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NTC 3905

Moose in the Nass Wildlife Area

Final Report

submitted to:

Forest Renewal BC, Skeena-Bulkley Region
Bag 5000, 1070 Main St., Smithers, BC V0J 2N0

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EXECUTIVE SUMMARY

A radio-telemetry study and population survey of moose in the Nass Wildlife Area (NWA), westcentral British Columbia, began in January 1997. Twenty adult moose captured and fitted with VHF radio-collars in 1997 and 18 in 1998 were relocated monthly until March 2000. All remained in the NWA.

A population size of 1292 ±38.1% in the entire 5926 km^2 surveyed area, and 724 ±39.8% in the 3677 km^2 NWA[1] was estimated from an aerial survey. Because these values exceed the maximum of ±25% as recommended by the RIC standards, it may be advisable to conduct another moose survey in the NWA during the coming winter after issues pertaining to sightability have been thoroughly addressed. During the 1997 survey, a total of 194 moose was observed: 99 cows, 34 bulls, 6 yearlings, 46 calves, and 9 unclassified moose. Accordingly, the sex ratio of the population was 37 bulls per 100 cows, and the ratio of calves to cows was 47:100.

The minimum pregnancy rate of the population, as determined through serological testing, was estimated at 81% for the 1997 sample and 77% for the 1998 sample. These estimates are considered minimum values because it is possible that one or more yearling cows were inadvertently sampled and yearlings are known to experience considerably lower pregnancy rates than adults. The minimum number of neonate calves:100 cows in 1997, 1998 and 1999 were estimated at 75:100, 85:100, and 89:100, respectively. The minimum ratio of calves:100 cows in January-February 1998, 1999, and 2000 was estimated at 47:100, 59:100, and 50:100, respectively. Opportunities to enhance the understanding of the population's production are presented under a locally run program that would collect and analyze data on reproduction and age structure.

As of 5 March 2000, seven of the 20 moose collared in 1997 had died as had five of the 18 collared in 1998. Hunting was the greatest cause of mortality of collared moose, accounting for 58% of the deaths. A maximum of four adults may have been killed by wolves (33%), but clear evidence of wolf predation was only observed in two cases (17%). The mean annual mortality of radio-collared moose in the NWA from 1997-2000 was estimated at 13.2%. This value probably underestimates the actual mortality of the adult segment of the population.

At least 71% of the moose population is believed to consist of migratory individuals. Bulls and cows moved considerable distances between seasonal ranges, but all remained within the NWA. The greatest straight-line distance between telemetry-determined locations was ≈75 km. Migratory animals moved a mean maximum straight-line distance of 43.2 km and non-migratory animals moved a mean straight-line maximum distance of 13.3 km. There was no indication that movement rate varied as a function of sex. Elevations used by collared moose ranged from 200 m (i.e., the main valley bottoms) to 1500 m (i.e., near treeline), with an average of 400 m. Again, no

[1] The actual size of the NWA is ≈16,200 km^2. The figure of 3677 km^2 represents that portion of the NWA that was stratified as potential moose habitat.

variation attributable to sex was apparent. Moose used higher elevations during the non-winter period.

Average straight-line movement rates between successive locations was variable among and within individuals across time. Two seasonal peaks in movement rates were evident for both sexes at roughly the same time of year, apparently in response to snow depths: (1) movements from winter to non-winter range during April-June (pre-calving) and (2) return movements back to winter ranges in December-January. Movement rates during the rut (i.e., September-October) were some of the lowest recorded during the year.

Multi-annual utilization distributions for all locations showed that overall seasonal range size was smallest in winter (December through April) and largest in non-winter (June through November). Multiannual home range size varied considerably, with a mean home range size from the 95% utilization distribution of 171 km^2 (262 km^2 according to the minimum convex polygon method). Multiannual home range size was highly correlated ($r=0.80$, $n=34$) with the maximum distance between any two locations, which supports the expected assumption that migratory individuals *tended* to have larger home ranges than non-migratory ones. However, because some migratory moose used adjacent seasonal ranges separated more by elevation than distance, this trend was not evident for all animals.

A variety of forested habitats across the full range of elevations in the Nass Wildlife Area are used intensively by moose. Habitat suitability modelling conducted by Yazvenko et al. (2000) accurately ranked the suitability of habitats according to observed use in both the winter and non-winter seasons.

Many moose are believed to cross the Nass River when migrating between seasonal ranges. The stretch of river in the vicinity of Van Dyke Island may be an important crossing area for moose that migrate between the winter habitats of the lower Cranberry River area and the summer habitats of the lower White River valley. Recommendations to preserve the integrity of that crossing area are presented. Primary considerations involve maintaining security cover and restricting vehicular access. Limits on access development into the lower White River are also discussed. Recommendations to establish Wildlife Management Areas at two key habitat locations are given. Any attempts to enhance moose habitat should be focused on winter ranges within the ICHmc1 and ICHmc2 biogeoclimatic variants.

Moose conservation and management in the NWA relies on the active participation of many players. Success of the recommendations made by the Nass Wildlife Committee and the willingness of the forest industry to accommodate moose management concerns (namely the effects of access and intensive silviculture) are believed to be key to ensuring the long-term viability of a harvestable moose population in the NWA.

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INTRODUCTION

The moose (*Alces alces*) is the largest species in the deer family (Cervidae). It is well adapted to the early successional stages of forests that can occur on suitable sites following forest fires or logging, but is also dependent on the cover provided by mature coniferous forests. Moose forage extensively on species of deciduous trees and shrubs that colonize logged sites soon after harvesting. Later successional stages of forests provide security cover, thermal cover, and access to forage during the winter. Thus, quality moose habitat consists of a mosaic of different, interspersed seral stages. In B.C., many enhanced forestry practices strive to shorten the duration of the earliest seral stages following logging, thereby promoting the rapid regeneration and growth of conifers. By truncating the early successional stages, the length of time that such areas provide suitable foraging conditions for moose is decreased. Further, the road access associated with such forestry operations can increase the vulnerability of moose to humans and other predators such as wolves.

The presence of moose in the Nass Watershed may be a relatively recent phenomenon that began this century. This view is supported by the fact that the traditional Nisga'a language does not have a name for this species. Regardless of whether moose have recently colonized the area or whether a small, local population simply irrupted as a result of improvements to the suitability of the regional environment, the Nisga'a have hunted moose for food, social, and ceremonial purposes for decades. During this century, the popularity of this species as a game animal with native and non-native people throughout its North American range has produced intensive management strategies aimed at conserving viable populations. As the consumptive demands on this species continue, an important component of moose harvest management is accurate inventory (abundance) data. Another important component is the geographic definition (distribution) of the population being managed. The former data are obtained through aerial surveys, while the latter is partially obtained by identifying the home ranges and movement patterns of individuals that are believed to be members of the population in question. Habitat management designed to maintain or enhance a moose population requires information specific to the population's needs for food, cover, and access to mates.

The combination of forestry practices and intensive harvest by hunters have led to considerable concern about the moose population in the Nass Watershed. The protection and enhancement of moose populations during forest harvesting and renewal requires information on the geographic and habitat-related distribution of moose, their population size and seasonal movements. Because moose may move long distances between seasonal ranges, they may be affected by forest practices and resource uses in distant parts of the study area or beyond the study area boundaries. It is critical to understand the factors affecting the moose population and, therefore, it is essential to determine the seasonal movements of moose using the Nass Watershed. Because of seasonal movements, it is difficult to manage moose populations in a relatively small area without considering the landbase that encompasses all of their seasonal ranges. Consequently, in 1997 a series of population, movement, and habitat studies of moose were initiated in the

Nisga'a Traditional Territory (containing the Nass Wildlife Area (NWA)). The results of the 1997 population survey were originally reported in Demarchi et al. (1997). However, as explained in this report, sightability corrections applied to those results are in error due to the incorrect use the Anderson and Lindzey (1996) sightability-correction model. Corrected values are presented in this report. Two other annual reports were prepared (Demarchi and Johnson 1998b; 1999). The results of the habitat study as reported in Yazvenko et al. (2000) comprise a key component of this study.

Objectives

Moose are an important species for many reasons including both consumptive and non-consumptive uses. As a result of public demand for this renewable resource, moose are actively "managed" throughout North America. Biologists and managers of moose require adequate information about moose populations so that harvests and habitat management can be conducted in ways that are best suited to attaining the goals of moose management. This study had the following objectives:

- To inventory moose in key portions of the Nisga'a Traditional Territory, including the NWA
- To record seasonal movement patterns of moose, between and within drainages and elevations in the middle to upper Nass River drainage, and adjacent drainage systems
- To assess probable causes of mortality of radio-collared moose
- To quantify second-order habitat selection (Johnson 1980) by moose
- To collect and interpret ancillary information that may contribute to moose management in the NWA

Ultimately, it is hoped that this research will provide biologists, wildlife managers, and others concerned about moose conservation in the Nass Valley with quantitative information that will benefit moose conservation.

STUDY AREA

The Nass Wildlife Area

The Nisga'a Traditional Territory is comprised of most of the Nass River watershed, and land that is east of the international boundary and south of the Unuk River and Treaty Creek (Figure 1). Excluding topographic effects on area, the Nisga'a Traditional Territory is ≈24,670 km^2. Within that territory, the Nass Wildlife Area (NWA) consists of all the Nisga'a Traditional Territory south of the height-of-land between Bowser Lake and Meziadin Lake to the confluence of the Taylor and Nass rivers, eastward along the Nass River then along Vile Creek to the height-of-land between the Nass and Skeena Basins (≈16,200 km^2; not including topographic area effects). The aerial survey was conducted within the Nisga'a Traditional Territory, while the radio telemetry study was centered within the NWA north of New Aiyansh.

Figure 1. Nass River Watershed.

The study area is predominately within the Interior Cedar Hemlock (ICH) biogeoclimatic zone, with lesser amounts of the Coastal Western Hemlock (CWH) zone in the southwest and the Mountain Hemlock, Englemann Spruce-Subalpine Fire, and Alpine Tundra biogeoclimatic zones at higher elevations (Banner et al. 1993). The area is within the Nass Basin ecoregion, Nass Ranges ecoregion, and the Coastal Gap ecoregion of the Coast and Mountains ecoprovince (Demarchi et al. 1990). The climate ranges widely from maritime in the southwest to continental in the northeast.

Conifers including western hemlock (*Tsuga heterophylla*), Roche spruce (*Picea sitchensis* x *glauca*), western redcedar (*Thuja plicata*), lodgepole pine (*Pinus contorta*), and subalpine fir (*Abies lasiocarpa*) are common. Deciduous species such as black cottonwood (*Populus balsamifera trichocarpa*), paper birch (*Betula papyifera*), trembling aspen (*Populus tremuloides*), red-osier dogwood (*Cornus stolonifera*) and willows (*Salix* spp.) are common on riparian habitats and some sites that have been disturbed by fire or logging. Clear-cutting of coniferous forests is the primary industry and it occurs throughout the forested portions of the study area. A detailed description of the vegetation communities in the study area is given by Yazvenko et al. (2000).

METHODS

Moose Population Survey

The population survey of moose in the study area followed a modification of the "stratified random block design" presented by Gasaway et al. (1986) and as conducted in the study area during February 1994 by B. C. Ministry of Environment, Lands and Parks (MELP) personnel (Wildlife Branch 1994). Information presented in Wildlife Branch (1994) assisted in the identification of potential moose habitat, and thus, survey boundaries. Polygons within the survey area corresponded to Broad Ecosystem Units (BEU) (Erwin et al. 1997). Digital BEU data were obtained from MELP. BEUs represent "permanent" areas of a landscape that are represented by distinctive plant communities (e.g., spruce-black cottonwood riparian) or physical structures (e.g., lakes, rock outcrops) that are meaningful to large species of wildlife.

We opted for a habitat-based approach to defining our sampling units for several reasons. First, moose exhibit patterns of habitat selection that can be predicted from appropriate habitat inventory data (Kelsall 1987; Timmerman and McNicol 1988; Langin and Eastman 1990). Second, the development of a local model of moose habitat selection facilitates the extrapolation of habitat-specific moose densities across both time (i.e., to provide the basis of habitat management prescriptions for areas with varying degrees of habitat capability[2] in order to maintain or enhance their suitability) and space.

[2] Habitat capability is defined as the *potential* of an area to support a species under ideal conditions. Habitat suitability represents the *actual* ability of an area to support a species *at a given time*. Thus it is possible for a site to have high capability (due to physical factors such as climate, soils, slope, aspect, etc.), but low suitability (e.g., due to: existing habitat conditions such as cover:forage ratios; proximity to roads; or proximity to other seasonal ranges).

Observations made by the author while searching for moose to capture and radio-collar prior to the survey provided a perspective of the relative local abundance and densities of moose in the study area. Survey maps (1:50 000 scale) of the BEUs were prepared from digital BEU data and TRIM data. These maps also indicated the location of areas within the moose survey conducted by MELP during 1994 (Wildlife Branch 1994).

Prior to going into the field, we used accepted knowledge of moose habitat requirements in order to identify potential moose wintering areas. That approach was initially used by MELP biologists for the 1994 survey. By identifying areas where the probability that moose were present was extremely low (typically areas of higher elevation and greater snow depths), survey efforts and costs are allocated more efficiently. Such areas are represented on mapping as uncoloured areas within the "zero" stratum. The Wildlife Branch (1994) report did not name areas that corresponded to the "zero" stratum as used in the present study. It is implied that the uncoloured areas depicted on the maps of Wildlife Branch (1994) had no potential to support moose and as such, were not considered part of the study area to be stratified. However, within the area that was initially delineated as potential moose winter range, a "nil" stratum was subsequently identified by Wildlife Branch (1994). No polygons within that stratum were surveyed in 1994.

The author, two observers and a pilot flew over the study area in a Bell 206 Jet-Ranger helicopter. All sightings of moose and fresh moose tracks were noted for each sampling unit (i.e., broad ecosystem polygon). The primary observer then subjectively assimilated that information and assigned each sampling unit to either the "high", "medium", "low" or "very low" stratum. Large polygons were subdivided into smaller ones if substantial variations in moose density were perceived across specific areas. During the reconnaissance and stratification process, polygons in the "high" stratum were defined as those with frequent moose sightings and extensive use as evidenced by an abundance of tracks. Units in the medium stratum had slightly lower perceived densities of observed moose and tracks than for the high stratum. Units in the "low" stratum had very low numbers of sightings and tracks. Polygons were assigned to the "very low" stratum if no moose or fresh tracks were observed. Because polygons were not searched completely during the reconnaissance phase, assignment to the "very low" stratum did not mean that it could be concluded with certainty that no moose occurred in such areas. Rather, the objective was to partition some of the variation in spatial densities of moose in order to reduce the size of the confidence interval of the final population estimate. Data from the "low" and "very low" strata were lumped for subsequent population analyses because of the similar densities of moose observed in those two strata.

Following the stratification flights, polygons were grouped by stratum and randomly selected for sampling (using the RAND function of Excel 5.0). Once a minimum of three units within each stratum had been sampled, an index of stratum variance was calculated ("in-the-field" variances were based on the number of animals observed divided by the duration of the survey for that polygon) in order to optimally allocate sampling effort.

Depending on size, polygons were either surveyed completely or sub-sampled by surveying a portion that was randomly chosen before arriving at the polygon. Regardless of the approach, we attempted to *census* the entire area covered. As a result, flights were typically below 50m altitude (AGL) and at 25-40 km/h (depending on tail-windspeed and the openness of the terrain). The distance between flight lines increased with the openness of the terrain, but generally corresponded to the 150-250 m widths recommended by Anderson and Lindzey (1996). In order to maximize survey efficiency by minimizing helicopter time spent ferrying between fuel caches and survey polygons, the survey duration of most polygons that were sub-sampled corresponded to the amount of time allowed between refueling. The area of most surveyed polygons was within recommended 10-30 km^2 range (Resources Inventory Committee 1997). To avoid fatigue, observers spent a maximum of 5 hours per day engaged in intensive searches.

A hand-held GPS unit (Magellan ProMARK X) logged the time and position (i.e., UTM coordinates and altitude) of the helicopter every 3 s (raw data were logged every 5 s). Sightings made by observers were recorded using a cassette recorder. Each observer recorded all sightings regardless of who initially made each sighting. Moose were classified by age (adult, yearling, calf) and sex (following Mitchell 1970) where possible. For each sighting, several other types of information were collected. They included the time (hh:mm:ss; for linking to the GPS database); the animal's initial behaviour (i.e., bedded, standing, feeding, etc.); the dominant cover type (e.g., spruce, cottonwood, hemlock-pine, etc.); and an estimate of the proportion of the ground within a 10-m radius around each animal that was obscured from view by vegetation (following Anderson and Lindzey 1996). Other significant sightings, including bald eagles, gray wolves (*Canis lupis*), wolverines (*Gulo gulo*), and wolf-kill sites, were also recorded. As a data backup, and to reduce the probability of recounting animals during the survey, all observations of moose were plotted on the navigational maps during the survey.

Data analyses to derive population estimates followed the methods for stratified random block analyses presented in Freese (1962). Data and formulas were entered into an EXCEL 5.0 spreadsheet.

The issue of sightability correction factors (SCFs), as developed from and applied to survey results of moose (and other ungulates), has been the subject of much literature (e.g., Cook and Jacobson 1979; Gasaway and Dubois 1987; Anderson and Lindzey 1996). Wildlife researchers have attempted to deal with problems related to sightability in a variety of ways. The method for addressing visibility bias as described by Resources Inventory Committee (1997) is called "two-stage sampling". Two-stage sampling *assumes* that intensive searches of a subsample (*i.e.,* the second-stage sample) of survey blocks will reveal *all* moose within each subsampled block. Although researchers recognize that this assumption is seldom satisfied during aerial surveys in forested environments, it is often assumed that failure to meet this requirement does not necessarily invalidate the results. The differences between the first- and second-stage samples are used to estimate the proportion of animals missed during first-stage sampling, and the differences are used to adjust the population estimate for survey blocks where only first-stage surveys are conducted. As acknowledged in the section on two-stage sampling in Resources Inventory Committee (1997), in much of the province "...the 'intensive' survey will still miss a substantial number of animals". Results from our attempts to visually locate radio-collared moose during routine monitoring[3] support this. Those findings indicated that even when intensive searches were conducted, the dense forest canopies that characterize much of the Interior Cedar Hemlock biogeoclimatic zone of the study area greatly reduced the probability of sighting a collared animal which, according to the VHF signal, was within a sightable range.

Our surveys of all blocks were conducted at an intensity comparable to the second-stage (intensive subsampling) surveying of the two-stage sampling design. Furthermore, the intensity (i.e., transect width and ground speed) with which our surveys were conducted were comparable to those of Anderson and Lindzey (1996). Therefore, the Anderson and Lindzey model was initially used to account for the "substantial number of animals" that was likely to have been missed. But because the population results yielded by the model were unrealistic, in order to achieve consistency with the 1994 survey, a SCF of 1.2 was subsequently applied to all results.

Moose Capture

Adult moose were captured[4] on wintering habitats in the Nass River valley (south and east side below Meziadin River; west side above Meziadin River) and Cranberry River valley using net guns from a Hughes 500 helicopter. Sampling efforts focused on low-elevation (150-550 m ASL) winter range between Dragon Lake to the south, Douse Creek to the east, and Hanna Creek to the north. Moose that were under heavier tree cover were hazed into open areas (e.g., meadows, swamps, cutblocks) where possible. Once netted, animals were hobbled and blindfolded during the handling process. For each animal captured, blood samples were taken for serological testing (i.e., pregnancy); hair and follicle samples were taken for tissue and genetic data-banking; a yellow, plastic, numbered eartag was affixed; and a Lotek VHF radio-collar (neck) with a mortality sensing switch (24-hr delay) was deployed. Battery life of the collars was rated at 48 months. Rumps were palpated for a general assessment of body fat (high; medium; low), and the presence of accompanying calves was noted. Further information collected for each animal included sex, estimated age (based on body size and tooth wear), capture date, and capture location (latitude and longitude) from the helicopter's GPS. Blood and hair samples were submitted to Dr. H. Schwantje (Wildlife Veterinarian, MELP) for archiving and analysis. Animal Handling Forms (RIC) were completed and submitted for inclusion in the provincial database.

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[3] These searches did not constitute formalized sightability trials as per the methods of Anderson and Lindzey (1996).
[4] Ministry of Environment, Lands and Parks Sundry permits C073152 and C073619

Pregnancy Testing

Serum samples of cow moose captured in 1997 and 1998 were analyzed for progesterone concentrations by the Endocrine Service Lab of the Western College of Veterinary Medicine, Saskatoon, Saskatchewan. Test results were cross-checked with field observations of collared cow moose with calves after April.

Radio Telemetry

Radio-collared moose were monitored using a Lotek SRX-400 radio-receiver and 2 H-antennas mounted on the skids of a Robertson-44 helicopter, a Bell 206 JetRanger helicopter, or a Cessna 206 fixed-wing airplane. An attempt was made to locate each moose at an interval of 3-4 weeks. For each monitoring session, several types of information were recorded:

- date and time of location;
- moose's location (from GPS[5]);
- whether or not moose was located by sight;
- number of calves observed near collared cow moose;
- number of other moose near collared moose;
- habitat description of location based on visual observations;
- initial behaviour of sighted moose; and
- all relevant comments.

A habitat category was recorded for each radio-location. Habitat categories included:

- cutblocks <20 years of age
- second-growth forest dominated by conifers
- second-growth forest dominated by deciduous trees
- second-growth mixed forests containing similar amounts of coniferous and deciduous trees
- mature forest dominated by conifers
- mature forest dominated by deciduous trees
- mature mixed forest containing similar amounts of coniferous and deciduous trees
- edge habitats (i.e., a boundary between habitat categories)
- meadow
- subalpine coniferous forest
- wetland

[5] The ± ≈100 m horizontal error associated with Selective Availability is not believed to have significant implications for the accuracy of home range calculations

Where possible, mortality signals were investigated on-foot. Information pertaining to the likely cause of mortality was recorded. An address and telephone number on the radio collars facilitated their return from hunter-killed animals. Animal Observation Forms (RIC) (location by radio-telemetry) were completed and submitted for inclusion in the provincial database.

Movements

Movement rates of individual moose were obtained by dividing the straight-line distances between successive locations by the number of days separating those locations. Obviously this approach does not represent the actual distance travelled by an animal, but it is useful for identifying when migrations between seasonal ranges occur.

The year was broken into two seasons according to general patterns of moose movement evident from the data: (1) winter (December through April), and (2) non-winter (May through November). The spatial separation of locations for each animal in each of the two seasons was visually examined using the GIS program MapInfo. To determine the migratory status of each moose, locations colour-coded by season, were plotted on-screen. Animals whose seasonal locations showed a clear spatial separation were deemed "migratory". Those with intermingling seasonal locations were deemed "non-migratory". Several animals had too few relocations to permit the assessment. With the exception of a few migratory individuals that displayed one or two non-winter locations mixed in with the winter locations (or vice versa; a product of variation in actual migration timing around the limits of the defined seasonal dates), seasonal locations were either clearly separated (clustered) or not. Because of this, it was not necessary to devise other quantitative decision-making algorithms (e.g., calculations based on interlocation distances) to assist in determining migratory status. NTS contours (1:250 000) were also plotted on-screen to supplement information for migratory animals with seasonal ranges differing in elevation (z-axis) as well as in east-west (x-axis) and north-south (y-axis) directions.

Habitat Use

Wildlife researchers use several approaches to handle the conversion of point-data to an area that represents the habitats used by an animal. We considered several of the most commonly used methods, including: (1) minimum convex polygon (Mohr 1947), (2) harmonic mean (Dixon and Chapman 1980), (3) Fourier series (Anderson 1982), (4) 95% ellipse estimators (Jennrich and Turner 1969; Koeppl et al. 1975), and (5) kernel density estimation (Worton 1989, 1995). Kernel density estimation was selected as the most appropriate method for the purposes of this study because it is considered to be state-of-the-art by researchers that perform such analyses (Seaman et al. 1998) and because it accurately depicts discrete core-use areas. The Home Ranger (Hovey 1999) software was used to perform the calculations in this regard. However, to facilitate comparisons with other studies, multi-annual 100% minimum convex polygon (MCP) home ranges were also calculated using the program Antelope (Bradbury and Vehrencamp 1998). Fixed kernel density estimates were calculated using a grid resolution of 255 (the maximum resolution permitted by the program). A least-squares cross-validation of the smoothing parameter (h) with a post-hoc adjustment factor of 0.8 was used, and values were standardized for covariance. The resulting contours around the moose locations represent the utilization distribution. For example, the 25% utilization contour delimits the area where there is a 25% probability that an animal is within that boundary at any given time, and as such, depicts core-use areas. The 95% utilization contour delimits the area where there is a 95% probability that an animal is within that boundary at any given time, and as such, represents the home range (seasonal home range where locations are analyzed by season). Topographic effects on area were not included. As recommended by Hovey (1999), home range sizes are reported using the fixed kernel estimator. Contour information output by The Home Ranger (Hovey 1999) was imported into ArcInfo for spatial analysis.

Digital weather records were obtained from the B.C. Ministry of Transportation and Highways, Snow Avalanche Programs, as recorded at the Endgoal, Meziadin, and Kitwanga weather stations. The Endgoal station is located beside Highway 37A, 2.7 km west of the Surprise Creek bridge (56° 06’ 00” N, 129° 30’ 30” E). The Meziadin station is located near the northeastern shore of Meziadin Lake (56° 06’ 00” N, 129° 18’ 18”E). The Kitwanga station is located in Kitwanga (55° 07’ 42” E, 128° 00’ 30” N). Weather records from the Meziadin station were not recorded until January 1999 during the winter of 1998-99.

Habitat mapping was prepared by Yazvenko et al. (2000) using the U.S. Fish and Wildlife Service's Habitat Evaluation Procedures. Models from Yazvenko et al. (2000) used to calculate habitat suitability are presented in Appendix I. Habitat selection can be viewed as a hierarchical process. According to Johnson (1980), first-order selection describes the physical or geographical range of a species or population (e.g., the distribution of moose by ecoprovince); second-order selection describes the home range of an individual within the species' or population's range; third-order selection describes the use of habitat components (e.g., food, cover) by an individual within its home range. For this study, analyses of habitat selection were conducted at scales generally commensurate with: (1) second-order selection—the habitat composition of seasonal home ranges in light of habitats considered "available" to the sample of collared moose; and (2) third-order selection—the habitat composition of core-use areas within individual seasonal home ranges.

Habitat preference was determined by overlaying the seasonal 95% utilization distributions on several habitat coverages: (1) biogeoclimatic subzones/variants in the entire mapped area (2) biogeoclimatic subzones/variants in an area within a single buffer of 10 km around a plot of *all* moose locations, (3) the winter habitat suitability index (HSI) map within the 10-km buffer, (4) the summer HSI map within the 10-km buffer; and by overlaying the respective seasonal 25% utilization distributions on: (1) the winter HSI map within each moose's winter 95% utilization distribution, and (2) the non-winter HSI map within each moose's non-winter 95% utilization distribution. The 10-km buffer was established to delineate an area that could reasonably be deemed as available to the animals in this study. The Johnson (1980) method, as calculated by the program

PREFER (Pankratz 1994), was used to determine habitat preferences. For all tests[6], α=0.05, and K=100. Results were presented in rank order of preference where habitat units that were not significantly different from one another were connected with an underscore.

RESULTS

Moose Population Survey

In February 1997, a total of 194 moose was observed in surveyed polygons: 99 cows, 34 bulls, 6 yearlings, 46 calves, and 9 unclassified moose. Two of 99 cows (2%) had twin calves, 39 cows (39%) had single calves, 3 lone calves were observed, and the remaining 58 cows (58%) were not observed with calves. During surveys, 4 bulls, 2 cows and 1 calf (the calf was with one of the cows) were observed outside survey boundaries. These latter observations were not used to develop population estimates, but were used to increase the sample sizes of data used to determine bull:cow and calf:cow ratios. The sex ratio of the population was 37 bulls per 100 cows, and the ratio of calves to cows was 47:100. Observations are presented in Appendix II. Incidental sightings during the survey are presented in Appendix III.

Application of Anderson and Lindzey's (1996) sightability model yielded unreasonable results (i.e., 33,114 ±95%); due in large part to the considerable number of moose sighted in the upper cover classes. The accuracy and precision of the Anderson and Lindzey model drops sharply at the upper cover classes (C. Anderson, pers. comm. 1998). Applying the same sightability correction used by MELP for the 1994 survey (i.e., 1.2) to the raw data yielded a population size of 1292 ±38.1% in the entire 5926 km^2 surveyed area, and 724 ±39.8% in the 3677 km^2 NWA[7].

Moose Capture, Radio-collaring, and Monitoring

Twenty moose were collared in January 1997 and 18 were collared in February-March 1998. During 45 relocation sessions[8] (separated by a mean of 25 days), from 3 to 44 relocations were obtained for individual moose. On average, 95% (SD=6%) of the radio-collars believed to be transmitting in the study area were detected during each session. Including capture sites, 1075 locations were obtained through 5 March 2000 (Appendix IV).

The moose population in the NWA contains both migratory and non-migratory animals (Table 1). Migratory moose represented 71% of the sample for which a strategy was identified. Separation between winter and non-winter ranges varied considerably.

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[6] K is a value in the Waller-Duncan Procedure (see Johnson 1980).
[7] The actual size of the NWA is ≈16,200 km^2. The figure of 3677 km^2 represents that portion of the NWA that was stratified as potential moose habitat.
[8] Eight sessions spanned two days each.

Although some bulls and cows moved considerable distances[9] between winter ranges near the Cranberry River and non-winter ranges to the north in the White River and upper Nass River valleys, all remained within the NWA.. Moose that undertook short migrations used winter and non-winter ranges that were adjacent to each other, but were separated by elevation whereby higher elevations were used during the non-winter season. Migratory animals moved a mean maximum straight-line distance of 43.2 km (SD=22.6 km; n=25) and non-migratory animals moved a mean straight-line maximum distance of 13.3 km (SD=8.0 km; n=9). The greatest straight-line distance between an individual's locations was 74.5 km (Moose 2; Table 1). Elevations used by collared moose ranged from 200 m (i.e., the main valley bottoms) to nearly 1500 m (i.e., near treeline), with an average of ≈400 m (Table 1). No variation attributable to sex was apparent. At 348 m (SD=157 m; n=498), the mean elevation of all winter locations was significantly lower ($p<0.001$; t-test) and less variable than the mean elevation during the non-winter period (i.e., 470 m; SD=251 m; n=577).

Average straight-line movement rates between successive locations of migratory moose varied among individuals and within individuals across time (Figure 2). Two seasonal peaks in movement rates were evident. The first occurred during April and June, followed by a second in December and January. Movement rates during the rut (i.e., September-October) were typically some of the lowest recorded during the year.

Each year, migration between winter and non-winter ranges corresponded to a time of the year when the snowpack was rapidly decreasing (Figure 2 and Figure 3). The onset of migration to wintering areas corresponded to periods of rapid increases in snowpacks. Based on field observations during relocation flights, snowpack in most of the study area likely falls between the two extremes depicted in Figure 3, with data from the Endgoal station and Kitwanga station being more representative of the northern and southern limits of the study area, respectively. Regardless of any absolute differences, the trends in snow accumulation and melting in the study area are expected to be very similar to those depicted by these extremes, given the correlation (r=0.55) between daily snowpacks at the Endgoal and Kitwanga stations and the similarities evident in Figure 3.

9 Straight-line distances from multi-annual data represented in Table 1 probably underestimate the actual distance moved during any given migration

Table 1. Migratory status, maximum straight-line distances between any two moose locations, elevations, 95% fixed kernel density multiannual home ranges, and 100% minimum convex polygon multiannual home ranges of radio-collared moose[a] through 5 March 2000. Bulls are underlined. Nass Wildlife Area.

			Elevation (m ASL)				Home Range (km^2)		
Moose[a]	Migratory Status	Maximum Distance (km)	Min	Max	Mean	SD	95% Kernel	100% MCP	Sample Size (n)
2	Migratory	74.8	170	763	408	167	384.0	804.8	35
10	Migratory	72.3	157	859	442	184	791.7	724.2	39
29	Migratory	69.9	155	831	412	190	591.8	589.7	25
3	Migratory	68.6	162	752	351	191	712.6	410.6	26
6	Migratory	66.6	160	361	259	45	255.2	424.4	44
8	Migratory	66.6	133	615	360	108	289.5	834.2	41
11	Migratory	64.7	147	570	348	85	529.7	633.1	45
13	Migratory	64.4	172	581	358	107	340.2	658.7	45
9	Migratory	64.2	145	608	335	101	209.4	470.3	41
33	Migratory	58.5	209	1062	590	240	129.6	611.7	22
23	Migratory	58.4	188	1018	583	218	252.4	502.3	23
27	Migratory	47.5	194	788	500	194	56.7	315.0	12
20	Migratory	41.8	186	931	341	202	99.8	148.7	41
32	Migratory	38.0	159	575	304	120	116.8	229.7	25
30	Migratory	33.0	200	924	562	189	47.3	120.7	25
26	Migratory	29.1	202	579	381	96	66.7	176.1	25
7	Migratory	23.5	143	516	367	103	74.6	58.0	44
36	Migratory	20.2	162	766	430	144	99.1	94.1	25
25	Migratory	19.9	217	1463	693	422	80.3	155.6	23
1	Migratory	18.4	201	1388	738	364	43.9	135.0	43
18	Migratory	18.4	187	446	309	63	139.2	122.7	29
12	Migratory	18.2	273	915	618	219	9.9	93.7	42
24	Migratory	16.5	291	1285	777	306	12.3	114.7	25
17	Migratory	13.5	259	891	434	160	34.6	47.8	44
16	Migratory	12.8	160	604	390	151	78.8	59.1	40
31	Non-Migratory	28.2	154	343	251	53	86.9	76.7	26
5	Non-Migratory	21.7	160	1270	430	301	36.8	120.1	39
15	Non-Migratory	19.7	205	329	256	33	55.0	55.1	43
14	Non-Migratory	11.3	154	548	249	103	40.2	29.8	27
22	Non-Migratory	10.7	219	450	359	49	15.3	24.5	26
34	Non-Migratory	8.4	257	630	432	125	28.1	17.7	25
4	Non-Migratory	8.1	154	588	326	139	55.3	25.6	18
28	Non-Migratory	6.9	244	424	311	48	35.0	14.6	11
38	Non-Migratory	4.7	253	502	308	73	27.1	8.2	11
37	Unknown	21.7	178	760	432	267	-	-	(4)
21	Unknown	15.5	152	554	344	122	-	-	(8)
35	Unknown	12.7	214	633	356	240	-	-	(3)
19	Unknown	2.7	270	305	282	15	-	-	(5)
			Mean Values		**414**	**222**	**171.3**	**262.0**	**31**

[a] Moose 1-20 were collared in 1997; Moose 21-38 were collared in 1998.

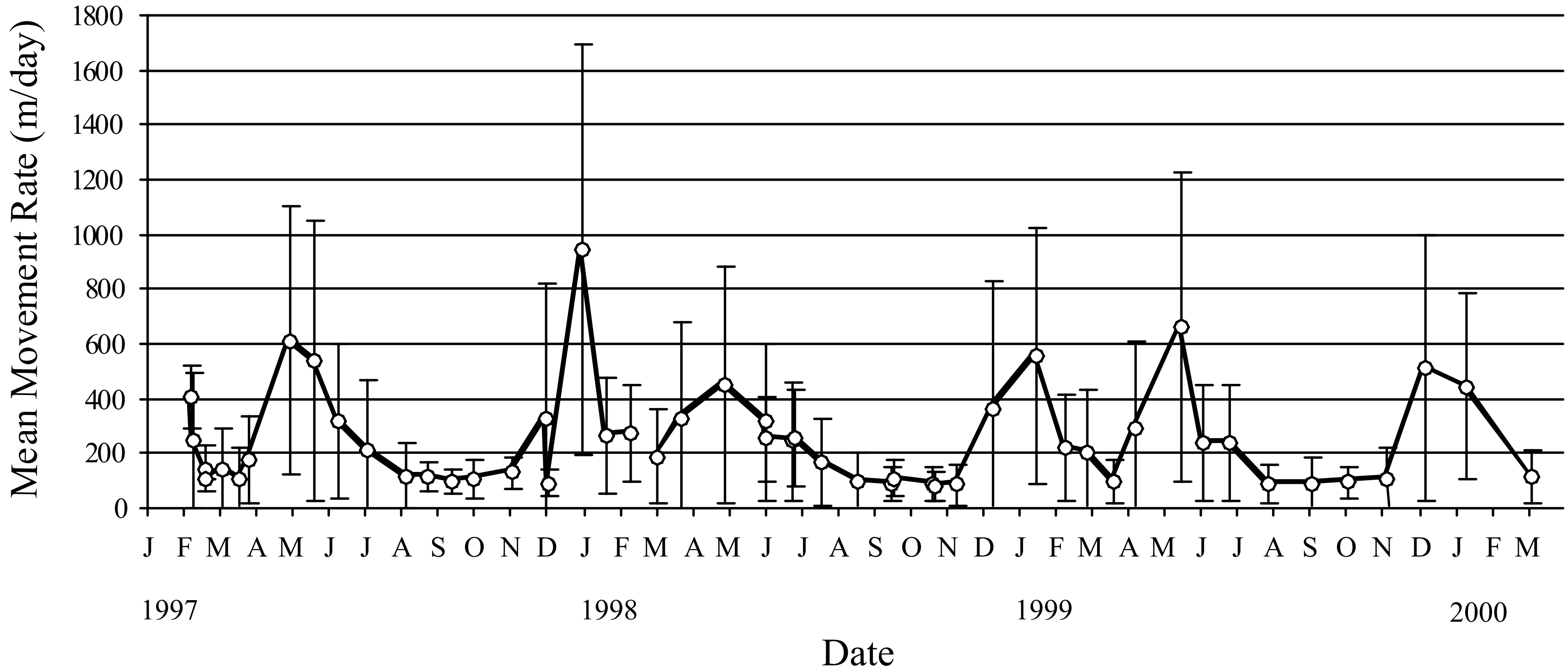

Figure 2. Mean daily straight-line movement rates of migratory adult moose from January 1997 through 5 March 2000. Error bars denote ±1 standard deviation. Sample sizes were a maximum of 10 until March 1998, and 19 thereafter.

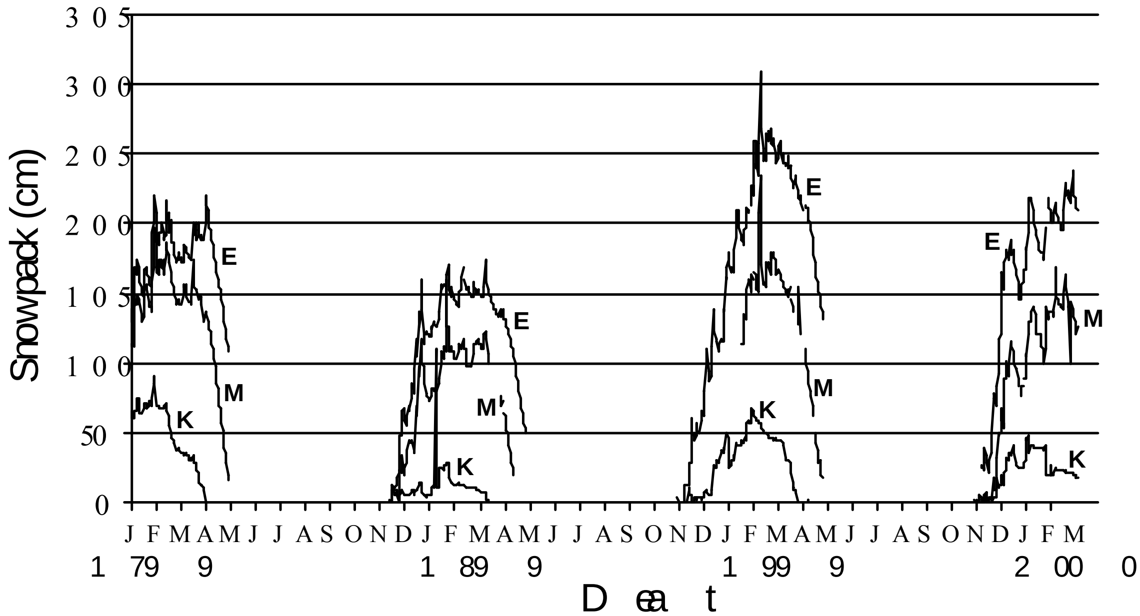

Figure 3. Total snowpack as measured daily at the Endgoal (E), Meziadin (M), and Kitwanga (K) weather stations between 1 January 1997 and 7 March 2000. Snow depth at the majority of locations used by collared moose is believed to be between the ranges of the Meziadin and Kitwanga data. Data were not collected at some stations on some days, hence the broken lines. Source: B.C. Ministry of Transportation and Highways.

Utilization distributions for the total area used during each of the two seasons by the radio-collared moose are presented in Figure 4 and Figure 5. For example, the 25% utilization contour delimits the area within which there is a 25% probability that an animal was present. Similarly, the 95% utilization contour delimits the area within which there is a 95% probability that an animal was present. As moose move between seasonal ranges, the contours around those locations change. Because the accuracy of the contours is partially a product of sample size, contours for seasons with fewer locations tend to be more expansive than those with larger sample sizes. More expansive contours also reflect more widely ranging movements. According to all levels of the utilization distributions, overall seasonal range size (for the pooled sample of radio-collared moose) was smallest in winter (Table 2). This fits the traditional pattern of moose behaviour in that they tend to restrict their movements during winter to a smaller area compared to other times of the year.

Figure 4. Utilization distributions of all moose locations during winter (December through April) between January 1997 and 5 March 2000.

Figure 5. Utilization distributions of all moose locations during non-winter (May through November) between January 1997 and 5 March 2000.

Table 2. Area (km^2) for five utilization distributions, as calculated using fixed-kernel estimation, of moose in the Nass Wildlife Area during two seasons and for the entire period from January 1997 through 5 March 2000. Sample size (n) indicates the number of relocations.

		Utilization Distribution (km^2)				
Season	n	25%	50%	75%	95%	99%
Winter	498	42.0	127.5	286.9	594.4	1051.9
Non-Winter	577	66.8	199.3	446.4	910.7	1628.0
Multiannual	1075	68.7	207.4	469.2	951.5	1641.8

According to the 95% utilization distributions, multiannual home range sizes of 34 moose ranged from 9.9-791.7 km^2, with a mean 171.3 km^2 (SD=206 km^2) (Table 1). Home range size was highly correlated (r=0.80, n=34) with the maximum distance between any two locations, supporting the assumption, as expected, that migratory individuals *tended* to have larger home ranges than non-migratory ones. However, because some migratory moose used adjacent seasonal ranges separated more by elevation than distance, this trend was not exhibited by all animals. Seasonal home range and core-use area estimates were obtained for 30 moose for which at least 10 locations during a season were obtained (Appendix V).

Pregnancy and Calf Production

Results from the 17 cow moose captured in 1997 indicated that 13 (81%) were likely pregnant, two (12%) were likely not pregnant, and the reproductive condition of two (12%) was indeterminate (Appendix VI). One of the latter two cows (Moose 19) died before the calving season and the other (Moose 16) was never sighted with a calf, implying she was probably not pregnant. Neither of the two cows likely not pregnant according to progesterone levels was observed with a calf believed to be theirs. Two "pregnant" cows (Moose 11 and Moose 18) were never observed with a calf. The pregnancy rate of the sample was estimated at 81% and, given that a minimum of 12 calves (including both members of sets of twins) were seen with 16 cows, the calving rate was estimated at 75 calves per 100 cows. One set of twins was observed.

Results from the 13 cow moose captured in 1998 indicated that 10 (77%) were likely pregnant, two (15%) were likely not pregnant (Moose 30 and Moose 37), and the reproductive condition of one (8%) was indeterminate (Moose 29) (Appendix VI). One of the “not pregnant” cows died before the calving season and her carcass was inaccessible. Despite repeated sightings of the other “not pregnant” cow and the “undetermined” cows, no calves were ever observed with them (Appendix VII). Assuming Moose 29 was not pregnant, the minimum pregnancy rate of the sample (n=13) was estimated at 77%. A minimum of 21 calves-of-the-year (including both members of sets of twins) accompanied the 27 cows that were alive at the beginning of the 1998 calving season (Appendix VII), suggesting a minimum calving rate of 78 calves per 100 cows. Given that Moose 25 and Moose 36 were not seen with calves but were pregnant according to serological testing, and assuming that each of those cows produced one calf, a more realistic calving rate may be 85 calves per 100 cows (n=23 calves; n=27 cows). Five sets of possible twins were observed.

No blood samples were analyzed in 1999. Results from two flights in June, during which we attempted to determine calf production, indicated that of 21 cows alive at the beginning of the 1999 calving season, 17 were sighted with a total of 15 calves (including both members of sets of twins) (Appendix VII). Of the four cows that were not sighted in June, only one (Moose 12) was subsequently observed with a calf that was probably hers. For 1999, this indicates a minimum *observed* calving rate of 89 calves per 100 cows (i.e., 16 calves, 18 cows). Three sets of twins were observed.

Mortality

Adults

Twelve mortalities of radio-collared moose occurred through 5 March 2000. Seven of the 20 moose collared in 1997 died during the study as did five of the 18 collared in 1998 (Table 3). The fates of two animals (Moose 9 and Moose 35) are unknown. Hunting was the greatest cause of mortality of collared moose, accounting for 58% (n=7) of all deaths (n=12). Only two mortalities (17%) are believed to have been caused by wolves (Moose 19 and Moose 28); however, wolf predation may have accounted for a maximum of four deaths (33%) if Moose 2 and Moose 37 were killed by wolves. The annual adult mortality, standardized to 1 March of each of the year was 9% in 1997-98, 23% in 1998-99, and 8% in 1999-2000. For the entire period, the average annual adult mortality[10] was 13.2%.

Table 3. Summary of moose mortalities through 5 March 2000. Moose numbered 1-20 were collared in January 1997; 21-38 were collared in late February-early March 1998. Males are identified by “m”.

Moose	Date Observed/ Reported	Actual/Estimated Date of Mortality	Cause
19	19-Mar-97	within days	abundant wolf sign; predation by wolves suspected
4	22-Jan-98	within 2 days	unknown; warm, emaciated carcass found in-tact
37	3-Jun-98	within 4 weeks	unknown, not recovered; remote, heavily forested area away from roads
21	21-Sep-98	same	hunter kill; collar returned by hunter
3m	23-Oct-98	same	hunter kill; collar returned by hunter
14	11-Nov-98	within 1 week	hunter kill; collar found near 5 moose gut-piles
18	16-Jan-99	within 5 weeks	hunter kill; cut collar found near gut-pile
28	16-Jan-99	within 5 weeks	abundant wolf sign; predation by wolves suspected
38	15-Jan-99	within 1 week	hunter kill; collar returned by a third party
27m	25-Jan-99	21-Jan-99	hunter kill; collar returned by hunter
2	10-Apr-99	within 24 hours	near road; wolves observed; no sign of struggle; cause unknown
16	7-Dec-99	4-Oct to 6 Dec	presumed hunter kill; cut collar found in a creek

Note: Moose 35 was never located after 1 May 1998; Moose 9 was not located after 5 November 1999.

[10] Exclusive of moose 35, which was unaccounted for after 1 May 1998 and exclusive of moose 9 for the period of 5 November 1999 through 5 March 2000.

Calves

Assuming that all surviving calves remained with their dams and that they were observed up to and including either of the monitoring flights in January 1998, mortality for calves up until that point was estimated to be 42% (i.e., 5 of 12 calves died). If the calf of Moose 4 survived, then mortality was estimated to be 33% (i.e., 4 of 12 calves died) for the same period. For surviving cows (n=16), the ratio of calves per 100 cows was estimated to be 47:100. If the calf of Moose 4 survived, that estimate was actually 50:100. This analysis was only carried out until late January 1998 because patchy snow conditions (i.e., poor sightability) and/or the association of two or more cows (i.e., indeterminate parentage) as observed on flights after that time confounded our method of monitoring calves with radio-collared cows.

Assuming that all surviving calves remained with their dams, and that if present, they were observed during either of the monitoring flights in December 1998 or January 1999, mortality for calves up until that point was estimated to be 21% (i.e., 15 of 19 calves survived). Assuming that the two calves of the two cows that died in January 1999 (i.e., Moose 28 and Moose 38) did not survive, for cows alive during the relocation flight in January (n=22), the minimum ratio of calves per 100 cows was estimated to be 59:100 (n=13 calves; n=22 cows). Survival of those two other calves would boost the minimum ratio up to 68:100.

Assuming that all surviving calves remained with their dams, and that if present, they were observed during the monitoring flights in December 1999 through March 2000, the minimum mortality for calves to that period was estimated to be 44% (i.e., seven of 16 calves died). Assuming the calf of Moose 16 did not survive, the minimum ratio of calves per 100 cows was estimated to be 50:100 (n=9 calves; n=18 cows). Moose 5 was excluded from that calculation because she was seen only once, for a brief period, during 1999.

Habitat Use

Point Locations

Habitat information obtained for individual positions from visual observations during the relocation flights is presented in Table 4. Because of the limitations inherent in statistically analyzing habitat preferences from such data (i.e., obtained only during the day and under favourable flying conditions), these data are only presented for general information purposes.

Moose used a variety of habitat types during each season (Table 4). As a proportion of use, mature coniferous habitat was used more than any other habitat. Relative use of that habitat was greatest during non-winter. Greatest use of stands of mixed coniferous and deciduous species occurred during winter. Young cutblocks (i.e., <20 yr) were used during both seasons, but proportionately more use occurred during winter.

Table 4. Distribution of moose locations in broad habitat types during the two seasons. Percentages are indicated in italics.

	Season			
Habitat	Winter		Non-Winter	
Cutblock <20 yr	70	*15.1*	67	*12.0*
2nd Growth Coniferous	26	*5.6*	20	*3.6*
2nd Growth Deciduous	0	*0.0*	2	*0.4*
2nd Growth Mixed	40	*8.6*	22	*3.9*
Mature Coniferous	145	*31.3*	240	*43.0*
Mature Deciduous	61	*13.2*	63	*11.3*
Mature Mixed	114	*24.6*	97	*17.4*
Edge	2	*0.4*	5	*0.9*
Meadow	0	*0.0*	1	*0.2*
Subalpine Coniferous	0	*0.0*	5	*0.9*
Wetland	5	*1.1*	35	*6.3*
Total	463		558	

Total numbers of locations by habitat type and the proportion of those locations for which the collared animal was sighted or not sighted are presented in Table 5. For more extensively used habitats, sightability was high in all but the mature coniferous habitat.

Table 5. Numbers and percent of locations by general habitat category for which the collared animal was sighted during relocation flights from 19 February 1997 through 5 March 2000, Nass Wildlife Area. Only tracking flights using a helicopter are included.

	Locations		Winter		Non-Winter	
Habitat	winter	nonwinter	not sighted	sighted	not sighted	sighted
Cutblock <20 yr	70	64	*0.0*	*100.0*	*4.7*	*95.3*
2nd Growth Coniferous	26	20	*3.8*	*96.2*	*10.0*	*90.0*
2nd Growth Deciduous	0	2			*0.0*	*100.0*
2nd Growth Mixed	40	21	*2.5*	*97.5*	*19.0*	*81.0*
Mature Coniferous	145	222	*48.3*	*51.7*	*59.5*	*40.5*
Mature Deciduous	61	60	*6.6*	*93.4*	*18.3*	*81.7*
Mature Mixed	113	87	*15.9*	*84.1*	*43.7*	*56.3*
Edge	2	2	*50.0*	*50.0*	*100.0*	*0.0*
Meadow	0	1			*0.0*	*100.0*
Subalpine Coniferous	0	5			*60.0*	*40.0*
Wetland	5	30	*20.0*	*80.0*	*16.7*	*83.3*
Grand Total/overall	**462**	**514**	***38.9***	***61.1***	***20.8***	***79.2***

Winter and Non-Winter Habitat Preferences

Yazvenko et al. (2000) summarized the habitat suitability of a large portion of the Nass watershed. Results from that study were used in analyses of habitat preference by moose during the winter and non-winter periods. The key results from that study are summarized in Table 6 and Table 7.

Table 6. Habitat suitability of different biogeoclimatic subzones for moose in the study area (mean values weighted by area); Nass Wildlife Area, B.C. From Yazvenko et al. (2000).

		Non-Winter				Winter		
Subzone/ Variant	Area (ha) [a]	Food	Cover	Repro-ductive	Overall	Food	Cover	Overall
ATp	112729	Mod. High	Very Low	Low	Low	Nil	Low	Very Low
CWHws1	24521	Mod. High	Mod. High	Low	Moderate	Low	Mod. High	Low
CWHws2	83103	Mod. High	High	Low	Moderate	Low	High	Low
ESSFwv	140604	High	High	Low	Mod. High	Low	High	Low
ICHmc1	183841	Moderate	High	Low	Moderate	Low	High	Moderate
ICHmc2	84727	Mod. High	Mod. High	Low	Moderate	Moderate	High	Moderate
ICHvc	56647	Mod. High	Mod. High	Low	Moderate	Very Low	Mod. High	Low
MHmm1	14447	Mod. High	Low	Low	Low	Very Low	Low	Very Low
MHmm2	121383	Moderate	Moderate	Low	Moderate	Very Low	Moderate	Low

Table 7. Areas (ha) and percent (italics) of total area assessed for the main HSI model components and outputs in each habitat suitability class for moose in the study area; Nass Wildlife Area, B.C. From Yazvenko et al. (2000).

	Non-Winter								Winter					
HSI Class	Food		Cover		Reproductive		**Overall**		Food		Cover		**Overall**	
Nil	0	*0*	212618	*26*	0	*0*	**0**	***0***	284548	*35*	212618	*26*	**179866**	***22***
Very Low	0	*0*	21301	*3*	0	*0*	**0**	***0***	49163	*6*	14180	*2*	**106563**	***13***
Low	249758	*30*	89914	*11*	624692	*76*	**203412**	***25***	367659	*45*	77316	*9*	**403595**	***49***
Moderate	65109	*8*	43207	*5*	143983	*18*	**383270**	***47***	116306	*14*	56715	*7*	**106474**	***13***
Moderately High	210647	*26*	19768	*2*	40699	*5*	**220860**	***27***	4328	*1*	20475	*2*	**25505**	***3***
High	296489	*36*	435197	*53*	12629	*2*	**14462**	***2***	0	*0*	440700	*54*	**0**	***0***

Analysis of the results of intersecting the 95% winter utilization distributions (UD) of the sample (n=30) with the biogeoclimatic subzones/variants in the habitat study area (Yazvenko et al. 2000) yielded the results in Figure 6, where biogeoclimatic units are ranked from most preferred (left) to least preferred (right). Underscoring connects units deemed to be not significantly different (α=0.05).

ICHmc2 ICHvc **CWHws2** **ICHmc1** MHmm2 ESSFwv

Figure 6. Preference for biogeoclimatic units during winter: 95% UD within entire mapped area.

Preference of biogeoclimatic units was fairly similar to those in Figure 6 when the composition of those units within the winter 95% UD of each moose was compared to the composition within a buffer around all (n=1075) moose locations, with the main exception that CHWws2 was the most preferred unit (Figure 7).

CWHws2 ICHmc2 ICHvc MHmm2 ICHmc1 ESSFwv

Figure 7. Preference for biogeoclimatic units during winter: 95% UD within the 10-km buffer.

According to the food component of the winter HSI model (Appendix I) habitats within the 10-km buffer that were rated "moderate" were most preferred (Figure 8). Within the winter 25% UD (core area) of each moose, habitats available within the winter 95% UD having a "moderately high" food value were preferred. In both instances, habitats with "nil" or "low" food value were least preferred (Figure 9).

Moderate Mod. High Very Low **Low** **Nil**

Figure 8. Preference for HSI units according to winter FOOD HSI: 95% UD within the 10-km buffer.

Mod. High Moderate Very Low Low Nil

Figure 9. Preference for HSI units according to winter FOOD HSI: 25% UD within the 95% UD.

According to the cover component of the HSI model, in winter and within the 10-km buffer, moose most preferred areas with "moderately high" cover, and least preferred ones with nil or low cover value (Figure 10). There was no apparent preference for any cover class when core areas within the winter range of each moose was examined (Figure 11).

Mod. High Moderate Very Low **High** Nil Low

Figure 10. Preference for HSI units according to winter COVER HSI: 95% UD within the 10-km buffer.

Mod. High Very Low Moderate Low High Nil

Figure 11. Preference for HSI units according to winter COVER HSI: 25% UD within the 95% UD.

When both food and cover were considered in the HSI model, habitat preference according to the composition of the 95% winter UD compared to the make-up of the area within the 10-km buffer fit the pattern that might be expected, whereby habitats rated highest were preferred most (Figure 12). This pattern did not hold true when core areas were examined within seasonal ranges. According to that analysis, little, if any, preference was evident (Figure 13).

Mod. High **Moderate** **Low** Nil Very Low

Figure 12. Preference for HSI units according to winter OVERALL HSI: 95% UD within the 10-km buffer.

Very Low Mod. High Nil Moderate **Low**

Figure 13. Preference for HSI units according to winter OVERALL HSI: 25% UD within the 95% UD.

Preference for biogeoclimatic units during the non-winter period (Figure 14) did not differ markedly from the winter period, as only a slight change in the order of statistically different preferences was observed.

ICHvc **CWHws2** **ICHmc2** ICHmc1 MHmm2 ESSFwv

Figure 14. Preference for biogeoclimatic units during non-winter: 95% UD within entire mapped area.

When the composition of biogeoclimatic units within the non-winter 95% UD of each moose was compared to the composition of biogeoclimatic units within a buffer around all (n=1075) moose locations, the two most preferred and the least preferred units remained that way, but changes in the preference order of the remainder were observed (Figure 15 cf. Figure 14). In general, the differences in preference between units were less.

CWHws2 ICHvc **MHmm2** ICHmc2 ICHmc1 ESSFwv

Figure 15. Preference for biogeoclimatic units during non-winter: 95% UD within the 10-km buffer.

According to the food component of the non-winter HSI model (Appendix I) habitats within the 10-km buffer that were rated "low" or "moderate" were most preferred (Figure 16). Within the non-winter 95% UD of each moose, composition of the non-winter 25% UD (core area) indicated that habitats having "moderately high" or "moderate" food values were preferred (Figure 17).

Low Moderate Mod. High High

Figure 16. Preference for HSI units according to non-winter FOOD HSI: 95% UD within the 10-km buffer.

Mod. High Moderate High Low

Figure 17. Preference for HSI units according to non-winter FOOD HSI: 25% UD within the 95% UD.

According to the cover component of the HSI model, in non-winter and within the 10-km buffer, moose most preferred areas with "moderate" or "moderately high" cover, and least preferred ones with nil or low cover value (Figure 18). There was very little apparent preference for any cover class when core areas within the non-winter range of each moose were examined (Figure 19).

Moderate Mod. High Very Low High Nil Low

Figure 18. Preference for HSI units according to non-winter COVER HSI: 95% UD within the 10-km buffer.

Mod. High Moderate Very Low Low Nil High

Figure 19. Preference for HSI units according to non-winter COVER HSI: 25% UD within the 95% UD.

When both food and cover were considered in the non-winter HSI model, habitat preference, according to the composition of the 95% non-winter UD compared to the make-up of the area within the 10-km buffer, fit the pattern that might be expected. Habitats rated highest were preferred most. But according to statistical testing, there was considerable overlap among categories (Figure 20). This pattern did not hold true when core areas were examined within non-winter ranges. According to that analysis, no habitat preference was evident (Figure 21).

High Mod. High Moderate Low

Figure 20. Preference for HSI units according to non-winter OVERALL HSI: 95% UD within the 10-km buffer.

Very Low Mod. High Nil Moderate Low

Figure 21. Preference for HSI units according to non-winter OVERALL HSI: 25% UD within the 95% UD.

DISCUSSION

Movements

As is typical of many moose populations (Hundertmark 1998), the population in the Nass Wildlife Area (NWA) contains both migratory and non-migratory (resident) animals. All moose that were accounted for remained within the NWA during the study. According to a review of moose in North America by Hundertmark (1998), only moose in Alaska are reported to move farther between seasonal ranges. For Alaska, Van Ballenberghe (1977) and Ballard et al. (1991) reported migration distances ranging from 8-94 km, and 16-93 km, respectively. The maximum distance reported by Edwards and Ritcey (1956) for their study in central B.C. was 64 km; less than that observed during this study. Even though some animals in this study migrated considerable distances, with the possible exception of one animal (Moose 35) that disappeared several months post-capture, all remained in the NWA. It is possible that observed residency within the NWA was biased by the geographic distribution of captured animals, but from the perspective of the population, such bias is believed to be modest for several reasons. First, capture effort was generally focused on the lower elevations of the Nass Valley between the lower Cranberry River and Meziadin Lake. The resulting distribution of captures largely reflects the distribution of moose as observed during the aerial survey in 1997, whereby density increased from north to south. This suggests that the southern part of the NWA contains most of the best winter range—a conclusion that is further substantiated by habitat suitability mapping (Yazvenko et al. 2000) and snowpack data, whereby snowpack increases substantially with latitude in the NWA. Negative effects of increased snow depths on moose have been documented (Peek 1998). Second, while doing relocation flights in the upper White River drainage, many uncollared moose were usually observed when collared animals were present. As collared moose began to migrate out of the White River valley in November-December, the number of uncollared moose sighted there declined sharply.

Movement of moose between their seasonal ranges is related to snow depth (Hundertmark 1998). Because snowpacks and the duration of snowcover in the study area increased with latitude and elevation, "long-distance" and "short-distance" migrants are believed to have been responding to this environmental factor. As snowpacks in the study area declined in late spring, migratory moose moved to non-winter ranges. Conversely, as snow accumulated in the early winter, migratory moose moved to their winter ranges. The northward movement to non-winter ranges, such as those near the White River, was likely due to the increased mobility of moose following the declining snowpack. While the movement of some ungulates in the spring has been tied to changes in forage quality, our observations indicated that movement to non-winter ranges occurs before any substantial phenological changes in plant species browsed by moose in the study area. Although the relocation schedule may not have been frequent enough to detect subtle differences in the onset of migration to non-winter ranges among pregnant cows, non-pregnant cows, and bulls, no consistent differences among these classes were evident during three springs. Migratory members of each group had typically left the winter ranges prior to the onset of the peak calving period (early June). Elevational differences between the seasonal ranges of "long-distance" migrants was minimal. For example, the difference in elevation between the non-winter range of the White River area and the winter range of the Cranberry River area is <300m. Yet, the differences in snow depths and the duration of snowcover were marked along this latitudinal gradient. Visual observations confirmed that snowfall occurred sooner, snow depths were greater, and snow cover persisted longer on the non-winter range of the White River valley compared to the winter range near the Cranberry River. A similar pattern existed along an elevational gradient, with upper elevations getting snow earlier, getting more snow, and retaining it longer than adjacent valley-bottom areas.

As snow depth increased on non-winter ranges, migratory moose moved to their winter ranges. The onset and rate of such migration is strongly tied to snow depth (Hundertmark 1998). Because movement to winter range is largely triggered by snow accumulation (Coady 1974), considerable variation in the onset of migration has been observed (e.g., Ballard et al. 1991). Although a detailed examination of the reasons why and when moose migrate was not undertaken in this study, it was apparent that snow depths during December triggered migration to winter ranges. Although the snow depths vary greatly along the north-south and elevational axes of the study area, a depth of ≈50 cm appeared sufficient to trigger migration to winter ranges (see Figure 2 and Figure 3).

Elevations below 800 m and in the vicinity of the Nass River, the Cranberry River, and the White River were used intensively by moose. Migration between seasonal ranges tended to parallel main watercourses. Moose use of migration corridors is traditional (LeResche 1972) and is passed from adult females to their offspring (Sweanor and Sandegren 1989). Moose cross the Nass River when moving between their seasonal ranges, and findings show that the stretch of river in the vicinity of Van Dyke Island (NAD 83 UTM Zone 9, 506000 E, 6184000 N) is probably an important crossing area for moose that migrate between winter habitats as far south as the lower Cranberry River area and non-winter ranges of the White River valley and areas immediately south of Meziadin Lake. The comparatively shallow water and gently sloped banks of the area near Van Dyke Island undoubtedly enhance the suitability of that area for crossing. Many of the radio-collared moose were located near the Van Dyke crossing. For example, on the relocation flight during the winter migration in December 1999, a radio-collared moose (Moose 29) was observed on the west bank of the Nass River just below Van Dyke Island. She was with eight other moose (two of which were right at the river edge as though preparing to cross). Her subsequent location was on her traditional winter range near the Cranberry River. Other areas where collared moose are believed to have crossed the Nass River include: near the Kinskuch River, near Cottonwood Island, and near the mouth of the White River.

Calf Production

Pregnancy

If the pregnancy rates of the NWA moose population are accurately reflected by the samples (i.e., 81% in 1997 and 77% in 1998), the population is at the lower end of the range of most other populations in North America. In a review of adult moose (i.e., excluding yearlings) pregnancy rates (n=17 to 278), Schwartz (1998) indicated that most North American moose populations fall within the 82-100% range, and that pregnancy rates are tied to habitat quality—pregnancy rates decline as habitat quality declines. Some research suggests that pregnancy rates are also related to (prime[11]) bull:cow ratios (e.g., Bubenik 1987; Rausch et al. 1974), while others have found no evidence of such a correlation (e.g., Thompson 1991). In a review of factors influencing cervid reproduction, Demarchi (1992) concluded that published evidence tends to support the hypothesis that habitat quality has a greater influence on moose populations than bull:cow ratios unless the bull:cow ratios are extremely low (e.g., 12:100 as reported by Ballard et al. (1991)). It is doubtful that a 37:100 bull:cow ratio, as observed during this study constitutes an “extremely low” ratio. It is important to note that the bull:cow ratio obtained during the population survey should not be compared to that of the sample of radio-collared moose. The collared sample is not believed to be random with regard to sex. The capture crew was directed to tag similar numbers of cows and bulls, but despite this, extreme difficulties were encountered in trying to tag *any* moose during 1998. This severely hampered the option of being able to select animals according to sex. As a result, animals were tagged with the objective of deploying all collars, with less emphasis on tagging similar numbers of cows and bulls. Under those conditions, the effects of sightability were probably significant. For example, a cow with two calves is much more likely to be sighted than a single bull simply because there are more animals to catch the crew’s eyes while the capture crew transits the area at speeds >100 km/h.

The Wildlife Harvest Strategy (Halladay and Demarchi 1996) stated that, subject to review and further investigation, moose harvests in B.C. should not reduce bull:cow ratios below 30:100. The ratio of 37:100 observed during this study is modestly above that minimum. If the actual pregnancy rate of the population is similar to that of the samples (i.e., 77-81%), it is possible that a bull:cow ratio of 37:100 is too low to maximize the pregnancy rate of adult cow

[11] “Prime” bulls are fully mature animals in the best physiological and reproductive condition relative to other animals in the same population.

moose in the study area, but there is no strong evidence to suggest this is the case. If low bull:cow ratios existed, it is reasonable to assume that animals would be forced to move around more during the rut in search of mates. Contrary to this, movement rates during the rut (September-October) were repeatedly some of the lowest observed during the year (Figure 2).

An alternate hypothesis for the low pregnancy rates is that the pregnancy samples included yearling females that were simply not pregnant because they were too young. According to data presented in Schwartz (1998), yearling moose invariably exhibit lower pregnancy rates than adults. Even though only adults are believed to have been tagged, it is not unreasonable to conclude that one or more yearling cows were inadvertently tagged. At the time of year the moose were captured, yearling cows (i.e., nearing 2 yr old), can have attained ≈80% of the mass of an adult cow[12], thereby making it very difficult to visually discriminate between the two age classes. Because age was estimated from animal size and not from cementum annuli counts, no objective measure of age is available.

While estimating the population's pregnancy rates from the small samples taken in 1997 and 1998 may be biased, it is still worth obtaining such information because the results can substantiate subsequent incidental observations of cows with and without calves. For example, if no calves were subsequently sighted with collared cows, the conclusion that the neonatal mortality was extreme would be erroneous if none of those cows had been pregnant when they were captured.

Many management units (MU) in B.C. support limited entry hunts (LEH) for antlerless (cow) moose. Data on moose reproduction (e.g., ovulation, pregnancy, twinning) obtained from an adequate sample of hunted animals can be an important source of information on population health. Such data are not available for this study. Of the three management units (MUs 6-15, 6-16, and 6-30) that overlap with the present study area, only 15 LEH authorizations were available for issue for the 1997 hunting season and all were in MU 6-30[13]. No cow moose permits were issued for resident hunters during the 1998 or 1999 hunting seasons because of concerns about a declining population in the area. Subsistence hunting of all male and female moose by First Nations continued.

Calving

Minimum calving rates were obtained for three years. At a minimum observed rate of 89 calves:100 cows, the 1999 rate was the highest (cf. 1997, 75:100; 1998, 68-75:100). It cannot be categorically concluded that the 1999 data represented a population-wide increase in calf production, because, as discussed above, some cows may have been immature yearlings when they were collared. Had any such yearlings been collared in 1997 or 1998, the 1999 calving rate probably best represents the population because all collared cows were then at least 3 years old and, therefore, had attained prime breeding age. Regardless of any demographic effects on calf production, the range of values obtained (i.e., 68-89 calves:100 cows) is within the range reported by other researchers in North America (i.e., 40-138 calves:100 cows; Van Ballanberghe and Ballard 1998).

[12] weight (kg)=500.8 – 499.5$e^{-0.0021t}$ where t=age in days; Schwartz (1998)
[13] This MU is mostly outside the Nass Wildlife Area.

Twinning rates varied among years. In 1997, twins represented only 17% of the calf crop, whereas in 1998 and 1999, twins represented 48% and 38%, respectively. Production of twins is primarily related to habitat quality and nutritional factors (Franzmann and Schwartz 1985). It cannot be concluded whether this change in twinning rate reflected habitat condition, weather severity, or natural variation in neonate predation resulting in biased estimates.

Calf production is an indicator of habitat quality, and only through the adequate production of calves can the size of a moose population be maintained or increased. But while calf production in the NWA may appear adequate when compared to other studies, it is only a component of the complex dynamics between a population and its environment and has limited utility on its own to infer conclusions about population dynamics.

Mortality

Adults

For the radio-collared sample of moose, the mean annual mortality of adults in the population was estimated at 13.2% (i.e., mean annual survival equals 86.8%) (n=3 years). This value is within the range of mean annual mortality of radio-collared adults (6-25%) as summarized by Van Ballenberghe and Ballard (1998:229). Hunting was the major source of mortality in the NWA, accounting for 58% of deaths (Table 3). The 13.2% figure for adult mortality probably *underestimates* the actual population rate for at least two reasons. First, the collared sample is biased towards cows, and despite the fact that there are more cows than bulls in the population, the harvest is biased towards bulls. There is no sport hunting for cows, and the First Nations harvest takes more than twice as many bulls as cows (Nisga'a Tribal Council 1999). Second, hunters may also avoid shooting collared animals (as requested by the Wildlife Branch). Thus, if hunters are less likely to shoot cows, and are less likely to shoot collared animals, mortality measured from a sample comprised mostly of collared cows will underestimate the actual mortality for the population.

Moose are exposed to a wide range of mortality factors throughout North America. Collisions involving moose and automobiles and moose and trains number in the thousands each year (Child 1998). However, these factors are not believed to have any significant implications for moose conservation in the study area. There is no railroad in the study area and vehicular traffic on Highway 37 is low by provincial standards. Ministry of Environment, Lands and Parks (1995) indicated that for the 5-year period 1989-93, an average of 23.6 moose were reported as rail-killed (all in the Skeena Valley) in MU 6-15 annually. That was the highest provincial value. From 1985 through 1999, an average of 2.4 moose were road-killed in the NWA (Nass Wildlife Committee, unpublished data). The single largest kill occurred in 1997, when 11 moose were reported killed by vehicles.

Calves

Measuring calf mortality was not one of the study's main objectives, hence, the study design does not accurately address this issue. Data on calf mortality during this study are highly speculative, and should not be interpreted as accurate for the small sample of collared moose or the population as a whole. These data have been presented in the event that they generate some relevant hypotheses that could be examined further.

The estimated minimum calf:cow ratio of 47:100 for January 1998, as shown by the radio-telemetry data, was the same as that observed during the aerial survey of moose in February 1997. A minimum calf:cow ratio of 59:100 was estimated for January 1999 and 50:100 in 2000. All of these ratios are less than the 73:100 calf:cow ratio observed by MELP during late-winter aerial surveys of the same area in 1994. Calf mortality within the first 6 weeks of life can be particularly high. In some moose populations, neonate mortality due to predation by gray wolves (*Canis lupus*) approaches 20%, and may be as high as 50% by black bears (*Ursus americanus*) or grizzly bears (*U. arctos*) (data cited in Ballard and Van Ballenberghe 1998). Healthy populations of all three of these species occur in the study area, but the extent of predation on moose calves in our study area is completely unknown. While predation by bears only occurs outside of the denning period (e.g., May-November), wolves are expected to prey on moose year-round. Ballard and Van Ballenberghe (1998) stated that predation on moose calves by wolves is likely to be greatest from January-May when deep, crusted snow conditions are likely to occur.

All observed calf:cow ratios were higher than the level of 30 to 45 calves:100 cows required to maintain stability in populations that sustain a harvest of 5 to 10% per year (Hatter and Bergerud 1991). Thus, from the perspective of population conservation, the observed calf:cow ratios appear to be adequate, suggesting that predation or other mortality factors as they apply to juveniles are not limiting recruitment. However, if the actual adult harvest rate was >10% (as may be the case, given that the hunting mortality of the collared sample is believed to underestimate the hunting mortality of the population; see above), the population would not necessarily have been stable—it could have been declining.

Habitat Use

Moose occur throughout the Nass Watershed, and during the course of this and other wildlife studies (i.e., Demarchi and Johnson 1998a; 2000), they have been observed in all habitats, including occasional sightings in the Alpine Tundra (AT) zone.

An objective of this research was to obtain information from a portion of the moose population, and apply that information to the population as a whole. Yet, it is doubtful that the moose radio-collared for this study represent a "random" sample of the moose population in the Nass Watershed. Because of fiscal and logistical considerations, capture locations were clumped near the lower elevations of the Nass and Cranberry river valleys. While this situation is not believed to be problematic for the study's objectives—especially since those areas appear to be among the most important moose habitats in the Nass watershed—this situation is, nonetheless acknowledged. Because of the comparative ease of moose capture in areas of higher habitat suitability compared to those with lower suitability according to Yazvenko et al. (2000) (e.g., browse-filled cutblocks cf. dense coniferous stands), the habitat preferences of sampled animals may not have been random. In this case, better agreement between the modelled winter habitat suitability and observed habitat use may have resulted than if animals were sampled randomly.

Two other factors may have influenced the observed distribution of collared moose—particularly their use of non-winter ranges. First, any factors that affected the population differently in different areas could, in part, account for the observation that a considerable amount of the study area rated as being of moderate or better non-winter suitability did not fall within the mapped utilization distributions. Such area-specific factors could include predation rates, hunter harvest rates (e.g., as moderated by differing degrees of human access), or other un-modelled factors pertaining to habitat suitability (e.g., forage quality). Second, the resulting utilization distributions reflect the sample size to a certain degree. Had the sample been larger (e.g., 150 moose), the areal extent of the utilization distributions would undoubtedly have been greater.

Radio-collared moose used all forested BEC subzones/variants in the northern half of the area mapped by Yazvenko et al. (2000). Lower elevation zones (i.e., ICH and CWH) were used throughout the year, but use of higher elevation zones (i.e., MH, ESSF) was greatest during the non-winter period. Seasonal differences are believed to reflect habitat selection primarily in response to relatively greater snow depths at higher elevations. As discussed above, most differences in the use of subzones/variants are also believed to reflect snow conditions, because the suitability of those units during the non-winter period tended to be fairly high according to HSI modelling. Most of the area receives an abundance of precipitation that is conducive to supporting the herbaceous and shrubby vegetation species preferred by moose.

There are several limitations to the BEC mapping as used to understand moose habitat use. These limitations influence the scale to which the preferences of different BEC units should be interpreted. BEC subzones/variants delineated by the provincial government were most likely mapped at a scale no greater than 1:250,000 which is considerably smaller than the 1:20,000 base at which the forest cover base of the HSI mapping was prepared. This small scale causes the BEC mapping to be insensitive to subtle habitat factors to which moose are probably responding. In the areas used by moose in this study, this is further compounded by the considerable interspersion of different BEC subzones/variants as a result of topographic effects (e.g., elevational and rain-shadow effects). Distinct boundaries between mapped subzones/variants are insensitive to the gradual changes that probably better characterize the landscape.

The HSI models were developed according to conventional knowledge of moose habitat selection and did not incorporate information gained during the present study (otherwise, using the models to test for habitat selection would have been meaningless as the results would have been assured a priori). The considerable agreement between the rank order of modelled HSI values and those within the seasonal home ranges of radio-collared moose is taken as a validation of the HSI models and an indication of their utility for depicting seasonal moose ranges as required for habitat conservation and management. Performance of the overall HSI models in predicting habitat use in core areas during winter and non-winter was lower than the overall HSI models' performance at a lower order of habitat selection (i.e., seasonal home range within a 10-km buffer around all moose locations). However, when model components were individually examined, it was apparent that in winter, use of core areas indicated a preference for food-rich sites. Conversely, no preference for cover was evident. During non-winter, the observed preference order of habitats based on their food or cover value did, with the notable exception of habitats rated "high" for food or cover, approximate that predicted by the HSI models. Many of the differences between food and cover classes were not significant.

Because at the patch level of scale, moose can move freely between habitats having: (1) high food but low cover value, and (2) high cover but low food value where such habitats are interspersed, overall suitability of the NWA for moose as presented by Yazvenko et al. (2000) is most likely underestimated—particularly during the non-winter period when animal mobility is greatest. The models do not incorporate any measure of adjacency (e.g., a stand of heavy cover next to an open foraging area is not rated different than one removed from such open areas). Yazvenko et al. (2000) attempted to incorporate a measure of adjacency into their models, but with unsatisfactory results. Nevertheless, it is reasonable to assume, as they did, that if the models incorporate a measure of adjacency, their ability to accurately predict habitat use at a finer scale (e.g., core areas within seasonal home ranges) would improve.

When the results of home range analysis were separated into the food and cover components of the HSI models, it was evident that in winter, food availability was a better predictor of habitat preference than was the availability of cover. During non-winter, this pattern was reversed. These findings corroborate the significance weightings of the seasonal HSI models developed by Yazvenko et al. (2000). Refer to Yazvenko et al. (2000) for a thorough review of seasonal habitat selection by moose.

CONCLUSIONS

According to this study, few, if any moose that winter in the NWA migrate out of the NWA during the non-winter period. Yet, moose migrate substantial distances between seasonal ranges within the NWA. Because only eight bulls were monitored, the degree to which the conclusion of "residency within the NWA" applies to males is less than for females. However, given that the antlerless (i.e., cow and calf) harvest (typically recognized as having a greater effect on population dynamics than the harvest of males for polygynous species such as the moose) is limited to First Nations, and that the peak of that harvest occurs during the winter period (Nisga'a Tribal Council 1999), for present management purposes, it is reasonable to assume that the moose population in the NWA remains within that managerial boundary. Because of limitations in our sampling design, the extent to which moose use the NWA during the non-winter period, but winter outside the NWA, is unknown. If such movements exist to a considerable extent, there could be implications for the sport harvest of bull moose that occurs during the latter portion of the non-winter period. If adequate adult sex ratios in and around the NWA persist, the extent to which this data gap confounds harvest management will probably be modest with regard to the NWA, though there could be more serious implications for areas outside it.

All forested BEC subzones/variants in the northern portion of the mapped area (Yazvenko et al. 2000) should be considered potential non-winter moose range. Most of these areas occur within migration distance of suitable winter range and the highly migratory nature of the moose in the NWA suggests that the population is capitalizing on this situation. From an evolutionary perspective, this is probably a successful strategy because migration off winter range during the non-winter period removes considerable foraging pressure that could lower the suitability of that range for wintering animals.

In winter, a range of BEC subzones/variants continues to be used. While it appears that most moose respond to increased snow depths (see above) by moving to areas that accumulate relatively less snow, a few moose (e.g., Moose 17) are capable of thriving and successfully rearing young in areas where snow depths can exceed 1.5 m in open sites. Observations near such areas indicate that snow depths are ameliorated by microclimates created by forest canopies and hydroriparian sites. For example, the shallow, snow-free channels of Hanna and Tintina creeks were observed to be used by moose. Such areas offer both easy locomotion and access to what is believed to be high-quality forage. However, for the greater population of moose in the NWA, the most important BEC variants during winter are probably ICHmc1 and ICHmc2. These units contain the majority of what is believed to be the best moose winter range in the mapped area due to relatively low snowpacks and an adequate supply of food and cover.

Habitat models presented by Yazvenko et al. (2000) are suitable for the purposes of habitat conservation and management. They accurately predicted the seasonal habitat preferences of moose as observed from the habitat make-up of seasonal home ranges within a larger area. Because the literature contains enough knowledge about moose habitat management at scales larger than those that the models appeared capable of predicting (e.g., core areas within seasonal home ranges), and because the models did not account for habitat adjacency or food quality, their failure to predict habitat use at the scale of core areas within seasonal ranges is not viewed as problematic. Information presented in this study, together with other literature will go a long way in helping to address issues of moose habitat conservation and management at both landscape and stand-level scales in the NWA.

Successful moose conservation in the NWA will rely on the concerted efforts of several stakeholders. Habitat management is largely in the hands of the forest industry. While moose and forestry have traditionally coexisted because logging created early seral stages and mixed-age habitat mosaics, intensive silvicultural practices of late may challenge that coexistence. "Brush control[14]", a silvicultural practice geared to reduce competition for light and nutrients between conifers and non-coniferous plants can reduce habitat suitability for moose because the targets of brush control are often species of plants consumed by moose. The degree to which any such reductions in habitat suitability have or will occur in the NWA is unknown. This aspect of moose habitat requires further research.

Hunting appears to be the most important factor affecting the survival of adult moose in the NWA. Predation by wolves, though it occurs, does not appear to be substantial at present. Because of the great effects hunting can exert on the population dynamics of moose, and because of the importance of moose in local subsistence and sport hunts, the Nisga'a Final Agreement identifies moose as a designated species. The Nass Wildlife Committee, consisting of representatives of the Nisga'a Tribal Council and the provincial government, will be responsible for ensuring that moose harvests are sustainable and that population objectives are met.

[14] As practiced using herbicides, manual brushing, and domestic sheep

It should be noted that the issue of animal sightability is likely to continue to confound efforts to obtain an accurate population estimate during future aerial population surveys in winter. The "1.2" correction factor assumes that 83% of the moose in a survey block are seen. In the author's opinion, this sightability is unrealistically high. Data in Table 4 and Table 5 provide speculative evidence supporting this claim. Most of the NWA is covered by a dense, coniferous overstorey. The probability of sighting a moose is strongly related to vegetation cover (this study; Anderson and Lindzey 1996). During winter and non-winter, radio-collared moose were located in coniferous habit more than any other habitat type. Using radio-telemetry from a helicopter, trackers were well aware of moose positions, yet, only ≈50% of the moose were actually seen when located in that habitat type during the winter. When all habitats were combined, sightability only rose to ≈60%. Even this value is believed to be higher than what could be expected during an aerial survey. Because the VHF beacon made trackers aware that they were over or near a collared moose, and because they often made several passes to pinpoint its location, the probability of sighting any given collared animal during winter was probably much higher than the probability of sighting any given uncollared animal by conducting a single pass over it during an aerial survey.

MANAGEMENT RECOMMENDATIONS

The area in the vicinity of Van Dyke Island is an important location at which moose cross the Nass River. The integrity of mature forest stands around that area should be maintained so as to provide an effective movement corridor between seasonal ranges. Of the 38 radio-collared moose, 13 (34%) crossed the Nass River. As many as 9 (69%) of those appeared to have crossed the Nass River in the vicinity of Van Dyke Island. Extrapolating these percentages to the moose sub-population that winters near the lower Cranberry River valley suggests that a substantial number of moose cross the Nass River. Also, because moose are very traditional in their use of migration routes (knowledge of the route is believed to be passed from cow to calf), moose have probably been crossing the Nass River at similar locations for many decades.

Judging by the lack of published literature on the subject, the role that migration corridors play in moose ecology is practically unknown. Even less is known about what constitutes an ideal corridor with regard to its structural (e.g., vegetation, topography, isolation from humans, security from predators) composition. However, there is reason to believe that many of the same features that constitute core-use moose habitat constitute good migrational habitat. Food for moose is likely to always be abundant along most areas of the floodplain of the Nass River. Given the presence of wolves, black bears, grizzly bears, and hunters in the Nass valley, adequate security cover is probably the most important habitat feature of an area used as a migration corridor. In light of currently available information about the migratory behaviour of moose in the Nass Valley, the following recommendations are made:

- The area along the Nass River between the UTM coordinates (Zone 9, NAD 83) 502,000 E, 6,189,000 N and 512,000 E, 6,174,500 N and within a buffer that runs 600 m either side of the center of the river should be identified as important moose habitat and managed as a migration corridor.
- No new public access developments should occur in that corridor.

- Forest harvesting plans should be reviewed and either approved, modified, or rejected by a professional wildlife biologist before any timber extraction or access developments occur inside the migration corridor.
- Forest harvesting outside the migration corridor should follow biodiversity guidelines under the Forest Practices Code—specifically, forest ecosystem networks (FENs) should be maintained to ensure the connectivity of the winter ranges to the southeast and the summer ranges to the northwest.
- Unless a professional wildlife biologist's review of forest harvesting plans concludes otherwise, access developments stemming from approved forestry activities within the buffer should be gated at the point of access from Highway 37 or any main haul road to prevent public access during the migratory periods of April through June and November through January.
- All access developments stemming from approved forestry activities within the buffer should be deactivated immediately upon completion of commercial forestry activities (i.e., harvest, planting, spacing).
- Provided the above recommendations are followed, and those under the terms of the wildlife harvest agreement between the Nisga'a and the province, at this time there is no need to further restrict opportunities to harvest moose in this area.

Second, because the timing of the combined hunting pressure from resident hunters and First-Nation hunters overlaps the rut, migration to winter range, and wintering period; temporal refuge from hunting is limited. This may bolster the need to provide or conserve areas of limited human access that act as refuges during the prime hunting seasons. Therefore, no roads should be built that would improve vehicular access into the riparian lowlands in the vicinity of the confluence of the White and Flat rivers, and that of the White River and Willoughby Creek. That area appears to be a very important summer range and rutting ground. It may also be an important staging area for moose preparing to migrate to southern winter ranges.

Third, as indicated by the Nass Wildlife Committee (1999), moose harvested by First Nations hunters have the potential to provide data important for moose management in the NWA. Efforts should be made to obtain cementum-annuli counts from the incisors of all harvested moose and reproductive tracts (i.e., vagina, uterus, and ovaries) of all cow moose harvested in the NWA. First Nations hunters should be asked to submit an incisor from every moose and the reproductive tracts of all cow moose to a First Nations technician. Tooth-grinding should be contracted to an experienced laboratory. The number of fetuses in each reproductive tract (i.e., 0, 1, or 2) could be easily recorded by the technician who would then tabulate the data in order that pregnancy rates be documented and used to enhance moose management in the NWA. For each recorded kill, the minimum amount of data should include: date, hunter name, kill location (UTM coordinates), animal sex, age, and number of fetuses. The Nass Wildlife Committee will be responsible for developing and implementing this inspection program.

Fourth, consideration should be given to designating the primary moose winter range (i.e., near Cranberry Junction; see Figure 4) a Wildlife Management Area under Section 4 of the provincial Wildlife Act. Such a designation would ensure that forestry practices would have to address the overwintering needs of a considerable proportion of the moose population in the NWA. Similar consideration should be given to the extensively used non-winter habitats of the

White River (see Figure 5). The expansive sedge marshes that occur in that area are unique to the study area.

Fifth, although there is no indication that present habitat conditions warrant enhancement, for future considerations, any attempts to enhance moose habitat should be focused on winter ranges within the ICHmc1 and ICHmc2 biogeoclimatic variants. Habitat enhancement should be guided by the winter habitat suitability model presented in Yazvenko et al. (2000) and this report, the discussion of moose habitat in Yazvenko et al. (2000), and published guidelines for moose habitat management (e.g., Thompson and Stewart 1998 and references therein).

Finally, because the revised values from the 1997 population survey exceed the maximum of ±25% as recommended by the RIC standards for management purposes, the Nass Wildlife Committee (1999) has recommended that another moose survey in the NWA during the winter of 2000-2001. Problems with the sightability of moose during aerial surveys in the NWA should be thoroughly addressed prior to conducting future inventories. The survey stratification method used by Demarchi (2000) should be considered for use in the NWA.

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APPENDICES

Appendix I. Habitat suitability models for moose in the Nass Wildlife Area, westcentral B.C. For a complete explanation, refer to Yazvenko et al. (2000).

Life Requisite	Important Habitat Factor	Measurable Habitat Variable	Habitat Variable Categories			Suitability Indices (SI)
FOOD	Browse Density	V1: Percent browse canopy cover	0	to	<1 %	0.0 (0.0)*
			1	to	<10 %	0.2 (0.2)
			10	to	<20 %	0.5 (0.4)
			20	to	<30 %	1.0 (0.6)
			30	to	<40 %	1.0 (0.8)
			40	to	100 %	1.0 (1.0)
FOOD	Browse Availability	V2: Two-thirds of mean browse height	0.0	to	<0.1 m	0.0
			0.1	to	<0.5 m	0.8
					0.5 m+	1.0
FOOD (SNOW)	Snow Depth	V3: See Snow Depth Model				
THERMAL COVER	Tree Density	V4: Percent tree canopy cover	0	to	<1 %	0.0
			1	to	<10 %	0.2
			10	to	<20 %	0.3
			20	to	<30 %	0.4
			30	to	<40 %	0.5
			40	to	<50 %	0.7
			50	to	<60 %	0.9
			60	to	100 %	1.0
THERMAL COVER	Coniferous Tree Density	V5a: Percent conifer canopy cover	0	to	<1 %	0.0
			1	to	<10 %	0.2
			10	to	<20 %	0.4
			20	to	<30 %	0.6
			30	to	<40 %	0.8
			40	to	<50 %	0.9
			50	to	100 %	1.0
FOOD (SNOW)	Coniferous Tree Density	V5b: Percent conifer canopy cover	0	to	<40 %	0.4
			40	to	<60 %	0.6
			60	to	<80 %	0.8
			80	to	100 %	1.0
THERMAL	Tree Size	V6: Mean tree	0	to	<5.0 m	0.4

Life Requisite	Important Habitat Factor	Measurable Habitat Variable	Habitat Variable Categories			Suitability Indices (SI)
COVER		height	5.0	to	<10.0 m	0.7
			10.0	to	<15.0 m	0.9
					15.0 m+	1.0
FOOD	Forb Availability	V7: Percent herbaceous ground cover other than sedges	0	to	<5 %	0.0
			5	to	<25 %	0.2
			25	to	<50 %	0.5
			50	to	<75 %	0.8
			75	to	100 %	1.0
FOOD & REPRODUCTIVE	Aquatic/Riparian Availability	V8: Percent of polygon area relative to area of aquatic/riparian habitat	0	to	<5 %	0.1
			5	to	<10 %	0.3
			10	to	<20 %	0.5
			20	to	<40 %	0.8
			40	to	100 %	1.0
FOOD (SNOW)	Coniferous Tree Height	V9: Mean conifer height	0	to	<1 m	0.0
			1	to	<5 m	0.2
			5	to	<10 m	0.4
			10	to	<15 m	0.6
			15	to	<20 m	0.8
					20 m+	1.0
FOOD (SNOW)	Biogeoclimatic Zone	V10: BEC zone			AT	0.0
					MH	0.1
					ESSF	0.1
					ICHvc	0.2
					CWHws2	0.4
					ICHmc1&2	0.9
					CWHws1	1.0
FOOD	Sedge Availability	V11: Percent cover of sedges	0	to	<1 %	0.0
			1	to	<5 %	0.5
			5	to	<20 %	0.8
					20 %+	1.0

* Value in parentheses is SI for winter model

Appendix I. continued

Non-winter moose model algorithm

HSI_{Food} =HIGHEST VALUE OF (V1SI*V2SI), OR ((0.4*V7SI)+(0.6*V8SI)), OR ((0.4*V8SI)+(0.6*V11SI))[a]

HSI_{Cover} =((0.6*V4SI)+(0.4*V5aSI))*V6SI[b]

$HSI_{Reproductive}$ =V8SI[c]

$HSI_{Overall}$ $=(0.3*HSI_{Food})+(0.3*HSI_{Cover})+(0.4*HSI_{Reproductive})$

Winter moose model algorithm

HSI_{Food} =V1SI*V2SI*V3SI[d]

HSI_{Cover} =V5aSI*V6SI[e]

$HSI_{Overall}$ $=(0.9*HSI_{Food})+(0.1*HSI_{Cover})$

a. The food value of an area for moose in non-winter is directly influenced by either the combination of browse species abundance which affects the production of palatable foliage, as measured by V1, herbaceous canopy cover (V7) and the amount of aquatic habitat (V8) or sedge cover (V11) and the amount of aquatic habitat (V8). Unfavourable values for browse height (V2) can only detract from the food value. Consequently, for any given cover type, the non-winter value is the combined SI value for browse abundance modified (multiplied) by the suitability (SI) value for browse height and the combined SI of herbaceous cover and aquatic habitat.

b. The cover value of an area in non-winter is directly influenced by tree canopy cover (V4) and more specifically, by conifer canopy cover (V5a). Unfavourable canopy height (V6) can only detract from cover value. Consequently, the cover rating results from the combined SI of the tree canopy cover and conifer canopy modified (multiplied) by the suitability (SI) value of canopy height.

c. The reproductive value of an area for moose is directly influenced by the presence of aquatic habitat.

d. The food value of an area for moose in winter is directly influenced by browse abundance, as measured by V1. Unfavourable values for browse height (V2) and snow depth (V3) can only detract from the food value. Consequently, for any given cover type, the winter food value is simply the SI value for browse abundance modified (multiplied) by the combined suitability (SI) values for browse height and snow depth.

e. The cover value of an area in winter is directly influenced by conifer canopy cover (V5a). Deciduous tree canopies probably provide negligible cover value. Unfavourable canopy height (V6) can only detract from cover value. Consequently, the cover rating results from the combined SI of the tree canopy cover and conifer canopy modified (multiplied) by the suitability (SI) value of canopy height.

Appendix II. Moose sightings by Broad Ecosystem Unit survey polygon. Nass Watershed, February 1997.

Polygon	Area Surveyed	Stratum	Bull	Cow	Yearling	Calf	Un. Class.	Total Seen
WR105381	15.93	H		1		1		2
				1		1		2
			1					1
				1				1
						1		1
				3		1		4
WR403999	16.77	H		1				1
				1				1
				1		1		2
			1					1
				1	1			2
				1	2			3
				1				1
						1		1
				1		1		2
WR403999	16.77	H				1		1
				1				1
				1		1		2
			1					1
HB104849	8.87	H		1	1			2
				1		1		2
			1					1
							1	1
				1		1		2
				1		1		2
						1		1
				1				1
				1		1		2
			2					2
				1				1
				1		2		3
				1		1		2
				1		1		2
				1				1
				1				1
				1		1		2
				1		1		2
				1				1
				1		1		2
				1		1		2

Polygon	Area Surveyed	Stratum	Bull	Cow	Yearling	Calf	Un. Class.	Total Seen
				1		1		2
				1		1		2
				1				1
				1		1		2
				1		1		2
				1		1		2
				1				1
			1					1
			1					1
IS404634	18.75	H	2	3				5
				1				1
				1				1
				1		1		2
			1					1
				2		1		3
				1				1
				1				1
			1				1	2
				1		1		2
				2				2
				1				1
						1		1
IS404634	18.75	H		1				1
				1				1
			3					3
IS404176	9.32	H		1		1		2
			1					1
			3					3
				1		1		2
			1					1
			1					1
				2				2
				1				1
				1		1		2
				1				1
			2					2
			1					1
							1	1
				1				1
				1				1
							1	1
				2				2
				1		1		2
			1					1

Polygon	Area Surveyed	Stratum	Bull	Cow	Yearling	Calf	Un. Class.	Total Seen
				1	1			2
WR104940	10.22	H		1				1
				1		1		2
				1				1
						1		1
				1		1		2
				1		1		2
				1				1
				1		1		2
				1				1
				1		1		2
			1					1
				1				1
			2					2
WR105724	5.12	M		1				1
			2					2
SR103835	11.62	M		1				1
							1	1
				1		1		2
				1		1		2
				1				1
HB104990	23.66	M	1	2				3
				1				1
				1		1		2
				1				1
IS104512	13.15	M						
HB105240	11.73	M	1					1
				3				3
				1		1		2
SF404354	6.2	M	1					1
							1	1
				1				1
			1					1
				1				1
				1				1
							2	2
FR107556	1.96	L						
HB105477	11.14	L						
HB105315	19.44	L						
IS103298	11.62	L		1	1			2
HB105849	8.39	N					1	1
IS103169	18.82	N		1				1
				1		1		2

Polygon	Area Surveyed	Stratum	Bull	Cow	Yearling	Calf	Un. Class.	Total Seen
IS404386	18.42	N		1				1
Total	79.87	H	28	78	5	41	4	156
	71.47	M	6	17	0	4	4	31
	44.16	L	0	1	1	0	0	2
	45.63	N	0	3	0	1	1	5
GRAND TOTAL	**241.13**		**34**	**99**	**6**	**46**	**9**	**194**

Appendix III. Summary of noteworthy incidental sightings made during reconnaissance flights and survey flights during the moose survey in the Nass Watershed, February, 1997.

Date	Sighting	Number	Comments
12/02/97	dead calf moose (whole)	1	On bank of Nass River 100 m below highway near Meziadin; possibly road-killed
22/02/97	dead calf moose (whole)	1	possibly shot and left on bank of Cranberry River; within sight of Highway 37
15/02/97	moose gut pile	1	hunter killed? — near Highway 37
18/02/97	moose gut pile	1	hunter killed — dragged to Nass Forest Service Road
11/02/97	moose kill-site	1	Likely killed and eaten by wolves
11/02/97	moose kill-site	1	Likely killed and eaten by wolves
12/02/97	moose kill-site	1	Likely killed and eaten by wolves
12/02/97	gray wolf	1	in river-bottom habitat of Cranberry River
12/02/97	gray wolf	5	bedded on bank of upper Nass River
12/02/97	gray wolf	9	on upper Nass River near a moose kill site
20/02/97	gray wolf	3	bedded on small lake near Cranberry Junction
23/02/97	gray wolf	6	bedded on snow in forest opening — Van Dyke area
various	gray wolf tracks	many	throughout study area
13/02/97	coyote	2	lower Tseax River
19/02/97	wolverine	1	lodgepole stand of large burn area, upper Nass River
various	river otter tracks	several	on lake and river ice throughout study area
various	porcupine tracks	many	throughout study area
13/02/97	great blue heron	1	lower Tseax River
13/02/97	Canada goose	6	Fishery Bay
12/02/97	common merganser	1	open water, Bell-Irving River
various	bald eagle	25 (total)	throughout study area
15/02/97	peregrine falcon	1	hunting passerines in clearcut in Cranberry River valley
various	ruffed grouse	4 (total)	throughout study area
various	grouse spp.	11 (total)	throughout study area
18/02/97	ptarmigan spp.	1	-
20/02/97	American dipper	1	Meziadin area
various	evening grosbeak	50 (total)	several flocks in Cranberry River valley
various	red crossbill/pine siskin	many	flocks observed throughout study area

Appendix IV. Capture locations and relocations of 38 radio-collared moose in the Nass Wildlife Area, 1997-2000. Locations are given in decimal degrees.

Moose	Date	Time	Latitude	Longitude
1	18-Jan-97	capture	55.3843	-128.8832
1	8-Feb-97	1227	55.4290	-128.7826
1	20-Feb-97	951	55.4358	-128.7657
1	5-Mar-97	1401	55.4420	-128.7735
1	19-Mar-97	1440	55.4408	-128.7717
1	27-Mar-97	858	55.4400	-128.7745
1	1-May-97	904	55.4318	-128.8057
1	21-May-97	925	55.3428	-128.8767
1	5-Jul-97	1615	55.3233	-128.7877
1	6-Aug-97	1020	55.3123	-128.7450
1	25-Aug-97	928	55.3240	-128.8023
1	13-Sep-97	937	55.3208	-128.7813
1	3-Oct-97	917	55.3168	-128.7502
1	3-Nov-97	1055	55.2847	-128.7083
1	3-Dec-97	1150	55.3040	-128.6850
1	2-Jan-98	945	55.3800	-128.7478
1	22-Jan-98	1042	55.3833	-128.7963
1	11-Feb-98	935	55.3890	-128.7623
1	4-Mar-98	1429	55.3873	-128.7673
1	25-Mar-98	1803	55.3875	-128.7667
1	1-May-98	936	55.3969	-128.7547
1	4-Jun-98	914	55.4244	-128.7422
1	27-Jun-98	929	55.3322	-128.7700
1	20-Jul-98	1325	55.3202	-128.6842
1	19-Aug-98	1315	55.2945	-128.7072
1	17-Sep-98	1436	55.3123	-128.7417
1	22-Oct-98	1353	55.2969	-128.7317
1	11-Nov-98	929	55.3008	-128.7122
1	10-Dec-98	934	55.4325	-128.8222
1	16-Jan-99	958	55.4035	-128.8435
1	9-Feb-99	1010	55.4118	-128.8438
1	28-Feb-99	940	55.4380	-128.7833
1	21-Mar-99	940	55.4442	-128.7808
1	10-Apr-99	1035	55.4322	-128.7992
1	17-May-99	914	55.4083	-128.8411
1	5-Jun-99	1027	55.4281	-128.7619
1	26-Jun-99	1020	55.2958	-128.7333
1	30-Jul-99	1218	55.3323	-128.7705
1	3-Sep-99	1126	55.3230	-128.7748
1	4-Oct-99	1739	55.3322	-128.7950
1	7-Dec-99	1010	55.2969	-128.7050
1	12-Jan-00	953	55.4175	-128.8322
1	5-Mar-00	933	55.4367	-128.7964
2	21-Jan-97	capture	55.6037	-128.4742
2	9-Feb-97	1114	55.6113	-128.4492
2	19-Feb-97	1440	55.6100	-128.4450

Moose	Date	Time	Latitude	Longitude
2	5-Mar-97	1216	55.6662	-128.4540
2	19-Mar-97	1208	55.6093	-128.4617
2	27-Mar-97	1146	55.6050	-128.4673
2	1-May-97	1024	55.7737	-128.8503
2	21-May-97	1333	55.8198	-128.9022
2	11-Jun-97	1131	55.9310	-129.0395
2	5-Jul-97	1225	55.9227	-129.4302
2	6-Aug-97	1432	55.9700	-129.3733
2	25-Aug-97	1318	55.9532	-129.4135
2	13-Sep-97	1311	55.9598	-129.3953
2	3-Oct-97	1100	55.9752	-129.3815
2	3-Nov-97	1430	55.9157	-129.3045
2	3-Dec-97	1025	55.9158	-129.2768
2	2-Jan-98	1119	55.6332	-128.6613
2	22-Jan-98	1157	55.6267	-128.6095
2	11-Feb-98	1108	55.6118	-128.4692
2	4-Mar-98	1323	55.6173	-128.4778
2	25-Mar-98	1055	55.6262	-128.6142
2	1-May-98	1557	55.8336	-128.9183
2	3-Jun-98	1420	55.9286	-129.3306
2	26-Jun-98	1424	55.9272	-129.3306
2	20-Jul-98	1811	55.9310	-129.3733
2	19-Aug-98	1605	55.9283	-129.3857
2	18-Sep-98	1528	55.9347	-129.3800
2	22-Oct-98	1757	55.9164	-129.3044
2	11-Nov-98	1054	55.9247	-129.3192
2	10-Dec-98	1109	55.7683	-128.8489
2	16-Jan-99	1139	55.6152	-128.5080
2	9-Feb-99	1138	55.6018	-128.4150
2	28-Feb-99	1122	55.5975	-128.4047
2	21-Mar-99	1042	55.6125	-128.4473
2	10-Apr-99	1220	55.6192	-128.5406
3	19-Jan-97	capture	55.6670	-128.7488
3	9-Feb-97	1430	55.6737	-128.7490
3	19-Feb-97	1354	55.6855	-128.7677
3	5-Mar-97	1608	55.6293	-128.7430
3	19-Mar-97	1141	55.6062	-128.7267
3	27-Mar-97	1205	55.6050	-128.7377
3	1-May-97	1257	55.8983	-129.0068
3	11-Jun-97	1245	56.1600	-129.1533
3	5-Jul-97	1258	56.1577	-129.1537
3	6-Aug-97	1317	56.1442	-129.1633
3	25-Aug-97	1440	56.1412	-129.1433
3	13-Sep-97	1423	56.1612	-129.1415
3	3-Oct-97	1145	56.1225	-129.1300
3	3-Nov-97	1600	56.1702	-129.1527

Moose	Date	Time	Latitude	Longitude
3	2-Dec-97	1257	55.8172	-128.9177
3	2-Jan-98	1315	55.7318	-128.8010
3	22-Jan-98	1205	55.6895	-128.7672
3	11-Feb-98	1325	55.6415	-128.6578
3	4-Mar-98	1022	55.6852	-128.7558
3	25-Mar-98	1217	55.7657	-128.8422
3	1-May-98	1500	55.9511	-128.9781
3	26-Jun-98	1205	56.1622	-129.1731
3	20-Jul-98	1604	56.0920	-129.0935
3	19-Aug-98	1852	56.1395	-129.1015
3	18-Sep-98	1330	56.1640	-129.1772
3	22-Oct-98	1725	56.0989	-129.1608
4	18-Jan-97	capture	55.4095	-128.8412
4	8-Feb-97	1258	55.4616	-128.8336
4	20-Feb-97	940	55.4672	-128.8250
4	5-Mar-97	1410	55.4810	-128.8262
4	19-Mar-97	1446	55.4715	-128.8245
4	27-Mar-97	905	55.4683	-128.8167
4	1-May-97	924	55.4545	-128.8415
4	21-May-97	1419	55.4633	-128.8745
4	11-Jun-97	919	55.4485	-128.8820
4	5-Jul-97	942	55.4317	-128.8860
4	6-Aug-97	1755	55.4213	-128.8897
4	25-Aug-97	942	55.4197	-128.8778
4	13-Sep-97	1023	55.4625	-128.8452
4	3-Oct-97	1431	55.4660	-128.8403
4	3-Nov-97	1236	55.4712	-128.8367
4	3-Dec-97	1118	55.4720	-128.8532
4	2-Jan-98	1006	55.4758	-128.8587
4	22-Jan-98	1025	55.4752	-128.8607
5	18-Jan-97	capture	55.4800	-128.8045
5	8-Feb-97	1422	55.5007	-128.7770
5	20-Feb-97	932	55.4942	-128.7668
5	5-Mar-97	1418	55.4935	-128.7683
5	19-Mar-97	1429	55.4940	-128.7678
5	27-Mar-97	915	55.4957	-128.7592
5	1-May-97	1433	55.4898	-128.9152
5	21-May-97	950	55.5613	-129.0690
5	11-Jun-97	935	55.5225	-129.0123
5	5-Jul-97	956	55.5383	-129.0097
5	6-Aug-97	1115	55.5363	-129.0577
5	25-Aug-97	1608	55.4713	-129.0953
5	13-Sep-97	1150	55.4727	-129.0850
5	3-Oct-97	945	55.5442	-129.0038
5	3-Nov-97	1641	55.5333	-129.0032
5	3-Dec-97	949	55.5142	-129.0235
5	2-Jan-98	1402	55.5017	-128.9803
5	22-Jan-98	1432	55.5335	-128.9955
5	11-Feb-98	1459	55.5195	-129.0198
5	4-Mar-98	1449	55.4918	-129.0347
5	25-Mar-98	1820	55.5268	-129.0483
5	1-May-98	1850	55.5128	-129.0172
5	3-Jun-98	1730	55.5503	-129.0608
5	19-Aug-98	1221	55.4765	-129.0778
5	18-Sep-98	1141	55.5218	-129.0805
5	23-Oct-98	1021	55.5006	-128.9894
5	11-Nov-98	1541	55.5086	-129.0014
5	10-Dec-98	1543	55.4989	-129.0294
5	9-Feb-99	1631	55.5367	-129.0030
5	28-Feb-99	1457	55.5328	-128.9947
5	21-Mar-99	1314	55.5457	-129.0028
5	10-Apr-99	1623	55.4897	-129.0264
5	17-May-99	1845	55.5164	-128.9936
5	26-Jun-99	1537	55.5322	-129.0006
5	30-Jul-99	1814	55.5352	-129.0393
5	5-Nov-99	1236	55.5069	-129.0269
5	7-Dec-99	1505	55.5089	-129.0350
5	12-Jan-00	1521	55.4889	-129.0039
5	5-Mar-00	1432	55.4789	-128.9997
6	19-Jan-97	capture	55.6333	-128.6685
6	8-Feb-97	1538	55.6093	-128.5252
6	19-Feb-97	1511	55.6158	-128.5100
6	5-Mar-97	1233	55.6143	-128.5180
6	19-Mar-97	1318	55.6107	-128.5175
6	27-Mar-97	1032	55.6107	-128.5330
6	1-May-97	1223	56.0230	-129.0917
6	21-May-97	1159	56.0353	-129.1442
6	11-Jun-97	1204	56.0292	-129.1353
6	5-Jul-97	1325	56.0438	-129.1578
6	6-Aug-97	1304	56.0665	-129.1558
6	25-Aug-97	1530	56.0473	-129.1448
6	13-Sep-97	1510	56.0572	-129.1595
6	3-Oct-97	1158	56.0833	-129.1503
6	3-Nov-97	1526	56.0455	-129.1490
6	2-Dec-97	1413	56.0752	-129.1138
6	2-Jan-98	1124	55.6380	-128.6563
6	22-Jan-98	1115	55.6310	-128.6782
6	11-Feb-98	1332	55.6387	-128.6702
6	4-Mar-98	1341	55.5988	-128.6172
6	25-Mar-98	1220	55.7675	-128.8540
6	1-May-98	1345	56.0392	-129.1458
6	3-Jun-98	1445	56.0508	-129.1411

Moose	Date	Time	Latitude	Longitude
6	26-Jun-98	1233	56.0367	-129.1475
6	20-Jul-98	1614	56.0692	-129.1453
6	19-Aug-98	1830	56.0533	-129.1302
6	18-Sep-98	1442	56.0602	-129.1487
6	22-Oct-98	1731	56.0422	-129.1525
6	11-Nov-98	1204	56.0400	-129.1356
6	10-Dec-98	1405	55.9378	-129.0208
6	16-Jan-99	1300	55.6468	-128.7030
6	9-Feb-99	1227	55.5865	-128.5625
6	28-Feb-99	1153	55.6137	-128.5757
6	21-Mar-99	1010	55.6227	-128.5322
6	10-Apr-99	1556	55.6439	-128.6731
6	17-May-99	1112	56.0444	-129.1278
6	5-Jun-99	1243	56.0208	-129.1164
6	26-Jun-99	1234	56.0272	-129.0892
6	30-Jul-99	1454	56.0523	-129.1367
6	3-Sep-99	1715	56.0778	-129.1523
6	4-Oct-99	1415	56.0764	-129.1422
6	5-Nov-99	1343	56.0436	-129.1528
6	12-Jan-00	1104	55.6125	-128.5000
6	5-Mar-00	1101	55.6072	-128.5722
7	19-Jan-97	capture	55.4918	-128.8073
7	8-Feb-97	1440	55.5532	-128.7090
7	19-Feb-97	1650	55.5695	-128.6932
7	5-Mar-97	1500	55.5537	-128.7162
7	19-Mar-97	1423	55.5548	-128.7230
7	27-Mar-97	922	55.5408	-128.7638
7	1-May-97	853	55.3983	-128.8808
7	21-May-97	936	55.4137	-128.8935
7	11-Jun-97	915	55.4080	-128.8982
7	6-Aug-97	1034	55.4112	-128.8697
7	25-Aug-97	947	55.4157	-128.8815
7	13-Sep-97	1005	55.4077	-128.8957
7	3-Oct-97	1441	55.4010	-128.8970
7	3-Nov-97	1230	55.4173	-128.8768
7	3-Dec-97	1124	55.4215	-128.8765
7	2-Jan-98	953	55.3952	-128.8768
7	22-Jan-98	1021	55.4747	-128.8515
7	11-Feb-98	1005	55.5390	-128.7592
7	4-Mar-98	1403	55.5435	-128.7655
7	25-Mar-98	1710	55.4450	-128.8598
7	1-May-98	1904	55.4125	-128.8911
7	3-Jun-98	900	55.4178	-128.8808
7	26-Jun-98	949	55.4033	-128.8950
7	20-Jul-98	1240	55.4097	-128.8957
7	19-Aug-98	1203	55.4172	-128.8893

Moose	Date	Time	Latitude	Longitude
7	18-Sep-98	1124	55.4202	-128.8773
7	23-Oct-98	1034	55.4200	-128.8731
7	11-Nov-98	957	55.4169	-128.8756
7	10-Dec-98	926	55.4406	-128.8725
7	16-Jan-99	1017	55.5350	-128.7605
7	9-Feb-99	1618	55.5748	-128.7112
7	28-Feb-99	1015	55.5628	-128.7147
7	21-Mar-99	1000	55.5512	-128.7243
7	10-Apr-99	1056	55.4419	-128.8464
7	17-May-99	857	55.4000	-128.8794
7	5-Jun-99	1743	55.4153	-128.8958
7	26-Jun-99	1002	55.3897	-128.8869
7	30-Jul-99	1250	55.4097	-128.8705
7	3-Sep-99	1828	55.4060	-128.8895
7	4-Oct-99	936	55.4139	-128.8808
7	5-Nov-99	1156	55.4717	-128.8078
7	7-Dec-99	1514	55.3956	-128.8839
7	12-Jan-00	1047	55.5600	-128.7064
7	5-Mar-00	958	55.5489	-128.7250
8	19-Jan-97	capture	55.5555	-128.7408
8	8-Feb-97	1500	55.5924	-128.6795
8	19-Feb-97	1714	55.5770	-128.6650
8	5-Mar-97	1451	55.5862	-128.6497
8	19-Mar-97	1412	55.5870	-128.6507
8	27-Mar-97	954	55.5833	-128.6577
8	1-May-97	1415	55.6045	-128.8057
8	21-May-97	1023	55.7805	-129.2373
8	11-Jun-97	1312	55.8987	-129.3082
8	5-Jul-97	1020	55.8332	-129.3127
8	6-Aug-97	1134	55.8602	-129.2948
8	25-Aug-97	1337	55.8530	-129.3495
8	13-Sep-97	1248	55.8782	-129.3267
8	3-Oct-97	1040	55.8778	-129.3313
8	3-Nov-97	1439	55.9202	-129.3305
8	3-Dec-97	1017	55.9050	-129.3055
8	2-Jan-98	1019	55.4757	-128.7783
8	22-Jan-98	1033	55.4270	-128.7533
8	11-Feb-98	950	55.4818	-128.8068
8	4-Mar-98	1416	55.5470	-128.7405
8	25-Mar-98	950	55.5250	-128.7752
8	3-Jun-98	1338	55.9300	-129.3297
8	26-Jun-98	1500	55.8500	-129.3117
8	20-Jul-98	1825	55.8483	-129.3087
8	19-Aug-98	1625	55.8608	-129.3043
8	18-Sep-98	1511	55.9032	-129.3280
8	22-Oct-98	1805	55.8867	-129.3283

Moose	Date	Time	Latitude	Longitude
8	11-Nov-98	1045	55.8947	-129.3417
8	10-Dec-98	1535	55.5233	-128.8731
8	16-Jan-99	1619	55.5975	-128.7550
8	9-Feb-99	1052	55.5852	-128.6645
8	28-Feb-99	1025	55.5782	-128.6713
8	21-Mar-99	1002	55.5613	-128.7030
8	10-Apr-99	1111	55.5564	-128.7186
8	26-Jun-99	1512	55.8594	-129.2975
8	30-Jul-99	1608	55.8407	-129.3220
8	4-Oct-99	1443	55.8942	-129.3414
8	5-Nov-99	1332	55.8697	-129.3250
8	7-Dec-99	1453	55.5008	-128.9483
8	12-Jan-00	1550	55.4567	-128.7939
8	5-Mar-00	947	55.4806	-128.7892
9	19-Jan-97	capture	55.6498	-128.7287
9	8-Feb-97	1446	55.5587	-128.7029
9	19-Feb-97	1658	55.5585	-128.7018
9	5-Mar-97	1424	55.5620	-128.7022
9	19-Mar-97	1418	55.5637	-128.7022
9	27-Mar-97	938	55.5623	-128.6987
9	21-May-97	1052	55.9872	-129.3402
9	11-Jun-97	1013	55.9125	-129.3283
9	5-Jul-97	1155	55.9025	-129.3348
9	6-Aug-97	1439	55.9132	-129.3285
9	25-Aug-97	1235	55.9035	-129.3018
9	13-Sep-97	1241	55.8977	-129.3195
9	3-Oct-97	1020	55.9177	-129.3232
9	3-Nov-97	1421	55.8903	-129.3228
9	3-Dec-97	1014	55.9048	-129.3082
9	2-Jan-98	1032	55.5652	-128.6915
9	22-Jan-98	1058	55.5583	-128.6562
9	11-Feb-98	1020	55.5667	-128.7027
9	4-Mar-98	1356	55.6000	-128.7172
9	25-Mar-98	1600	55.5953	-128.7510
9	1-May-98	1356	55.9306	-129.2058
9	3-Jun-98	1328	55.9239	-129.3475
9	26-Jun-98	1429	55.9053	-129.3014
9	20-Jul-98	1750	55.9045	-129.3128
9	19-Aug-98	1611	55.9080	-129.3047
9	18-Sep-98	1517	55.9160	-129.3160
9	22-Oct-98	1811	55.8994	-129.3144
9	11-Nov-98	1041	55.8914	-129.2925
9	10-Dec-98	1236	55.8747	-129.2756
9	16-Jan-99	1106	55.5702	-128.6478
9	9-Feb-99	1253	55.5988	-128.7118
9	28-Feb-99	1009	55.5575	-128.6970

Moose	Date	Time	Latitude	Longitude
9	21-Mar-99	954	55.5650	-128.7133
9	10-Apr-99	1115	55.5633	-128.6914
9	17-May-99	1254	55.8728	-129.3192
9	5-Jun-99	1318	55.9056	-129.3394
9	26-Jun-99	1453	55.8692	-129.3267
9	30-Jul-99	1558	55.8942	-129.3295
9	3-Sep-99	1515	55.9013	-129.3233
9	4-Oct-99	1440	55.8942	-129.3414
9	5-Nov-99	1303	55.8969	-129.3200
10	19-Jan-97	capture	55.6317	-128.6850
10	9-Feb-97	1440	55.6136	-128.6078
10	19-Feb-97	1456	55.6095	-128.5825
10	5-Mar-97	1247	55.6208	-128.5845
10	19-Mar-97	1357	55.6260	-128.6030
10	27-Mar-97	1000	55.6250	-128.6483
10	6-Aug-97	1411	56.0253	-129.3650
10	25-Aug-97	1350	56.0225	-129.3138
10	13-Sep-97	1330	56.0365	-129.3550
10	3-Oct-97	1110	56.0168	-129.3342
10	2-Dec-97	1452	55.9485	-129.2490
10	2-Jan-98	1337	55.7582	-128.8590
10	22-Jan-98	1419	55.6525	-128.7583
10	11-Feb-98	1319	55.6398	-128.6512
10	4-Mar-98	1258	55.6243	-128.6270
10	25-Mar-98	1130	55.6338	-128.6548
10	1-May-98	1308	56.0117	-129.1125
10	3-Jun-98	1410	56.0269	-129.2911
10	26-Jun-98	1335	56.0306	-129.2858
10	20-Jul-98	1731	56.0182	-129.2750
10	19-Aug-98	1525	56.0422	-129.2982
10	18-Sep-98	1448	56.0087	-129.2953
10	22-Oct-98	1826	55.9686	-129.2333
10	11-Nov-98	1108	55.9614	-129.2192
10	10-Dec-98	1223	55.9567	-129.2042
10	16-Jan-99	1213	55.6353	-128.6500
10	9-Feb-99	1107	55.6203	-128.5113
10	28-Feb-99	1052	55.6102	-128.5080
10	21-Mar-99	1032	55.6095	-128.5012
10	10-Apr-99	1128	55.6233	-128.4669
10	17-May-99	1223	55.9461	-129.1997
10	5-Jun-99	1302	55.9625	-129.1969
10	26-Jun-99	1430	56.0111	-129.3731
10	30-Jul-99	1525	56.0145	-129.3298
10	4-Oct-99	1502	55.9806	-129.2197
10	5-Nov-99	1316	55.9517	-129.2314
10	7-Dec-99	1104	55.9456	-129.1239

Moose	Date	Time	Latitude	Longitude
10	12-Jan-00	1141	55.6375	-128.7267
10	5-Mar-00	1037	55.6361	-128.5458
11	19-Jan-97	capture	55.6008	-128.7357
11	8-Feb-97	1512	55.5957	-128.5756
11	19-Feb-97	1414	55.6007	-128.5618
11	5-Mar-97	1530	55.6205	-128.5148
11	19-Mar-97	1326	55.6223	-128.4805
11	27-Mar-97	1018	55.6292	-128.4868
11	1-May-97	1109	55.8562	-128.9693
11	21-May-97	1043	55.9290	-129.2908
11	11-Jun-97	1300	55.9242	-129.3140
11	5-Jul-97	1145	55.8920	-129.2913
11	6-Aug-97	1156	55.9140	-129.3153
11	25-Aug-97	1223	55.8988	-129.2870
11	13-Sep-97	1232	55.9048	-129.3122
11	3-Oct-97	1005	55.9038	-129.2990
11	3-Nov-97	1443	55.9353	-129.2722
11	3-Dec-97	1037	55.9417	-129.2080
11	2-Jan-98	1319	55.7352	-128.7955
11	22-Jan-98	1110	55.6327	-128.6460
11	11-Feb-98	1339	55.6432	-128.6492
11	4-Mar-98	1010	55.6617	-128.6608
11	25-Mar-98	1124	55.6622	-128.6598
11	1-May-98	1124	55.6703	-128.6744
11	3-Jun-98	1051	55.7417	-128.8594
11	26-Jun-98	1637	55.8847	-129.0683
11	20-Jul-98	1758	55.9180	-129.3250
11	19-Aug-98	1616	55.9225	-129.3305
11	18-Sep-98	1459	55.9105	-129.2950
11	22-Oct-98	1754	55.9372	-129.2758
11	11-Nov-98	1058	55.9375	-129.2697
11	10-Dec-98	1214	55.9453	-129.2003
11	16-Jan-99	1336	55.7612	-128.8545
11	9-Feb-99	1300	55.6763	-128.7817
11	28-Feb-99	1113	55.6088	-128.4722
11	21-Mar-99	1104	55.6233	-128.4983
11	10-Apr-99	1132	55.6228	-128.6361
11	17-May-99	1231	55.9264	-129.2097
11	5-Jun-99	1309	55.8903	-129.2825
11	26-Jun-99	1417	55.8831	-129.2819
11	30-Jul-99	1553	55.8858	-129.2887
11	3-Sep-99	1535	55.9242	-129.2925
11	4-Oct-99	1435	55.9039	-129.3175
11	5-Nov-99	1319	55.9403	-129.2661
11	7-Dec-99	1244	55.8447	-129.0333
11	12-Jan-00	1200	55.6814	-128.7608
11	5-Mar-00	1137	55.6919	-128.7456
12	19-Jan-97	capture	55.6270	-128.6177
12	9-Feb-97	1140	55.5915	-128.4037
12	19-Feb-97	1633	55.5787	-128.3870
12	5-Mar-97	1205	55.6022	-128.4110
12	19-Mar-97	1201	55.5972	-128.4113
12	27-Mar-97	1154	55.6080	-128.4365
12	1-May-97	957	55.6250	-128.6447
12	21-May-97	1442	55.6517	-128.5692
12	11-Jun-97	1426	55.6290	-128.6238
12	5-Jul-97	1520	55.6633	-128.5550
12	25-Aug-97	1021	55.6783	-128.5687
12	13-Sep-97	1700	55.6948	-128.5837
12	3-Oct-97	1359	55.6682	-128.5802
12	3-Nov-97	1301	55.6598	-128.5498
12	2-Dec-97	1231	55.6907	-128.5977
12	2-Jan-98	1059	55.6373	-128.5878
12	22-Jan-98	1126	55.6408	-128.5443
12	11-Feb-98	1058	55.6000	-128.4032
12	4-Mar-98	1303	55.6385	-128.5885
12	25-Mar-98	1102	55.6250	-128.6415
12	1-May-98	1106	55.6500	-128.5861
12	3-Jun-98	1621	55.6861	-128.5681
12	26-Jun-98	1103	55.6756	-128.5567
12	20-Jul-98	1506	55.6738	-128.5697
12	19-Aug-98	1050	55.6752	-128.5705
12	18-Sep-98	1041	55.6802	-128.5870
12	23-Oct-98	1121	55.6575	-128.5378
12	11-Nov-98	1428	55.6856	-128.5869
12	16-Jan-99	1133	55.6097	-128.4673
12	9-Feb-99	1146	55.5892	-128.3647
12	28-Feb-99	1110	55.6103	-128.4797
12	21-Mar-99	1024	55.6380	-128.5942
12	10-Apr-99	1140	55.6236	-128.6469
12	17-May-99	938	55.6394	-128.5964
12	26-Jun-99	1201	55.6906	-128.5819
12	30-Jul-99	1347	55.6903	-128.5833
12	3-Sep-99	1305	55.6877	-128.5977
12	4-Oct-99	1018	55.6575	-128.5672
12	5-Nov-99	1551	55.6900	-128.5953
12	7-Dec-99	1329	55.6358	-128.5964
12	12-Jan-00	1415	55.6097	-128.4814
12	5-Mar-00	1406	55.5911	-128.4400
13	21-Jan-97	capture	55.6063	-128.5433
13	8-Feb-97	1521	55.5805	-128.5875
13	19-Feb-97	1618	55.6017	-128.5460

Moose	Date	Time	Latitude	Longitude
13	5-Mar-97	1236	55.6125	-128.5370
13	19-Mar-97	1335	55.6220	-128.4952
13	27-Mar-97	1026	55.6075	-128.5515
13	1-May-97	1037	55.7933	-128.8607
13	21-May-97	1236	55.9067	-129.1150
13	11-Jun-97	1030	55.8843	-129.3092
13	5-Jul-97	1151	55.9038	-129.2905
13	6-Aug-97	1454	55.8992	-129.2897
13	25-Aug-97	1244	55.9133	-129.2760
13	13-Sep-97	1220	55.8955	-129.2913
13	3-Oct-97	1031	55.9018	-129.2922
13	3-Nov-97	1448	55.9352	-129.2700
13	3-Dec-97	1038	55.9418	-129.2080
13	2-Jan-98	1107	55.6038	-128.5318
13	22-Jan-98	1144	55.5947	-128.4925
13	11-Feb-98	1045	55.6025	-128.5418
13	4-Mar-98	1316	55.6042	-128.5920
13	25-Mar-98	1049	55.6050	-128.5955
13	1-May-98	1144	55.7783	-128.8486
13	3-Jun-98	1351	55.8761	-129.3186
13	26-Jun-98	1441	55.9133	-129.2786
13	20-Jul-98	1802	55.9432	-129.2810
13	19-Aug-98	1520	55.9552	-129.2813
13	18-Sep-98	1506	55.9242	-129.2768
13	22-Oct-98	1818	55.9489	-129.2769
13	11-Nov-98	1105	55.9428	-129.2597
13	10-Dec-98	1507	55.8331	-129.0061
13	16-Jan-99	1319	55.6943	-128.7747
13	9-Feb-99	1155	55.6073	-128.4908
13	28-Feb-99	1102	55.6188	-128.4975
13	21-Mar-99	1053	55.6212	-128.4568
13	10-Apr-99	1238	55.6186	-128.4586
13	17-May-99	1425	55.8983	-129.0233
13	5-Jun-99	1329	55.9533	-129.2744
13	26-Jun-99	1410	55.9431	-129.2611
13	30-Jul-99	1545	55.9533	-129.2867
13	3-Sep-99	1506	55.9555	-129.2765
13	4-Oct-99	1454	55.9506	-129.2956
13	5-Nov-99	1324	55.9475	-129.2861
13	7-Dec-99	1256	55.7542	-128.8389
13	12-Jan-00	1351	55.7356	-128.7767
13	5-Mar-00	1208	55.7331	-128.7831
14	20-Jan-97	capture	55.8052	-128.8733
14	19-Feb-97	1327	55.8268	-128.8562
14	5-Mar-97	1057	55.8238	-128.8497
14	19-Mar-97	1117	55.8268	-128.8553
14	27-Mar-97	1228	55.8300	-128.8593
14	1-May-97	1029	55.7822	-128.8573
14	21-May-97	1326	55.8280	-128.9105
14	11-Jun-97	1046	55.8090	-128.8970
14	5-Jul-97	1037	55.7957	-128.8998
14	6-Aug-97	1644	55.8140	-128.8832
14	25-Aug-97	1047	55.7840	-128.8920
14	13-Sep-97	1615	55.7898	-128.9000
14	3-Oct-97	1333	55.7853	-128.8920
14	3-Nov-97	1318	55.7975	-128.8992
14	2-Dec-97	1244	55.8005	-128.8530
14	2-Jan-98	1305	55.7802	-128.9008
14	22-Jan-98	1405	55.7670	-128.8720
14	4-Mar-98	1248	55.7327	-128.8667
14	25-Mar-98	1204	55.7305	-128.8647
14	1-May-98	1155	55.7989	-128.9056
14	3-Jun-98	1121	55.7997	-128.8644
14	26-Jun-98	1931	55.7847	-128.8853
14	20-Jul-98	1941	55.8128	-128.9107
14	19-Aug-98	1712	55.8125	-128.9022
14	18-Sep-98	1210	55.7948	-128.8430
14	23-Oct-98	1133	55.7867	-128.8483
14	11-Nov-98	1323	55.8056	-128.8689
15	20-Jan-97	capture	55.8513	-128.9287
15	9-Feb-97	1404	55.8338	-128.8962
15	19-Feb-97	1312	55.8308	-128.9147
15	5-Mar-97	1042	55.8303	-128.9123
15	19-Mar-97	1104	55.8317	-128.9162
15	27-Mar-97	1236	55.8310	-128.9117
15	1-May-97	1309	55.9272	-129.0123
15	21-May-97	1225	55.9015	-129.0180
15	11-Jun-97	1142	55.9292	-128.9852
15	5-Jul-97	1459	55.8685	-128.9725
15	6-Aug-97	1513	55.9195	-128.9987
15	25-Aug-97	1109	55.9100	-129.0162
15	13-Sep-97	1548	55.8762	-128.9555
15	3-Oct-97	1305	55.8400	-128.9220
15	3-Nov-97	1330	55.9327	-128.9970
15	2-Dec-97	1303	55.8603	-128.9495
15	2-Jan-98	1233	55.8463	-128.9167
15	22-Jan-98	1339	55.8402	-128.9093
15	4-Mar-98	1048	55.8000	-128.8092
15	25-Mar-98	1406	55.7948	-128.8295
15	1-May-98	1532	55.9008	-128.9647
15	3-Jun-98	1528	55.9281	-129.0042
15	26-Jun-98	1138	55.9100	-129.0114

Moose	Date	Time	Latitude	Longitude
15	20-Jul-98	1902	55.9045	-128.9980
15	19-Aug-98	1818	55.9037	-129.0037
15	18-Sep-98	1233	55.8347	-128.9097
15	11-Nov-98	1400	55.8908	-128.9911
15	10-Dec-98	1131	55.9331	-129.0158
15	16-Jan-99	1400	55.9225	-129.0067
15	9-Feb-99	1346	55.9235	-128.9957
15	28-Feb-99	1331	55.9187	-128.9940
15	21-Mar-99	1205	55.9172	-128.9975
15	10-Apr-99	1456	55.8983	-128.9586
15	17-May-99	1041	55.9247	-129.0064
15	5-Jun-99	1419	55.8561	-128.9336
15	26-Jun-99	1216	55.8928	-128.9772
15	30-Jul-99	1705	55.9073	-129.0048
15	3-Sep-99	1409	55.9010	-128.9943
15	4-Oct-99	1310	55.8994	-128.9925
15	5-Nov-99	1442	55.8869	-128.9836
15	7-Dec-99	1203	55.8489	-128.9325
15	12-Jan-00	1236	55.8536	-128.9189
15	5-Mar-00	1335	55.8664	-128.9231
16	20-Jan-97	capture	55.8060	-128.8668
16	19-Feb-97	1320	55.8410	-128.8967
16	5-Mar-97	1049	55.8402	-128.8943
16	19-Mar-97	1111	55.8445	-128.8927
16	27-Mar-97	1240	55.8423	-128.8935
16	1-May-97	1330	55.8725	-128.8688
16	21-May-97	1346	55.8732	-128.8257
16	11-Jun-97	1411	55.8743	-128.8197
16	5-Jul-97	1448	55.8742	-128.8485
16	6-Aug-97	1536	55.8617	-128.8413
16	25-Aug-97	1201	55.8770	-128.8303
16	13-Sep-97	1635	55.8842	-128.8723
16	3-Oct-97	1307	55.8403	-128.9202
16	3-Nov-97	1400	55.8487	-128.8840
16	2-Dec-97	1312	55.8337	-128.9197
16	2-Jan-98	1250	55.8025	-128.8763
16	22-Jan-98	1345	55.7918	-128.8663
16	4-Mar-98	1103	55.8308	-128.8470
16	25-Mar-98	1428	55.8300	-128.8458
16	1-May-98	1740	55.8647	-128.8136
16	3-Jun-98	1603	55.8494	-128.8003
16	26-Jun-98	1819	55.8806	-128.8258
16	20-Jul-98	1908	55.8750	-128.8472
16	19-Aug-98	1749	55.8893	-128.8455
16	18-Sep-98	1238	55.8353	-128.9123
16	23-Oct-98	1232	55.8517	-128.8836

Moose	Date	Time	Latitude	Longitude
16	11-Nov-98	1408	55.8469	-128.9408
16	10-Dec-98	1456	55.8342	-128.9081
16	16-Jan-99	1350	55.8333	-128.8450
16	9-Feb-99	1332	55.8205	-128.8365
16	28-Feb-99	1314	55.8470	-128.8617
16	21-Mar-99	1149	55.8407	-128.8822
16	10-Apr-99	1520	55.8481	-128.9069
16	17-May-99	1030	55.8331	-128.8994
16	5-Jun-99	1426	55.8081	-128.8800
16	26-Jun-99	1129	55.8667	-128.8608
16	30-Jul-99	1718	55.8623	-128.8330
16	3-Sep-99	1354	55.8668	-128.8385
16	4-Oct-99	1036	55.8967	-128.8594
16	7-Dec-99	1424	55.7808	-128.8578
17	20-Jan-97	capture	56.1117	-129.2353
17	9-Feb-97	1340	56.1093	-129.2233
17	19-Feb-97	1042	56.1180	-129.2247
17	5-Mar-97	1000	56.1167	-129.2180
17	19-Mar-97	1031	56.1208	-129.2323
17	27-Mar-97	1301	56.1223	-129.2375
17	1-May-97	1212	56.1263	-129.2690
17	21-May-97	1108	56.1708	-129.3173
17	11-Jun-97	1219	56.1460	-129.3313
17	5-Jul-97	1246	56.1160	-129.2727
17	6-Aug-97	1347	56.1515	-129.3332
17	25-Aug-97	1424	56.1393	-129.3550
17	13-Sep-97	1410	56.1578	-129.3418
17	3-Oct-97	1132	56.1465	-129.3328
17	3-Nov-97	1543	56.1630	-129.3332
17	2-Dec-97	1427	56.1802	-129.3563
17	22-Jan-98	1316	56.1223	-129.2505
17	11-Feb-98	1244	56.1180	-129.2408
17	4-Mar-98	1212	56.1195	-129.2283
17	25-Mar-98	1342	56.1260	-129.2277
17	1-May-98	1322	56.1408	-129.2442
17	3-Jun-98	1254	56.1486	-129.2833
17	26-Jun-98	1216	56.1653	-129.3319
17	20-Jul-98	1625	56.1417	-129.3313
17	19-Aug-98	1841	56.1597	-129.3513
17	18-Sep-98	1336	56.1502	-129.3402
17	22-Oct-98	1517	56.1603	-129.3394
17	11-Nov-98	1144	56.1803	-129.3547
17	10-Dec-98	1322	56.1875	-129.3597
17	16-Jan-99	1457	56.1387	-129.2417
17	9-Feb-99	1531	56.1367	-129.2327
17	28-Feb-99	1345	56.0925	-129.2280

Moose	Date	Time	Latitude	Longitude
17	21-Mar-99	1246	56.0883	-129.2350
17	10-Apr-99	1423	56.1294	-129.2411
17	17-May-99	1123	56.1194	-129.2722
17	5-Jun-99	1250	56.1167	-129.2658
17	26-Jun-99	1252	56.1669	-129.3211
17	30-Jul-99	1511	56.1620	-129.3440
17	3-Sep-99	1703	56.1785	-129.3598
17	4-Oct-99	1405	56.1375	-129.3464
17	5-Nov-99	1400	56.1672	-129.3386
17	7-Dec-99	1117	56.1033	-129.2428
17	12-Jan-00	1258	56.0997	-129.2583
17	5-Mar-00	1315	56.0908	-129.2614
18	21-Jan-97	capture	55.6080	-128.5238
18	9-Feb-97	1055	55.6190	-128.4940
18	19-Feb-97	1426	55.6030	-128.4680
18	5-Mar-97	1223	55.6155	-128.4733
18	19-Mar-97	1212	55.6162	-128.4982
18	27-Mar-97	1136	55.6038	-128.5450
18	1-May-97	1009	55.6287	-128.6700
18	21-May-97	1505	55.5873	-128.7027
18	11-Jun-97	1440	55.5767	-128.7243
18	5-Jul-97	1533	55.6158	-128.6500
18	6-Aug-97	1728	55.5717	-128.7047
18	25-Aug-97	1005	55.5870	-128.6763
18	3-Oct-97	1422	55.5538	-128.7188
18	3-Nov-97	1245	55.5763	-128.7383
18	3-Dec-97	1110	55.5435	-128.6818
18	2-Jan-98	1042	55.5727	-128.6050
18	22-Jan-98	1132	55.6005	-128.4695
18	11-Feb-98	1033	55.5918	-128.5947
18	4-Mar-98	1310	55.5938	-128.5898
18	25-Mar-98	1725	55.5455	-128.7050
18	1-May-98	1757	55.5858	-128.6969
18	3-Jun-98	935	55.5564	-128.6981
18	26-Jun-98	1012	55.5372	-128.7303
18	19-Aug-98	1150	55.5742	-128.7035
18	18-Sep-98	1111	55.5915	-128.7242
18	23-Oct-98	1045	55.5456	-128.7064
18	11-Nov-98	1531	55.5364	-128.7208
18	10-Dec-98	1013	55.5464	-128.7078
18	16-Jan-99	1028	55.5440	-128.7183
19	20-Jan-97	capture	56.0572	-129.2017
19	9-Feb-97	1327	56.0797	-129.2187
19	19-Feb-97	1036	56.0760	-129.2217
19	5-Mar-97	945	56.0710	-129.2223
19	19-Mar-97	1040	56.0683	-129.1995

Moose	Date	Time	Latitude	Longitude
20	20-Jan-97	capture	55.8513	-128.9287
20	9-Feb-97	1417	55.7853	-128.8218
20	19-Feb-97	1336	55.7885	-128.8325
20	5-Mar-97	1108	55.7918	-128.8403
20	19-Mar-97	1126	55.7897	-128.8250
20	27-Mar-97	1218	55.7817	-128.8127
20	1-May-97	1231	56.0130	-129.0437
20	21-May-97	1215	56.0173	-129.0618
20	11-Jun-97	1151	55.9460	-129.0405
20	5-Jul-97	1431	55.9555	-129.0397
20	6-Aug-97	1628	55.9752	-129.0512
20	25-Aug-97	1541	55.9733	-129.0650
20	13-Sep-97	1530	55.9733	-129.0608
20	3-Oct-97	1246	55.9773	-129.0518
20	3-Nov-97	1336	55.9233	-129.0260
20	2-Dec-97	1356	55.9688	-129.0525
20	2-Jan-98	1243	55.8368	-128.9280
20	22-Jan-98	1335	55.8248	-128.9108
20	4-Mar-98	1038	55.7823	-128.8233
20	25-Mar-98	1410	55.7823	-128.8310
20	1-May-98	1452	55.9725	-129.0583
20	3-Jun-98	1158	55.9689	-129.0536
20	19-Aug-98	1811	56.0863	-129.0785
20	18-Sep-98	1402	56.0667	-129.0642
20	22-Oct-98	1744	56.0211	-129.0183
20	11-Nov-98	1158	56.0131	-129.0292
20	10-Dec-98	1307	55.9797	-129.0672
20	16-Jan-99	1526	55.8715	-128.9642
20	9-Feb-99	1323	55.8407	-128.9147
20	28-Feb-99	1300	55.8182	-128.9053
20	21-Mar-99	1154	55.8043	-128.8762
20	10-Apr-99	1529	55.7844	-128.8308
20	17-May-99	1102	55.9844	-129.0656
20	5-Jun-99	1347	56.0125	-129.0553
20	26-Jun-99	1230	56.0119	-129.0561
20	30-Jul-99	1637	56.0303	-129.0238
20	4-Oct-99	1534	55.9394	-128.9478
20	5-Nov-99	1435	55.9344	-129.0347
20	7-Dec-99	1211	55.8392	-128.9222
20	12-Jan-00	1214	55.7400	-128.8172
20	5-Mar-00	1222	55.7928	-128.8297
21	28-Feb-98	capture	55.4848	-128.8072
21	25-Mar-98	1715	55.4643	-128.8435
21	1-May-98	1916	55.4222	-128.8953
21	3-Jun-98	847	55.3806	-128.8933
21	26-Jun-98	956	55.4019	-128.8950

Moose	Date	Time	Latitude	Longitude
21	20-Jul-98	1303	55.3647	-128.9310
21	19-Aug-98	1231	55.4037	-128.9030
21	18-Sep-98	1130	55.4052	-128.8753
22	1-Mar-98	capture	55.6252	-128.6593
22	25-Mar-98	1115	55.6370	-128.6637
22	1-May-98	1820	55.6222	-128.6447
22	3-Jun-98	1010	55.6328	-128.6475
22	27-Jun-98	830	55.6472	-128.7022
22	20-Jul-98	2000	55.6352	-128.6608
22	19-Aug-98	1125	55.6352	-128.6747
22	18-Sep-98	1059	55.6430	-128.6578
22	23-Oct-98	1102	55.6114	-128.6356
22	11-Nov-98	1522	55.6100	-128.5956
22	10-Dec-98	1039	55.6464	-128.6719
22	16-Jan-99	1206	55.6080	-128.6335
22	9-Feb-99	1240	55.6338	-128.6107
22	28-Feb-99	1200	55.6337	-128.6340
22	21-Mar-99	1113	55.6338	-128.6518
22	10-Apr-99	1605	55.6358	-128.6561
22	17-May-99	1002	55.6300	-128.6375
22	5-Jun-99	1637	55.6325	-128.6667
22	26-Jun-99	1108	55.6503	-128.6319
22	30-Jul-99	1326	55.6432	-128.6885
22	3-Sep-99	1251	55.6338	-128.6337
22	4-Oct-99	956	55.6433	-128.6347
22	5-Nov-99	1146	55.6056	-128.6433
22	7-Dec-99	1319	55.6211	-128.6478
22	12-Jan-00	1113	55.5789	-128.5817
22	5-Mar-00	1110	55.6339	-128.6503
23	1-Mar-98	capture	55.6127	-128.6745
23	25-Mar-98	1150	55.6782	-128.7008
23	1-May-98	1645	55.8922	-128.8850
23	3-Jun-98	1111	55.7828	-128.8386
23	26-Jun-98	1830	55.8853	-128.8522
23	20-Jul-98	1928	55.9150	-128.8433
23	19-Aug-98	1910	56.0225	-128.9145
23	18-Sep-98	1309	56.0012	-128.8817
23	23-Oct-98	1225	55.9547	-128.8550
23	11-Nov-98	1257	55.9531	-128.8642
23	10-Dec-98	1417	55.9203	-128.8531
23	16-Jan-99	1604	55.6208	-128.4698
23	9-Feb-99	1131	55.6247	-128.4723
23	28-Feb-99	1135	55.6055	-128.4095
23	21-Mar-99	1047	55.5927	-128.3925
23	10-Apr-99	1246	55.6114	-128.5286
23	5-Jun-99	1512	55.8986	-128.8581

Moose	Date	Time	Latitude	Longitude
23	30-Jul-99	1734	55.8978	-128.8598
23	3-Sep-99	1432	56.0255	-128.9145
23	5-Nov-99	1508	55.9967	-128.8897
23	7-Dec-99	1311	55.6564	-128.6633
23	12-Jan-00	1121	55.6258	-128.5794
23	5-Mar-00	1402	55.5944	-128.4131
24	28-Feb-98	capture	55.4235	-128.8087
24	25-Mar-98	1746	55.4015	-128.8167
24	1-May-98	919	55.3911	-128.8767
24	4-Jun-98	850	55.3114	-128.7114
24	27-Jun-98	937	55.3369	-128.7681
24	19-Aug-98	1325	55.3345	-128.7363
24	17-Sep-98	1444	55.3102	-128.6883
24	22-Oct-98	1405	55.3153	-128.6622
24	11-Nov-98	933	55.3147	-128.6658
24	10-Dec-98	952	55.3158	-128.6775
24	16-Jan-99	941	55.3613	-128.6563
24	9-Feb-99	1030	55.4288	-128.7132
24	28-Feb-99	957	55.4288	-128.7098
24	21-Mar-99	945	55.4247	-128.7125
24	10-Apr-99	1047	55.4236	-128.7156
24	17-May-99	1824	55.3911	-128.8836
24	5-Jun-99	1016	55.3989	-128.8247
24	26-Jun-99	1031	55.3375	-128.7600
24	30-Jul-99	1207	55.3362	-128.7713
24	3-Sep-99	1132	55.3402	-128.7455
24	4-Oct-99	1749	55.3117	-128.6672
24	5-Nov-99	1622	55.3128	-128.6708
24	7-Dec-99	1013	55.3133	-128.6639
24	12-Jan-00	945	55.4139	-128.8286
24	5-Mar-00	1458	55.3153	-128.6689
25	28-Feb-98	capture	55.4235	-128.8087
25	25-Mar-98	1751	55.4333	-128.8075
25	1-May-98	910	55.3894	-128.8542
25	4-Jun-98	934	55.3914	-128.7119
25	20-Jul-98	2025	55.4113	-128.6842
25	19-Aug-98	1300	55.4572	-128.6627
25	17-Sep-98	1425	55.4523	-128.6570
25	22-Oct-98	1434	55.4497	-128.6472
25	11-Nov-98	948	55.4439	-128.6372
25	16-Jan-99	955	55.3933	-128.8527
25	9-Feb-99	1008	55.4038	-128.8440
25	28-Feb-99	946	55.4355	-128.7933
25	21-Mar-99	936	55.4400	-128.7955
25	10-Apr-99	1024	55.4375	-128.7811
25	17-May-99	917	55.4106	-128.8406

Moose	Date	Time	Latitude	Longitude
25	5-Jun-99	1752	55.3903	-128.8025
25	26-Jun-99	1038	55.3869	-128.8053
25	30-Jul-99	1238	55.4730	-128.8063
25	4-Oct-99	1757	55.4500	-128.6539
25	5-Nov-99	1616	55.4439	-128.6367
25	7-Dec-99	1029	55.4269	-128.8089
25	12-Jan-00	1015	55.3117	-128.6681
25	5-Mar-00	924	55.4439	-128.8197
26	1-Mar-98	capture	55.6175	-128.6483
26	25-Mar-98	1458	55.7383	-128.7283
26	1-May-98	1620	55.7969	-128.7367
26	3-Jun-98	1057	55.7692	-128.8414
26	26-Jun-98	1908	55.7856	-128.7408
26	20-Jul-98	1919	55.8123	-128.8120
26	19-Aug-98	1727	55.7883	-128.7807
26	18-Sep-98	1253	55.7820	-128.7123
26	11-Nov-98	1438	55.6417	-128.6325
26	10-Dec-98	1100	55.6403	-128.6506
26	16-Jan-99	1058	55.5667	-128.6567
26	9-Feb-99	1233	55.6135	-128.6397
26	28-Feb-99	1205	55.6008	-128.6288
26	21-Mar-99	1125	55.5887	-128.6210
26	10-Apr-99	1143	55.6219	-128.6411
26	17-May-99	1511	55.7861	-128.7253
26	5-Jun-99	1436	55.7886	-128.7881
26	26-Jun-99	1154	55.7864	-128.6933
26	30-Jul-99	1402	55.8035	-128.7270
26	3-Sep-99	1329	55.7713	-128.6965
26	4-Oct-99	1028	55.7628	-128.6989
26	5-Nov-99	1600	55.6228	-128.6508
26	7-Dec-99	1314	55.6375	-128.6572
26	12-Jan-00	1131	55.6211	-128.6494
26	5-Mar-00	1011	55.5706	-128.6586
27	1-Mar-98	capture	55.6307	-128.5182
27	25-Mar-98	1140	55.6858	-128.7593
27	1-May-98	1206	55.7864	-128.8939
27	3-Jun-98	1705	55.7811	-129.1764
27	26-Jun-98	1558	55.7589	-129.1889
27	20-Jul-98	1849	55.7835	-129.1982
27	19-Aug-98	1650	55.7578	-129.1975
27	18-Sep-98	1542	55.8060	-129.2065
27	23-Oct-98	1148	55.7867	-129.2011
27	11-Nov-98	1030	55.7819	-129.1889
27	10-Dec-98	1523	55.6819	-128.7169
27	16-Jan-99	1217	55.6312	-128.6572
28	1-Mar-98	capture	55.6252	-128.6593

Moose	Date	Time	Latitude	Longitude
28	25-Mar-98	1155	55.6662	-128.6950
28	3-Jun-98	1033	55.6550	-128.7347
28	27-Jun-98	814	55.6658	-128.7378
28	20-Jul-98	1957	55.6683	-128.7377
28	19-Aug-98	1102	55.6463	-128.6938
28	18-Sep-98	1154	55.6352	-128.7143
28	23-Oct-98	1112	55.6508	-128.7047
28	11-Nov-98	1504	55.6431	-128.6869
28	10-Dec-98	1045	55.6472	-128.6886
28	16-Jan-99	1230	55.6555	-128.6687
29	1-Mar-98	capture	55.6307	-128.5182
29	25-Mar-98	1225	55.8167	-128.9203
29	1-May-98	1527	55.9044	-129.0175
29	20-Jul-98	1741	55.9238	-129.4183
29	19-Aug-98	1637	55.9223	-129.4223
29	18-Sep-98	1457	55.9065	-129.3122
29	22-Oct-98	1800	55.9008	-129.3389
29	11-Nov-98	1049	55.8944	-129.3367
29	10-Dec-98	1230	55.9139	-129.2856
29	16-Jan-99	1155	55.6317	-128.5315
29	9-Feb-99	1110	55.6180	-128.4947
29	28-Feb-99	1142	55.6270	-128.4908
29	21-Mar-99	1036	55.6040	-128.4720
29	10-Apr-99	1549	55.6875	-128.7719
29	17-May-99	1244	55.8969	-129.3178
29	5-Jun-99	1314	55.8933	-129.3375
29	26-Jun-99	1443	55.9211	-129.4242
29	30-Jul-99	1534	55.9327	-129.4003
29	3-Sep-99	1526	55.9138	-129.3220
29	4-Oct-99	1430	55.9231	-129.3286
29	18-Oct-99	capture	55.9138	-129.3433
29	5-Nov-99	1307	55.9153	-129.3028
29	7-Dec-99	1430	55.7678	-128.8592
29	12-Jan-00	1418	55.6119	-128.4742
29	5-Mar-00	1119	55.6261	-128.6781
30	1-Mar-98	capture	55.6653	-128.6825
30	4-Mar-98	1013	55.6602	-128.6657
30	25-Mar-98	1418	55.7325	-128.8220
30	3-Jun-98	1645	55.7919	-129.1011
30	27-Jun-98	724	55.7781	-129.0625
30	20-Jul-98	1840	55.7920	-129.1352
30	19-Aug-98	1700	55.7952	-129.1247
30	18-Sep-98	1538	55.7882	-129.1295
30	23-Oct-98	1144	55.7878	-129.1194
30	11-Nov-98	1034	55.7847	-129.1300
30	10-Dec-98	1253	55.8269	-129.0472

Moose	Date	Time	Latitude	Longitude
30	16-Jan-99	1313	55.7065	-128.7728
30	9-Feb-99	1600	55.7070	-128.7547
30	28-Feb-99	1216	55.7020	-128.7748
30	21-Mar-99	1134	55.7038	-128.7608
30	10-Apr-99	1545	55.7069	-128.7756
30	17-May-99	1528	55.7864	-129.1136
30	5-Jun-99	1544	55.7825	-129.0236
30	26-Jun-99	1525	55.7750	-129.0839
30	30-Jul-99	1801	55.7883	-129.1308
30	4-Oct-99	1518	55.7861	-129.1303
30	5-Nov-99	1255	55.7883	-129.1253
30	7-Dec-99	1437	55.7442	-128.8372
30	12-Jan-00	1156	55.6908	-128.7528
30	5-Mar-00	1149	55.7039	-128.7692
31	1-Mar-98	capture	55.6245	-128.6592
31	25-Mar-98	1108	55.6335	-128.6642
31	1-May-98	1117	55.6378	-128.6836
31	3-Jun-98	1025	55.6411	-128.7258
31	27-Jun-98	800	55.6692	-128.7247
31	20-Jul-98	1955	55.6608	-128.7477
31	19-Aug-98	1110	55.6590	-128.7455
31	18-Sep-98	1205	55.7718	-128.8480
31	23-Oct-98	1135	55.7906	-128.8644
31	11-Nov-98	1510	55.6858	-128.7639
31	10-Dec-98	1050	55.6722	-128.7425
31	16-Jan-99	1304	55.6657	-128.7318
31	9-Feb-99	1059	55.5918	-128.5877
31	28-Feb-99	1043	55.5975	-128.5767
31	21-Mar-99	1018	55.6062	-128.5728
31	10-Apr-99	1303	55.6600	-128.7017
31	17-May-99	1015	55.6803	-128.7436
31	5-Jun-99	1621	55.6519	-128.7225
31	26-Jun-99	1115	55.6772	-128.7397
31	30-Jul-99	1333	55.6677	-128.7272
31	3-Sep-99	1318	55.6717	-128.7608
31	4-Oct-99	1633	55.7689	-128.8406
31	5-Nov-99	1537	55.7711	-128.8406
31	7-Dec-99	1301	55.6875	-128.7686
31	12-Jan-00	1150	55.6850	-128.7494
31	5-Mar-00	1129	55.6497	-128.7356
32	2-Mar-98	capture	55.8008	-128.8325
32	25-Mar-98	1505	55.7428	-128.7587
32	1-May-98	1635	55.8439	-128.8631
32	3-Jun-98	1139	55.8144	-128.8850
32	26-Jun-98	1841	55.8478	-128.8378
32	20-Jul-98	1938	55.8167	-128.9382

Moose	Date	Time	Latitude	Longitude
32	19-Aug-98	1717	55.8190	-128.9053
32	18-Sep-98	1228	55.8417	-128.8570
32	11-Nov-98	1312	55.8214	-128.9256
32	10-Dec-98	1448	55.8131	-128.9161
32	16-Jan-99	1144	55.6092	-128.5383
32	9-Feb-99	1115	55.6047	-128.4778
32	28-Feb-99	1057	55.6168	-128.5183
32	21-Mar-99	1014	55.5743	-128.5310
32	10-Apr-99	1540	55.7197	-128.7844
32	17-May-99	1456	55.8269	-128.8164
32	5-Jun-99	1600	55.8403	-128.8997
32	26-Jun-99	1124	55.8250	-128.9169
32	30-Jul-99	1726	55.8548	-128.8710
32	3-Sep-99	1348	55.8537	-128.8702
32	4-Oct-99	1301	55.8186	-128.8836
32	5-Nov-99	1521	55.8200	-128.9258
32	7-Dec-99	1218	55.8225	-128.9042
32	12-Jan-00	1422	55.6014	-128.4719
32	5-Mar-00	1044	55.6239	-128.5325
33	2-Mar-98	capture	55.6308	-128.5650
33	25-Mar-98	1023	55.6335	-128.5027
33	1-May-98	1542	55.8939	-129.0000
33	26-Jun-98	1750	56.0447	-128.8692
33	20-Jul-98	1545	56.0652	-128.8845
33	19-Aug-98	1903	56.0857	-128.9095
33	18-Sep-98	1317	56.0545	-128.8747
33	23-Oct-98	1211	56.0389	-128.8464
33	11-Nov-98	1247	56.0650	-128.8758
33	10-Dec-98	1435	55.8606	-128.8447
33	16-Jan-99	1159	55.6337	-128.5918
33	9-Feb-99	1203	55.6243	-128.5690
33	28-Feb-99	1104	55.6190	-128.4847
33	21-Mar-99	1100	55.6328	-128.4978
33	10-Apr-99	1255	55.6303	-128.5844
33	17-May-99	1053	55.9336	-129.0039
33	5-Jun-99	1409	55.9653	-129.0131
33	30-Jul-99	1647	56.0562	-128.8663
33	5-Nov-99	1457	56.0581	-128.8731
33	7-Dec-99	1307	55.6792	-128.7000
33	12-Jan-00	1125	55.6322	-128.5964
33	5-Mar-00	1025	55.6256	-128.4906
34	2-Mar-98	capture	55.6358	-128.4933
34	25-Mar-98	1015	55.6413	-128.5058
34	1-May-98	1048	55.6244	-128.5036
34	3-Jun-98	949	55.6119	-128.4872
34	26-Jun-98	1037	55.6283	-128.4767

Moose	Date	Time	Latitude	Longitude
34	20-Jul-98	1445	55.6177	-128.4623
34	19-Aug-98	1141	55.6225	-128.4862
34	18-Sep-98	1047	55.6243	-128.4727
34	23-Oct-98	1055	55.6144	-128.5025
34	11-Nov-98	1445	55.6061	-128.5289
34	10-Dec-98	1028	55.6228	-128.4994
34	16-Jan-99	1120	55.6133	-128.4428
34	9-Feb-99	1121	55.6230	-128.5167
34	28-Feb-99	1107	55.6167	-128.4842
34	21-Mar-99	1107	55.6212	-128.4915
34	10-Apr-99	1229	55.6403	-128.5011
34	17-May-99	948	55.6389	-128.5414
34	26-Jun-99	1057	55.6211	-128.4753
34	30-Jul-99	1314	55.6107	-128.5235
34	3-Sep-99	1241	55.6247	-128.4712
34	4-Oct-99	1009	55.6214	-128.5144
34	5-Nov-99	1139	55.6275	-128.4806
34	7-Dec-99	1334	55.6233	-128.5172
34	12-Jan-00	1100	55.6333	-128.4875
34	5-Mar-00	1053	55.6114	-128.4175
35*	4-Mar-98	1238	55.7412	-128.8323
35	25-Mar-98	1214	55.7610	-128.8395
35	1-May-98	1614	55.8436	-128.7433
36	2-Mar-98	capture	55.7488	-128.7953
36	25-Mar-98	1440	55.8068	-128.7767
36	1-May-98	1608	55.8131	-128.7894
36	3-Jun-98	1550	55.8358	-128.7664
36	26-Jun-98	1858	55.8333	-128.7667
36	20-Jul-98	1922	55.8348	-128.7768
36	19-Aug-98	1742	55.8398	-128.7728
36	18-Sep-98	1219	55.8150	-128.8000
36	11-Nov-98	1307	55.8478	-128.8322
36	10-Dec-98	1443	55.7958	-128.8500
36	16-Jan-99	1330	55.7670	-128.8278
36	9-Feb-99	1312	55.7800	-128.8543
36	28-Feb-99	1442	55.7440	-128.7617
36	21-Mar-99	1140	55.7375	-128.7710
36	10-Apr-99	1532	55.7731	-128.8442
36	17-May-99	1504	55.8211	-128.7831
36	5-Jun-99	1455	55.8303	-128.7714
36	26-Jun-99	1138	55.8444	-128.7822
36	30-Jul-99	1744	55.8163	-128.7380
36	3-Sep-99	1339	55.8450	-128.7633
36	4-Oct-99	1613	55.7961	-128.7992
36	5-Nov-99	1529	55.8219	-128.7833
36	7-Dec-99	1232	55.7931	-128.8619

Moose	Date	Time	Latitude	Longitude
36	12-Jan-00	1210	55.7458	-128.8244
36	5-Mar-00	1200	55.7394	-128.8125
37	2-Mar-98	capture	55.6383	-128.5855
37	25-Mar-98	1611	55.6332	-128.7495
37	1-May-98	1838	55.5675	-128.8964
37	3-Jun-98	1800	55.5356	-128.8769
38	2-Mar-98	capture	55.6018	-128.5220
38	25-Mar-98	1038	55.5895	-128.5140
38	1-May-98	1043	55.6128	-128.4825
38	3-Jun-98	955	55.6128	-128.4819
38	26-Jun-98	1025	55.6067	-128.5186
38	20-Jul-98	1453	55.6042	-128.4978
38	19-Aug-98	1138	55.6078	-128.4850
38	18-Sep-98	1052	55.6122	-128.5440
38	23-Oct-98	1053	55.6094	-128.5144
38	11-Nov-98	1450	55.6081	-128.5378
38	10-Dec-98	1023	55.6253	-128.5517

*Note: no capture location was recorded for moose 35

Appendix V. Sizes (km^2) of seasonal home ranges (95% utilization distribution) and core use areas (25% utilization distribution) for 30 radio-collared moose as calculated by kernel density analysis. Sample sizes are indicated by "n". Nass Wildlife Area.

			Utilization Distribution	
Season*	Moose ID	n	25%	95%
Winter	1	21	1.6	19.2
	2	18	6.1	105.0
	3	12	6.9	93.9
	5	20	1.7	19.0
	6	20	11.4	165.6
	7	21	13.8	179.3
	8	21	4.7	59.5
	9	18	3.4	77.6
	10	21	22.3	284.1
	11	21	65.3	694.9
	12	20	1.2	13.4
	13	21	13.0	180.6
	14	10	2.5	34.8
	15	20	5.1	61.2
	16	17	1.2	16.3
	17	20	1.6	14.8
	18	14	8.6	79.0
	20	20	4.3	74.6
	22	11	1.2	13.8
	23	11	11.2	126.2
	24	11	0.6	6.2
	25	10	1.0	9.2
	26	11	1.5	15.9
	29	11	20.6	392.2
	30	12	30.6	427.8
	31	11	37.0	325.0
	32	11	119.5	1244.0
	33	11	2.6	27.0
	34	11	0.6	5.9
	36	11	7.6	62.3
Non-winter	1	22	6.3	72.7
	2	17	10.7	116.7
	3	14	5.7	84.7
	5	19	9.6	101.5
	6	24	1.6	16.5
	7	23	1.1	10.7

			Utilization Distribution	
Season*	Moose ID	n	25%	95%
	8	20	7.3	71.6
	9	23	3.4	46.7
	10	18	8.3	64.5
	11	24	7.4	91.2
	12	22	4.4	46.1
	13	24	1.7	18.6
	14	17	2.3	22.1
	15	23	3.2	34.8
	16	23	7.9	92.1
	17	24	0.5	4.6
	18	15	13.3	135.3
	20	21	2.5	33.4
	22	15	3.6	32.7
	23	12	12.9	131.0
	24	14	4.4	51.8
	25	13	4.7	75.0
	26	14	3.3	28.2
	29	14	2.9	27.0
	30	13	0.2	2.9
	31	15	6.7	70.0
	32	14	4.2	39.3
	33	11	9.7	155.7
	34	14	2.3	25.5
	36	14	2.5	30.9

*Winter: December through April; Non-winter: May through November

Appendix VI. Results of pregnancy testing of cow moose captured in the Nass Wildlife Area in 1997 and 1998. Refer to Appendix VII for a detailed summary of cow and calf observations.

Year	Cow Moose #	Progesterone (ng/mL)	Serum Progesterone Status*
1997	1	3.8	pregnant
	2	3.7	pregnant
	4	2.8	pregnant
	5	0.6	not pregnant
	6	3.4	pregnant
	7	2.8	pregnant
	9	0.1	not pregnant
	10	5.2	pregnant
	11	3.2	pregnant
	12	6.3	pregnant
	13	2.5	pregnant
	14	3.0	pregnant
	16	1.2	unknown
	17	6.5	pregnant
	18	2.7	pregnant
	19	1.1	unknown
	20	2.9	pregnant
1998	21	5.3	pregnant
	22	7.9	pregnant
	23	5.8	pregnant
	24	6.1	pregnant
	25	6.5	pregnant
	26	6.2	pregnant
	28	7.7	pregnant
	29	1.0	unknown
	30	0.1	not pregnant
	32	4.2	pregnant
	36	3.8	pregnant
	37	0.1	not pregnant
	38	6.5	pregnant

*Low progesterone values indicates poor hormone production and may indicate no pregnancy, loss of fetus, or an animal that simply does not produce much of the hormone.

Appendix VII. Dates on which cow moose captured in 1997 and 1998 were sighted. The number of calves sighted (i.e., 0-3) near each cow is indicated within each circle. The beginning of each calving season is delineated by underlining. Yearlings with cows after the beginning of the calving season are underlined (e.g., Moose 21 on 3 June 1998; Moose 22 on 5-June 1999). Shading represents cow mortalities; hatching indicates a missing animal. Note: it cannot be assumed in every instance that all calves were those of the collared cows, nor that the lack of a calf sighting implied a barren cow. The lack of sightings during summer, 1998 reflects the use of a fixed-wing aircraft at that time.

	Moose Number																												
Date	1	2	4	5	6	7	9	10	11	12	13	14	16	17	18	19	20	21	22	23	24	25	26	28	29	30	32	36	37	38
08-Feb-97					①	⓪	⓪		①		①																			
09-Feb-97		①								⓪				⓪	⓪	⓪	⓪													
19-Feb-97						⓪	⓪	①	③	⓪	⓪			⓪	⓪	⓪														
20-Feb-97			⓪																											
05-Mar-97			⓪		①	⓪	①	⓪			①				⓪															
19-Mar-97			⓪	⓪		①	①	①	⓪	⓪				⓪	⓪		⓪													
27-Mar-97	⓪	①	⓪		①		⓪	⓪	①	⓪	①		⓪	⓪	⓪															
01-May-97	⓪	①			①						①	①																		
21-May-97													⓪				⓪													
11-Jun-97		①	①			①			⓪	①		①		⓪			①													
05-Jul-97	①	⓪	⓪	⓪			⓪		⓪		②		⓪	①	⓪															
06-Aug-97	①	⓪	①	⓪		①	⓪	⓪			⓪	①	⓪																	
25-Aug-97	①	⓪	①	⓪		①	⓪	⓪	⓪	⓪	⓪	①	⓪	①			⓪													
13-Sep-97	①	⓪	①	⓪	⓪		⓪	⓪	⓪		⓪	①	⓪	⓪			①													
03-Oct-97	⓪	⓪	⓪	⓪	①	①	⓪	⓪	⓪	①	⓪	⓪	⓪	⓪			①													
03-Nov-97		⓪	①	⓪	①	①	⓪		⓪		⓪	①	⓪	①	⓪		①													
02-Dec-97					①			①		①		①	⓪	①			①													
03-Dec-97		⓪	①	⓪		①	⓪	⓪	⓪		⓪				⓪															
02-Jan-98		⓪	⓪	⓪	①	①	⓪	①	⓪	①	⓪		⓪		⓪		①													
22-Jan-98		⓪		①	①	①	①	①	⓪		⓪	①	⓪	①	⓪		①													
11-Feb-98	①	⓪		⓪	①	①	⓪	②	⓪	①				①	⓪															
04-Mar-98		⓪			①		⓪	⓪		①	⓪		⓪	①	⓪		①									⓪				
25-Mar-98		⓪		⓪	①	①		⓪		①	⓪	③		①	⓪		①	⓪	⓪	⓪	⓪	⓪			②	⓪			⓪	

Appendix VII continued

	Moose Number																													
Date	1	2	4	5	6	7	9	10	11	12	13	14	16	17	18	19	20	21	22	23	24	25	26	28	29	30	32	36	37	38
01-May-98	⓪				⓪	⓪	⓪	⓪			⓪	①		⓪	⓪		⓪	②	⓪		⓪	⓪			⓪		⓪			①
03-Jun-98		②		⓪		①			⓪		①	①		②			⓪	②	①				①	②		⓪	①	⓪		①
26-Jun-98						①	①	①			⓪	①		①	⓪			①									①	⓪		⓪
27-Jun-98	⓪			⓪															②		①			⓪		⓪				
20-Jul-98																														
22-Oct-98	⓪	②					⓪	①	⓪		⓪			②			①				⓪				⓪					
23-Oct-98				⓪		①							⓪		⓪				②							⓪				⓪
11-Nov-98	⓪	②				①	⓪	⓪	⓪		⓪	⓪	⓪		⓪		①		②		⓪	⓪	①		⓪	⓪	①	⓪		①
10-Dec-98	⓪	②		⓪	⓪	①	⓪	⓪	⓪		⓪		⓪	②	⓪		①			①	⓪		①	①	⓪	⓪	①			⓪
16-Jan-99	⓪	②			⓪	①	⓪	①	⓪	②	⓪		⓪	②	⓪				②	①	⓪	⓪	①	⓪	⓪		①			
09-Feb-99		②		⓪	⓪	①	⓪	①	⓪	②	⓪			②			⓪		②	⓪		⓪	①		⓪		⓪	⓪		
28-Feb-99	⓪	②		⓪		①	⓪	①	⓪	②	⓪		⓪	①			⓪		②	①		⓪	①		⓪	⓪	①	⓪		
21-Mar-99	⓪	②		⓪	⓪	①	①	⓪	⓪	②	⓪		⓪	①			⓪		②	①		⓪	①				①	⓪		
10-Apr-99	⓪	⓪		⓪	⓪	⓪	⓪	①	⓪	⓪	⓪			⓪			⓪		⓪	⓪			⓪		⓪		⓪	⓪		
17-May-99	⓪				⓪	⓪	⓪		⓪	⓪	⓪		⓪	⓪							⓪	⓪	⓪		⓪	⓪				
05-Jun-99	⓪				②	②		②	⓪		①		①	①			⓪		②	⓪					①	①				
26-Jun-99	⓪					①	⓪	⓪	⓪		①		①				①			⓪		①			①	①	①	①		
30-Jul-99							⓪																				①			
03-Sep-99	⓪					⓪					①		①							⓪							①	⓪		
04-Oct-99	⓪					①	⓪	⓪	⓪		①		①				①		⓪		⓪	①	⓪		⓪		①			
05-Nov-99					⓪	①	⓪	①	⓪	①	①			①					⓪	⓪	⓪	①	⓪		⓪	⓪	⓪			
07-Dec-99	⓪					①		⓪	⓪	①	①			①			①		⓪	⓪	⓪	①	⓪		⓪	⓪	①	①		
12-Jan-00	⓪				⓪	①		⓪	⓪	①	⓪			⓪			①		⓪	⓪	①		⓪		⓪	⓪	①	⓪		
05-Mar-00	⓪			⓪	⓪	①		⓪	⓪	①	①			①			①		⓪	⓪	⓪	①	⓪		⓪	⓪	⓪	⓪		