HELICOPTER OR FIXED-WING AIRCRAFT: A COST-BENEFIT ANALYSIS FOR MOOSE SURVEYS IN YUKON TERRITORY

Cor M.M. Smits, Richard M.P. Ward and Douglas G. Larsen
Yukon Department of Renewable Resources, P.O. Box 2703, Whitehorse, Yukon Territory, Canada Y1A 2C6

ABSTRACT: The cost-effectiveness of using helicopters and fixed-wing aircraft in stratified random block surveys for moose is compared in two areas of Yukon Territory, Canada. Low-intensity stratification surveys were carried out with fixed-wing aircraft in both areas. Subsequently a number of sample units in each of 3 moose density strata were surveyed by helicopters in one area and fixed-wing aircraft in the other area. Sightability bias was determined by high-intensity searches of subsections of some sample units by helicopter in both areas. To achieve similar precision levels in moose population estimates, the fixed-wing technique was shown to be 15.9% more expensive than the helicopter technique at current helicopter and fixed-wing aircraft charter rates. This seemed to be the result of a greater sightability correction factor and associated sampling variance with the fixed-wing technique compared to the helicopter technique. Helicopter charter rates would have to be $\geq$4.6 higher than fixed-wing aircraft rates for the fixed-wing technique to be more cost-effective.

ALCES VOL. 30 (1994) pp.45-50

In Yukon Territory, aerial surveys to determine moose abundance are generally done using a stratified random block sampling technique modified from Gasaway *et al.* (1986). We typically use fixed-wing aircraft (Cessna 185, 206, Maule M-7) for stratification. Unlike the original technique where Super Cubs are used (Gasaway *et al.* 1986), helicopters (Bell 206) are used for the census and estimation of sightability bias (Larsen 1982). Helicopters were initially chosen for the census because of windy survey conditions and a shortage of experienced Super Cub operators in the Yukon Territory. Costs of a typical survey are approximately (Can.) $15,000-20,000 per 1,000 km² of survey area (1993 rates).

The increase in experienced Super Cub operators in the Yukon Territory in recent years has prompted the Yukon Department of Renewable Resources to re-evaluate the cost-effectiveness of Super Cubs for moose surveys. Computer simulation suggested (Smits, unpubl. data) that costs could be reduced by as much as 40% while maintaining similar precision levels if PA-18 Super Cubs were used for the census portion of the survey instead of helicopters. The estimation of the sightability bias would continue to be done using helicopters in order to enable valid comparisons with earlier surveys.

During autumn 1993, field comparisons of helicopters and Super Cubs for the census portions were conducted. This report summarizes the effects of these aircraft substitutions on survey costs and precision levels of population estimates.

STUDY AREAS

The Super Cub survey was flown in a 3,275 km² area in southwestern Yukon Territory, near Whitehorse. The helicopter survey (3,049 km²) was flown in central Yukon Territory, near Mayo (Fig. 1). Moose habitat and distribution, and survey conditions were similar between both areas. The topography of both areas varies between rolling (750-1,200 m. ASL), and mountainous terrain (1,500-1,800 m. ASL, with some portions of the southwestern area between 1,800-2,100 m. ASL). Treeline occurs between 1,050-1,200 m. ASL. Dwarf shrub birch (*Betula spp.*) and

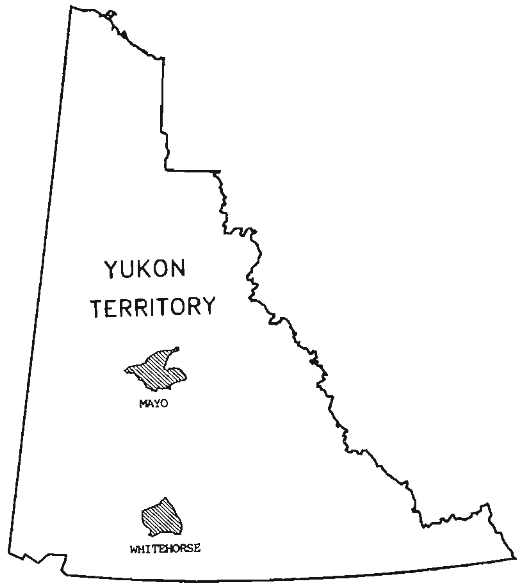

Fig. 1. Location of the moose survey areas in Yukon Territory, Canada.

willow (*Salix spp.*) are the predominant vegetation in the subalpine zone (treeline to 1,500 m ASL). On the lower slopes, white spruce (*Picea glauca*) and lodgepole pine (*Pinus contorta*) are the dominant tree species.

METHODS

The technique used in both areas followed that of Gasaway *et al.* (1986).

Stratification of Survey Areas

Each survey area was flown in its entirety using two airplanes (Cessna's 185, 206, or Maule M-7) at search intensities of 0.51-0.66 min/km^2 at altitudes of 60-80 m. to obtain crude estimates of moose numbers. Sample units were subsequently grouped into three strata based on similar moose density.

Census

The Mayo survey area was censused using two helicopters (Bell 206) at search intensities of 2 min/km^2. Survey altitude was 60-80 m. The Whitehorse survey area was surveyed by Piper PA-18 Super Cub and Piper PA-12 at search intensities of 1.9 min/km^2. Sample units were randomly selected without replacement in each stratum. The number of sample units flown was the minimum required to reduce the 90% CI to 20% of the population estimate or as many as the project budget allowed.

Sightability Correction

We assumed that >95% of moose present in an area would be seen if the area was searched at 4 min/km^2 (Gasaway *et al.* 1986). Therefore, to estimate sightability bias, we flew additional helicopter surveys (sightability plots) at that intensity. Sightability plots comprised portions of some of the sample units flown during regular censuses: approximately 1/4 of the area in each selected sample unit in the Mayo helicopter area; 1/4 - 1/2 of the area in each selected sample unit in the Whitehorse Super Cub area. Sightability plots were flown immediately after the corresponding sample unit was censused.

Statistical Analysis

Calculations of moose population abundance and sex/age composition parameters followed Gasaway *et al.* (1986), and were performed using the computer program MOOSEPOP (Reed, 1989).

Cost-Benefit Comparison

A valid cost comparison of using Super Cubs versus helicopters for the census portion of stratified random block surveys requires comparing survey results of similar precision levels. An attempt was made to achieve a 90% CI of at least ±20% of the population estimate in both the helicopter and Super Cub census areas. However, the budget was not sufficient to achieve this goal within the Super Cub area. The total number of sample units required to reach this precision level within the Super Cub area was therefore estimated by simulating the effect of increasing the number of sample units and/or sightability plots searched using the user-define option in MOOSEPOP. Reported survey costs include aircraft charter costs and all personnel costs associated with completing the survey.

RESULTS

The helicopter (Mayo) and Super Cub (Whitehorse) surveys were flown during November 20 - December 1, and November 4 - 17, 1993, respectively. Although only a slightly greater percentage of helicopter survey area (43.8 vs 37.9) was censused, the confidence interval of the moose population estimate was about twice as precise (17.4% vs 34.4%) (Table 1). This was the result of the smaller sightability correction factor and its sampling variance at Mayo relative to Whitehorse.

MOOSEPOP indicated that in the Super Cub (Whitehorse) area, 129 sample units and 50 sightability plots would be required to reduce the 90% CI for the population estimate to 17.4% (i.e., the same precision level achieved in the helicopter survey; Table 2). The most cost-effective sampling regime to achieve that precision level was calculated to require censusing all sample units within the area and 24 sightability plots. Under the latter sampling regime, the total survey cost would amount to \$18,336.13 per 1,000 km² (Table 1), compared with a cost of \$15,815.65 per 1,000 km² for the helicopter technique. The Super Cub technique would be 15.9% more expensive at current helicopter and Super Cub rates in Yukon Territory. As helicopter rates may increase substantially, we simulated the relationship between helicopter charter rates and total survey costs in the Mayo and Whitehorse 1993 surveys (Fig. 2). Helicopter charter rates would have to be ≥4.6 times higher than Super Cub rates before the Super Cub technique would be considered more cost-effective.

A cost comparison between the two techniques must also consider the relative amount of charter time spent ferrying to and from staging points. The time spent ferrying relative to surveying is a function of aircraft characteristics (i.e., cruise speed and range) and of location of staging points relative to the survey area. Table 3 compares the relative amounts of time spent ferrying and surveying in both study areas. The similarity in the relative amounts of ferry and survey time during stratification of both study areas suggests that staging points were situated efficiently in both areas. The relatively greater percentage of ferry time used by Super Cubs in the Whitehorse survey compared to helicopters in the Mayo survey suggests that Super Cubs were less efficient in the use of their charter time. Although this was due partly to their relatively lower cruise speed

Table 1. Actual and simulated results and associated costs* of the Mayo and Whitehorse moose surveys.

	Survey Area (sampling scenario)		
	Helicopter	Super Cub	
	Mayo (actual)	Whitehorse (actual)	Whitehorse (simulation)
Size of study area (km²)	3049.4	3274.60	3274.60
Percentage of area surveyed	43.8	37.9	100
No. of strata	3	3	3
Sightability correction factor (SCF_0)	1.03	1.36	1.36
Sampling variance of SCF_0	0.001	0.031	0.031
90% C.I. of population estimate	T_e±17.4%	T_e±34.4%	T_e±17.4%
Stratification cost per 1,000 km²	\$5,344.97	\$3,761.65	\$3,761.65
Survey cost per 1,000 km²	\$10,470.68	\$6,507.50	\$14,574.48
Total cost per 1,000 km²	\$15,815.65	\$10,269.15	\$18,336.13

*costs include aircraft charter (including fuel) and personnel wages for hours surveyed.

Table 2. Distribution of survey effort by aircraft type and survey component in the Mayo and Whitehorse North survey areas.

	MAYO					WHITEHORSE				
SURVEY COMPONENT	NO. OF SU's[1] FLOWN	NO. OF SCF_o[2] PLOTS FLOWN	NO OF HOURS FLOWN: HELICOPTER	NO OF HOURS FLOWN: CUB	NO OF HOURS FLOWN: OTHER*	NO. OF SU's FLOWN	NO. OF SCF_o PLOTS FLOWN	NO. OF HOURS FLOWN: HELICOPTER	NO. OF HOURS FLOWN: CUB	NO. OF HOURS FLOWN: OTHER*
Stratification	120 (all)	-	-	-	42.5	192 (all)	-	-	-	36.3
Census:										
Actual	52	6	58.1	-	-	73	15	14.7	68.2	-
Simulation	n/a	n/a	n/a	n/a	n/a	129	50	49.0	120.5	-
						192	24	23.5	179.4	-

*Aircraft included: Cessna 206, Cessna 185, Maule M-7
[1]SU = Sample Unit
[2]SCF_o = Sightability Correction Factor

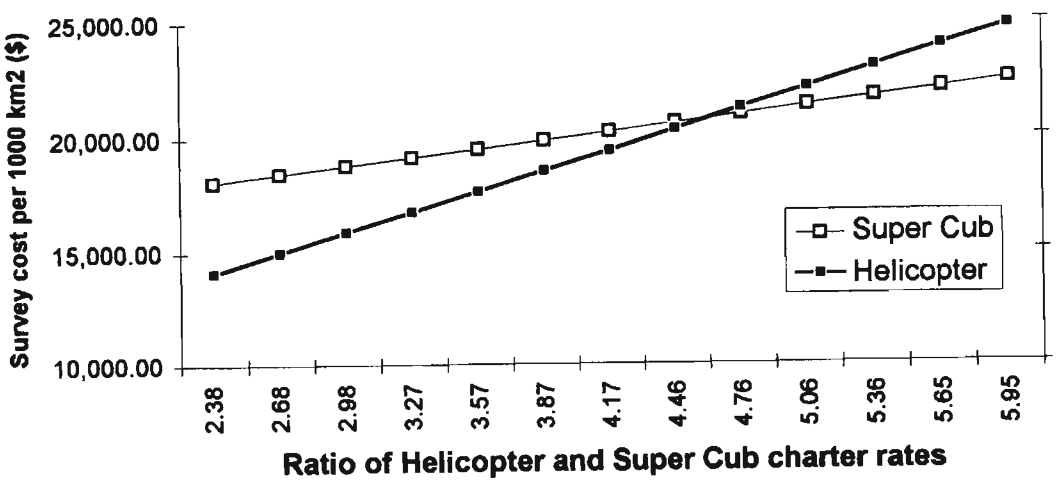

Fig. 2. Cost comparison between moose surveys by helicopter and Super Cub at varying charter rates and a fixed Super Cub charter rate of $168/hr. (incl. personnel costs).

and range, it was also due to the inability of one Super Cub to use a particular refuelling site due to technical problems. We expect, therefore, that Super Cub surveys can be done somewhat more cost-effectively than indicated here.

DISCUSSION

The stratified random block survey technique has been used in Yukon Territory since the early 1980's and the effort to achieve a 90% C.I. of approximately ±20% of the population estimate has been relatively constant. The survey effort required to reach a similar precision level using the helicopter technique described is similar to past surveys. The Super Cub technique had not been used previously in Yukon Territory. Therefore it is not clear whether the estimated greater effort required to reach the target precision level is typical for Yukon conditions. Survey conditions, however, were good with continuous snow cover and little or no turbulence, while both pilots and observers were experienced in surveying moose. We, therefore, do not expect that the sightability correction factor can be much reduced given similar habitat characteristics and search effort.

Sightability and its associated sampling variance has a great effect on precision levels relative to other factors (Gasaway *et al.* 1986). Survey costs of the Super Cub technique

Table 3. Relative ferry and survey times during stratification and census of the Mayo and Whitehorse moose study areas.

SURVEY AREA	SURVEY COMPONENT	TYPE OF AIRCRAFT	FERRY TIME hrs. (%)	SURVEY TIME hrs. (%)
Mayo	Stratification	Fixed-wing*	9.2 (21.6%)	33.3 (78.4%)
	Survey	Helicopter	15.1 (26.0%)	43.0 (74.0%)
Whitehorse	Stratification	Fixed-wing*	8.5 (23.4%)	27.8 (76.6%)
	Survey	Super cub	29.5 (43.4%)	39.4 (56.6%)
		Helicopter	4.1 (27.9%)	10.6 (72.1%)
			33.6 (40.7%)	49.0 (59.3%)

*Cessna 185 or 206, or Maule M-7

might therefore be reduced by increasing search effort from Super Cubs which would increase sightability and presumably reduce variance of sightability plots. This would require fewer sightability plots flown by helicopter. For the Super Cub technique to become more cost-effective than the helicopter technique, the increased cost associated with greater search effort must be more than off-set by a reduction in helicopter cost associated with surveying fewer sightability plots. At the current substantial price difference between helicopter and Super Cub surveys, it appears unlikely that such a modification would lower the cost of using Super Cubs below that of conducting the census with helicopters. Even if charter rates were such that the Super Cub technique was more cost-effective than the helicopter technique, we believe that other factors like crew safety and number of down days should be considered. Fixed-wing aircraft are generally considered less safe in mountainous terrain under windy conditions. They are also more frequently unable to fly surveys due to poor weather compared to helicopters.

ACKNOWLEDGEMENTS

We wish to thank K. Egli, B. Gilroy, T. Hunter, B. MacLean, D. McDiarmid, P. Merchant, S. Moses, L. Patterson, R. Rivard, J. Sydney, B. Slough, J. Sutton, M. Waterreus, and N. Young who were observers during the surveys. Aircraft charter was provided by Action Aviation, Aerokon Aviation, Big Salmon Air, Coyote Air Service, Osprey Air, and Capital Helicopters. Pilots J. Brook, D. Denison, T. Hudgin, G. Speinhagen, C. Untershute, and D. Washington, provided excellent flying service. The paper gained much in clarity by the comments of S. Westover and two anonymous reviewers. We also thank H. Stirling for drafting the figures and D. Milne for typing the report.

REFERENCES

GASAWAY, W.C., S.D. DUBOIS, D.J. REED, and S.J. HARBO. 1986. Estimating moose population parameters from aerial surveys. Biological Papers. Univ. of Alaska 22:1-108.

LARSEN, D. G. 1982. Moose inventory in southwest Yukon. Alces 18:142-167.

REED, D.J. 1989. MOOSEPOP Program documentation and instructions. Unpubl. report, Alaska Dept. Fish and Game. Fairbanks. 15pp.