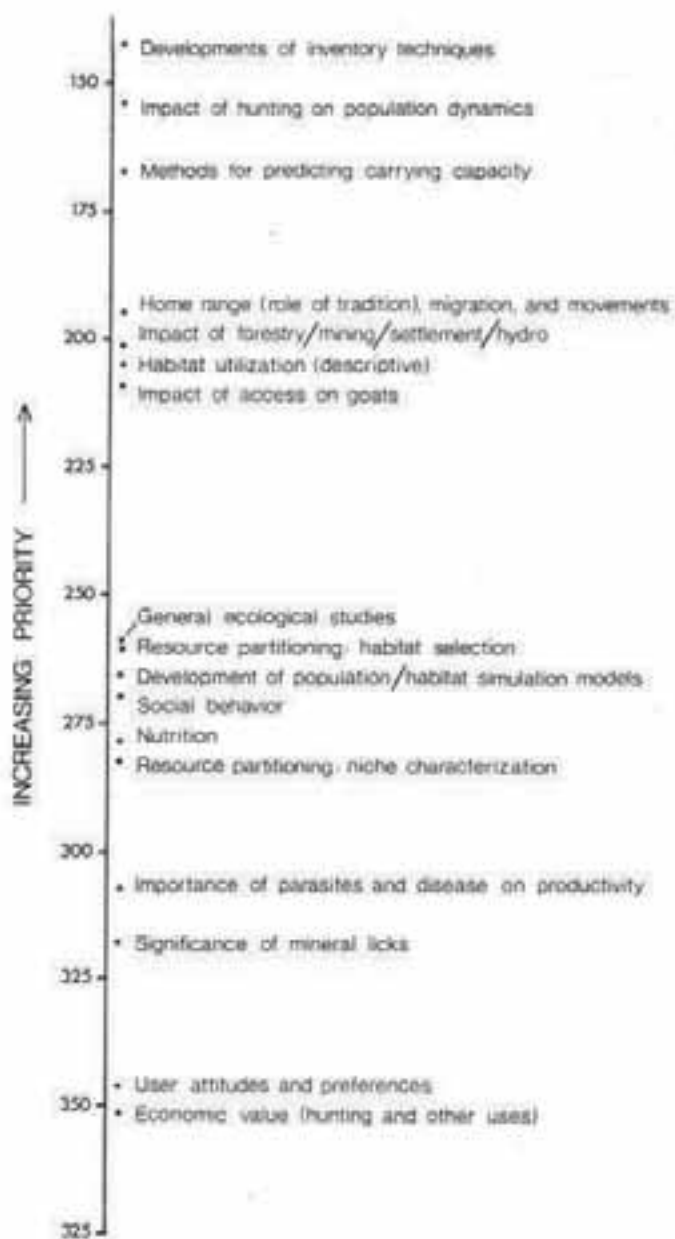
325 —

INCREASING PRIORITY ———→

Figure 3. Priorities for mountain goat research as assessed by 28 biologists in northwestern North America.

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priorities will be in the thrust of future research and whether or not contemporary management problems are solved. Nevertheless, considering the diverse affiliations and responsibilities of the participating biologists, the degree of agreement is remarkable.

The relative importance of topics is illustrated in Fig. 3. The highest research priority was clearly for inventory techniques (Fig. 3). This need was expressed both by researchers and managers. This a developmental topic that represents a major impediment to further activity, both in research and management. Successful inventories require an appreciation of a species' biology before a suitable sampling scheme can be devised. Also there is a need to establish acceptable criteria for precision and accuracy. These criteria depend upon the objectives stated for management, and upon the types of inventory needed to meet these objectives. For example, are inventories needed most for total herd size, sex ratio or productivity estimates? Is the same intensity of inventory required for all regions of a state or province? These questions are not so much ones requiring research as ones requiring greater support for management programs.

The research topic that ranked second was the impact of hunting on population dynamics. Since managers lacked reliable inventory techniques, changes in mountain goat populations often went undetected. Also inadequate inventories on sex and age ratios were insensitive to changes in goat herds. The research need was well expressed as : "The overwhelming need in goat research must deal with their widespread declines and the controversy over goat's ability to sustain a hunter harvest in many areas." (F. J. Singer, pers. comm.). Sufficient information exists to demonstrate the low productivity of this species. Goats obviously require more careful herd management than do species such as moose and deer. Even more so since it is particularly difficult to regulate harvest of young or females only through specific seasons. Female-only seasons in southeastern British Columbia were of limited success (R. Demarchi, pers. comm.). It seems that the problem is not so much what the sustainable harvest should be (although this does require research), but rather how to manage the distribution and numbers of hunters into specific areas at specific times within the limits of current budgets, and management areas that are too large to be effective. The main solution to the problem is more administrative than investigative.

A second aspect of hunting impacts is more clearly a research topic: is hunting additive or compensatory mortality? Kuck (1976 and this symposium) believes that it is additive. In a species with characteristically low productivity, assumptions regarding mortality have great significance.

The third most important topic was developing methods to predict carrying capacity. This topic has obvious application to both native and introduced mountain goats. One comment offered was "We totally lack any means of relating populations to habitat capacity -- maybe this approach is not completely practical with mountain goats." The concept of carrying capacity has intrigued and puzzled biologists for decades. For domesticated herbivores, range carrying capacity is defined as: "the maximum numbers which can graze each year on a given area of range, for a specific number of days, without inducing a downward trend in forage production, forage quality or soil." (Stoddart and Smith 1955: 172). This definition and most that are offered for wild animals related to food supply (Edwards and Fowle 1955). That carrying capacity is determined by food supply is an untested assumption for mountain goat. Even if food were limiting, we do not know what aspect of food supply is in shortest supply -- amount, protein, energy, selenium, etc. A combination of controlled laboratory studies and studies of introduced herds offer prospects of gaining insight into limiting factors. Similar to developing inventory techniques, devising methods to assess carrying capacity require a basic understanding of key aspects of the species biology before useful ways can be developed.

The next four topics ranked approximately the same: home range, migration and movements; impacts of forestry, mining, settlement, and hydroelectric developments; habitat utilization; and impact of access (Fig. 3). These topics are inter-related since assessing impacts requires baseline information on habitat use, movements and migrations. For most developments, little "before" type of data exists so that most assessments are made after the fact. In some cases, such as the situation described by Pendergast in this symposium, the changes in goat numbers are so dramatic that even scanty baseline data are sufficient to demonstrate declines. Generally, showing that declines occur is a relatively straightforward matter.

Why they occur is undecided since the possible causes have not been isolated adequately. Three commonly suggested effects of resource developments are: loss of habitat, increased kill through improved access, and desertion through disturbance and psychological stress. This latter factor is important for both non-consumptive and consumptive uses of mountain goats. In unusual cases, losses of habitat may be large enough to reduce range supply significantly. However, this is probably not true in most cases and, in fact, certain limited cases of strip mining may create escape terrain (Pendergast and Bindernagel, this symposium). The latter two effects of impact are more difficult to disentangle and it is only through appropriately designed experiments that the correct answer will be obtained.

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The next six topics were ranked as of intermediate importance (Fig. 3). In subject matter they were concerned with resource partitioning, social behaviour, nutrition and development of simulation models.

Four topics ranked low in priority. In decreasing order, they were: importance of parasites and disease in productivity, significance of mineral licks, user attitudes and preferences, and economic value (Fig. 3). The low rank of the latter two subjects is surprising since they continually arise in discussions on management objectives and resource trade-offs. Perhaps these items were considered more in need of application rather than in need of further research. Certainly, user surveys are standard tools of market management, but evaluating a non-market resource continues to pose a research challenge.

The following topics were also suggested by respondents:
1. Parasitology and viral diseases
2. Intra-specific competition with other ungulates
3. Techniques for live-trapping and handling
4. Reproductive potential and survival
5. Effects and level of predation (3 times)
6. Identification of a manageable unit: herd or habitat basis
7. General life history
8. Dynamics of invasions (transplants)
9. Influence of weather on reproduction and survival

These suggestions were not ranked since they were not available to everyone for assessment. They revealed one shortcoming of questionnaire surveys pointed out in the Methods, that is, omitting major subjects in the topics. For example, no titles were listed that related to competition, predation or behaviour of transplants. These omissions reflect my provincial bias since in British Columbia, we appear to have little problems with competition or predation, and are not transplanting mountain goats.

Useful comments were offered on research and its application to management. Some biologists felt that while more research is needed, we should concentrate more on the application of results. Better attempts to publish completed research and other communication methods. One biologist felt that the real problem was people management, and that we should use knowledge gained through research to influence political and public attitudes.

Current Research and Research Needs

Evaluating the agreement in priorities between research needs and papers at this symposium was difficult. Some papers were reviews rather than reports of research projects. Others were comprehensive and dealt with many of the topics listed on the questionnaire. Still others treated the questionnaire topics peripherally rather than as the main theme. For these reasons, I counted some papers for more than one topic if they treated the topics in detail.

Bearing in mind the above qualification, it was nonetheless surprising to find that the null hypothesis of no correlation was not rejected ($r_s = 0.33$, df = 12, tabulated r_s at 0.05 level = 0.412 in table P of Siegal (1956: 284). If the symposium topics accurately reflected on-going research and my classification of their topics is representative, then it appears that research is not directed according to the priorities of the questionnaire respondents.

Obviously, redirecting research on the basis of this single, simple test is unwise. Yet it does suggest that fish and wildlife agencies and parks should carefully re-examine their research programs with respect to management needs.

RECOMMENDATIONS

1. Direct research towards priority topics.
2. Direct research away from primarily descriptive projects to experimental approaches.
3. Reduce the lag between research results and management application by improving communication and by publishing results promptly.
4. Researchers should interpret their findings more thoroughly.
5. Hold regular mountain goat workshops at two year intervals, possibly in conjunction with the Northern Wild Sheep Workshop.
6. Define objectives clearly for mountain goat management so that the role of research can be more effective.

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