COMPARISON OF FIXED-WING AND HELICOPTER SEARCHES FOR MOOSE IN A MID-WINTER HABITAT-BASED SURVEY

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ABSTRACT: We conducted a mid-winter habitat-based survey in Terra Nova National Park and an adjacent hunted area (Moose Management Area 27) to compare the reliability and accuracy of using fixed-wing and helicopter aircraft for counting moose. Forest inventory mapping was the primary consideration in defining block boundaries because this readily available information could be easily interpreted by observers during aircraft navigation, and because map classes could be chosen in a way expected to reduce variability in moose distribution. Blocks were also classified from forest inventory mapping as being either open (mean crown closure of all stands < 50%), or dense (mean crown closure of all stands > 50%). We tested the precision of fixed-wing and helicopter aircraft for counting moose in blocks with open and dense crown cover by increasing the time spent during second searches with each aircraft type. More moose were seen in open blocks during second searches with increased flying time in both fixed-wing aircraft (100%) and helicopters (160%) than in dense forest cover blocks (12% and 43%, respectively). We also compared the accuracy of the two aircraft types in each crown cover class by recounting the same blocks at a similar intensity. Verifying the accuracy of fixed-wing counts with helicopter searches of the same 8 blocks (the same crew flew approximately the same time), we found that the helicopter counts were on average 78% higher. We conclude that for highest accuracy and best classification of animals during a moose survey, helicopter counting is superior to fixed wing counting.

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The stratified random block design (Gasaway et al. 1986) is a widely used and recommended technique for surveying moose (*Alces alces*) populations (Timmermann and Buss 1998). A consistent problem, especially for aerial census of forested habitats, is determining the number of animals missed due to poor visibility (Samuel and Pollock 1981, Timmermann 1993). Corrections for bias are often incorporated into a final population estimate, but visibility bias depends on many untested factors such as the study area, snow and weather conditions, observer experience, dominant vegetation, and the type of aircraft used in the survey (Peterson and Page 1993, Rivest et al. 1995, Anderson and Lindzey 1996).

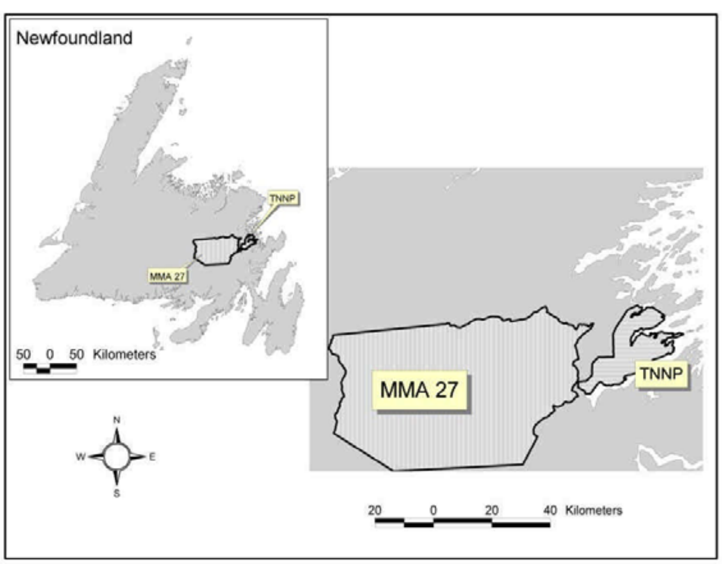
Another problem is that topographic maps are often used to navigate within blocks but may lead to imprecise survey results where there is insufficient detail for identifying block boundaries. Creating survey blocks containing uniform habitat types can reduce variability in moose distribution within blocks (Gasaway et al. 1986), and can provide an opportunity to assess moose visibility by recounting in uniform canopy cover situations. In this study, we used Geographic Information System (GIS) technology and forest inventory databases to generate detailed field maps and to improve navigational and survey accuracy. Wildlife managers in other regions have recently incorporated Global Positioning Systems (GPS) and on-board computer mapping to enhance navigation and overall survey efficiency (Lynch and Shumaker 1995, Poole et al. 1999). GPS was not used in this moose survey since block boundaries were designed to follow landscape features that were easily recognizable from the air. Our objectives were to: (1) test the precision of using fixed-wing aircraft and helicopters to count moose in blocks with open and dense crown cover by increasing the time spent during second searches with each aircraft type; and (2) compare the accuracy of the 2 aircraft types in each crown cover class by recounting moose in the same blocks at a similar intensity.

STUDY AREA

Terra Nova National Park (TNNP; 48° 34' 00" N, 54° 00' 00" W) is a large protected area (410 km^2) located in the north central boreal forest subregion (Meades and Moores 1994) of eastern Newfoundland (Fig. 1). The maritime climate in this area is characterized by brief, cool summers and relatively moderate winters. Mean seasonal temperatures range from -5.8°C in February to 16.4°C in July, and mean annual precipitation is approximately 1,200 mm (Deichmann and Bradshaw 1984). Topography is hilly (elevation < 200 m) and forests comprise about 70% of the area (Gauthier et al. 1977). Forest communities in TNNP are largely dominated by late-successional black spruce (*Picea mariana*), although mixed balsam fir (*Abies balsamea*) stands are prevalent along coastal areas. Most forest stands are interspersed with fens, barrens, and small water bodies resulting in a naturally fragmented landscape.

Moose Management Area 27 (MMA 27) is located to the immediate west of TNNP and is 3,620 km^2 in area (Fig. 1). Forest types, climate, and topography are similar to TNNP. Commercial timber harvesting has changed forest age distribution in the northern and eastern areas to younger age classes, with about half of stands < 40 years old and only 13% of stands > 80 years old. Moose density was last assessed in 1989 at 1.7 / km^2 (Mercer 1995). The annual harvest in MMA 27 is 200-300 moose per year (150-200 either-sex and 150-200

Fig. 1. Location of the 2 study areas, Terra Nova National Park (TNNP) and Moose Management Area 27 (MMA 27) in eastern Newfoundland.



male-only licences have been allocated annually to this management area since 1990).

METHODS

A modification of the stratified random block survey (Gasaway et al. 1986) was used to count moose in TNNP and MMA 27 from mid-January to late March 2001. Though the survey was conducted over a relatively wide time period, snow depth and condition did not change significantly and their potential effect on moose distribution was considered minimal. Prior to stratification of the 2 units into regions of suspected uniform moose density, potential survey block boundaries were digitized using ArcView GIS 3.2. Boundaries encompassed areas of similar habitat. Exact block areas were calculated using the Xtools extension for ArcView; these ranged from 4-6 km^2. Forest inventory mapping was used to define all boundaries because observers could easily interpret this readily available information during aircraft navigation. Map classes could be chosen in a way to reduce variability in moose distribution. Easily discernible map classes chosen to aid in navigation included lake shorelines, streams, roadsides, forest edges along bogs, barrens and clearcuts, and abrupt transitions between stands of different species composition. Continuous patches of productive and insect-damaged balsam fir were incorporated within single blocks wherever possible, moose winter distribution being primarily associated with these forest types. Blocks were also classified from forest inventory mapping as being either open (mean crown closure of all cover types < 50%), or dense (mean crown closure of all cover types > 50%). Stratification over both units was carried out in a Cessna-185 aircraft flying parallel strips spaced approximately 200 m apart at an altitude of 50-150 m. A front-seat navigator and 2 rear-seat observers were instructed to find expected areas of uniform moose density for the purpose of identifying 2 strata (high and low moose density) in TNNP and 4 strata in MMA 27 (areas were expected to be very high, high, low, and very low moose density). Only 30% of MMA 27 was flown during stratification because of the large area and finite resources for the project. The remaining area was stratified based on past survey results and expected moose densities in different habitat types. Observers also made checks at this time of the assessment by GIS of suitable census block boundaries and the designation of open and dense cover blocks. Blocks were then randomly assigned to be censused according to stratum: sampling effort in the very high-density stratum (MMA 27 only) equaled 100% because there were only 4 blocks in this stratum, in the high-density stratum approximately 20%, in the low-density stratum approximately 5-10%, and in the very low-density stratum (MMA 27 only) approximately 5%. Whenever possible, census counts followed fresh snowfalls by < 48 hours and were always conducted when snow depth was > 60 cm. Observer seat assignment was the same as during stratification and a similar flight pattern was followed. Between 10 and 60 minutes were allotted for each census block. Population estimates followed Gasaway et al. (1986) and were derived from helicopter counting only, since most blocks were surveyed with this aircraft type.

To test the reliability of fixed-wing and helicopter aircraft in blocks with open and dense crown cover we approximately doubled the amount of time spent during second searches and used new crew members in the same aircraft. Doubling of effort was not always achieved (particularly for helicopter surveys) because of the high amount of time spent during initial searches. For this test, 6 blocks were recounted from fixed-wing aircraft (3 in open and 3 in dense cover), and 8 blocks were recounted using helicopters (4 in open and 4 in dense cover). Data collected from western Newfoundland during January 2000 were used to supplement helicopter recounts in blocks with open crown cover since poor snow conditions prevented us from completing the desired replicate in this crown cover class during our survey. To compare the accuracy of fixed-wing and helicopter aircraft for sighting moose, the same crew spent approximately the same amount of time in each aircraft during recounts in 8 blocks (3 in open and 5 in dense cover). All recounts were done within 1-2 hours following the initial survey to reduce the probability of moose moving into adjacent blocks. Moose were classified as male and female adults and unclassified yearlings and calves. Sex determination was based on presence of the vulva patch and/or the presence or absence of antlers (Timmermann 1993).

RESULTS

Survey results indicated that there were 308 ± 114 moose (90% CI) in TNNP and 2,140 ± 380 moose in MMA 27. Mean moose density was 0.75 and 0.59/ km^2 in TNNP and MMA 27, respectively. During the survey, a total of 72 moose were observed in TNNP and 301 moose in MMA 27. Of the total count in MMA 27, 203 (67%) were observed in the very high-density stratum, largely in recently cutover areas.

More intensive second searches (100-177% longer) from fixed-wing aircraft produced 36% more moose in the total counts for 6 blocks (Table 1). Second searches of blocks from helicopter with a more modest increase of flying time (31-144%), resulted in 74% more moose in 8 blocks (Table 2).

We found that the fixed-wing counts averaged 56% of the helicopter counts (42% S.D.) when counting the same 8 blocks (Fig. 2). Moose classification was possible from a helicopter but difficult from a fixed-wing aircraft. About 80% of moose observed were classified into sex and age-class from a helicopter, while only 8% of moose observed from the fixed-wing aircraft could be classified into age and sex categories.

Overall, more moose were seen in second searches of open blocks, 100% more (fixed-wing) and 160% more (helicopter), compared to dense forest cover blocks, 12% more (fixed-wing) and 43% more (helicopter; Tables 1 and 2). In the fixed-wing and helicopter comparisons (Fig. 2), count replicates 1-5 were in dense cover blocks and replicates 6-8 in open cover blocks. Correction factors representing the increase in moose seen from a helicopter compared to a fixed-wing aircraft were 67% (58% S.D.) and 49% (36% S.D.) in open and dense blocks, respectively.

DISCUSSION

Focusing block boundaries on habitat characteristics is an effective means to help delineate blocks, stratify, and assess accuracy of moose population surveys. Observ-

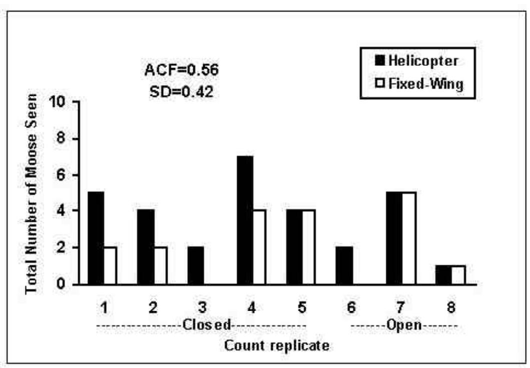


Fig. 2. Total number of moose counted in the same blocks by helicopter and fixed-wing aircraft. The aircraft correction factor, ACF, is the ratio of counts in fixed-wing to the counts in helicopter and is reported with its standard deviation, SD. Note that 28% less time was spent using helicopter for replicates 1, 7, and 8.

Table 1. Flying time (min) and number of moose seen during first and second searches of open and dense blocks using fixed-wing (Cessna-185) aircraft. The second search covered the same area as the first search, but was carried out by different observers in the same aircraft.

Cover	Replicate	First Search Flying time (min)	First Search Moose count	Second Search Flying time (min)	Second Search Moose count
Open	1	17	0	34	1
	2	22	2	46	3
	3	13	1	36	2
Dense	1	30	4	60	4
	2	38	4	76	5
	3	15	0	30	0

ers felt that aircraft navigation and block boundary identification was facilitated by use of forest cover type maps. These maps also allowed us to use forest cover in our assessment of visibility bias. Gasaway et al. (1986) recommended separate correction factors for each density stratum but variability in correction factors does not contribute much to the confidence interval in final population estimates in some areas (Crête et al. 1986). We thus recommend generally that counting accuracy be assessed as much as possible under different flying conditions rather than by stratum. In our example, if at least half of the moose were missed in open blocks, then more than half of the moose present were missed because of poorer visibility through dense forest cover. This observation allows us to conclude that a correction factor of > 2 is

Table 2. Flying time (min) and number of moose seen during first and second searches of open and dense blocks using a Bell 206-B or 206-L helicopter. The second search covered the same area as the first search, but was carried out by different observers in the same aircraft.

Cover	Replicate	First Search Flying time (min)	First Search Moose count	Second Search Flying time (min)	Second Search Moose count
Open	1	25	3	49	3
	2	7	0	13	6
	3	13	2	19	2
	4	13	0	17	2
Dense	1	45	4	71	6
	2	34	2	51	1
	3	59	5	90	6
	4	27	3	66	7

warranted for largely forested survey units and is consistent with the findings of Oosenbrug and Ferguson (1992) who reported a mean sightability correction factor of 2.6 for 4 heavily forested blocks in east-central Newfoundland. Moose sightability decreases with an increase in forest cover (Drummer and Aho 1998, Quayle et al. 2001) and this decline may be near zero visibility in the most dense cover classes (Anderson and Lindzey 1996). Bergerud and Manuel (1969) report considerable variation in the number of moose seen during recounts in open and dense cover blocks in central Newfoundland. We see no support in current Newfoundland survey procedures for the statement by Gasaway et al. (1986) that > 95% of moose present in open canopied forests would be found had our search intensity been 4 min/km^2; in fact, we exceeded this intensity in most of our sample blocks (including blocks in open areas).

The best estimate of visibility bias during aerial survey may result from testing for the visibility of radio-collared animals (Crête et al. 1986, Peterson and Page 1993, Drummer and Aho 1998). Attempts have also been made to compare stratified random block survey to a mark-recapture population estimate with collared animals (Oosenbrug and Ferguson 1992), but random mixing of collared and uncollared moose in large survey areas may not be a sound assumption.

For highest accuracy and best classification of animals during a moose survey, our study shows that helicopter counting is superior to fixed-wing counting. To save costs where classification results are not crucial to a survey, initial fixed-wing counts with limited helicopter recounting may achieve lower variability along with acceptable accuracy in population estimates (Crête et al. 1986). Our overall fixed-wing accuracy comparing helicopter counts (aircraft correction factor, ACF = 0.56) was relatively higher than the 0.29 ACF achieved by Crête et al. (1986). This was probably the result of a combination of more open blocks and longer flying time. Flying with fixed-wing produced lower variability in counting, with increased flying time (higher overall effort correction factor, ECF = 0.73; Table 1) than helicopter (ECF = 0.58; Table 2) in both open and dense cover.

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REFERENCES

Anderson, C. R., Jr., and F. G. Lindzey. 1996. Moose sightability model developed from helicopter surveys. Wildlife Society Bulletin 24:247-259.

Bergerud, A. T., and F. Manuel. 1969. Aerial census of moose in Central Newfoundland. Journal of Wildlife Management 33:910-916.

Crête, M., L. P. Rivest, H. Jolicoeur, J. M. Brassard, and F. Messier. 1986. Predicting and correcting helicopter counts of moose with observations made from fixed-wing aircraft in southern Quebec. Journal of Applied Ecology 23:751-761.

Deichmann, K. H., and D. B. Bradshaw. 1984. Terra Nova National Park resource description and evaluation. Environment Canada. Terra Nova National Park, Glovertown, Newfoundland and Labrador, Canada.

Drummer, T. D., and R. W. Aho. 1998. A sightability model for moose in Upper Michigan. Alces 34:15-19.

Gasaway, W. C., D. J. Reed, and S. J. Harbo. 1986. Estimating moose population parameters from aerial surveys. Biological Papers of the University of Alaska, Number 22. Fairbanks, Alaska, USA.

Gauthier, Poulin, Theriault, Ltd. 1977. A biophysical classification of Terra Nova National Park. A report for Parks Canada, Atlantic Region. Historic Properties, Halifax, Nova Scotia, Canada.

Lynch, G. M., and G. E. Shumaker. 1995. GPS and GIS assisted moose surveys. Alces 31:145-151.

Meades, W. J., and L. Moores. 1994. Forest site classification manual: a field guide to the forest types of Newfoundland. Forestry Canada and Newfoundland Department of Forestry and Agriculture, FRDA Report Number 003. St. John's, Newfoundland, Canada.

Mercer, W. E. 1995. Moose management plan for Newfoundland. Report on file with Wildlife Division, Newfoundland and Labrador, St. John's, Newfoundland, Canada.

Oosenbrug, S. M., and S. H. Ferguson. 1992. Moose mark-recapture survey in Newfoundland. Alces 28:21-29.

Peterson, R. O., and R. E. Page. 1993. Detection of moose in midwinter from fixed-wing aircraft over dense forest cover. Wildlife Society Bulletin 21:80-86.

Poole, K. G., G. Mowat, and D. Pritchard. 1999. Using GPS and GIS for navigation and mark-recapture for sightability correction in moose inventories. Alces 35:1-10.

Quayle, J. F., A. G. MacHutchon, and D. N. Jury. 2001. Modeling moose sightability in south-central British Columbia. Alces 37:43-54.

Rivest, L. P., F. Potvin, H. Crepeau, and G. Daigle. 1995. Statistical methods for aerial surveys using the double count technique to correct visibility bias. Biometrics 51:461-470.

Samuel, M. D., and K. H. Pollock. 1981. Correction of visibility bias in aerial surveys where animals occur in groups. Journal of Wildlife Management 45:993-997.

Timmermann, H. R. 1993. Use of aerial surveys for estimating and monitoring moose populations – a review. Alces 29:35-46.

______, and M. E. Buss. 1998. Population and harvest management. Pages 559-615 *in* A. W. Franzmann and C. C. Schwartz, editors. Ecology and management of the North American moose. Smithsonian Institution Press, Washington, D.C., USA.