INTEGRATION OF MOOSE AERIAL SURVEY AND HUNTER HARVEST INFORMATION TO ESTABLISH FUTURE HARVESTS IN THE SOUTHWEST YUKON

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Abstract: Moose (Alces alces) population and harvest estimates were determined for Game Management Subzones (GMS) in the Southwest Yukon survey area from data described in Larsen (1982) and Kale (1982).

The harvestable surplus was determined by comparing the post-hunt 1981 population for each GMS to the expected pre-hunt 1982 population. An additional adult male harvest, called the allowable overharvest, was also calculated by allowing the harvest to decrease the adult bull:adult cow ratio to 30:100. Twenty computer simulation scenarios with varying fecundity and survival rates were considered prior to selecting optimistic parameter values.

Management conclusions were based on decision criteria that compare the allowable harvest and allowable overharvest to the average annual harvest and population level. When the criteria were applied to the 47 GMS in the Southwest Yukon survey area, 16 (34%) of the GMS can still support an unrestricted bulls only harvest, 23 of the GMS (47%) should have a permit regulated bulls only harvest, while the remaining 8 GMS (17%) should be closed to moose hunting entirely.

In recent years, the quality of the data base for moose management in the Yukon has greatly improved. Game Management Subzones (GMS) have been introduced along with an expanded hunter questionnaire program (Kale, 1982). Systematic aerial surveys have also been undertaken to accurately assess moose population levels in priority areas (Larsen, 1982). These improvements now permit population and harvest data to be integrated on small geographical areas that are sensitive to local changes in moose abundance and productivity and hunter access and success.

Yukon moose management objectives are consistent with the goal of the Yukon Department of Renewable Resources, "to manage game species to provide for their continued existence while allowing for harvest at maximum sustainable yield level", (Yukon Wildlife Branch). Implicit in this management objective is the concept that management policies must ensure that local moose populations either remain stable or increase. Since at the present time, the Yukon Government does not have land use management responsibility, the only management parameter it can manipulate, is hunting by licenced hunters. Therefore, to obtain the management goal of "maximum sustainable yield", the annual harvest must be carefully balanced with annual production and other forms of natural mortality.

This paper describes an analytical technique that can be used to integrate aerial survey data and harvest estimates for small management units. The procedure relies on a computer simulation model that projects population levels determined during aerial surveys to the next pre-hunt time period so that the harvestable surplus can be determined. Management conclusions are based on a decision-making framework that compares the harvestable surplus to historical harvest levels to determine the optional harvest strategy.

METHODS AND DISCUSSIONS

Estimation of GMS population levels

Although the 1981 moose aerial survey (Larsen 1982) was designed to produce population estimates for four study areas, the sample units (s.u. as per Gasaway et al: 1981) were also used to estimate population levels in all 47 GMS in the survey area. In most cases, s.u. boundaries were consistent with GMS boundaries and could be allocated to specific GMS. In rare situations, where s.u.'s overlapped GMS boundaries, a percentage of the s.u. area was assigned to each adjacent GMS.

Any moose that was observed in the regular survey was added to the appropriate GMS population, while estimates of moose in unsurveyed sample units were produced by multiplying the area of the sample unit by the average population density in that stratification level. The formula for a total GMS population was:

$$\text{EST. POP. GMS} = \sum_{j=1}^{4} \sum_{i=1}^{m(j)} \text{sampled pop. in s.u. } (j,i) + \sum_{j=1}^{4} \text{pop. den. } (j) \times \sum_{i=1}^{n(j)-m(j)} \text{area of unsampled s.u. } (j,i)$$

where est. pop. = estimated total population

s.u. (j,i) = the "i th" sample unit in stratum j,

j = stratum level (1=high, 2=medium, 3=low, 4=extremely low),

n(j) = total number of sampling units in stratum j,

m(j) = total number of sampling units in stratum j, and

pop. den.(j) = population density for stratum j.

Population density for each stratification level was calculated for each of the four survey units by:

$$\text{pop. den } (j) = \frac{\sum_{i=1}^{n(j)} \text{observed pop in s.u. } (j,i)}{\sum_{i=1}^{n(i)} \text{area of pop in s.u. } (j,i)}$$

Although these formulae only show total population estimates, similar formulae were used to calculate the number of moose by sex and age (male calves, yearling males, adult males, female calves, yearling females, and adult females) (Larsen, 1982).

Population Projection Computer Model

Since the 1981 aerial surveys were flown in October and November 1981, the above GMS estimates indicate the 1981 post-hunt population levels. From this starting point, the populations were projected to the pre-hunt 1982 time period using the following computer simulation algorithms (Figure 1):

1. Winter survivorship rates were applied to all age classes.
2. The spring calf crop was calculated from yearling and adult female fecundity rates.
3. The age of all age classes was incremented.
4. Summer survivorship rates were applied to all age classes.

Twenty scenarios were run to determine the sensitivity of model parameters. High, medium and low estimates of winter survivorship, female fecundity and summer survivorship were based on available and relevant data from other jurisdictions (Table 1).

In all except the extremely optimistic scenarios with high winter survival of adults and calves ($>$ .90), and relatively high summer survival of calves ($>$ .36), the 1982 pre-hunt GMS populations were at such levels that when the average annual harvests were added, the 1982 post-hunt populations would be lower than the 1981 post-hunt populations. This situation would have resulted in a decline in the herd. In most cases, the result could be attributed to the low number of surviving calves being unable

Fig.1

COMPUTER SIMULATION MODEL FOR CALCULATING HARVESTABLE SURPLUS

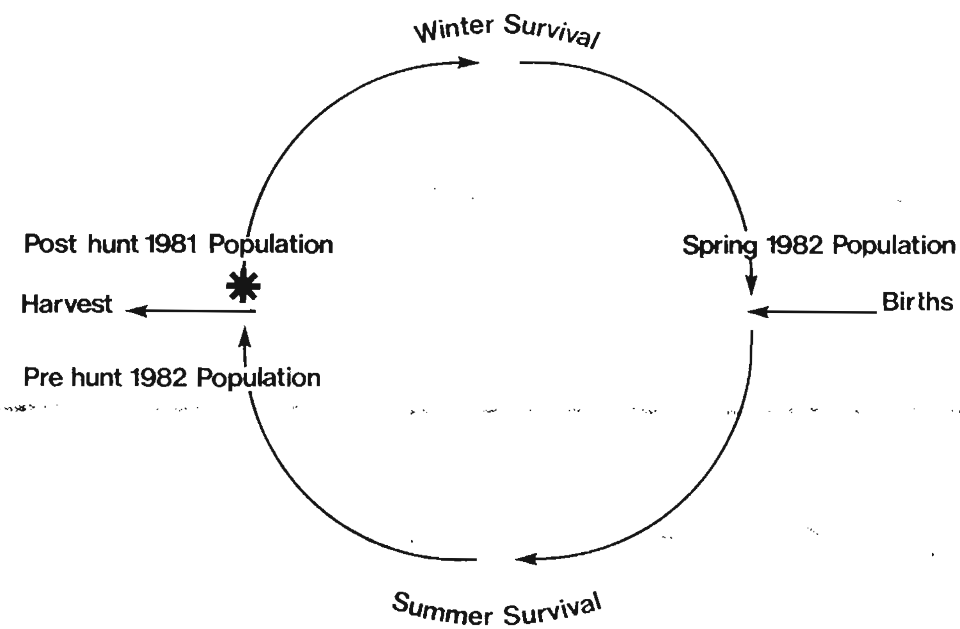

TABLE 1

Range of population projection parameters selected from other jurisdictions, for simulation sensitivity analysis.

Parameters	Range low	Range medium	Range high	Source low	Source medium	Source high
Female fecundity[a]						
24 months at parturition	0.00[b]	0.57	1.11	Edwards and Ritchey cited in Simkin (1974)	Mytton and Keith (1981)	Gasaway et al (1982)
36 months at parturition	0.80[b]	1.16	1.67	Edwards and Ritchey (.76) cited in Simkin (1974)	Gasaway et al (1982)	Mytton and Keith (1980)
Summer survival[c]						
calves	0.10	0.20	0.70	-	Rausch and Bratlie (.70-.20) (1967)	Rausch and Bratlie (.70-.20) (1967)
adults	0.95	-	1.0	-	-	-
Winter survival[d]						
calves	0.50	0.75	0.90	Peek (.39-.76) (1971)	Van Ballenberg (.78-.79) (1979)	-
adults	0.80	0.90	0.94	Mytton and Keith (.84) (1981)	-	Gasaway et al (.80-.94) (1982)

a. calves born per female.

b. pregnancy rate (number of conceptions)

c. from parturition to pre-hunt (August 1st)

d. from post-hunt (October 31st) to parturition

to replace the number of adults that died from non-hunting sources. This was consistent with the low calf:adult female (22:100) and low yearling:adult female (24:100) ratios observed during the 1981 aerial survey.

After the parameter sensitivity analysis, the following parameter values were selected as the basis for management conclusions:

winter survivorship of calves = .75

winter survivorship of yearlings and adults = .94

yearling female fecundity = 1.11

adult female fecundity = 1.67

summer survivorship of calves = .20

summer survivorship of yearlings and adults = 1.0

These parameter values were obtained from either optimistic or intermediate scenarios. They were chosen because any management conclusions based upon them would be the least restrictive to licenced hunting. If under these parameter values, hunting restrictions must be implemented, then, under all other "reasonable" scenarios, more restrictions would have to be applied.

The expected 1982 moose harvests for each GMS were calculated as the average harvest from 1979 and 1980 resident and non-resident harvests in each GMS. Resident harvests were estimated from questionnaires, while non-resident harvests were determined from outfitter declarations. The expected harvest was then subtracted from the harvestable surplus to determine the net population change under existing hunting regulations.

In addition, a second type of harvestable surplus was calculated by allowing the harvest to decrease the adult bull:adult cow ratio to 30:100. This statistic, called the allowable over-harvest, removed adult males from the population. We speculate that pregnancy rates for this population, which is highly clumped in distribution during the rutting period (Larsen 1982), would not be affected by this skewed sex ratio.

Yukon Moose Harvest Strategies

Until recently, hunter access to game resources in the Yukon has been very liberal. In most areas, both resident and non-resident hunters have enjoyed 3 months (August 1st - October 31st) moose season with either 2 weeks to 1 month antlerless seasons during the rut in September. As long as only crude harvest estimates were available and no population estimates existed, it was impossible to determine if these seasons were realistic or not. Now that better quality data are available, it is theoretically possible to tailor hunting regulations to local conditions.

At the present time, only four regulation states are legislatively possible and socially acceptable:

1. Open antlered and antlerless seasons. This is the prevailing

regulation state in most areas of the Yukon. Under this state, neither the number of hunters nor total harvest are regulated.

2. Open antlered seasons. This state has a 3-month antlered moose season, thereby protecting antlerless moose from being hunted. Under this state, an unrestricted number of hunters can harvest an unrestricted number of adult male moose.

3. Permit antlered moose seasons. This regulation state restricts the number of licenced hunters that can hunt in a GMS.

4. Closed seasons. This regulation state prohibits moose hunting in designated GMS.

The above regulation states were condensed into three categories (open, permit and closed seasons) because it was felt that, if hunting restrictions were necessary, antlerless moose hunting should be restricted first.

To maintain moose populations at existing levels and yet produce the maximum sustainable yield, decision-making criteria were developed to assign the optimum regulation state to each GMS. The criteria and their justification were:

1. If the GMS population was less than 10, then the GMS should be "closed". It was felt that moose populations at this extremely

low level should not be hunted.

2. If there was no allowable harvest and the allowable over-harvest was less than 4, then the GMS should be "closed". This criteria was designed to protect GMS populations that had no allowable harvest and very little allowable over-harvest. The significance of the allowable over-harvest limit equalling 4 is explained under criteria 3.

3. If the planned harvest (sum of the allowable harvest and one quarter of the allowable over-harvest) is less than the average annual harvest, then the GMS should be under a "permit system". This criteria compares animals available to be harvested with the harvest that would be expected under the "open" season regulation state. Since the available harvest is less than the "open" season harvest, the harvest must be limited by permits. The animals available for harvest are the allowable harvest plus some fraction of the allowable over-harvest. Since the allowable over-harvest is removing adult males from the population without replacement, the allowable over-harvest can be extracted only once. It was decided to "use up" the allowable harvest over a four year period.

4. If the planned harvest is greater than the average annual harvest, then the GMS should be "open". Since the available harvest exceeds the average harvest, "open" season hunting will not affect the population.

MANAGEMENT CONCLUSIONS

When the above decision-making criteria were applied to the 47 GMS in the southwestern Yukon survey area, 16 (34%) GMS can support "open season" hunting, 23 (47%) GMS should be under "permit hunting" and 8 (17%) GMS should be "closed to hunting" (Table 2 and Appendix A). It was estimated that the pre-hunt 1982 population in the survey area was about 2,700 moose of which approximately half of the animals would be subjected to "open season" hunting and half under "permit hunting" only. The 8 GMS that are closed to hunting only have a total of 45 moose.

In past years, the average harvest by resident and non-resident hunters has been 204 of which 165 were adult males. This compares to an allowable harvest of 63 bulls for the entire survey area. Most of the moose available for harvest are those in the allowable over-harvest category. For example, in open GMS, 166 adult males can be removed from the GMS populations without impairing the reproductive capability of the females. In these GMS, only 34 animals are being removed annually from an annual allowable harvest of 35 and an allowable over-harvest of 166. These open areas can support considerable additional hunting pressure and harvest.

The GMS under permit hunting can not support an open season. The average harvest in the past was approximately equal to the allowable harvest and allowable over-harvest. In these areas, open season hunting would remove most of the allowable over-harvest

TABLE 2

Management conclusions as derived from a summary of the harvestable male surplus for each GMS in the Southwest Yukon.

Regulation	Number of GMS %	Total Population	Total[a] allowable harvest	Total[b] over-harvest	Total[c] average harvest	Total[d] expected harvest
Closed	8 (17%)	45	1	5	10	0
Permit[e]	23 (49%)	1,355	26	112	121	54
Open	16 (34%)	1,334	35	166	34	38
Total	47 (100%)	2,734	63	283	165	92

a. Total allowable harvest - pre-hunt 1982 pop. minus post-hunt 1981 pop., while maintaining the existing average male:female sex ratio of 49:100.

b. Total allowable overharvest - pre-hunt 1982 pop. minus post-hunt 1981 pop. and allowing for a skewed male:female sex ratio of 30:100.

c. Total average harvest - average 1979-1980 combined resident and non-resident harvests.

d. Total expected harvest - closed = 0

permits = allowable harvest + ½ the allowable over-harvest

open = previous average harvest

e. The number of permits was calculated as: 2 x expected harvest, given an expected 50% success rate.

in one year and result in hunting closures within the next few years. The allocation of permits was based on the expected success rates for resident hunters. Overall, Yukon moose hunters are 30% successful, however, a higher success rate of 50% is expected from permit hunters as they should exert a greater level of effort. Therefore, the number of permits to be allocated was set equal to twice the sum of the planned harvest. In the 23 GMS with permits, a total of 108 permits should be allocated to effect a harvest of 54 adult males. This would be a 55% reduction in harvest from previous years.

Although the total moose harvest in the study area would be reduced (from 165 adult males to 92), it should be noted that many of the open GMS can support an additional harvest of about 100% above the 1979-1980 levels.

Throughout this analysis, no mention has been made of other forms of man-induced mortality. In the Yukon, Natives have the right to hunt for food on all unoccupied Crown Land. Since Natives are not required to have licences, it is impossible to monitor their wildlife harvests. Native harvest "guesstimates" for the southwestern Yukon survey area range around 50% of the harvest by licenced hunters. Likewise the harvest by poachers is unknown but potentially significant in some areas. Neither of these factors were considered in the computer simulation and therefore, the analyses presented in this paper probably significantly underestimate the total annual mortality and thus more restrictive hunting regulations would be required.

CONCLUSIONS

The techniques described in this paper allow aerial survey data and harvest estimates to be integrated to produce management conclusions. Although the population projection parameters and decision-making criteria might need to be modified for other jurisdictions, the overall philosophy can be applied, providing accurate population and harvest estimates are available for local moose populations.

The development of predictive moose management models and a decision-making framework allows hunting regulations to be tailored to balance annual harvests with the productivity of local moose populations. The models and framework can be used to form new regulations or predict what will happen if optimum regulations are not adopted.

Aerial surveys planned for the fall of 1982 will test the validity of the techniques outlined in this paper.

APPENDIX A

Management conclusions for GMS in the Southwestern Yukon showing estimated 1982 pre-hunt population sizes, average annual past bull harvests, allowable bull harvests, allowable bull overharvests, optimum regulation state and expected harvest under optimum regulations.

GMS	Estimate Population Size	Average Annual Past Harvest	Allowable Harvest	Overharvest	Optimum Regulation State	Expected Harvest
5-35	10	0.9	0.0	2.6	Closed	0.0
5-36	42	2.8	0.9	4.6	Permit	2.0
5-37	3	0.9	0.0	0.2	Closed	0.0
5-38	92	4.5	0.5	19.8	Open	4.5
5-39	36	1.0	0.4	3.8	Open	1.0
5-40	100	4.8	0.1	21.0	Open	4.8
5-41	201	7.6	1.1	22.8	Permit	6.8
5-42	80	0.6	1.9	15.1	Open	4.6
5-45	170	3.2	2.7	40.8	Open	3.2
5-46	60	6.6	0.0	20.2	Permit	5.0
5-47	100	1.3	2.1	1.5	Open	1.3
7-01	85	3.8	5.1	0.6	Open	3.8
7-02	172	1.4	7.7	24.1	Open	1.4
7-03	160	12.2	5.2	10.6	Permit	7.8
7-04	74	5.2	4.8	3.6	Open	5.2
7-05	43	1.9	3.0	2.1	Open	1.9
7-06	79	9.2	3.9	2.0	Permit	4.4
7-07	140	10.4	2.7	12.5	Permit	5.8
7-08	86	6.7	0.6	3.1	Permit	1.4
7-09	24	2.6	0.3	0.0	Permit	0.3
7-10	13	1.6	0.3	5.2	Permit	1.6
7-11	5	0.0	0.3	0.0	Closed	0.0
7-12	7	0.9	0.3	0.4	Closed	0.0
7-13	37	5.3	0.6	4.8	Permit	1.8
7-14	25	2.3	0.5	1.2	Permit	0.8
7-15	8	4.4	0.5	0.0	Closed	0.0
7-16	29	6.7	0.6	1.0	Permit	0.8

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GMS	Estimate Population Size	Average Annual Past Harvest	Allowable Harvest	Overharvest	Optimum Regulation State	Expected Harvest
7-17	57	3.0	1.3	3.9	Permit	2.3
7-18	27	3.0	1.0	3.6	Permit	1.9
7-19	25	6.1	1.1	0.9	Permit	1.3
7-20	18	2.3	0.4	0.7	Permit	0.6
7-21	84	8.0	1.2	0.0	Permit	1.2
7-22	118	2.8	2.0	10.9	Open	2.8
7-23	107	0.5	0.2	9.9	Open	0.5
7-24	59	6.1	0.8	6.7	Permit	2.5
7-25	36	0.0	2.9	0.0	Open	0.0
7-26	43	4.9	1.0	2.2	Permit	1.5
7-27	51	4.2	1.6	0.8	Permit	1.8
7-28	1	1.1	0.0	0.2	Closed	0.0
7-29	17	0.4	0.3	0.8	Open	0.4
7-30	56	2.5	0.6	3.9	Permit	1.6
7-31	14	4.7	0.1	0.2	Permit	0.1
7-32	69	1.5	1.0	8.1	Open	1.5
7-33	35	0.8	0.6	3.9	Open	0.8
7-34	5	0.8	0.0	0.8	Closed	0.0
7-35	6	0.8	0.2	0.3	Closed	0.0
9-03	25	2.2	0.5	1.5	Permit	0.9
TOTAL	2734	164.5	62.9	282.9		92.1

REFERENCES

GASAWAY, W. C., S. D. DUBOIS and S. J. HARBO. 1981. Estimating Moose Abundance and Composition. Alaska Department of Fish and Game Manual, Fairbanks, Alaska. 62Pb.

GASAWAY, W.C., R. STEPHENSON, J. DAVIS, P. SHEPHERD and O. BURRIS. 1982. Interrelationship of Prey, Man and Wolves in Interior Alaska. Draft (under review Wildl. Monographs).

KALE, W. 1982. Estimation of Moose Harvest for "Smaller" Management Units in the Yukon. Alces Vol. 18.

LARSEN, D.G. 1982. Moose Inventory in the Southwest Yukon. Alces Vol. 18.

MYTTON, W.R. and L. B. KEITH. 1981. Dynamics of Moose Populations near Rochester, Alberta, 1975-1978. Canadian Field Naturalist. 95(1):39-49.

PEEK, J. M. 1971. Moose Habitat Selection and Relationships to Forest Management in North Eastern Minnesota, Ph.D. Thesis, Univ. of Minn.

RAUSCH, R.A. and A.E. BRATLIE. 1967. Assessments of Moose Calf Production and Mortality in South Central Alaska. Proc. Western Assoc. State Game and Fish Commissioners. 45:140-146.

SIMKIN, D.W. 1974. Reproduction and Productivity of Moose. Le Naturaliste Canadien 101:517-525.

VAN BALLENBERGHE, V. 1979. Productivity Estimates of Moose Populations: A Review and Re-evaluation. 15th N. Am. Moose Conf. and Workshop, Soldotna, Alaska.