- MANAGEMENT PROGRAM DRAFT PROPOSAL -
OPTIONS FOR INCREASING MOOSE NUMBERS, SOUTHERN YUKON

Prepared by
D.G. Larsen and D.A. Gauthier

04/25/85

Submission of the Moose/Predator Technical Committee
Government of Yukon

(For Discussion Purposes Only)

Yukon
Renewable Resources

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TABLE OF CONTENTS

STUDY GOAL

It is the goal of the Government of Yukon to increase the numbers of moose in low density populations in southern Yukon to meet resident needs. It is also the goal to ensure the continued presence of self-reproducing predator populations in areas of moose enhancement.

We recognise, (1) that moose exist in a complex, dynamic and interactive system, and therefore any attempt to manipulate their numbers should involve consideration of other ungulates, human harvest, predators, and alternate prey species of those predators, (2) that these factors may act in combination to affect numbers and thus should be studied concurrently, (3) that necessary information on the interaction of these factors can best be obtained through experimental means, and (4) that numerous options exist to potentially realize the dual goals.

Any options to be considered by Government of Yukon to increase moose numbers must involve to some degree consideration of factors that limit the growth of moose populations. With knowledge of those factors, we have the option of pursuing short- (1 to 3 years) versus long-term

(>3 years) programs to increase moose numbers, through either passive (manipulation through hunting regulations) or active (manipulation through Government field programs) means. Ideally, we prefer a short-term approach which is most likely to produce results uncomplicated by confounding effects and will allow evaluation of conditions in other areas of Yukon. We consider the active approach more feasible than the passive given the sparse human population and limited access within the study area. We present two options as means to increase low density, stable or declining moose populations in southern Yukon, and ensure the continued presence of predator populations. As background, we provide a brief summary of data from a completed research program in a 20000 sq.km. (7800 sq.mi.) area in southern Yukon conducted to (1) identify demographic characteristics of moose, and (2) identify limiting factors to moose population growth.

BACKGROUND INFORMATION

Prior to 1980, little information on moose numbers, distribution or population dynamics was available in Yukon. While the Yukon Fish and Wildlife Branch has jurisdiction relative to management of moose populations and the responsibility for establishing moose harvest regulations, it has had inadequate information upon which to base management decisions. Information gathered from hunter questionnaires revealed that moose were the primary game species for resident Yukon hunters (for example, 22000 man/days hunting moose compared to 5000 man/days for caribou, the next highest hunting effort). Hunting effort for moose is high (mean=30 days/moose kill). However, success rates are low (25%) relative to results from other regions of North America (Timmerman 1981). In addition, 30% of all moose harvested by resident hunters in Yukon, and 30% of the hunting effort, occurrs on 3% of total Yukon lands in southern Yukon. This area has the greatest human population.

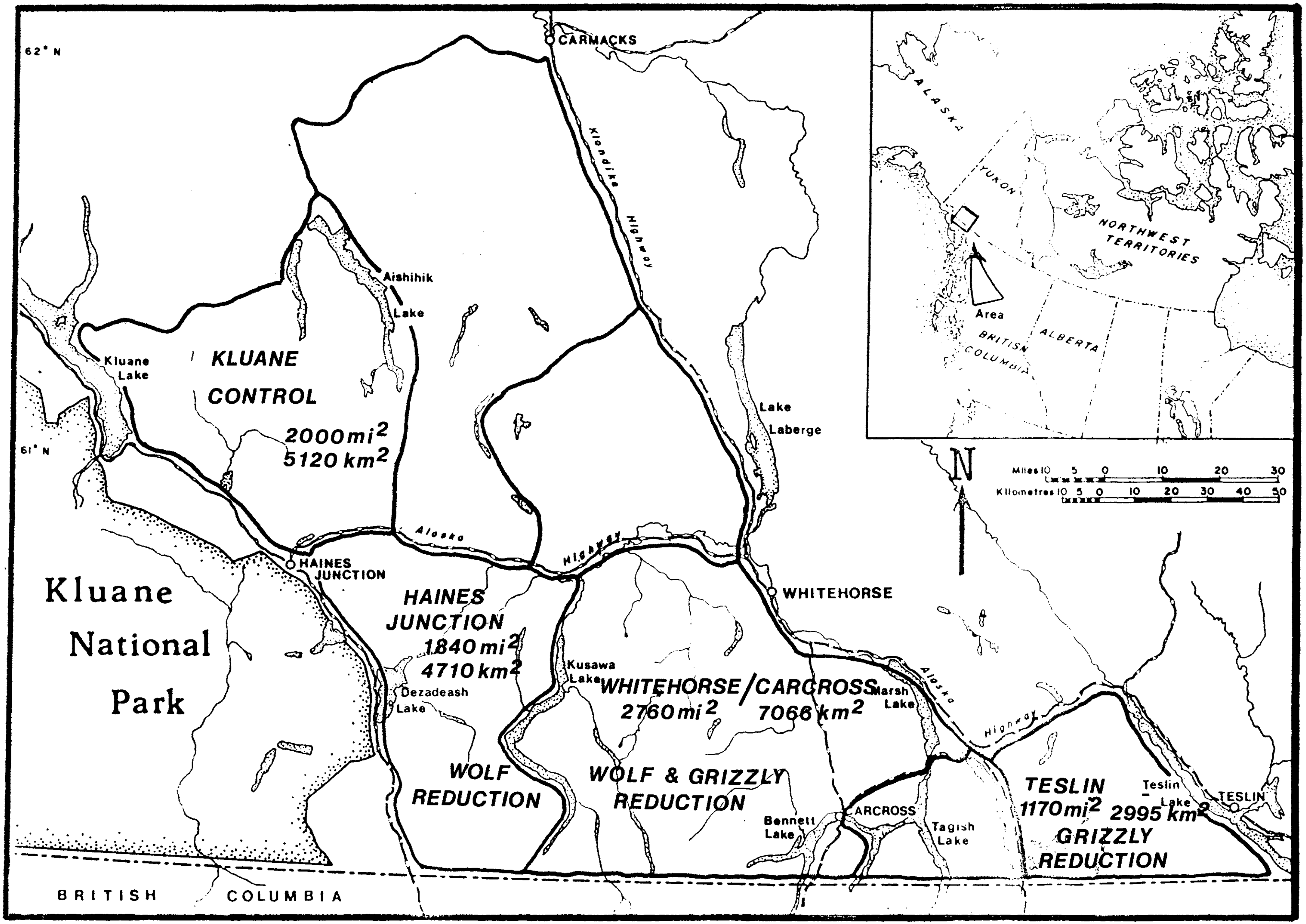
The low hunter success rate may be a relatively recent phenomenon since anecdotal data suggests relatively high success rates in the 1960's and early-1970's. Hunter harvest statistics from that period are either inadequate or unavailable and therefore the timing of the suspected decline are conjectural. Human harvest in southern Yukon has been traditionally directed to areas of road and river access, that is, primarily within the lowland-forested regions. Moose numbers in these accessible areas would, therefore, be subject to the greatest potential for reduction.

The high hunter effort and low success rates in recent years suggested that moose numbers were low. The importance of moose for both consumptive and nonconsumptive users, the concern that moose numbers had declined to low levels, and the lack of data upon which to base management strategies prompted the Fish and Wildlife Branch to initiate a study to document moose numbers and to investigate potential mechanisms influencing population size.

The study was conducted in a region of Yukon where moose utilization was heaviest (derived from hunter questionnaire results) and thus the potential impact of hunting the greatest. Five contiguous blocks (Fig. 1) were chosen - Kluane, Haines Junction, Whitehorse, Carcross and Teslin. Study area boundaries defining the five blocks were based on major physiographic and human barriers to moose movement suggesting the moose populations in each region were likely relatively discrete.

Population dynamics theory for large ungulates in North America suggests six factors which potentially act to limit moose numbers. These factors are (a) forage and climate, (b) disease/parasites, (c) changes in reproduction and sex ratios, (d) ingress/egress, (e) human harvest, and (f) natural predators. The objectives of the study were (1) to accurately assess moose population composition, distribution and changes in numbers over time, and (2) to assess the

FIG. 1. Map of moose/predator management program study area, southern Yukon.



62° N
61° N
CARMACKS
Klondike Highway
Aishihik Lake
KLUANE CONTROL
2000 mi²
5120 km²
Kluane Lake
Alaska Highway
HAINES JUNCTION
WHITEHORSE
Lake Laberge
Kluane National Park
HAINES JUNCTION
1840 mi²
4710 km²
Kusawa Lake
WHITEHORSE / CARCROSS
2760 mi²
7066 km²
Marsh Lake
Dezadeash Lake
WOLF REDUCTION
WOLF & GRIZZLY REDUCTION
Bennett Lake
CARCROSS
Tagish Lake
TESLIN
1170 mi²
2995 km²
GRIZZLY REDUCTION
Teslin Lake
TESLIN
BRITISH COLUMBIA
N
Miles 10 5 0 10 20 30
Kilometres 10 5 0 10 20 30 40 50
ALASKA
YUKON
NORTHWEST TERRITORIES
Area
BRITISH COLUMBIA
ALBERTA

influence of the above six factors on moose population growth.

Objective 1

An evaluation of existing census techniques led to the selection in 1980 of a Fall moose census technique based upon a stratified random sampling approach developed for moose in Alaska (Gasaway et al. 1983). This method was tested in the Carcross area of Yukon and modified to more practically suit Yukon physiography and climate (Larsen 1982).

The combined results of censuses conducted in the blocks between 1980 and 1984 revealed low moose numbers, low calf numbers, poor recruitment and skewed adult sex ratios (Larsen 1982; Markel and Larsen 1982, 1984; Johnson and McLeod 1983). This substantiated earlier concerns about low numbers. The results from radio-telemetry studies indicated that each block contained relatively discrete populations. Fall surveys using different survey techniques (Hoefs 1974) and dating back to 1974 revealed consistently low calf/cow ratios and low recruitment. Surveys in Kluane National Park, adjoining the Haines Junction block , have shown low calf/cow ratios in Fall populations since 1974 (unpublished Kluane National Park Warden Report Series). These results suggested that the problem was not limited to hunted moose populations and was probably not a recent phenomenon. Studies in Teslin, Whitehorse, Carcross and Haines Junction in 1983 and 1984 revealed relatively old-age cows (Larsen and Gauthier, in prep.). These combined results revealed that moose populations were either declining or at a low-density stability with little prospect for increase due to poor recruitment and declining numbers of reproductive-age animals.

Objective 2

Forage and climate, disease/parasites, changes in reproduction and sex ratios, ingress/egress, human harvest, and natural predators were assessed. A summary is shown in Figure 2.

(a) Forage and Climate

If forage/climate effects were limiting moose numbers, we predicted some combination of the following, (i) evidence of poor physical condition, (ii) high utilization of habitat (for example, evidence of overbrowsing of preferred forage species, particularly on winter range); concentration of

FIG. 2. Summary of background information.

THE PROBLEM
- Low calf/cow ratios
- Old aged cows
- Low moose numbers
- Declining moose numbers

Investigate factors limiting moose numbers in areas of low moose numbers & high harvest demand

Potential Limiting Factors

FORAGE-CLIMATE
- Physical condition of animals excellent
- No evidence of overbrowsing
- Habitat can support more moose
- High fecundity rates
- Conclude forage likely not limiting

Assess relationship between winter severity and calf survival rates

If manipulation of other limiting factors results in an increase in moose numbers, initiate a forage utilization study

If forage utilization is high, consider habitat manipulation study (eg. prescribed burning) dependent on density moose reach after manipulation

DISEASE-PARISITES
- Virological tests negative
- Ticks rare in Yukon
- P.tenuis not recorded in Yukon
- Brucellosis not common
- Conclude disease-parasites likely not limiting

Continue to monitor condition of radio-collared animals

REPRODUCTION-SEX RATIOS
- Consistently high reproductive rates
- normal twinning rates
- Fecundity rate in populations of 1 moose/mi² same as in populations of .5 moose/mi² suggesting little density-dependant effect on numbers

Continue to monitor reproductive rates, twinning rates sex ratios

PREDATION
- 82% of all calves born die by 01 Nov.; 86% by 15 May
- 95% of all calves that die were preyed upon by bears/wolves
- Causes of calf mortality:
  - 67% grizzly bears
  - 23% wolves
  - 5% non predators
  - 3% black bears
  - 2% cause unknown
- Grizzly bears and wolves were major cause of moose mortality
- Adult moose mortality: 10% annual natural mortality, 75% due to wolves, 25% to grizzly bears
- Is predation major limiting factor? Test- Remove grizzly bears/wolves

HUMAN HARVEST
- Resident, non-resident and native harvest removes 8% of the estimated moose population. Does not include estimate of poaching losses
- Calves account for only 1% of annual legal harvest
- Conclude that human harvest is not a major mortality factor and likely not limiting

- Cow harvest eliminated (previously accounted for 15% of total legal harvest)
- Bull harvest season restricted
- Develop harvestable surplus model

INGRESS-EGRESS
- No evidence of substantial egress to cause declines
- Conclude loss of animals to egress not likely

Continue to monitor movements of radio collared animals moose resulting in local overbrowsing should also be evident, and (iii) low fecundity and pregnancy rates.

Cows were equipped with radio-collars in 1983 and again in 1984. Gross external physical examination of these cows by a veterinarian revealed animals were in excellent physical condition in late-winter, the period when we would expect animals to be in poorest physical condition (Franzmann and LeResche 1978). There was no evidence from hematological and chemical analyses of blood samples to indicate that animals were in poor physical condition (Glover and Larsen, in prep.). Subjective evaluation of habitat revealed overbrowsing in concentrated rutting areas but no observations of concentrations of moose were noted in late-winter, nor was overbrowsing noted on ranges in late-winter, a period of high stress. Pregnancy rates were at normal-to-high levels (mean=89%) with normal-to-high fecundity rates (mean=1.3 calves in utero /pregnant cow), and normal twinning rates (23% of pregnant females).

Since none of the predictions were supported, it was concluded that forage effects were likely not significant in affecting moose numbers. It should be noted that habitat manipulation would, therefore, likely be ineffective in increasing moose numbers.

Climatic data to assess the influence of winter and calving climate severity on moose productivity and calf survivorship were collected in 1983 and 1984 and will continue to be collected during the winters and in conjunction with calf mortality studies. No evidence of climatic effects on productivity and calf survival are evident to date.

(b) Disease/parasites

Analyses of blood samples from captured cow moose revealed no evidence of disease. Major diseases and parasites which have been suggested as possible causes in moose declines (or at least to have definite detrimental effects on moose), are D. albipitus (Anderson and Lankester 1974), P. tenuis (Prescott 1974), and Brucellosis spp. (Anderson 1975). These diseases and parasites are rare to nonexistent in Yukon. We conclude that disease/parasites are not likely currently limiting moose numbers. However, physical condition of animals will continue to be assessed through samples taken from radio-collared moose.

(c) Altered sex ratios and reproductive rates

Sex ratios were approximately 50 males per 100 females, a relatively normal sex ratio for North American moose populations in which males are preferentially hunted (Bishop and Rausch 1974). Skewed sex ratios down to 30 males per 100 females do not have a negative short-term effect on reproductive rates or timing of birth in southern Yukon moose populations (Larsen and Gauthier, in prep.). Reproductive rates were consistently high. The fecundity rate in populations of 1 moose/sq.mi. are not significantly different from populations at 0.5 moose/sq.mi. in southern Yukon. This suggests that there has been little density-dependent effect on numbers, at least at those densities. We conclude that reproductive rates and skewed sex ratios were not likely significant factors influencing changes in moose numbers. Sex ratios, reproductive and twinning rates will continue to be monitored.

(d) Ingress/egress

Monitoring of radio-collared cow movements showed no significant movement between the 4 blocks intensively studied (n=30 cows/block). Therefore, neither ingress nor egress was a factor affecting numbers. However, seasonal movement of animals was documented between the Haines

Junction block and Kluane National Park. The magnitude and extent of this movement is currently being assessed. Adjustments to population estimates from Fall censuses for that study area will depend upon the results of the movement study. Current information indicates that ingress/egress are not likely significant factors influencing changes in moose numbers. The movement and distribution of moose will continue to be monitored by telemetry.

(e) Human harvest

Human harvest annually removes approximately 8% (240 animals) of the estimated prehunt Fall moose population. This figure includes an estimate of native harvest, although losses to poaching are unknown. Few moose calves were harvested (1% of the annual legal harvest, or approximately 6 calves/year). This represents <1% of the calf population for the entire study area. We conclude that human harvest by itself is not likely a limiting factor to moose population growth, but may act to limit numbers in conjunction with other factors. In response, the harvest of females has been eliminated (in the past, the harvest of females accounted for approximately 15% of total legal harvest or 1% of the total population), and the male harvest season has been restricted in accessible areas from a 90 day season to a 15 day season.

(f) Predation

If predation were acting to limit the growth of moose numbers, we would predict (i) that the number of moose killed by predators is significant in relation to moose productivity, that is, predators constitute the major source of mortality, (ii) that bears and wolves would be the major predators, (iii) that bears and(or) wolves would act to remove predominantly calves from the population, primarily in the calving/postcalving period, and (iv) that this reduction of calves would result in an increasingly older-aged moose population.

In 1983, 76 moose calves were radio-collared during the calving period and monitored for one year. Eighty-six percent of all calves that were born died over one year. Of the total mortality, 63% was due to grizzly bears, 26% to wolves, 5% to non-predators, 2% to black bears and 4% to unknown predators. Grizzly bear predation was the primary cause of moose calf mortality in the first six weeks of life. After 1 November, wolves were the only detectable cause of moose calf mortality. The majority of calf mortality occurred in the calving/postcalving period (15 May to 17 July).

In 1983 and 1984, a total of 120 adult cows were radio-collared and monitored. The annual adult natural mortality rate averaged approximately 10%, with the majority of adult mortality occurring in the summer. All mortality was due to predation, of which 75% was due to wolves and 25% due to grizzly bears.

Wolf populations were aerially censused in 1983 and 1984, revealing a wolf density of 1 wolf/84 sq.km. (Hayes et al. 1985), similar to the highest densities determined in other naturally regulated wolf populations in northwestern North America (Haber 1977; Gasaway et al. 1983). The ratio of moose per wolf was 10:1, suggesting that wolf predation was potentially limiting moose numbers based on a ratio index developed by Gasaway et al. 1983. Radio telemetry studies of 2 packs in 1983 and 1984 showed that moose were the primary winter prey species followed by Dall's sheep. Pack consumption rates were 1 moose per 7 days (Hayes, in prep.).

We have not censused grizzly bear densities within the study area. Research from Kluane National Park which abuts the study area documented a grizzly bear density of 1 bear/26 sq.km. (1/10 sq.mi.) (Pearson 1975). Smith (Government of Yukon, unpubl. data) concluded that a reasonable bear density estimate for the study area is likely one bear per 50 sq.km. (1/19 sq.mi.). Table 1 provides a brief review of bear density estimates from

TABLE 1. Northern interior grizzly bear densities (km^2/bear).

STUDY LOCATION	SOURCE	RESEARCHER POPULATION DENSITY
W.Alaska Range, C. Alaska	Reynolds,'83	41
Nelchina Basin, S.C. Alaska	Miller&Ballard '82; Miller et al. '82	41
Susitna Range, S.C. Alaska	Miller&McAllister,'82; Miller,	41-62
Denali Park, C. Alaska	Dean, '76	24-38
W.C. Alberta, boreal forest	Nagy, pers. comm.	50-75
Auriol Range, S.W. Yukon	Pearson,'75	23-28

* Adult female densities are based on data in publications and(or) communications with researchers.

northern interior grizzly bear studies in relatively similar habitat to the study area. Based upon a conservative density estimate of 1 bear/50 sq.km., we estimate 400 bears within the area. We propose in a later section a method to assess actual bear densities.

Sheep and caribou are additional prey species of wolves; hare and beaver may also be preyed upon. Sheep populations have been censused in the Kluane, Haines Junction and Whitehorse blocks, revealing a density range of .17-.47 sheep/sq.km.. Evidence over ten years of surveys reveals relatively stable sheep populations in those blocks. No sheep inhabit the Teslin and Carcross blocks. Caribou are found in all but the Haines Junction block. Densities range from .04-.05 caribou per sq.km. based on surveys conducted from 1978 through 1980. Hare densities in Kluane Park and the Kluane block reached a peak of 9.7 hares/ha in 1980 and declined to a low density of .05 hares/ha (Ward 1985) in 1983, the year of the first moose calf mortality study. The only information available for beaver is from Teslin and the northeast section of the Whitehorse block. Densities ranged from 3-15 km. per active colony (Slough, Gov. Yukon, unpublished data).

Conclusion

It was concluded that the primary cause of low moose numbers was insufficient recruitment to replace adult losses, and that predation, primarily by grizzly bears, was the major reason for low recruitment. While grizzly bears and wolves were identified as the major sources of moose mortality, the question remained as to whether predation was the major limiting factor to moose population growth, such that reduction of predator numbers would result in a positive rate of moose population growth. The most effective test to determine limitation is reduction of the factor(s) suspected to be limiting, accompanied by knowledge of changes in other factors which may potentially act concurrently to limit population growth.

CONSIDERATIONS FOR FUTURE RESEARCH

The above research findings suggest that reduction of grizzly bear and wolf numbers should result in increases in moose calf survivorship with resultant increases in recruitment and increased population growth rates. We recognise that there are many study design permutations which would allow us to attain the dual goals outlined initially, and to conduct an adequate test of the prediction stated above. However, any study designed to assess that prediction must take into account the following factors.

<u>(1) Short-term versus long-term recovery programs</u>

(a) There is an older age structure to the reproductive segment of the moose population in the study area. If a recovery program is not put in place, we predict that increasingly fewer reproductive females will be present in the population. A short-term recovery strategy is thus preferable to a long-term strategy.

(b) Recovery of a declining, low-density moose population will likely take longer than in a declining or stable higher-density population. Therefore, the most rapid recovery should result through short-term rather than long-term strategies.

(c) Temporal changes in confounding effects are less likely to occur in a short-term experiment.

Therefore, we would prefer to adopt an approach which allows a relatively short-term test of the prediction that reduction of grizzly bear and wolf numbers will result in an increase in calf survivorship with resultant increase in recruitment and population growth rates.

(2) Multi-block predator prescription design versus single predator prescription design

The test that we choose should allow an evaluation of the effect of possible changes in other limiting factors which may act to affect moose numbers, as well as the interaction among limiting factors. Assumptions which are inherent to our prediction are (a) that another potential limiting factor does not assume immediate importance in limiting moose numbers (for example, that moose numbers are not relatively close to the limiting effect of forage/climate), and (b) that there are no significant compensatory effects among limiting factors (for example, that with a significant number of grizzly bears removed, wolves, black bears, and(or) remaining grizzly bears do not remove a substantial number of calves that would otherwise have been taken by the grizzly bears which were removed). Regarding the first assumption, we have briefly reported on research findings which indicate that moose numbers are currently not likely limited by either forage or climate conditions, disease/parasites, changes in reproduction or sex ratios, ingress/egress and(or) human harvest. We are controlling human harvest and have no evidence to suggest that the other factors mentioned will assume an immediate limiting effect upon reduction of predators.

Regarding the second assumption, we have two alternatives, (i) we can ignore the issue of compensation and reduce both grizzly bear and wolf numbers across the study area in a short time period, that is, apply a single predator prescription reduction program, or (ii) we can test for compensation through the reduction of different combinations of predators either across different geographic areas (spatial option) or in the same area through time (temporal option). The first alternative has two serious disadvantages; we do not have the resources for such an extensive reduction program and it would not provide results which could be used with any assurance in other areas. The second alternative would overcome both of these obstacles through the use of either a spatial or temporal block design, that is, areas where grizzly bears and wolves are both removed, and areas where grizzly bears-only and wolves-only are removed. A control area where no prescribed manipulation is undertaken would serve to assess the effect of possible changes in other potential limiting factors which may act to affect moose numbers concurrently with the manipulation of predator numbers. We propose five areas in southern Yukon for use as different prescription blocks (see Fig. 1 and Table 2) - (a) the Haines Junction block for wolf-only reduction in the spatial option; in the temporal option, wolf-only reduction would be conducted first, followed at a later date by grizzly bear reduction, (b) the Whitehorse/Carcross block (hereafter referred to as the

Table 2. Predator reduction programs in each study block according to the spatial and temporal options.

STUDY BLOCK	SPATIAL OPTION	TEMPORAL OPTION
Haines Junction	wolf-only reduction	wolf reduction followed by grizzly bear reduction
Whitehorse/Carcross	both wolf and grizzly bear reduction	both wolf and grizzly bear reduction
Teslin	grizzly bear-only reduction	no predator reduction
Kluane	no predator reduction	no predator reduction

Whitehorse block) for both grizzly bear and wolf reduction, (c) the Teslin block for grizzly bear-only reduction in the spatial option; no predator reduction would be conducted in this block in the temporal option, and (4) the Kluane block which would be used as a control area.

Ideally, we would predict that calf and adult survivorship should increase in all reduction blocks, but should not increase significantly in the control block. These predictions are dependent upon three factors - the ability of monitoring techniques to accurately assess changes in mortality rates, our ability to detect compensation among other mortality factors, and our ability to successfully remove predators. Two independent techniques are proposed to assess changes in both calf and cow mortality rates and causes of mortality. The first involves radio-collaring both calves and cows. Calves would be collared in the calving period and their survivorship and causes of mortality would be monitored over time. In the grizzly bear-only reduction block, if nothing else shows a compensatory response, we predict an immediate increase in calf survivorship within this block relative to previous years and compared to the control block within the same year. If predators compensate for the bear reduction through either the remaining grizzly bears removing more calves, or other predators (wolves, black bears) removing more calves, then the predicted increase may not occur or be detectable. If wolves, for example, do show a compensatory response, then they should kill more calves than in previous years. The causes and rate of cow mortality will be monitored annually with spatial and temporal comparisons. This technique is useful as a measure of causes of calf and cow mortality and as a short-term measure of rate of mortality but may be inadequate as a long-term measure of the rate of mortality owing to sample size inadequacies. A second and more accurate long-term estimate of survivorship in calves and adults is provided by assessment of composition in Fall censuses of the moose population. The census results provide a measure of the accuracy of estimates, but can result in wide confidence limits around estimates. As a measure of significant increases in calf and adult survivorship, therefore, substantial increases in Fall survivorship are required. These substantial increases are predicted in both the grizzly bear/wolf and grizzly bear-only reduction areas. Any confounding effects of possible compensatory predation in the grizzly bear-only reduction block would be assessed in a collared-calf mortality study. It should be recognized that changes in survivorship in the wolf-only reduction block or control block may not be detectable in terms of their statistical significance owing to wide confidence limits on population estimates.

(3) Passive versus active management

"Passive" management in this context refers to the use of current or liberalized hunting and trapping regulations to reduce predator numbers. "Active" management refers to the reduction of predators directly by government personnel. If we wish to pursue a short-term strategy of increasing moose numbers through grizzly bear/wolf reduction, we recommend the active management strategy. Sufficient grizzly bears must be removed in order to detect a change in moose numbers. We propose that 50% of estimated bear numbers in reduction blocks should be removed over a maximum of a two year period. Maintaining the current level of grizzly bear/wolf harvest through hunting and trapping regulations would not result in a sufficient reduction of predators over a short period. The gradual reduction of predators over a number of years may be countered by ingress of predators into the area. A short-term active management strategy would minimize this problem. We have already reported that moose populations in the study area are declining with this "status quo" management of predators. Grizzly bear hunting regulations were liberalized in 1984 and did not result in a substantial increase in bears removed. This method is likely an ineffective short-term technique by itself. Greater liberalization of regulations may be an effective short-term technique, but would likely require such regulation changes as reduction of trophy fees and tag fees, use of calf distress calls, spotting from aircraft and allowance of baiting, some of which are not acceptable at this time. The effectiveness of further liberalization could be tested if allowed in one of the two bear reduction blocks, that is, the Whitehorse or Teslin blocks. Active Government participation in bear reduction through field programs provides the best opportunity for reduction of bears in a relatively short time period as well as an opportunity to estimate bear numbers and ensure that bears are not eradicated.

We recognise two feasible methods for bear reduction by Government personnel - killing of bears or live-trapping and relocation out of the reduction blocks. If bears are to be trans-located, they should be moved at least 480-650 km. (300-400 mi.) in order to prevent their return and therefore allow maximum opportunity for increases in moose numbers. A combination of Departmental involvement in reduction and(or) liberalization of grizzly bear hunting regulations may provide the most feasible means of removing sufficient numbers of bears to effect a significant change in moose numbers over a short-term period.

(4) Applicability of results to other areas

We should be able to assess the results of the chosen test as to whether they are applicable to other areas. For example, can we predict that the result of a reduction of predators in one study area may also be achieved by a similar reduction in a similar study area elsewhere?

(5) Removal of sufficient numbers of predators

The test should ensure that neither grizzly bears nor wolves in the study area are eradicated by the reduction program while at the same time ensuring that sufficient numbers of predators are removed to provide an adequate test of the hypothesis.

(6) Estimating or not estimating bear numbers

As mentioned earlier, actual bear numbers in the study area are unknown, although using a density of 1 bear/50 sq.km. yields an estimate of approximately 400 bears. When this density estimate is applied to the bear reduction blocks (Whitehorse and Teslin), the estimated populations are 141 and 60 bears, respectively, or reduction goals of 70 and 30 bears, respectively, in the two blocks.

There are no documented effective means of censusing grizzly bears over a large area in a short time period. One long-term method is a total census of bears, involving a multi-year telemetry study. The time, expense and lack of documented capability of this method to provide accurate estimates suggests it would not be an appropriate method to pursue. A second method based on sampling and use of radio-collared animals in a capture-recapture method of population estimation may provide a more practical short-term solution (Ballard and Miller 1981).

It is important to attempt an accurate estimate of bear numbers. If we did not have accurate estimates and if changes in moose numbers were documented following predator reduction , we would lack accurate predictive capability, that is, the percent bear reduction required to effect a desired change in moose numbers. Furthermore, we would not know the number of bears which must be left after bear reduction to ensure the continuation of a bear population in the region.

It must be recognized, however, that even with an accurate estimate of bear numbers, we have no information on what number of bears should be left to ensure their continued presence in the study area. The reduction of grizzly bears without an accurate estimate may, therefore, be an acceptable option given (a) the potentially high density of bears, (b) the relatively small size of the reduction area in relation to bear home ranges and dispersal capabilities, and (c) potentially poor capture success. It is more likely that we will be unable to remove sufficient bears (owing to logistical difficulties), than the alternative concern that too many bears will be removed.

(7) Reduction versus non-reduction of wolf numbers

We have suggested that there may be practical limitations to the reduction of bears such that the 50% bear-reduction goal is not achieved. Grizzly bear reduction by itself may not prove an effective technique due to practical limitations. Given that wolves account for 26% of total calf natural mortality and 75% of total adult natural mortality, and that reasonable success rates in removing wolves have been demonstrated, it follows that moose calf survivorship may be most significantly affected by reduction of both bears and wolves.

Estimates of wolf numbers between 1982-1985 have been based on total census counts. A reduction goal of 70% of estimated wolf numbers has been set for the Whitehorse block. Wolf populations can be reduced at harvest rates greater than 23-38% according to Keith (1983), greater than 20% according to Gasaway *et al.* (1983) and 50% according to

Mech (1970). Gasaway et al. (1983) removed up to 61% of wolf numbers in study areas in Alaska producing a rapid decline in wolves, and consequent increase in moose survivorship. It is an objective of this study to increase moose numbers over a relatively short time period. It is our judgement that to effect a change in wolf numbers which will be manifested in decreased predation rates on moose over a short time period will require a substantial reduction in wolf numbers. We have chosen a reduction level of 70% to achieve that goal. Population estimates obtained for moose from Fall censuses have confidence limits varying from 10-30%. Therefore, relatively substantial changes in moose numbers are required for us to be able to detect a measurable change in moose numbers following predator reduction. If wolves are an important limiting factor to the growth of moose numbers, then substantial reductions in wolf numbers (for example, 70%) should result in a measurable change in moose numbers. The post-reduction response of wolf numbers relative to any changes in their prey base has important management implications. For example, can wolf numbers quickly increase following reduction and through a numerical and(or) functional response act to significantly depress moose numbers?

The following proposals are based on a study design prepared by Hayes (1985). We propose that the ability of wolf populations to exert a limiting effect on moose numbers following wolf reduction be assessed and the mechanisms by which they achieve potential limiting effects. We identify four major components to that assessment.

(a) Given that there will be a significant increase in the proportion of wolf pups in the population as the wolf population declines from reduction, we hypothesize that such an increase would not be due to an increase in litter sizes. If there is an increase in the proportion of pups in the population, it may be due to two factors - (i) pack fracturing, (ii) ingressing wolves establishing smaller territories, or some combination of the two.

(b) Given that the mean age of females will likely decrease in the population as wolf numbers decline, we propose the null hypotheses that - (i) the mean age of reproductive females will not decrease, and (ii) the proportion of reproductive females will not increase.

(c) Given that sheep are an important prey base for wolves (shown from food habits studies), we hypothesize that the proportion of sheep to moose kills in wolf diet will not change following wolf reduction.

(d) If we pursue the spatial option within the experimental block design suggested in point (2) above, we have predicted that the highest moose population growth rate will occur in the Whitehorse block due to concurrent grizzly bear and wolf reduction, while the Haines Junction block will have significantly less moose population growth due to wolf-only reduction. Given this prediction, we will assess wolf population growth rates between Haines Junction and Whitehorse blocks. If a difference in wolf population growth rates is noted, we predict that higher growth rates will occur in the Whitehorse block. Differences between the two blocks may be due to increased availability of moose as a prey item in Whitehorse relative to Haines Junction. We predict that the proportion of younger-aged moose among wolf kills will increase following wolf reduction, and that this will occur in both Whitehorse and Haines Junction blocks. If the reduction rates for both bears and wolves are achieved in the Whitehorse block, then Fall censuses conducted subsequent to the reductions should demonstrate increased calf moose survivorship.

(8) Effect of predator reduction on other ungulate species

Although the primary goal of this program is to assess the effects of predator reduction on moose numbers, it is possible that such reductions may affect the numbers of other ungulate species (sheep, caribou) of management importance. Data are available on the population size, distribution and composition of sheep and caribou within the reduction blocks. During and after the period of predator reduction, inventories of sheep and caribou should be conducted to assess their response to that reduction. It is possible that wolf food habits may change as their overall density declines, with possible shifts among the three ungulate species. Wolf food habits should, therefore, be documented subsequent to wolf reduction.

OPTIONS FOR FUTURE RESEARCH

In the previous section, we identified eight major factors which affect the type of study design chosen to achieve the dual study goals. Although we initially identified numerous program designs, past actions partially dictate the range of actual options available. For example, wolf reduction which has already been conducted in the Whitehorse and Haines Junction blocks precludes a bear-only option in those blocks.

We recognize two realistic options which attempt to incorporate aspects of those major factors, and which may result in increased moose numbers. Option 1 describes a long-term, single prescription program, combining both active and passive approaches. Option 2, which is our preferred option for reasons to be discussed, describes a short-term reduction program within a multi-block design relying upon active management techniques.

Option 1

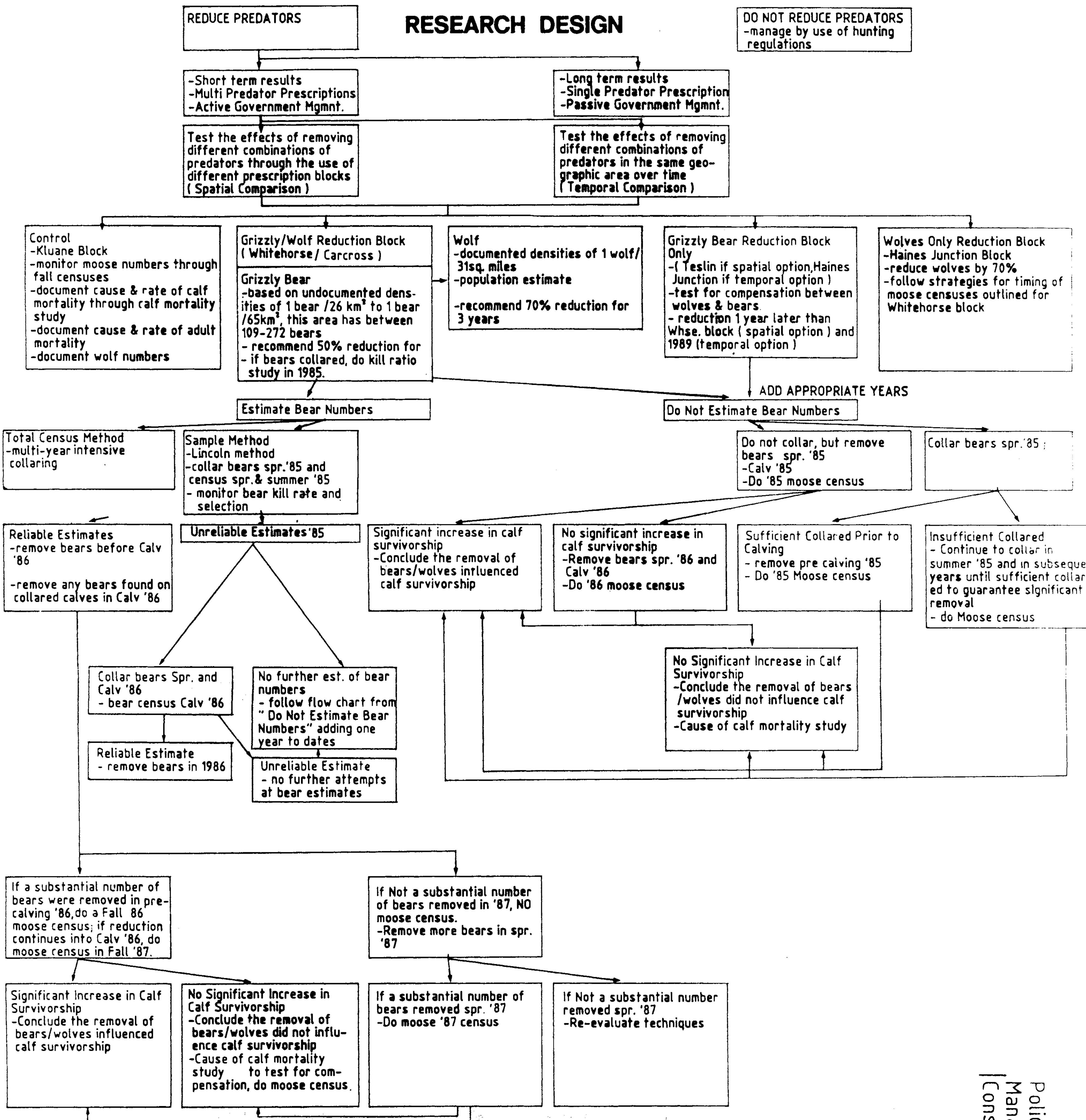
We propose 70% reduction of wolf numbers throughout the study area by active management combined with 50% reduction of grizzly bear numbers through the use of bear harvest regulations (outlined in point (3) above). Seventy percent reduction of wolf numbers will be achieved in the Whitehorse and Haines Junction blocks in 1985. Wolves have not yet been removed from the Carcross block. We propose that once the 70% goal has been achieved that wolf numbers be kept at that level until the bear reduction goal is achieved. In the wolf reduction blocks, the 70% goal should be maintained for three years. In this option, grizzly bear reductions would be conducted through liberalization of bear hunting regulations, preferably through gross liberalization of regulations, as opposed to "status quo" management or mild liberalization (as occurred in 1984). Changes in moose numbers would be monitored through Fall censuses in each block, and related to trends in numbers prior to predator reductions. Relative to the seven factors outlined in the previous section, this option suffers the disadvantage of being a relatively long-term recovery program. If we were to conduct bear-reduction through Government field programs, we would ensure the greatest chance of success in reducing bear numbers. If, however, we rely on liberalization of hunting regulations, we have less chance of success in removing the necessary number of animals. Without such estimates and given that we cannot conduct tests for compensatory predation in this option (since it is a single predator prescription design), the results would have limited applicability to other areas and thus would be of limited management value. Furthermore, without an accurate estimate of bear numbers, we lack the ability to predict if bear populations will be maintained in the area. Thus, while this option may result in an increase in moose numbers its many disadvantages weigh against its acceptance.

Option 2

Figures 3 and 4 provide a summary of this option and are useful in following the accompanying text description. We propose a five year study, commencing 1985, of the effects of predator reduction on the growth rate of moose in southern Yukon. This program will include an assessment of changes in predator populations and other ungulate populations. We propose that a multi-block predator prescription design be adopted, employing Government field programs to reduce grizzly bear and wolf numbers with liberalization of predator hunting and trapping regulations. This proposal will test the effect of removing different combinations of predators on moose numbers through the use of different predator prescription blocks, and allows the choice of either the spatial option (reduction of

FIG. 3. Flow chart of options for moose/predator management program, southern Yukon.

- -



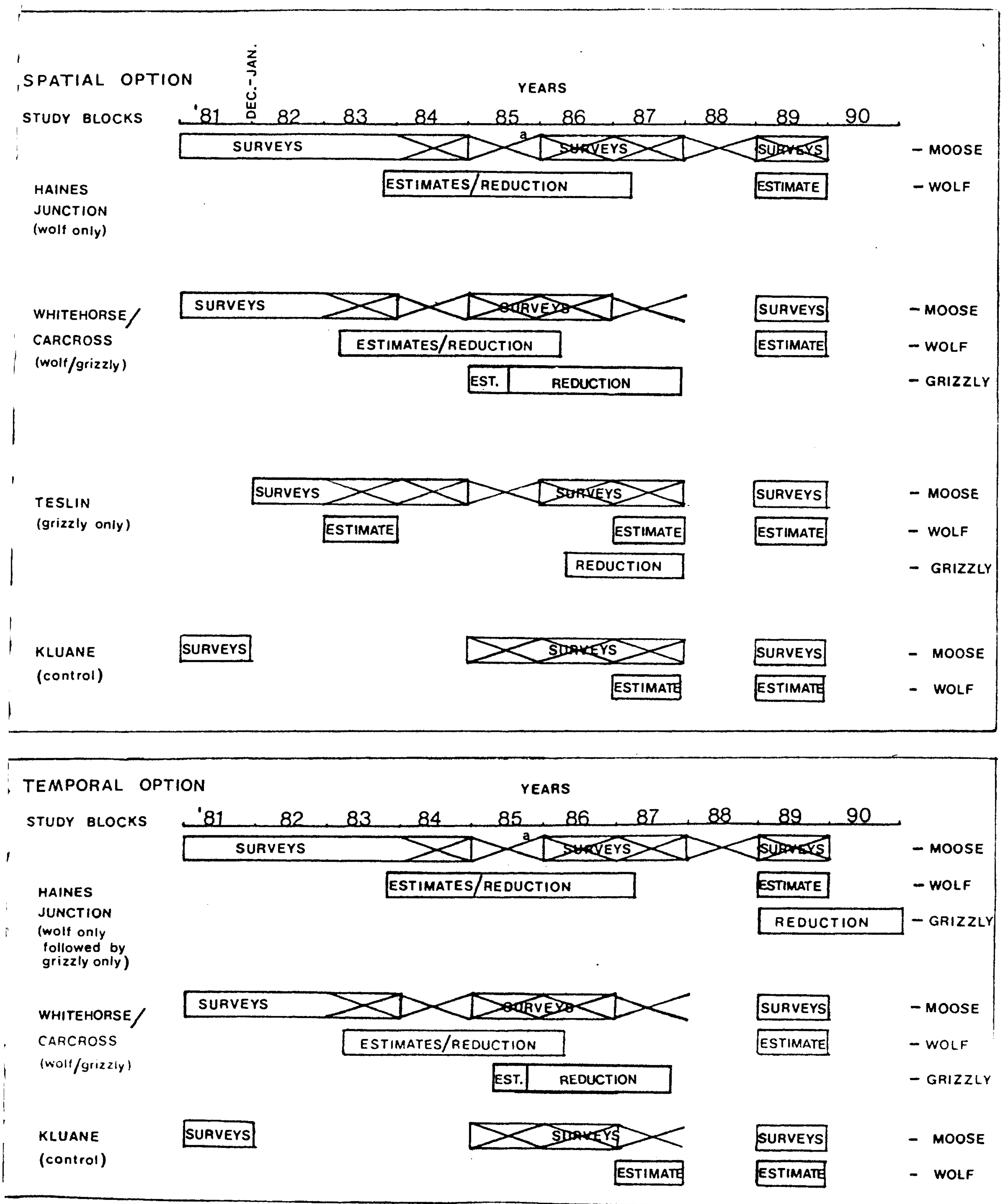
Given that moose numbers increase as a result of the predator reduction program:

Sociological Concerns: What is the optimum number of moose?
What is the demand for moose?

Biological Concerns: What is the carrying capacity?
1)Increase moose numbers beyond carrying capacity threshold level
2) Increase moose numbers incrementally until demand is satisfied
3) Conduct a carrying capacity study once regulation of moose by predators has been documented

Policy Management Considerations

FIG. 4. Scheduling for moose/predator management program according to spatial and temporal options.



a   = either calf &/or adult mortality study bears/wolves, bears-only, wolves-only and no reduction in spatially separated geographic areas over the same time period), or the temporal option (test the effect of removing different combinations of predators in the same geographic area over time). It also allows the option of whether or not to estimate bear numbers.

If the research findings summarized previously are correct, we predict that reduction of both grizzly bears and wolves should result in the greatest rate of increase in annual calf survival and of moose numbers, followed by the grizzly bear-only reduction block and then the wolf-only reduction block.

(1) Grizzly/Wolf reduction block (Whitehorse/Carcross)

Regardless of whether the spatial or temporal study design is chosen, the prescription in this block remains the same. We have crudely estimated from literature sources a bear density of 1 bear/50 sq.km. or 141 bears within this block. We have the option of whether or not to attempt a more accurate estimate. If we elect to estimate bear numbers, we have two possible techniques, outlined in Section 6, previously. We believe that potentially the best short-term method is a mark-recapture estimate. We suggest that subsequent to denning (Spring 1985), the Whitehorse block be searched for grizzly bears and all adult bears encountered be equipped with radio-collars. We propose collaring of moose calves during the calving period of 1985, monitoring of those collared calves and collaring of adult bears that prey upon those or any other observed calves (we note that 30 separate bears were observed consuming moose calves in 1983). Since we know bears prey significantly on collared calves, daily monitoring of calves should result in locating bears. We further propose that the type of prey taken by collared bears and the rate of kill be monitored on a twice-daily basis for three one-week periods (post-denning, calving, post-calving). The collaring of bears allows the opportunity to monitor the rate of kill of prey by bears, selection of prey of those bears over time, and the age/sex of bears preying upon moose. We recognise that the act of collaring and intensively monitoring bears may change their rate of predation on neonates, however, we have no adequate test of this relationship (see Section 2 below).

During the calving period, we would census bears using mark-recapture ratios for population estimation. We recognize the inherent difficulties regarding visual location of bears in both the collaring and censusing operations such that any estimate of numbers may be unreliable due to unacceptable confidence limits around the estimate. We will accept confidence limits of no greater than 20% around the estimate. Confidence limits greater than 20% are unacceptable for our use in relating possible prey increases to levels of predator reduction and in applying results to other regions. We have made a crude estimate based on literature sources of 141 grizzly bears in the Whitehorse block. We recommend that no less than 28 bears (20% of the crude estimate) be equipped with radio collars as a marked sample for use in the mark-recapture estimate.

If a reliable estimate of bear numbers is obtained (as defined above) , we will relocate bears from the Whitehorse block in 1986, prior to moose calving. The question remains as to how many bears to remove. We have suggested a goal of 50% of the bear population. If we only removed those collared bears that had been captured at moose calf sites the previous year, we suspect this would account for only 11-27% of the total estimated bear population in the Whitehorse block. This is based on the number of bears seen at collared calf kills in 1983 (n=30) and crude estimates of bear numbers based on densities established from northern studies (range=1 bear/26 sq.km. to 1 bear/65 sq.km.). Based on an estimate of 1 bear/50 sq.km., there may be 141 bears in the Whitehorse block. Removal of 50% of that number would necessitate a reduction of 70 bears in the Whitehorse (n=60) and Carcross (n=10) blocks.

If a substantial number of bears are removed (judged as 50% of the 1985 bear estimate) prior to calving 1986, then a Fall 1986 moose census in the Whitehorse block will be done. If, however, it is necessary to continue to relocate bears to achieve the 50% target through the 1986 calving period, then a Fall moose census would not be done until 1987. If the results of the moose census in either 1986 or 1987 show a significant increase in moose calf survivorship when compared to the results of previous years, and surveys in the non-reduction block (see Section 4 below) reveal no significant changes in moose calf survivorship, then we will conclude that reduction of predators influenced moose calf survivorship. If no significant increase in moose calf survivorship is found and surveys in the non-reduction area reveal no significant changes in moose calf survivorship, then it is possible that reduction of predators did not significantly influence moose calf survivorship. We would then recommend a re-evaluation of the policy of bear reduction as a technique to increase moose numbers. However, lack of significant change in numbers does not necessarily indicate lack of influence by bears. Possible explanations may be that insufficient numbers of bears were removed, ingress of bears from surrounding areas and compensation among grizzly bears, or by wolves and(or) black bears.

If we are unsuccessful in removing 50% of the estimated bear population in 1986, no moose census will be conducted in that year. Additional bears will be removed in 1987. If the target goal is reached, a Fall moose census will be conducted in 1987. If, however, we fail to reach the target goal in this second attempt, we recommend a re-evaluation of techniques and the policy of bear removal.

If we obtain an unreliable estimate of bear numbers in 1985, we have the option of not attempting any further estimate of bear numbers. The alternatives available under that option will be discussed later. First, we will consider the option of repeating the bear collaring and census operations first begun in 1985. We could collar bears in Spring 1986 and conduct a bear census prior to the calving period. We could also continue collaring bears in during calving and conduct a bear census in that period. If a reliable estimate were obtained, we would relocate bears in 1986, although we would not conduct a Fall moose census until 1987 (assuming the 50% reduction goal for bears had been achieved). Our interpretation of the results of that Fall census would follow the description given earlier. It is possible that we could obtain an unreliable estimate again in 1986. If this occurs, we recommend that no further bear estimates be attempted. At this point, we would be in relatively the same position as if we had never attempted a bear estimate, or if we had decided after an unsuccessful bear estimate in 1985 to discontinue further attempts at obtaining bear numbers.

We have the option of not attempting to estimate bear numbers in 1985 or subsequently, and have outlined some of the problems associated with this alternative. The concern exists that bears may be eradicated in the bear-reduction blocks. We have given reasons as to why this is unlikely. Even in the unlikely event that bears were eradicated, reduction blocks are small enough to suggest that they may be repopulated from surrounding grizzly bear populations.

In the event that the decision not to estimate bear numbers is taken, we suggest two alternatives. The first is that bears be removed in the post-denning period and again in the moose calving period. If the results of a Fall 1985 census show a significant change in moose calf survivorship, with no significant change in calf survivorship in the non-reduction area, then we will conclude that reduction of predators influenced calf survivorship. If the Fall 1985 census reveals no significant change in calf survivorship, then we recommend further reduction of bears in Spring 1986 and calving 1986, and a Fall 1986 moose census. We have stated what our conclusion will be in the event that calf survivorship significantly increases. If it does not, then we recommend a calf mortality study in calving 1987 with no further reduction of bears until the results of that study are reviewed.

The second option in the event that bear numbers are not estimated, is that, rather than simply removing bears, grizzly bears be radio-collared in Spring 1985. The movements of these bears should be monitored and any other bears they associate with would also be radio-collared. This approach would be taken due to uncertainty over our ability to remove sufficient bears in a short time period, that is, accumulate a sufficient number of bears which can be removed when desired. If sufficient numbers of bears have been collared then reduction can proceed. If, however, it is judged that there are insufficient numbers of collared bears, we would collar bears preying on collared calves in Summer 1985 and again after denning in 1986. If a sufficient number of bears are collared, bear reduction would take place in 1986. If it is felt that insufficient numbers of bears have been collared, then collaring would continue through calving of 1986 and into 1987. Even though we have the option of not attempting a bear estimate, it is our strong and unanimous recommendation that an estimate be attempted. If we are successful in estimating bear numbers we will monitor trends in bear numbers and composition in the post-reduction period.

The discussion to this point has dealt primarily with bears. We have proposed that wolves also be reduced in this block. Seventy percent reduction of wolf numbers has been achieved in the Whitehorse/Carcross block. At the time that both wolf and bear reduction goals have been achieved, reduction efforts will stop, and the post-reduction phase of the study will commence for both wolves and bears. We have outlined the hypotheses to be tested on wolves in the previous section.

(2) Bear-only reduction block (Teslin)

The purpose of bear-only reduction is to test the effect of reduction of only that species in affecting moose calf survivorship relative to the other predator-prescription blocks. The Teslin block also provides the opportunity to determine if wolves consume additional moose that would otherwise have died due to bear predation. Relative to reduction of bears, the same options apply as have been previously described. What ever options are chosen relative to bear reduction, they must be identical in both the Teslin and Whitehorse blocks.

We mentioned in the previous section our lack of ability to test the effects of capturing bears on their subsequent predation behaviour. This test cannot be conducted due to the lack of funding to conduct a study of the causes of moose calf mortality in Teslin in 1985 to compare with that done in the Whitehorse block. No collaring or census of bears will be conducted in Teslin in 1985. If an acceptable estimate of bear densities is obtained from the Whitehorse block, we propose applying that estimate to the Teslin block, and relocating 50% of Teslin bears in either 1986 or 1987.

(3) Wolf-only reduction block (Haines Junction)

The purpose of the wolf-only reduction block is similar to that described for bears in Teslin. Removal rates of 70% of estimated numbers maintained over a three year period have been set as the goal for this block.

If the spatial option is chosen, wolf-only reduction will be conducted in this block. Tests of hypotheses regarding wolves in the post-reduction phase will be similar to those described earlier in point (7) of the previous section. If, however, the temporal option is chosen, we propose a post-reduction period after wolf removal of only two years in which no reductions are carried out, to be followed by a reduction of grizzly bears, using methods described earlier for the Whitehorse block.

(4) Non-reduction block (Kluane)

The purpose of the non-reduction block is to provide evidence of moose population characteristics in an area undisturbed by predator reduction. Although we have inferred from research findings that such factors as forage, disease/parasites, reproductive rates/sex ratios, ingress/egress and human harvest are likely not the main factors acting to limit moose population growth, they may change over time in such a way as to increase their effect on moose numbers. Changes in those factors concurrent with predator reduction would confound interpretation of results. The non-reduction block allows some measure of changes in those factors which can be evaluated against results obtained from predator reduction blocks.

We recognize the necessity of having a substantially large geographic area somewhat removed from the predator reduction blocks. Moose numbers and population parameters such as calf-cow ratios, productivity, twinning rates and calf survivorship will be monitored prior to, during and after predator reduction in the predator-prescription blocks. A moose calf mortality study should also be conducted in the non-reduction block. Wolf numbers will be estimated; bear numbers will not due to funding constraints.

We are concerned that predator reduction in adjoining reduction blocks does not affect predation on moose in the non-reduction block. Unfortunately, we have no effective means of testing this potential.

In addition to this non-reduction block as a 'control', we have the ability in this study design to compare results before and after reduction in a block, as well as a comparison among the different prescription blocks.

The proximity of Kluane National Park, its status as an undisturbed predator-prey complex and the years of accumulated data on moose numbers provides the opportunity to use the Park as a check on the Kluane block data and as a comparison with data from the prescription blocks.

(5) Fate of translocated bears

Bears are to be relocated a distance of 480-650 km. (300-400 mi.) from the study area. We propose that 20 bears be equipped with radio-collars and their movements and fate subsequent to the relocation monitored by weekly survey flights until denning. The frequencies of the 20 collared bears will also be monitored by field staff within the study area to determine if any of these bears return.

(6) Additional prey species

We have identified the need to monitor the reponse of sheep and caribou populations to predator reduction, and changes in wolf food habits with reduced wolf numbers. Reduction of wolf numbers to 70% of pre-removal levels will be achieved in 1985. Sheep censuses will be conducted in Kluane (no wolf or bear reduction) and in Whitehorse (wolf-bear reduction) blocks in July of the year following successful achievement of the 50% bear reduction goal. Fall caribou censuses wilI be conducted in the same year as the sheep censuses. Comparisons for both caribou and sheep data will be made between data collected before and after the predator reduction in each of the blocks specified as well as between the control and treatment blocks.

MANAGEMENT IMPLICATIONS

Assuming that moose numbers show a positive increase due to predator reduction, the concern exists as to the utilization of those increased numbers, that is, can we set a goal for the optimum number of moose in a given area? Currently, moose densities range between 1.8 to 2.6

moose/sq.km. (0.5 to 1.0 moose/sq.mi.). These densities are perceived to be too low by users. We suspect from preliminary range assessment and the condition of animals that the study areas can support higher numbers of moose. Without detailed assessment of range carrying capacity, however, it is unrealistic to propose an optimum moose density. Furthermore, we cannot rely on user recommendations of optimum moose density. At least three options are available - (1) continue to increase moose numbers until they reach a forage limitation threshold with the clear danger of large-scale losses in numbers due to starvation, or numbers reach some other limiting factor below a forage limit, (2) increase moose numbers incrementally until demand by users is satisfied, assuming that such fine-tuning is within the control of managers', or (3) conduct a study of nutritional carrying capacity of the range to allow recommendations on the number of moose the range may support. Regardless of the chosen option, management prescriptions for optimum moose densities or numbers are based on values additional to biological considerations. A study to assess the ability of range to sustain moose can be conducted to provide direction on the maximum densities possible but cannot answer the question as to what densities are appropriate to meet societal needs.

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