SPREADSHEET MODELS FOR THE BEVERLY AND KAMINURIAK HERDS, NWT

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ABSTRACT

A spreadsheet model for the Beverly and Kaminuriak barren-ground caribou herds was prepared in order to determine whether or not there was a harvestable surplus beyond current domestic use which could be used commercially. This evaluation involved using the model with several caribou population experts at a modeling workshop in November 1985 in Edmonton, plus further modeling and analysis later in Yellowknife. The model's main assumptions are that hunting and natural mortality are totally additive, that immigration is equal to emigration, that no parameters are density-dependent and that calf survival and adult mortality rates are constant within each simulation trial of ten years. In order to do our best to relate the model to our actual field data-gathering techniques, we linked all of the mortality parameters through two formulae which relate directly to ratios we collect in the field. Based on conservative survival and reproductive estimates, we concluded from the model's predictions that both herds may be used beyond what is currently being harvested.

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INTRODUCTION

A population model was prepared to determine whether or not there was a harvestable surplus of barren-ground caribou (*Rangifer tarandus groenlandicus*) for commercial (non-domestic) use from the Beverly and Kaminuriak herds. This question originated with the Beverly/Kaminuriak Caribou Management Board in April 1985 because they had been asked to provide their recommendations regarding several requests which had been received by the Government of the Northwest Territories for commercial quotas on these two herds. This report covers a modeling workshop held in Edmonton on November 18, 1985 as well some further modeling and analysis which took place later in Yellowknife.

METHODS

This caribou population model uses the Financial Spreadsheet portion of the Appleworks Software Program. It will operate on any Apple IIe or IIc. Copies of the actual model diskette are available upon request from the senior author.

The flow chart (Figure 1) presents the sequence of calculations which occur over a simulated one year period. The model is projected over a ten year period. We begin with an initial population size of adults at mid-June, subtract natural mortality, subtract hunting mortality, and add the recruitment of new adults the next spring. The resulting value is used as the initial population size for the next year.

Assumptions

There are several important assumptions upon which this model is based:

1. Hunting mortality and natural mortality are considered totally additive at all population levels. This means that the rate of hunting will not affect the rate of natural deaths, and/or vice versa.

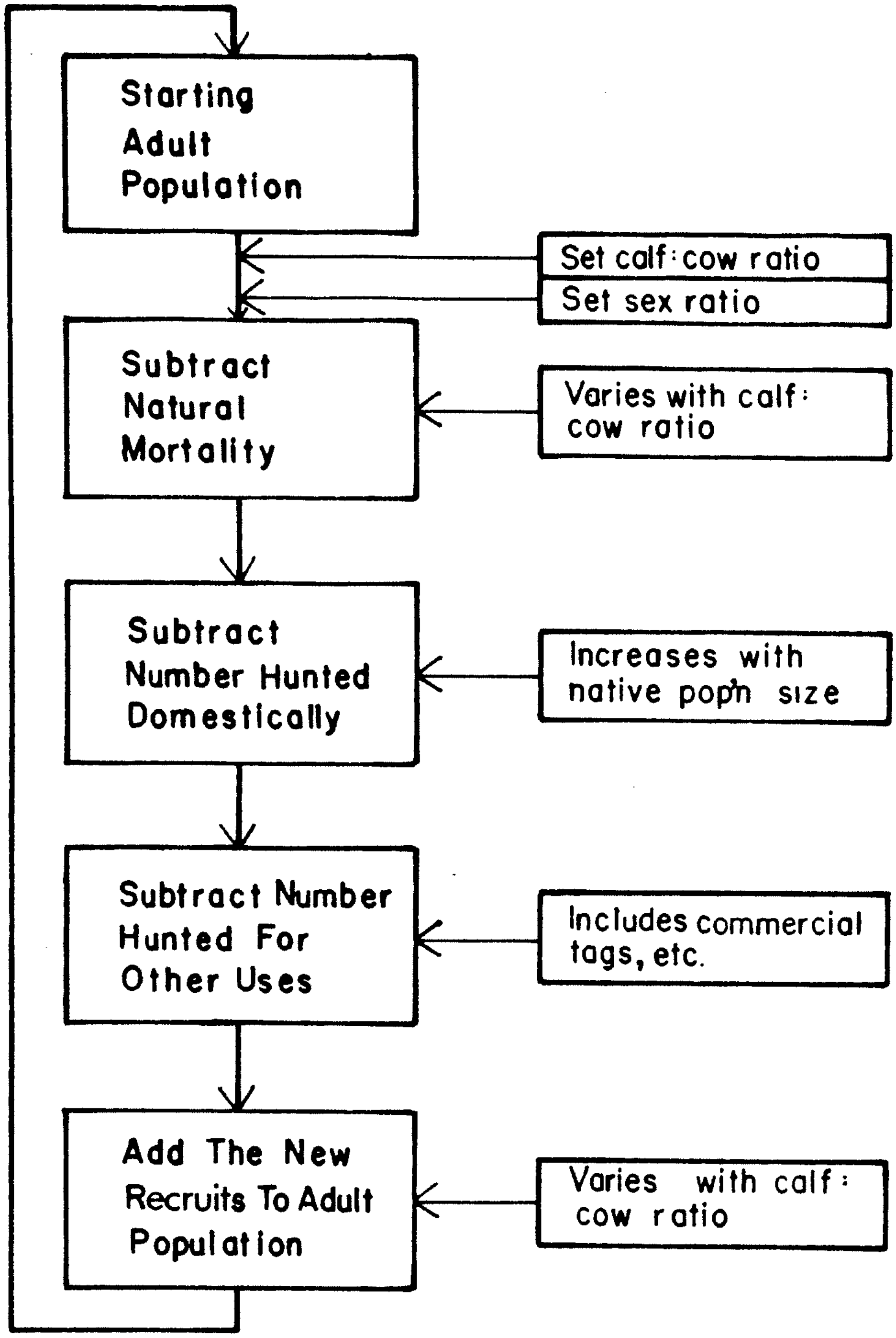

Figure 1. The sequence of calculations in any simulated year in the caribou model.

2. Immigration is equal to emigration. This assumption is more important to note with this model than with many others in view of the major movements of calving caribou between herds which apparently occurred within the last ten years (Heard and Calef 1986). We assume that such movements will not occur during the next ten years for these two populations.

3. Birth rates, natural mortality rates and hunting mortality rates are not density-dependent. There are insufficient data available to allow this factor to be incorporated into this model with any confidence.

4. Hunting mortality figures are associated with the correct herd. It is sometimes impossible to designate animals taken in the northern Keewatin or around the East Arm of Great Slave Lake to the correct herd.

5. Wolves are the major cause of natural mortality for all age classes of caribou.

6. Calf survival and adult mortality rates are constant within each simulation trial of ten years.

Definitions, Equations and Rates

Additional definitions and explanations are required for certain items only. These details are presented in the order they appear in the model, using the column letters found in the Spreadsheet and in Appendix A:

B. Calf:cow ratios in the spring - We used 30:100 which is the midpoint for the last eight years. This ratio is conservative as the most recent data suggest values near 40:100. Cows are all females one year of age or older.

C. Starting population - This is the number of animals one year of age or older on June 1. The only animals not included are the newly born calves. We used the photo estimates for the initial population size; 320,000 for the Kaminuriak herd and 335,000 for the Beverly herd.

D. Sex ratio - This is recorded as the percentage of females in the adult population. We used 55% for the Kaminuriak herd (Heard and Calef 1986) and 62% for the Beverly herd (A. Gunn pers. comm.). These values are from data presented by the workshop participants.

H. Percentage of one year olds - We have used a relationship which links how we collect the data as a calf:cow ratio (the number of calves for every 100 cows) in March to the survival of those same calves to one year olds in June of that same year. This relationship is based on a regression of the following data which were presented at the workshop: that is, calf:cow ratios of 20, 30, and 41 should represent 10, 14 and 18 percent one year olds, in the entire population, respectively (based on 55-60% cows in the adult population). The regression formula is $y = 0.38x + 2.44$, where y = percent one year olds and x = calves:100 cows. This formula merely allows us to vary the calf:cow ratios between 20 and 41 without having to change the percentage of one year olds also. We do in fact, vary the ratio from 15 to 45:100 cows, somewhat beyond the bounds of our initial interpretation.

I. Adult natural mortality - This was calculated using Bergerud's formula of 13.8 - [calf recruitment (% one year olds) * 0.3865] (Bergerud 1983). Using a percentage of one year olds of 14% would provide us with a natural mortality rate of 13.8 - (14 * 0.3865) = 8.4% for both sexes.

K. Number of adult females dying - This was determined to be 45% of all the caribou which died from both hunting and natural causes. We had no data to back up or dispute this factor, but used the simulations to determine that 45% was necessary to keep the original sex ratio in place.

M. Number hunted - This is the estimated kill provided by the various participants. We have multiplied the original hunting estimates by 1.25 to provide for wounding losses. The hunting totals included 6% calves. The total number of caribou lost due to hunting will increase over time at 3.5%, the same rate at which the human population is currently increasing in northern communities (Hamelin 1979).

Q,R,S. Non-domestic harvest - This is the number of caribou harvested for other than domestic reasons such as commercial use, trophy hunting, resident hunting, etc. These non-domestic uses would require a tag. Within the model we have multiplied the number of tags issued by 1.25 to provide for wounding losses.

W. Number of female recruits - This is the number of female calves (one-half of all calves) which survived the first year (0.5 * starting calf:cow ratio * number of cows at May 31).

Full details of the model are found in Appendix A.

RESULTS

Kaminuriak Herd

For the simulations of the Kaminuriak herd we used the 1985 photographic estimate of 320,000 for the starting population size (Heard and Calef 1986). Initially we kept the domestic harvest at about 6,600 animals and varied the calf:cow ratios to examine the effects of changing natural mortality rates (Figure 2). The population stabilizes at approximately 24 calves:100 cows, well below what we find in the field. The current ratios we are finding are about 41:100, which result in a continuing increase in the population to 1,001,000 in 10 years. In the opinion of the people at the workshop, a ratio of 30:100 is probably a more realistic average over the next several years, but this still results in a population of 496,000 by 1995. When we simulated the worst rates that we have found, a four year average of 20:100, the population declines to 241,000 in 10 years.

Our next simulations involved changing the number of animals harvested - both for domestic and non-domestic purposes. Non-domestic purposes would require special tags before the caribou could be hunted. In the previous simulations we increased the domestic harvest at the same rate that it has been projected the native population itself will increase over the next decade i.e., at 3.5% per year. Additionally, we multiplied the number of harvested animals (domestic and non-domestic) by the 1.25 to

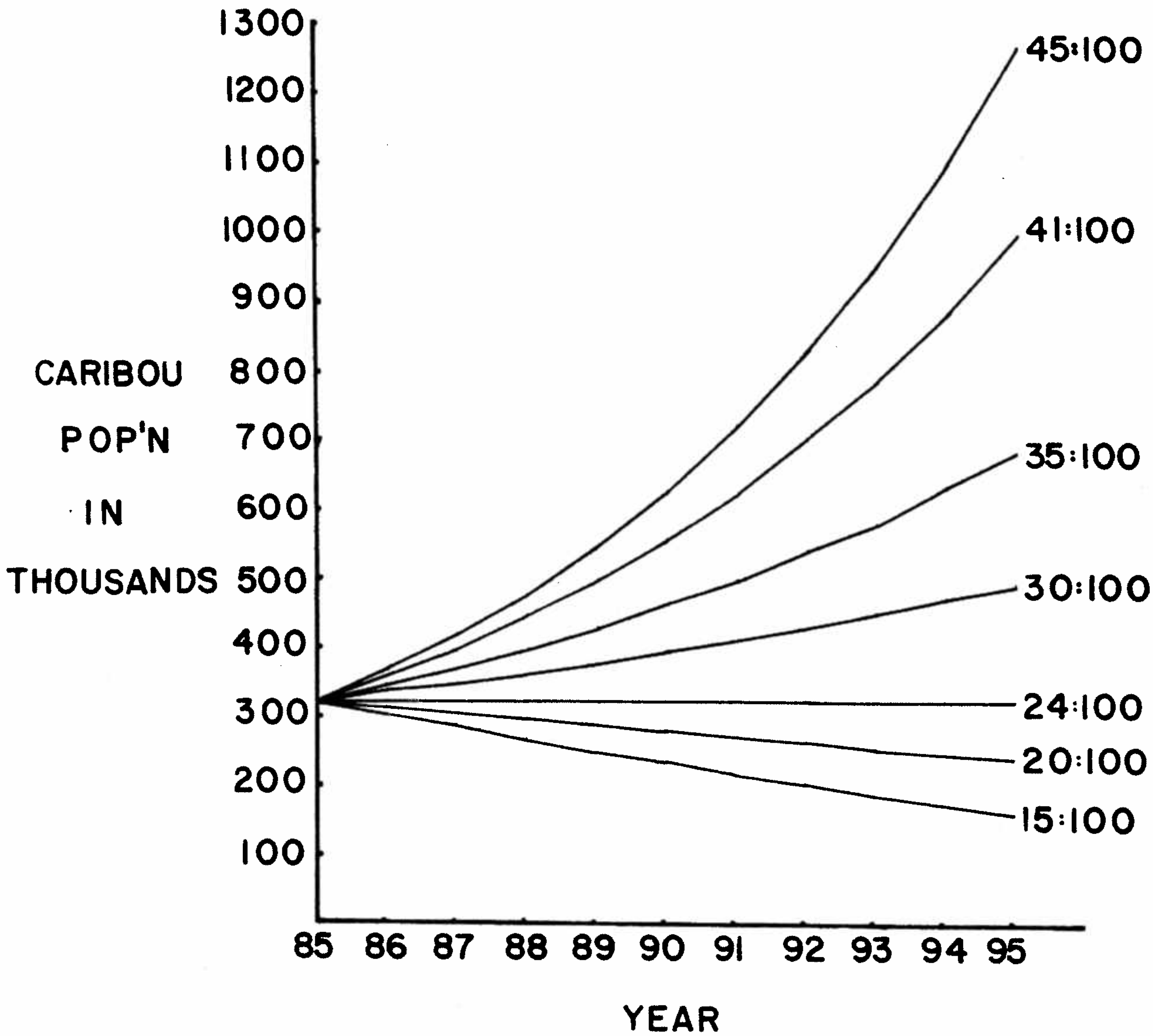

Figure 2. The predictions of the Kaminuriak model with various calf:cow ratios. (The caribou population size was extremely sensitive to the calf:cow ratios i.e., the natural mortality rates. We are currently finding a ratio of 41:100.)

account for additional animals lost due to wounding and non-recovery. This does not take into account any wastage which may occur once the carcasses are brought back to the communities. The factor of 1.25 is based on many people's subjective guesses and still awaits the gathering of hard data before any other number can be considered. The calf:cow ratio was set at 30:100.

A starting domestic harvest of 15,000, as would be recorded in a harvest study, is actually considered in this model to be a harvest which increases from 19,000 to 26,000 after multiplying in the 1.25 wounding factor and the 3.5% increase in native population. In fact, it is with this starting domestic harvest of 15,000 that the caribou population remains stable over the ten years (Figure 3). The actual harvest of 6,600 occurring now, of course, results in the herd increasing to 496,000. A tripling of the current domestic harvest to 20,000 results in a decline to 225,000 by 1995.

A harvest for non-domestic purposes is multiplied by the 1.25 wounding factor but does not increase with the number of native people in this model. Any non-domestic harvest less than several thousand caribou per year will not appear on Figure 4 as the impact was insignificant and unmeasureable at the caribou population levels with which we are dealing. This is not to say that lower quotas are not important to individuals or communities, or that granting many smaller quotas and/or removing all flexibility for managers is not important - only that harvesting another 1-2,000 more caribou from a population of over

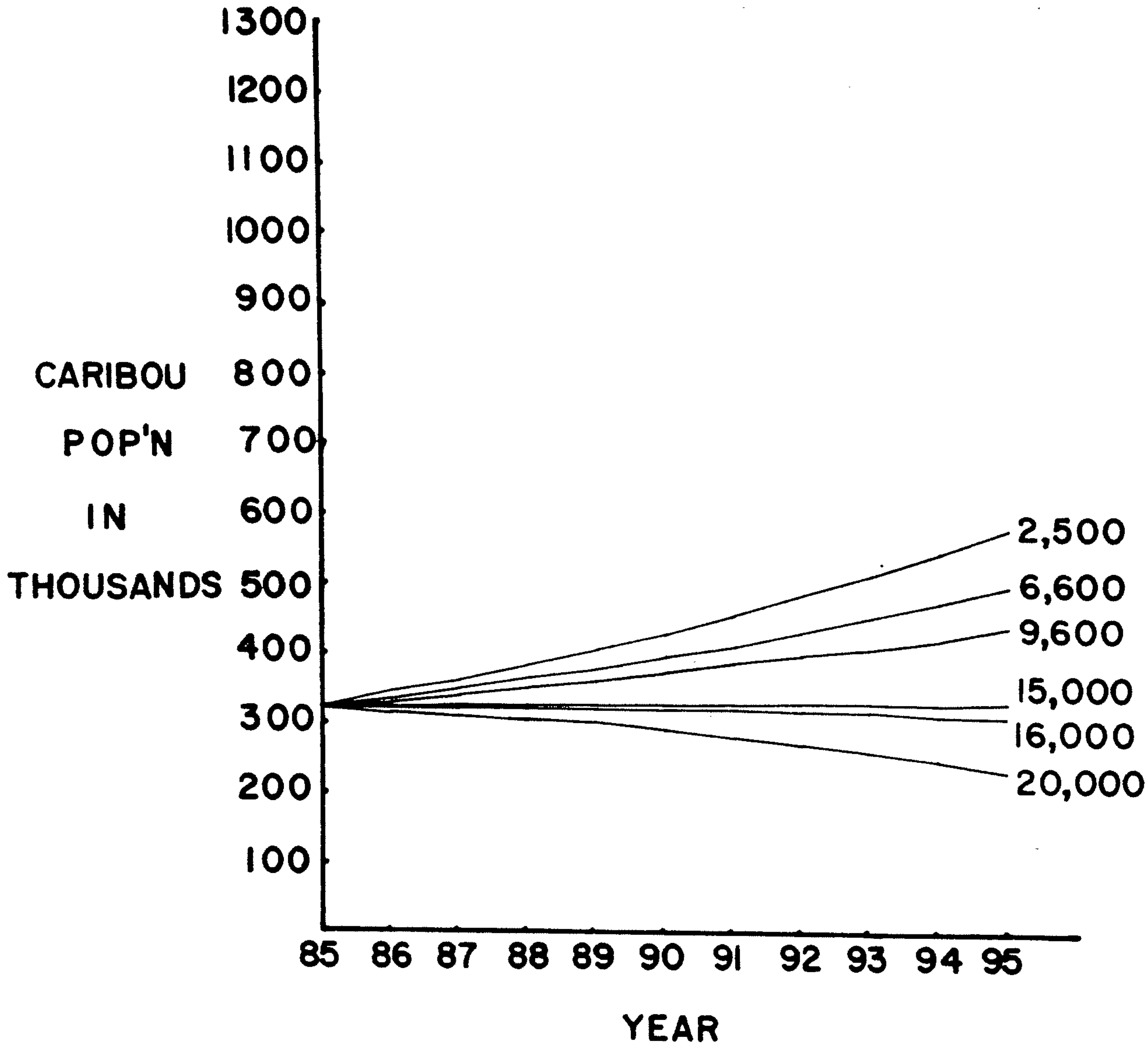

Figure 3. Simulated trends in the Kaminuriak herd under varying domestic harvest levels. (We estimate the current harvest to be approximately 6,600 animals.)

300,000 will have little impact on the caribou herd.

If we harvested both males and females on a non-domestic quota, the population continued to increase until we harvested close to 5,000 of each sex for a total harvest of 10,000 animals (Figure 4). If we harvested 10,000 males and no females then our population continued to increase to 432,000. If we increased the harvest to 20,000 males we still found an increase to 367,000 caribou but there were only 25,000 or 7% males remaining - a situation that would not allow for continued successful ruts to occur (in domestic reindeer breeding at least 10% males are considered necessary) and which would also lead one to believe that the 367,000 estimate may be somewhat unbelievable.

Beverly Herd

For the simulations of the Beverly herd we followed the same procedure as we did for the Kaminuriak. We used the 1984 photographic estimate of 335,000 for the starting population size (C. Gates pers. comm.). One other difference from the Kaminuriak herd is a sex ratio of 62% females (A. Gunn pers.comm.). Using our current best estimate of the domestic harvest of 8,200 animals, we were able to stabilize the population at a calf:cow ratio of 22:100, much less than the 41:100 we are currently finding (Figure 5). If there were no domestic harvest, the population stabilized at a ratio of 17:100. Using the current

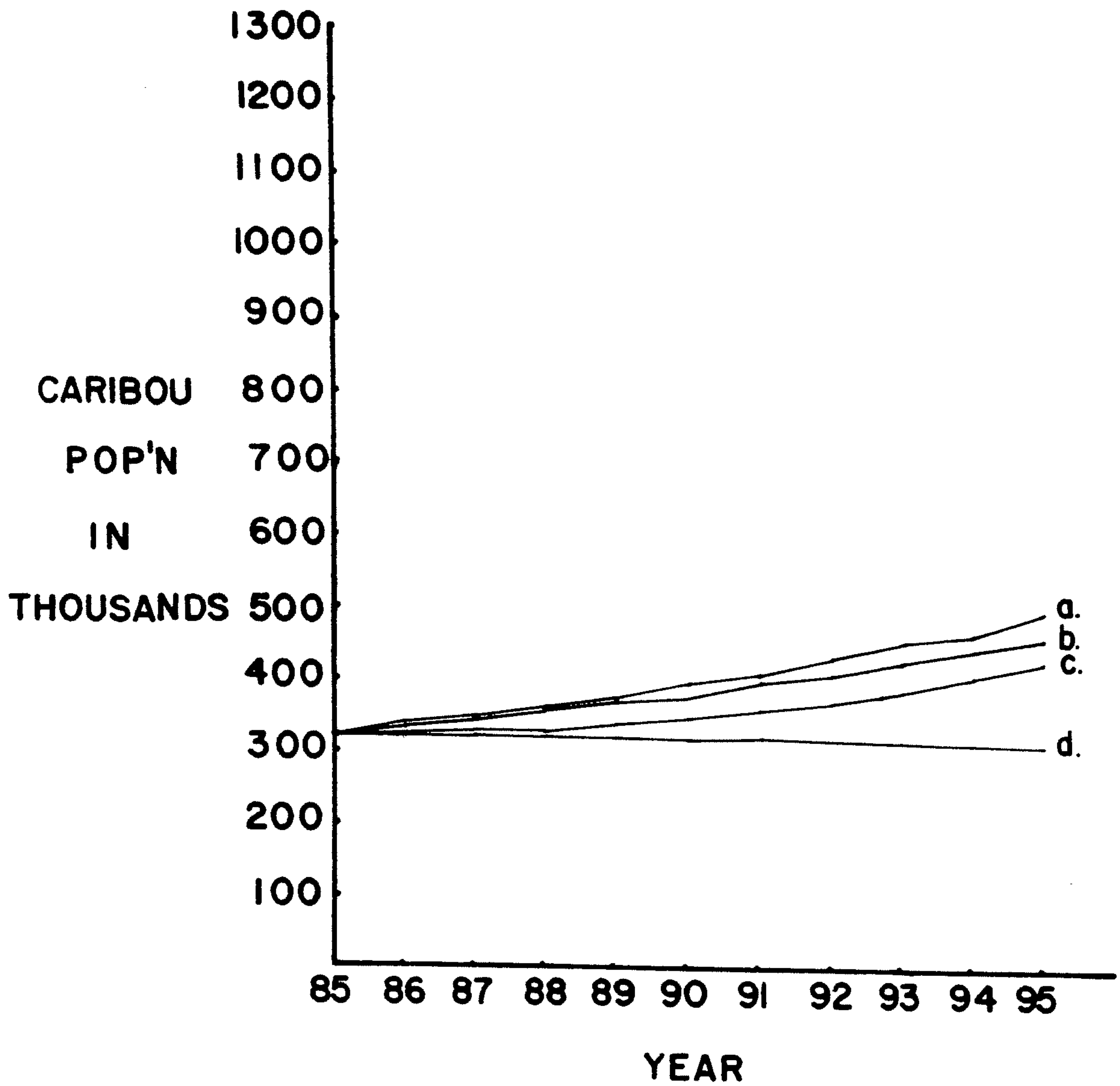

Figure 4. Simulated trends in the Kaminuriak herd under varying non-domestic quotas. [(a) 0 males and 0 females, (b) 1,000 males and 1,000 females, (c) 10,000 males only, and (d) 5,000 males and 5,000 females.]

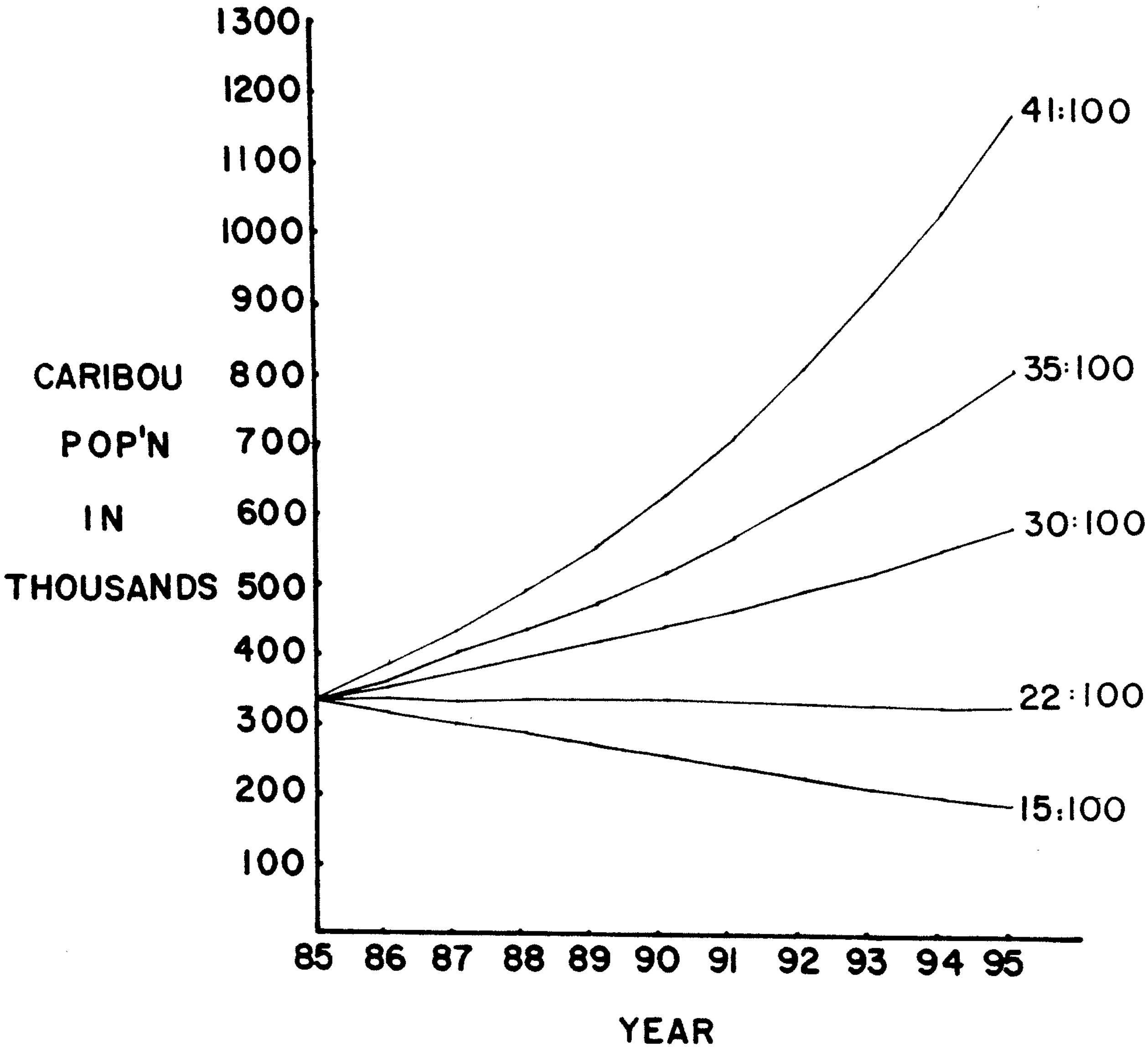

Figure 5. The predictions of the Beverly model with various calf:cow ratios. (We are currently finding a ratio of 41:100 for this herd as well.)

ratio of 41:100 and the current domestic harvest of 8,200, the population increases to 1,185,000 in 10 years. If we use the average ratio of 30:100 recommended in the workshop, then the population reaches 585,000 in the 10 years. Our lowest ratio of 15:100 results in a population of 180,000.

A domestic harvest of 20,000, more than twice the current harvest, results in a stable population over a 10 year period (Figure 6). Any lower harvest allows the population to increase. The sex ratio tends to change over time more quickly in this model, which suggests we may have overcompensated in our attempt to maintain the 62% female sex ratio by setting sex-specific natural and hunting mortality rates.

The model suggests a non-domestic harvest of 5,000 females and 5,000 males each year results in a population of 398,000 in 1995 (Figure 7). A harvest of 10,000 males for non-domestic reasons would result in a population of 520,000. Once again we would have to be careful of the sex ratio as only 144,000 of the 520,000 would be males (28%).

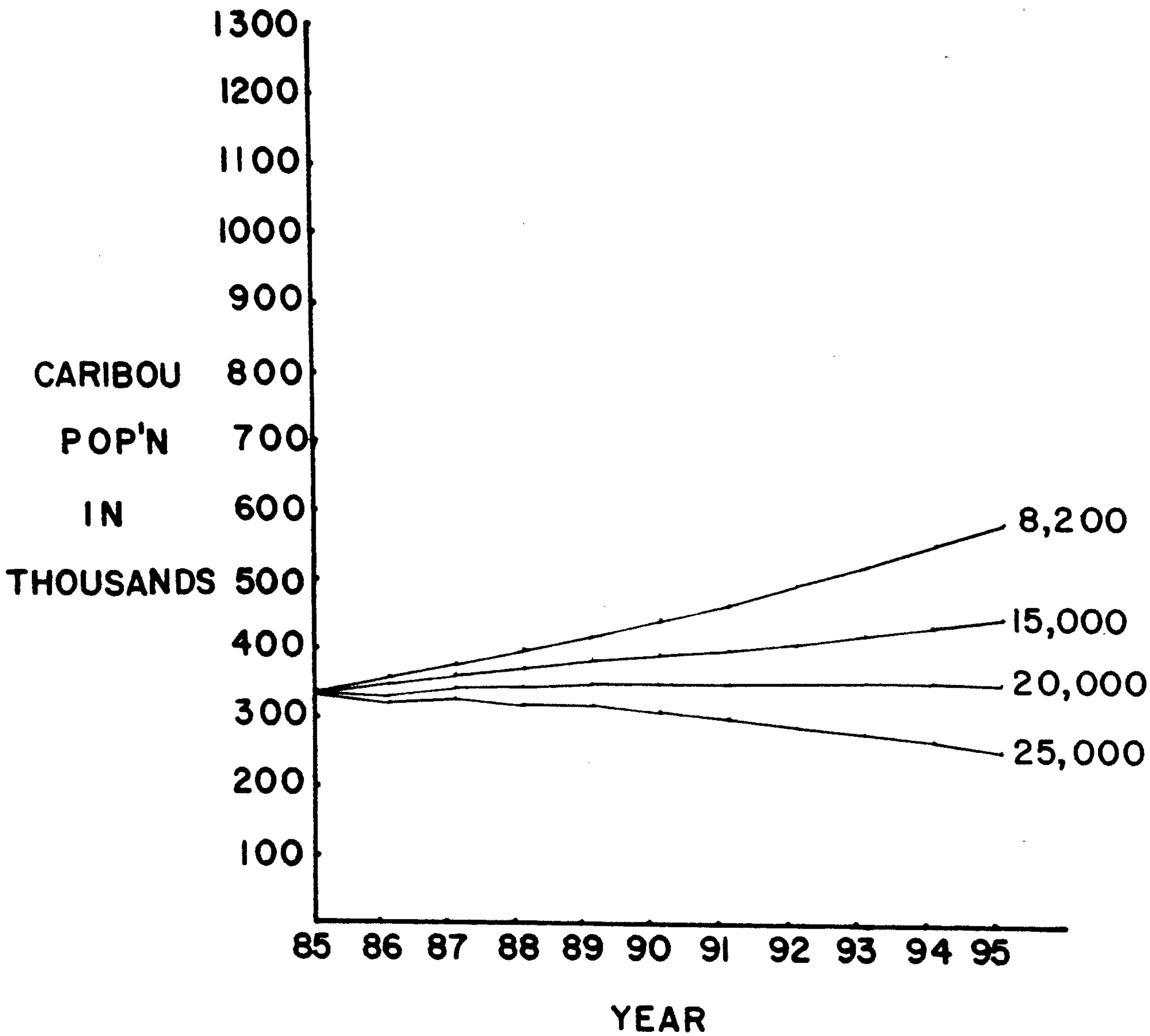

Figure 6. Simulated trends in the Beverly herd under varying domestic harvest levels. (We estimate the current harvest to be approximatley 8,200 animals.)

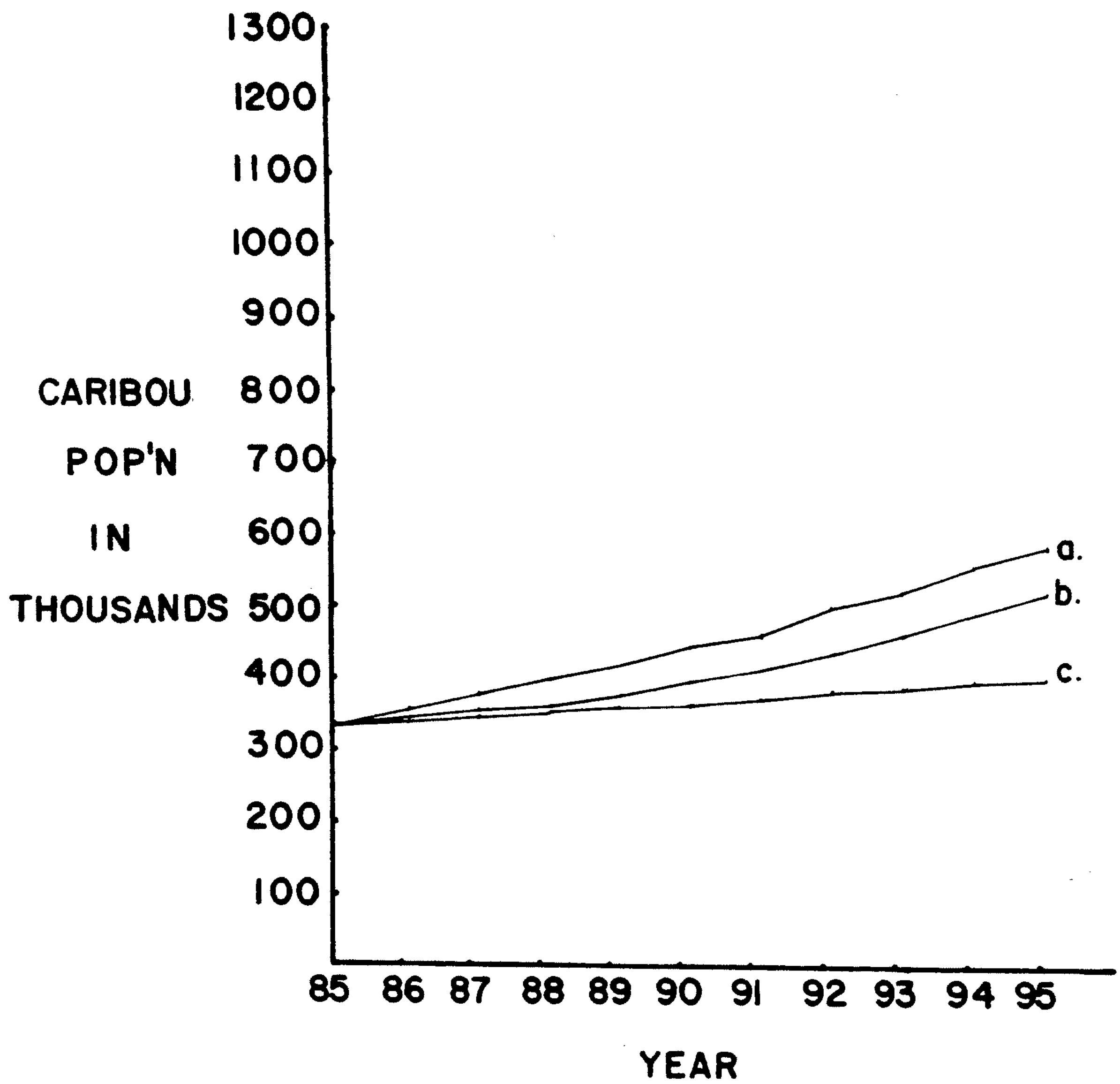

Figure 7. Simulated trends in the Beverly herd under varying non-domestic quotas. [(a) 0 males and 0 females, (b) 10,000 males only, and (c) 5,000 males and 5,000 females.]

DISCUSSION

The Model and its Assumptions

Our intent was to produce a simple model which would relate the ecology of the barren-ground caribou herds to the data we were gathering and which would allow us to consider the impacts of the wildlife management decisions which had to be made. The model was restricted to a 10 year term so that it could be closely linked to the management of the herds and their management plans. There are several assumptions of the model listed previously which require further comment. The third assumption which stated that birth rates, natural mortality rates and hunting mortality rates were not density-dependent received much discussion at the workshop. There was insufficient good data on barren-ground caribou for these rates over the various densities which were to be considered in order to include density-dependence in this model. In addition, one would not expect to see, at the population level, much of a density-dependent effect over the 10 year term of our simulations. Although we all agreed that there probably were density-dependent effects in play, we felt that without good data the model would be better served by assuming no impact.

The fifth assumption stated that wolves were the major cause of mortality for all age classes of caribou and the sixth assumption basically says that their impact is constant over the period of each simulation of ten years. The impact of wolf predation is reflected in the two formulae which link together the March calf:cow ratio, the June percentage of one year olds and the percentage adult mortality. Thus, although we did not set an exact natural mortality rate based on wolf predation, we did establish our model on the basis of data we actually collect in the field. We believe wolf predation will affect the natural adult mortality rate, the calf:cow ratio (which we collect in the field in March) and the percentage of one year olds (which we collect in the field in June). In this model we change the calf:cow ratio and see how this affects the herd over a ten year period. Through the relationships described in the equations in steps H and I, this automatically changes the percentage of calves which survive to one year of age and the adult mortality rate and then the model calculates the predicted population size, another parameter for which we collect field data. Currently, we collect calf:cow ratio data annually and data to estimate population size and percentage of one year olds every three years.

The Management Decision

The overall objective of the modeling exercise was to determine whether or not there was a harvestable surplus of caribou for commercial use from Kaminuriak and Beverly caribou populations. This objective was met. Our general conclusion is that expanded use of both herds is possible beyond what is currently being harvested. This conclusion holds even though we have simulated the populations using a calf:cow ratio of 30:100, 25% lower than that which we are currently finding. A total harvest as high as 15,000 for the Kaminuriak herd and 21,000 for the Beverly herd in 1987 could be considered. Coincidentally, these levels are extremely close to that which the users have indicated their current theoretical demands actually are, i.e., 3 caribou per person on the ranges, or 16,000 for the Kaminuriak herd and 21,000 for the Beverly herd. However, if normal hunting practices are followed, it is impossible for all users to have the opportunity to hunt sufficient caribou to reach the theoretical demand because of the caribou's annual movement patterns. In fact, during the 1984/85 season the average kill over both ranges was 1.1 caribou per individual (1985/86 Annual Report - Bev./Kam. Caribou Mgmt. Board). Only two communities averaged 3.0 or more caribou harvested per individual - Lac Brochet and Baker Lake. Therefore, one could consider other uses for the difference between the theoretical demand and the actual use - probably 5-8,000 caribou per year.

The model reveals certain characteristics about this population which would have to be monitored closely if managers decided to harvest at a rate close to the predicted sustainable yield at the present density and rate of increase. The characteristics to consider can basically be broken down into two sets. Firstly, the characteristics which will tell us that the assumptions listed earlier are still holding (hunting and natural mortality rates, immigration and emigration, birth rates, good hunter kill location data, and basic information on the relationship between caribou and wolves). Secondly, those characteristics or rates upon which this model is constructed and depends (calf:cow ratios and their linkage to natural mortality rates and percent one year olds, sex ratios). If managers decide that harvest rates should stay at their current levels then certain of our data gathering techniques should be refined, but major research program changes may not be necessary. Our major knowledge gaps are natural mortality information, and the reasons for, or possibility of, major shifts between calving areas (immigration/emigration).

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PERSONAL COMMUNICATIONS

C. Gates, Bison Biologist, Department of Renewable Resources, Government of the Northwest Territories, Fort Smith, NWT.

A. Gunn, Regional Biologist, Department of Renewable Resources, Government of the Northwest Territories, Coppermine, NWT.

LITERATURE CITED

Bergerud, A.T. 1983. The natural population control of caribou. pp. 14-61 in F.L. Bunnell, D.S. Eastman, and J.M. Peek, (eds.), Symposium on natural regulation of wildlife populations. March 1978, Vancouver, B.C. Publ. Univ.Idaho, Moscow, Idaho.Proc.#14.

Beverly/Kaminuriak Caribou Mgmt. Board. 1985/86. Annual Report.

Hamelin, L. 1979. Contribution to the Northwest Territories Population Studies 1961-1985. Science Advisory Board of the N.W.T. 54 pp.

Heard, D.C. and G.W. Calef. 1986. Population dynamics of the Kaminuriak caribou herd, 1968-1985. Rangifer Special Issue No. 1, 1986, pp. 159-166.

APPENDIX A. The Full Details of the Model

The capitalized letters on the left side are the letters used in the Spreadsheet. Calculations proceed from A through to AF and then begin again at A. "!" means that a full explantion of the equation has been presented in the body of the report.

A - year - starts at mid-June.

B! - calf:cow ratio - set at 30:100.

C! - total population of caribou one year of age and older - set initially and then changes with AB.

D! - starting sex ratio.

E - number of females in population = C * D/100.

F - number of males in population = C - E.

G - calculated sex ratio as it changes - 100 * E/C.

H! - percentage of one year olds = (0.381 * B) + 2.443.

I! - natural mortality annual percentage = 13.8 - (0.3865 * H).

J - number of caribou dying from natural mortality = I * C * 0.01.

K! - number of females dying from natural mortality = J * 0.45.

L - number of males dying from natural mortality = J - K.

M! - number of caribou hunted domestically.

N - percent hunted = 100 * M/C.

O - number of females hunted - 0.45 * M.

P - number of males hunted = M - O.

Q,R,S! - number of caribou hunted for a non-dometic purpose.

T - pre-recruitment population size in May = C - J - M - S.

U - number of females in the May population = E - K - O - Q.

V - number of males in the May population = F - L - P - R.

W! - number of female recruits = B * U * 0.5 * 0.01

X - number of male recruits = W.

Y - total number of recruits - W + X.

Z - actual percent one year olds = (Y/(Y + TO) * 100.

AA - just repeats H to compare rates.

AB - new population size at the end of May = T + Y.

AC - number of females in the end of May population = W + U..

AD - number of males in the end of May population = X + V.

AE - percent change in population = 100 * ((AB - C)/C).

AF - actual recruitment rate = Z/((100 - Z) * 100).