An Analysis of the Status of Elk and Moose Populations in Prince Albert National Park, Saskatchewan, with Monitoring Options.

By

© Paul M. Tarleton

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ABSTRACT

Elk (Cervus elaphus) and moose (Alces alces) are native to the area of Prince Albert National Park (PANP). The clearing of land for homesteads and hunting by settlers caused local declines, particularly in elk abundance. With the establishment of PANP, abundance increased due to the effects of protection, predator control and landscape management practices. Elk numbers declined gradually after reaching a peak in the mid-to-late 1950's. The decline was probably due to the combined effects of the cessation of management practices designed to enhance elk abundance, an elk slaughter and the conversion of reportedly excellent elk habitat into a community pasture. Elk abundance appears to have declined abruptly since the 1976-1977 winter. Mortality data show that at least a portion of the decline may be attributed to hunting. Elk abundance is currently at an historic low level.

Moose abundance appears to have declined gradually from an apparent peak in the mid-to-late 1950's, although the evidence for a decline in moose abundance is not as singular as is the case for elk. The PANP moose population is not subject to the same magnitude of harvest pressure as the elk population.

Aerial survey results from 1968-1985 were analyzed. Variation in survey methods and survey conditions unnecessarily clouded the conclusions drawn from comparisons among surveys. The absence of a long-term survey strategy created wide gaps between some survey years. Such gaps made it impossible to quantify the impacts of various mortality factors on elk and moose abundance. Elk aggregation behavior and an inadequate sampling intensity employed in most surveys (25% of park area) caused confidence intervals for elk abundance estimates to be too wide for management needs. The precision of moose abundance estimates was acceptable for management purposes. Trend line analysis suggested an annual rate of decline of 8% for elk and 5% for moose.

Options for monitoring elk and moose populations were presented ranging from an annual systematic transect survey of approximately 50% of the park area (102 transects) to an annual stratified survey. A frequency of one survey per year was recommended due to the need for a regular program of monitoring which would be sensitive to yearly changes in regulating factors such as hunting mortality, weather severity, and predation.

An additional recommendation is that managers recognize the importance of the decline in elk abundance relative to the natural area represented by PANP and repriorize elk management within the Park Conservation Plan.

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Chapter I

INTRODUCTION

1.1 BACKGROUND

Canada's national parks exist for the purpose of "perpetuating an environment essentially unaltered by human activity" (Parks Canada 1980). The management goal which has been adopted for Prince Albert National Park (PANP) is "to ensure the perpetuation of naturally evolving land and water environments and their associated species (Parks Canada 1980 a). Natural factors such as predation, disease, weather severity and the availability of food, rather than anthropogenic factors, must largely regulate the abundance of wildlife in a national park. The goal which resource managers seek to achieve in a national park is a state known as natural regulation of populations.

Elk (*Cervus elaphus*) and moose (*Alces alces*) are native to the area of PANP. Dyck (1977) noted that both elk and moose were important components of the diet of Indians in the Northern Plains and Parkland in what is now Saskatchewan. The explorer Anthony Hendy reportedly ate elk in 1754 during his travels along the North and South Saskatchewan Rivers (Dyck 1977) and Henry Kelsey reported that he ate moose during his travels of 1690-1 in the same area (Willans 1955). More specifically, Hudson Bay Company Journals (Johnson 1967) from Carleton House, approximately 70 km west of present day Prince Albert, indicate that elk meat was an important source of food when bison meat was not available. Reports from Dominion Lands surveyors indicate that elk were present in the southeastern corner of PANP (Morrier 1911) and that moose were found in the northwestern corner (St. Cyr 1910), the southwestern corner (Montgomery 1911) and the southeastern corner (Morrier 1911).

The elk of PANP have been identified as _C.e._ _manitobensis_ by Soper (1949). Bryant and Maser (1982) estimated that 9500 _C.e._ _manitobensis_ remain on the continent. Elk once ranged the entire province of Saskatchewan south of Lake Athabasca (Richards and Fung 1969) but their distribution is now limited to a narrow band through the centre of the province and to one small pocket in each of southwestern and southeastern Saskatchewan. Bryant and Maser (1982) estimated the combined population of _C.e._ _manitobensis_ and _C.e._ _nelsoni_ in Saskatchewan to number 2000 individuals. The elk population of PANP is important because it can potentially represent the natural condition of a subspecies which has probably declined markedly from pre-settlement levels.

Elk and moose in PANP have been subject to the influence of human activity since the onset of settlement in Central

Saskatchewan. Hunting, predator control and habitat change are some examples of human activities which have influenced moose and elk populations in PANP. Park managers are now faced with the task of reducing the extent of human impacts and encouraging the restoration of natural controls upon a system which has endured over sixty years of human influence. This practicum represents a step in that process. It includes an assessment of the historic and present status of moose and elk in PANP, an interpretation of trends in abundance and an assessment of the current monitoring program with recommendations for continued monitoring.

1.2 PROBLEM STATEMENT

The maintenance of naturally regulated populations of elk and moose in PANP is a goal which is solidly based in Environment Canada, Parks policy. However, historic records show that elk and moose populations in PANP have been subject to continued unnatural influence since the arrival of European settlers in the area of the park. The relative impacts of natural and unnatural regulating factors upon elk and moose populations in PANP have not been described previous to this report.

Hunting is a factor known to act upon the moose and elk populations of PANP. Hunting seasons adjacent to the boundary of PANP are regulated by the Province of

Saskatchewan and thus management of PANP elk and moose populations is a shared responsibility. Although the agencies which share that responsibility do not share identical management objectives for elk and moose, rational management can proceed if decisions are based upon a sound monitoring program.

The Interim Park Conservation Plan (Anions et al. 1986) for PANP ranked the maintenance of an indigenous elk population in a natural state as an issue of moderate priority. The plan targeted the development of a cooperative elk management strategy between Environment Canada, Parks and the Saskatchewan Department of Parks and Renewable Resources (DPRR) as a project goal. The need for such a strategy was underscored by the results of the 1984 hunting season when licenced hunters killed 145 elk adjacent to PANP's boundaries (Ewert and Collingwood 1985). Aerial surveys estimated elk abundance to number 496 at the time. The foundation for a cooperative management strategy may prove to be accurate monitoring and analysis of the status of elk in PANP.

The most recent aerial survey data (Collingwood et al. 1985) suggest that elk abundance has declined to a level well below that which would be expected under purely natural conditions. However, the results of aerial surveys in PANP have exhibited remarkable variability among yearly estimates of abundance. Managers needed to know if the recent apparent decline in elk abundance was real or simply a product of factors such as sampling error or survey bias.

1.2.1 Historic Description and Analysis

A summary of historic regulating factors, management practices and trends in abundance was needed to generate an understanding of how elk and moose populations in PANP arrived at their present status. A considerable body of local information about yearly winter severity, ungulate and predator abundance and management activity was available for analysis.

1.2.2 Literature Review

A review of literature related to aerial survey analysis and survey design was employed to assist managers in assessing the suitability of the aerial survey design employed in PANP. Recommendations for improving the efficiency of the survey design and analysis were partially drawn from the literature review.

1.2.3 Statistical Analysis

The calculation of standard errors, confidence intervals and an assessment of trends in abundance were necessary components of a quantitative analysis of the status of elk and moose in PANP. These analyses were needed so that survey results could be assessed to determine if the observed yearly variations were caused by actual changes in abundance.

1.2.4 Monitoring Strategies for Moose and Elk in PANP

Monitoring of elk and moose in PANP has varied according to the availability of manpower and capital. The absence of a long term strategy for monitoring and assessing elk and moose populations has created a situation in which several reports have been produced but the resulting information has not been integrated and complementary. In some cases, survey results have been obscured by differences in yearly survey timing and methods. Monitoring strategies which combined the optimal survey technique with the most efficient use of resources were required for PANP.

1.3 STUDY OBJECTIVES

The objectives of this study were:

1. to analyze information from historic sources and generally describe the history of elk and moose in PANP up to recent times;
2. to employ a review of relevant literature and an historic description of elk and moose in PANP in an analysis of the present status and trend in abundance;

3. to analyze the results of aerial surveys from 1968 to 1985, determine the precision and accuracy of survey techniques and evaluate survey results to determine trends in abundance;
4. to identify and recommend options for monitoring trends in the abundance of elk and moose in PANP;
5. to identify existing information deficiencies and recommend a strategy for addressing those deficiencies on the basis of their priority;
6. to present results and recommendations in a manner which is compatible with the Natural Resources Management Process so that managers may successfully implement recommendations.

1.4 LIMITATIONS

1. This study does not address the impact of illegal hunting in PANP, for which few data are available. The Interim Park Conservation Plan for PANP (Anions et al. 1986) has not identified the issue of illegal hunting as an item of priority.
2. Alternate survey techniques are considered in this report only as adjuncts to aerial surveys. Such techniques as pellet or track counts, which may be particularly useful for estimating local ungulate abundance, are not considered because this study has a general rather than an area-specific focus.

3. The concept of natural regulation will be discussed as it relates to ungulates generally, however, a quantitative description of natural regulation applied to the ungulate-predator-vegetation system in PANP is beyond the scope of this report.

Chapter II

METHODS

2.1 THE NATURAL RESOURCE MANAGEMENT PROCESS

The Natural Resource Management Process (NRMP) is a framework which Environment Canada, Parks has adopted for providing a rational approach to the management of the resources in a national park. The NRMP comprises a number of steps, two of which are central to this report. The "Resource Description and Analysis" is a step which is designed to describe and assess the status of the resources in a national park. The description and assessment of moose and elk populations which is contained in this report was intended to serve as a partial input for the wildlife portion of the Resource Description and Analysis for PANP (Didiuk 1986).

The "Park Conservation Plan" is a step in the NRMP which has the objective of providing "a documented, integrated and priorized course of action for the management of parks' natural resources" (Parks Canada 1982). This step in the process "defines natural resource problems, proposes resource management actions and presents a documented, priorized plan to prepare and/or implement them" (Parks

Canada 1982). The portions of this report which address information requirements, monitoring programs and management strategies have been intended for consideration during the preparation of a Park Conservation Plan for PANP.

2.2 HISTORIC DESCRIPTION AND ANALYSIS OF ELK AND MOOSE IN PANP

A review of information related to elk and moose populations in PANP was conducted in: the University of Manitoba Library; the Prince Albert National Park library and files; the Warden Service Library and files in Waskesiu Lake and the Environment Canada, Parks library in Winnipeg. Most of the information was available in unpublished form. The historic description and analysis of elk and moose populations in PANP forms Chapter 3 of this report.

2.3 LITERATURE REVIEW

A review of literature related to aerial survey techniques, natural regulation of populations and elk and moose biology was conducted in the libraries of the University of Manitoba and Saskatchewan, the Environment Canada, Parks library in Winnipeg and the PANP library and the Warden Services library in PANP. The information was summarized and employed in the analysis of the status of elk and moose in PANP, and in identifying options for monitoring elk and moose in PANP.

2.4 DATA COLLECTION

2.4.1 Aerial Surveys

Aerial ungulate surveys in PANP have followed a design established by Tener (1954). Investigators have employed a transect survey, east-west transects of equal width having been used to systematically sample the park's area. Two observers recorded elk and moose sightings from either side of the plane. Only those sightings observed along the transect and within a given width of transect were recorded. The aircraft did not circle in order to verify a count. One navigator helped the pilot to maintain the correct course. Survey design is detailed more thoroughly in Chapter 4.

The location of individual transects and the number of transects employed have not remained standard during the aerial survey program. Few investigations recorded the areas of the individual transects, but all investigators identified the starting location for the first transect and also indicated the distance between transects. From this information, it was possible to determine the location and area of every transect flown.

2.4.2 Analysis of Survey Results

The count per transect was compiled from yearly aerial survey reports. Millette and Galbraith (1976) recorded the transect count graphically, so that actual count per transect for 1976 was determined from an interpretation of the graphic display and from a computer-produced list of elk and moose observations which was provided by Environment Canada, Parks. The quantitative results from the 1971 survey (Allan and Millard 1971) were ignored due to an apparent error in the recording of observations. Yearly counts per transect are shown the Appendix.

The location and length of each transect was determined from the yearly reported starting location of transect 1 and from the reported distance between transects. The length (east-west) of each transect was measured on a 1:125,000 map of PANP. The area of each transect was determined by multiplying the reported transect width by the transect length.

Flight maps were available for the years 1982, 1984 and 1985 (Collingwood 1982, Collingwood _et al_. 1985; Minton[1] pers. comm.) and for those years the transect area could be verified from known flight lines. The areas which have been determined for individual transects represent the true transect area as accurately as possible.

Some investigators (McGillis and Armbruster 1968; Allan and Millard 1971, Young, Millard and Leader 1973 and Galbraith and Millette 1974) included individual transect areas in their reports. However, in some cases these areas did not appear to be consistent. For the sake of accuracy,

[1] Minton, P., Park Warden, PANP.

transect areas for all surveys have been recalculated. These are shown in the Appendix.

Formulae and statistical procedures which were employed in the analysis of survey results are shown in Chapter 4.

Chapter III

HISTORIC DESCRIPTION OF ELK AND MOOSE IN PANP

3.1 INTRODUCTION

The purpose of this chapter is to describe the historic status of elk and moose populations in PANP. An important component of this description is an interpretation of factors which have influenced elk and moose populations in the past. In this chapter, the impact of regulating factors will be related to apparent changes in the abundance of elk and moose in PANP.

3.2 STUDY AREA

3.2.1 Description

Prince Albert National Park is situated in central Saskatchewan (figure 1) and it represents the natural region known as the Southern Boreal Plains and Plateaux within the Environment Canada, Parks system plan (Parks Canada 1972).

Padbury *et al*. (1978) characterized the area as being typical of the Mixedwood section of the Boreal Forest Region with the exception of a small area of aspen groveland found in the park's southern region. An important characteristic of the vegetation in PANP is the south-north gradient from aspen-grassland to boreal forest.

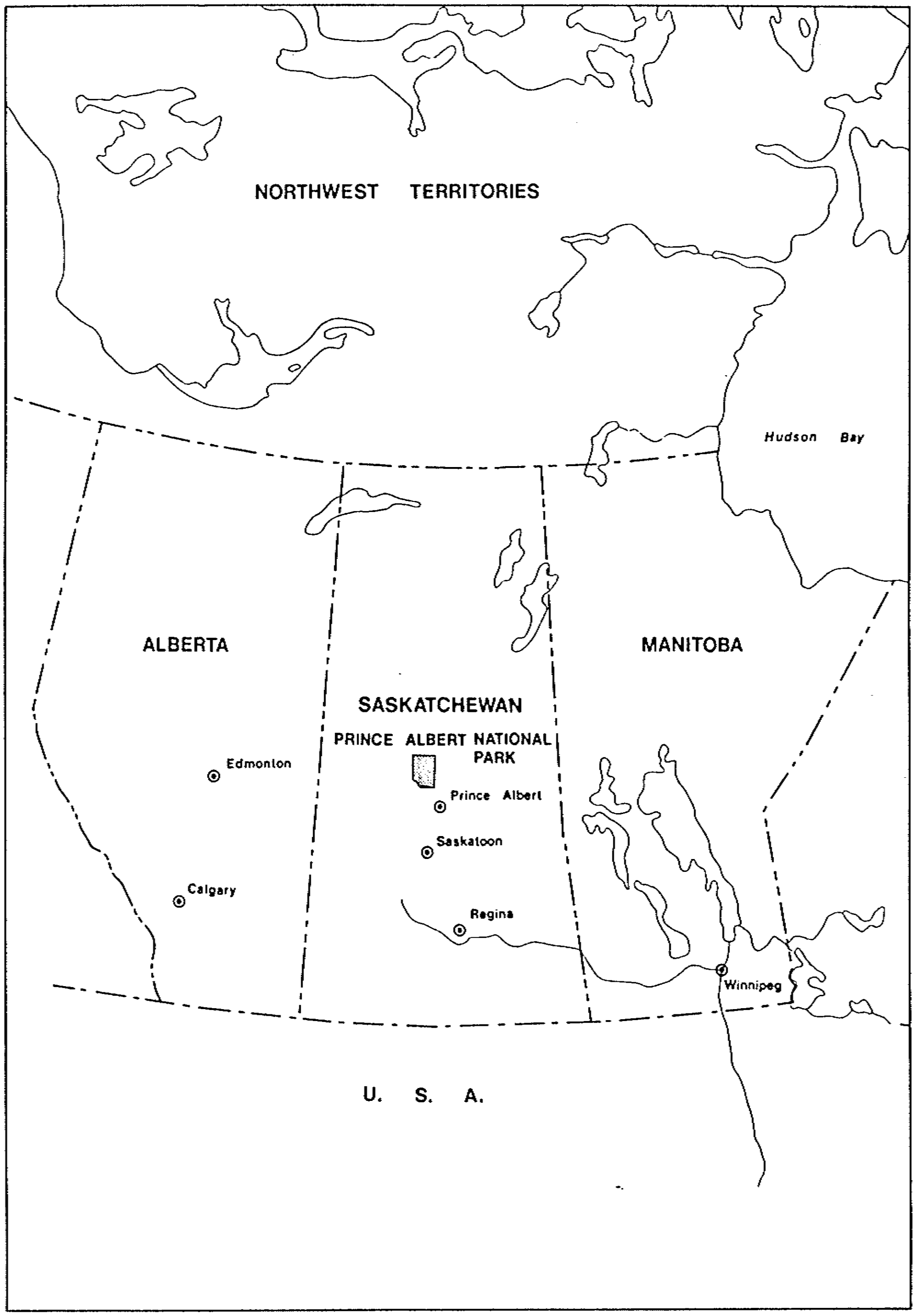

Figure 1: Location of Prince Albert National Park (PANP).

Mean daily temperatures in PANP range between -21.8°C and 16.4°C, and the mean annual temperature of Waskesiu Lake townsite is -0.1°C (Cote 1984). The mean frost-free period at Waskesiu Lake is 85 days (Cote 1984). The climate of PANP is dry. Mean yearly snowfall at Waskesiu Lake is 149.3 cm and the winter mid-month mean snow depth ranges between 24 and 51 cm (Cote 1984).

The boundaries of PANP enclose an area of approximately 3875 km^2 (Gimbarzevsky 1973) (figure 2). The land which borders PANP is used for a variety of economic and recreational purposes. Logging concerns operate close to the park's northern, northwestern and eastern boundaries. Agriculture is the predominant land use close to the southern and southwestern boundaries of the park. Hunting is an activity which takes place immediately adjacent to all of the park's boundaries.

Some economic use was made of the park's resources prior to the area's establishment as a national park in 1927. Forestry operations were active in the southern part of the park until about the time of World War I. After the park was established, some harvest of timber from within the park was permitted (Shortt 1977). Hunting and trapping was relatively important activities in the park area prior to 1927 (Shortt 1977).

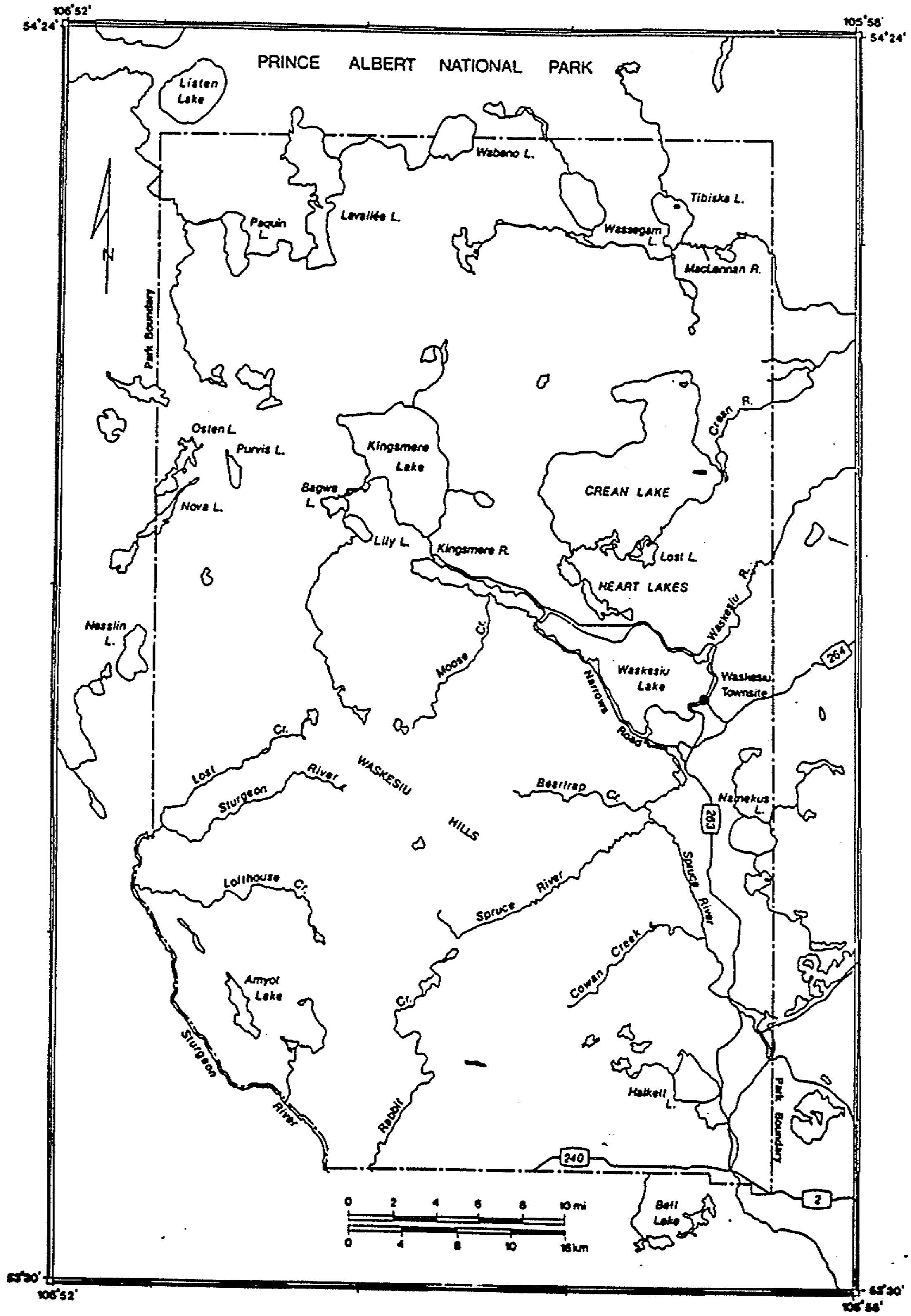

Figure 2: Prince Albert National Park.

The varied habitats within PANP shelter a unique wildlife community including mule deer (Odocoileus hemionus), white-tailed deer (Odocoileus virginianus), caribou (Rangifer tarandus) and bison (Bison bison) as well as elk and moose. Large predators in PANP include wolf (Canis lupus), coyote (Canis latrans), black bear (Ursus americanus) and cougar (Felis concolor), the latter having been sighted once recently.

3.2.2 Historic Aspects

The Sturgeon River Forest Reserve was the forerunner of PANP. The purpose of the forest reserve was to conserve the commercial timber resource, and the area which is now the southern half of PANP was a relatively important source of lumber for the growing Prince Albert area. During World War I the Prince Albert Lumber Company logged an area of approximately 322 km^2 inside the reserve near Sandy Lake (Shortt 1977). Large forestry operations ceased after 1919, but small selective cutting operations continued until the mid-1950's (Millard[1] pers. commun.). Cameron (1975) explained that mature jack pine (Pinus banksiana) and white spruce (Picea glauca) were harvested in PANP, but suggested that fire has probably been a more important factor than forestry in shaping the present park landscape.

[1] Millard, C.M. Park Warden, PANP.

Gimbarzevsky (1973) documented wild fire in PANP up to 1973. The most severe period of forest fire in PANP occurred from 1940-1949, when 991 km^2 burned. By comparison, only 138 km^2 burned during the period 1950- 1970 (Gimbarzevsky 1973). The policy of immediate suppression of wild fire, as practiced in PANP, may have inclined the park habitat away from the grassland-aspen subclimax described by Bird (1961) for the aspen parkland area, towards a condition where even-aged stands of aspen (*Populus tremuloides*) have become the dominant habitat type.

Carbyn and Armbruster (1968) described the successional mechanism of aspen encroachment upon grasslands in PANP. Cameron (1975) found that the grassland area of PANP increased from 1927 to 1947, at least partially due to intentional burning and forest fires. Cameron (1975) found that after 1947, grassland areas in PANP decreased. Carbyn and Armbruster (1968) showed that some grassland areas in PANP decreased by over 60% between 1947 and 1962 as a result of aspen invasion into grassland areas. Cameron (1975) concluded that the balance between grassland and aspen/shrub habitat in PANP had been tipped in favour of aspen/shrub habitat due to the absence of fire in recent years.

Trottier *et al*. (1983) found that grasslands and grasses were important seasonal components of elk habitat and dietary needs in Riding Mountain National Park, Manitoba. It is possible that loss of grassland habitat since 1947 has caused the habitat in PANP to become steadily less optimal for elk.

In order to determine how PANP grassland might be properly managed, Parks Canada initiated a study of the effectiveness of prescribed burns in maintaining grassland habitat at natural levels. As a component of that study, Samoil et al. (1977) determined that an increase in grassland in PANP would favour elk populations. In another component of the same study, Trottier (1985) found pellet-group analysis to indicate that elk preferred newly-burned experimental plots. The management of PANP grassland is an ongoing concern which has not been resolved to date.

The first settlers near the park site filed for title of their land in the Cookson area, south of the park site, in 1913 (Larsen 1981). Settlement never extended into the park on a large scale. Cameron (1975) reported the presence of two ranch operations in the southwestern corner of the park and concluded that they had little impact on the park's habitats.

Boundary revisions have created some changes in the type of habitat contained within the park. Historic estimates of wildlife abundance must therefore be considered in light of the park's size at the time of the estimate. An important loss of elk habitat occurred in 1948, with the most recent of the boundary revisions. At that time the area known as the Cookson pasture was excised from the park and converted to a community pasture. The Cookson pasture now lies directly south of PANP. The size of the Cookson pasture was only 60.7 km^2 but it contained "some of the best winter elk range" in the area (Banfield 1951). The Cookson pasture consisted of upland shrub-grassland habitat and was known locally as "the home of the elk" (Millard[1] pers. commun.).

Banfield (1951) suggested that the loss of the Cookson pasture had no serious effect on the local elk population, but also observed that elk had caused extensive damage to standing grain along the park's southern boundary during the autumn of 1950. The excision of the Cookson pasture may have reduced the amount of fall/winter habitat available within PANP and, therefore, increased the incidence of elk emigration from PANP during periods of reduced food availability.

3.3 MANAGEMENT OF ELK AND MOOSE IN PANP

3.3.1 Natural Regulation

The goal for managers of elk and moose in PANP is natural regulation of populations. Peek (1980) defined natural regulation as "that set of controlling mechanisms that serves to limit or control population densities in the absence of human influence". PANP ecosystems are

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[1] Millard, C.M. Park Warden, PANP.

unavoidably influenced by artificially-created park boundaries and adjacent land uses, so that a truly natural system is impossible to achieve.

Park policy states "natural resources within national parks will be protected and managed with minimal interference to natural processes to ensure the perpetuation of naturally evolving land and water environments and their associated species" (Parks Canada 1980). Therefore management of ungulate populations must ensure that viable populations continue to exist at a natural level of abundance under, as nearly as possible, natural conditions.

Caughley (1979) suggested that the natural growth pattern for ungulates was a cycle of irruptions and crashes arising from the dynamic relationship between ungulate abundance and the quantity and quality of available forage. Rounds (1977) suggested that several such cycles have occurred in Riding Mountain National Park (RMNP) during the past century. Caughley (1979) believed that such density-dependent fluctuations would continue until the system stabilized at an ecological (K) carrying capacity. Macnab (1985) indicated that K carrying capacity was the equilibrium usually pertinent to national parks, characterized by a relatively high ungulate abundance and relatively low quantities and qualities of forage.

Caughley (1979) has suggested that wild ungulates are naturally regulated by the availability and quality of their food supply rather than other factors. Pimlott (1967) suggested that the impact of predation on natural systems may sometimes be wrongly discounted simply because all systems which have been studied have been disturbed by man. Pimlott (1967) and Houston (1982) felt that the impact of large predators should not be discounted in an ungulate-vegetation-prey system. Extrinsic factors including weather, resource availability, parasites and predation are accepted as potential regulating factors among ungulate populations.

3.3.2 Protection

The Sturgeon River Forest Reserve was established in 1914 and its establishment may have afforded some protection to wildlife, although the level of protection is unknown. Elk were subject to intense hunting pressure throughout Canada and locally. By 1918, the "slaughter" of elk in the "elk fields north of Prince Albert" (Scott 1919) had become a controversial local issue. In 1919, the Province of Saskatchewan reacted to a Canada-wide elk decline by amending the Game Act to ban elk hunting (Saskatchewan 1919). The ban on elk hunting in Saskatchewan remained in effect until 1935 (Saskatchewan 1937).

Elk were not abundant in PANP when it was established. Banfield (1951) reported that elk were "rare and local in distribution" in 1923 according to Dominion Forestry Service officer Geo. Davies. In 1927, elk tracks which were sighted reportedly indicated that elk were moving toward PANP from the east (Millard[1] pers. commun.).

The establishment of PANP in 1927 afforded protection to wildlife although poaching was a concern. Park Superintendent J.A. Wood (1929) observed that enforcement patrols were necessary from the beginning of the hunting season until the end of the winter because "a large number of residents in close proximity to the park do not recognize the game laws and hunt during the winter months". Park officials reported that elk and moose abundance in PANP had inceased by the the spring of 1929 (Anonymous 1929) at least partly as a result of resource protection. A general increase in elk and moose numbers reportedly continued until 1942 (Banfield 1951).

3.3.3 Predators and Predator Control

In the early days of PANP, wolves were not numerous. The first sighting of wolf tracks in the Sturgeon River Forest Reserve was reportedly made by E. Millard in 1923 (Banfield 1951). Wolves and coyotes were regarded by park staff as undesirable species and were shot on sight by wardens from

[1] Millard, C.M. Park Warden, PANP.

the time the park was established. In 1929, park wardens recommended that traps as well as rifles should be employed in predator control efforts (Anonymous 1929).

Wolf and coyote control continued in PANP until approximately 1954. A description of wardens' duties (Anonymous 1940) made it clear that wardens were to shoot wolves and coyotes on sight. Cyanide guns were introduced as a means of wolf control in 1947 and den hunting was undertaken in 1950 (Banfield 1951).

Wolf abundance reportedly increased from 1930-1942 (Banfield 1951) despite predator control measures. In response, a "conscientious" program of predator control was introduced in 1942 (Soper 1949). From the autumn of 1942 to the spring of 1943, 22 wolves were destroyed (Soper 1943) within the boundaries of PANP. Banfield (1951) reported that 29 wolves were destroyed during 1947-8 to 1949-50. Unfortunately the number of wolves destroyed in other years has not been recorded.

The predator control program in PANP was discontinued prior to the 1951-2 season, but fox and wolf control was reinstated quietly in 1952-3 in response to an outbreak of rabies in Saskatchewan (Canada Department of Northern Affairs and Natural Resources 1954). That control program continued in PANP in 1953- 4. Organized predator control ended in PANP in 1954.

Wolf and coyote control has continued outside the boundaries of PANP. For example in 1968, 44 wolves were destroyed within 4 miles (6.4 km) of the boundaries of PANP in a provincial predator control program (Malfair 1968). There is no direct evidence that the wolf population in PANP has declined as a result of predator control outside of the park's boundaries. Carbyn (1983) suggested that wolf control programs had limited impact on elk abundance since small packs of wolves could kill elk.

The abundance of wolves in PANP has been estimated occasionally since the park's formation (table 1). Most of the estimates have been guesses based upon the observed frequency of wolf tracks and sign. Incidental sightings from the aerial ungulate survey of 1982 (Collingwood 1982) indicate that the wolf population of PANP was high during the winter of 1982. This observation is corroborated by Ewert and Minton (1983) who estimated an average density of 1 wolf/13.1 km^2 in the southwestern corner of PANP in 1981-82. Ewert and Minton (1983) also observed a 29% incidence of mange (*Sarcoptes scabeii*) in their study population which may indicate that the local wolf population was at a relatively high density in the winter 1981- 82. Ungulate mortality due to predation may have been at an historic high level in 1981-82, a possible factor in the low ungulate abundance estimates derived from the 1982 aerial survey.

TABLE 1

Estimates of wolf abundance and observations during aerial ungulate surveys, PANP.

Year	Abundance Estimate	Sightings during Ungulate Survey	Source
1939-40	81		Soper 1940
1952	18-26		Banfield 1952
1954	low		Tener 1954
1955	low		Tener 1955
1959	62		Jervis 1959
1960	"not plentiful"		Jervis 1960
1961	80		Jervis 1961a
1962	40		Jervis 1962
1964	73		Gilroy 1964
1968		0	McGillis and Armbruster 1968
1971		31	Allan and Millard 1971
1973		0	Young et al. 1973
1974		18	Galbraith and Millette 1974
1977	50		Henry 1977
1981	50		Allan 1981
1982		61	Collingwood 1982
1985		5	Collingwood et al. 1985

Long term predator control programs in PANP may have suppressed the impact of predation on ungulate populations. By suppressing predation, park managers created an environment unnaturally tending (in the absence of compensating mortality) towards an increase in ungulate abundance. Cessation of predator control in 1954 probably exerted a negative pressure on ungulates several years later. Part of the apparent decline in elk and moose abundance after the mid 1950's was probably a result of increased predation.

3.3.4 Hay Harvesting

Farmers were allowed to harvest hay in PANP until approximately 1968 (Cameron 1975). This practice occured mostly along the southwestern boundary where some patches of meadow and grassland were harvested annually. Cameron (1975) suggested that the practice of haying may have delayed the incursion of aspen onto grassland areas, thereby maintaining an important component of elk habitat.

3.3.5 Spring Burning

From approximately 1930 (Cameron 1975) until 1958 (Petersen and Henry 1978), park wardens burned the shrub-grassland area along the southern and southwestern boundary of PANP every spring. The reasons for this practice were to reduce the risk of wildfire and to maintain an open, grassy countryside which was aesthetically pleasing to humans and favourable to elk. Cameron (1975) suggested that yearly spring burns were an effective means of preventing the encroachment of aspen onto grassland areas. The cessation of spring burning is one factor which may have contributed to the recent apparent loss of grassland habitat documented by Carbyn and Armbruster (1968). Personal observations by Millard[1] (pers. commun.) confirm that the southwestern boundary area, especially along the west side road, is much less open than was the case in the 1950's and 1960's.

3.3.6 Elk Slaughters

In 1959, park managers decided to conduct an elk slaughter "in the interests of wildlife management" (Jervis 1959). Jervis (1959) characterized PANP forage conditions as being "excellent and sufficient in all areas", so it may be reasonable to assume that the slaughters were initiated not as a result of overcrowding but rather as a response to landowner complaints about elk depredation of their crops. Banfield (1951) documented the incidence of such complaints in the fall of 1950.

The slaughter took place in the southern one-third of PANP. Jervis (1959) estimated that there were 1100 elk in PANP when the slaughter began. The elk which were killed at the start of the program were apparently in excellent

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[1] Millard, C.M. Park Warden, PANP.

condition (Jervis 1960), but by the end of the first season (March - April 1960) the herds were scattered and the elk were in poor condition (Jervis 1960).

During the same season, 1959-60, hunting mortality around the park's boundaries were relatively heavy (Jervis 1960a) and neighboring landowners killed an additional 100 elk while defending their crops from elk depredation (Jervis 1960a).

At the beginning of the second slaughtering season, 1960 - 1961, Jervis (1960a) estimated that the elk population of PANP was in good condition and numbered 600, a decline of 45% in one year. The slaughter program continued until February 13, 1961. When the program ended, 127 elk (25 adult males, 72 adult females, 80% of which were pregnant; 17 male calves and 13 female calves) had been destroyed (Jervis 1961) in total. The remainder of the herd was in a "scattered and wild" condition (Jervis 1961).

The elk slaughter of 1959-1961 combined with relatively heavy hunting mortality, high losses to landowners and the discontinuation of the predator control program exerted a substantial negative influence on the PANP population in the early 1960's.

3.3.7 Monitoring

3.3.7.1 Elk Abundance and Mortality

Prior to 1954, all estimates of elk abundance were subjective assessments based upon the investigator's observations of elk, elk tracks, forage conditions and other elk sign. Elk apparently increased from being "rare and local in distribution" in 1927 (Banfield 1951) to number 3500 in 1940 (Soper 1940). Soper's (1940) impression that elk in PANP outnumbered moose shows that elk had increased from relative rarity in 1927 to a population which was in the same order of magnitude as moose. Whether or not elk actually outnumbered moose at the time is open to question because elk are a more gregarious species and would likely have been observed in larger groups than moose.

Elk numbers may have declined after 1940 but recovered during the mid-1950's at the time of the first aerial surveys of the PANP (table 2). The first three aerial surveys, 1954-5-6, differed from subsequent aerial surveys by employing a transect width of 0.80 km rather than 0.40 km. Caughley _et al_. (1976) showed that the magnitude of an aerial count is related inversely to transect width; thus it is probably safe to assume that the 1954-5-6 surveys underestimated elk abundance in relation to more recent surveys. Banfield's (1956) estimate of 1340 elk is probably conservative because the survey was undertaken in poor viewing conditions at a time when the snow was very deep.

TABLE 2

Estimates of elk abundance for PANP, 1940-1985

Year	Estimate	Method	Source
1940	3500	unknown	Soper 1940
1947	400-500	unknown	Banfield 1951
1950	400-500	unknown	Banfield 1951
1954	943	aerial survey	Tener 1954
1955	568	aerial survey	Tener 1955
1956	1340	aerial survey	Banfield 1956
1959	1100	unknown	Jervis 1959
1960	600	unknown	Jervis 1960a
1961	600	unknown	Jervis 1961a
1962	1000	unknown	Jervis 1962
1964	438	unknown	Gilroy 1964
1964	700-1000	unknown	Ashley 1964
1968	996	aerial survey	McGillis and Armbruster 1968
1971	1900[1]	aerial survey	Allan and Millard 1971
1973	1098	aerial survey	Young *et al*. 1973
1974	452	aerial survey	Galbraith and Millette 1974
1975	1204	aerial survey	West *et al*. 1975
1976	940	aerial survey	Millette and Galbraith 1976
1977	1212	aerial survey	Whaley 1977
1982	416	aerial survey	Collingwood 1982
1984	496	aerial survey	Minton[2] pers. commun.
1985	212	aerial survey	Collingwood *et al*. 1985

[1] 1971 survey results may be high due to mathematical inaccuracy. Original counts are not available so survey results have been ignored in later analysis.

[2] Park Warden, PANP.

TABLE 3

Known[1] Elk mortality from hunting adjacent to PANP, 1972-3 to 1984-5.

Winter	Licenced Hunting	Non-licenced Hunting	Total	% of Population[2]	Source
1972-3	58	11	69	-	Young *et al*. 1973
1973-4	N/A	N/A	-	-	-
1974-5	N/A	N/A	-	-	-
1975-6	N/A	N/A	-	-	-
1976-7	N/A	N/A	-	-	-
1977-8	40	9	49	4.0	Collingwood 1982
1978-9	62	86	148	-	Collingwood 1982
1979-80	18	32	50	-	Collingwood 1982
1980-1	19	94	113	-	Collingwood 1982
1981-2	17	20	37	-	Collingwood 1982
1982-3	29	5	34	8.2	Collingwood 1983
1983-4	21	8	29	-	Collingwood 1984
1984-5	145	11	156	31.5	Ewert & Collingwood 1985

[1] some mortalities may have gone unreported
[2] % of population estimated from the aerial survey conducted in the previous winter.

very deep. The 1956 estimate may therefore demonstrate that the PANP elk population reached a peak just prior to the elk slaughters of 1959-60.

Estimates which are available since 1964 show that except for two instances the estimated elk abundance in PANP fluctuated about a value of 1000 until 1977. In 1971, the estimated abundance was 1900 (Allan and Millard 1971) but inspection of survey results shows that this estimate should be discounted as it was made in error. The 1974 survey estimated abundance at 452 elk (Galbraith and Millette 1974). The 1974 survey suggested that the elk population had declined by 59% from 1973. The 1975 survey (West et al. 1975) suggested that elk increased by 166% from 1974-1975. Obviously, no population could actually increase that rapidly so as Galbraith and Millette (1974) suggested, there was a reason other than a true decline in abundance for the low count of 1974.

McGillis and Armbruster (1968) and Millette and Galbraith (1976) observed that the 1968 and 1976 aerial surveys were undertaken in less than ideal viewing conditions. It appears to be a safe assumption that the 1968, 1974 and 1976 aerial surveys all underestimated abundance relative to other surveys. Based upon an assessment of aerial survey conditions, it is apparent that the PANP elk population numbered in excess of 1000 individuals from 1964 to 1977.

The 1982 aerial survey (Collingwood 1982) produced an estimate 66% lower than the 1977 estimate. Subsequent surveys do not demonstrate a substantial recovery as was the case in 1974-1975. The 1985 survey (Collingwood et al. 1985) produced the lowest population estimate ever recorded for elk in PANP.

Collingwood (1982) suggested that hunting mortality may have been an important factor in the elk decline from 1977 to 1982. He showed that 464 elk died from various causes during that period. Collingwood (1982) also raised the possibility that the late date of the 1982 survey (March 10-19) and poor viewing conditions may partially account for the low 1982 estimate.

Hunting is a source of ecosystem incompleteness (Houston 1971) in a national park. Although the argument might be advanced that moderate hunting pressure will not influence ungulate abundance because mortality factors are compensatory, Keith (1983) and Bergerud et al. (1983) have suggested that hunting mortality and predation are additive.

Data from 1972-73 to 1984-5 (table 3) show that known hunting mortality has exceeded 100 individuals in 1984-85, 1980-81 and 1978-79.

Since PANP aerial surveys have been conducted after the annual hunting season, aerial survey results should demonstrate the immediate impact of hunting of elk abundance. Although 1978-79 and 1980-81 were years of high hunting mortality, the impact of those hunting seasons is unknown because no aerial surveys were undertaken in those years. The absence of an annual monitoring program made it impossible to quantify the immediate impact of hunting on the elk population.

3.3.7.2 Moose Abundance and Mortality

Estimates of moose abundance made prior to the introduction of aerial surveys were largely subjective based upon observations of moose sign. Moose are known to have been distributed throughout the area of PANP (Crean 1910) prior to the establishment of the park. Millar (1915) speculated that in general moose were less vulnerable than elk to the hunting pressures of the settlement period because of their selection of dense forest habitat. In 1921, moose were reportedly numerous in the "wooded districts" of Northern Saskatchewan (Canada 1921).

After PANP was established, moose abundance reportedly increased (Anonymous 1929) probably in response to protection and predator control. Moose abundance (table 4) likely increased until 1942-43, stabilized briefly, then increased again in response to increased forage availability caused by the large forest fires which occurred in 1939-1942 (Banfield 1951).

TABLE 4

Estimates of moose abundance for PANP, 1940-1985

Year	Estimate	Method	Source
1940	1900	unknown	Soper 1940
1954	1073	aerial survey	Tener 1954
1955	1053	aerial survey	Tener 1955
1956	1220	aerial survey	Banfield 1956
1959	640	unknown	Jervis 1959
1960	2000	unknown	Jervis 1960a
1961	2200	unknown	Jervis 1961a
1962	1800	unknown	Jervis 1962
1964	459	unknown	Gilroy 1964
1968	1548	aerial survey	McGillis and Armbruster 1968
1971[1]	2972	aerial survey	Allan and Millard 1971
1973	1788	aerial survey	Young et al. 1973
1974	964	aerial survey	Galbraith and Millette 1974
1975	2060	aerial survey	West et al. 1975
1976	1776	aerial survey	Millette and Galbraith 1976
1977	1880	aerial survey	Whaley 1977
1982	936	aerial survey	Collingwood 1982
1984	1110	aerial survey	Minton[2] pers. commun.
1985[3]	860	aerial survey	Collingwood et al. 1985

[1] 1971 survey results may be high due to mathematical/recording inaccuracies.
[2] Park Warden, PANP.
[3] 1985 Survey was in essence an elk survey comprising only the southern one-half of PANP, and therefore the 1985 moose estimate is not directly comparable with other years.

The moose population of PANP may have increased until approximately 1960-1961 and remained at relatively stable levels thereafter. Jervis (1960, 1962) estimated that moose numbered approximately 2000 individuals and observed that ticks (Dermacentor sp.) had become prevalent among the moose population. Gilroy's (1964) low estimate of 459 cannot be explained as the method of estimation is unknown.

Of the aerial survey estimates, 1968, 1971 and 1974 have produced unusual estimates. The 1968 survey was conducted under poor viewing conditions, late in the winter (McGillis and Armbruster 1968) and may be expected to have produced a relative underestimate. The 1971 and 1974 surveys produced inaccurate estimates and should be discounted. With the 1968, 1971 and 1974 survey results excluded, the available estimates show that the estimated PANP moose population was between 1750 and 2200 individuals from 1960 to 1977.

Collingwood (1982) found survey results to indicate that the moose population had declined by 50% from 1977 to 1982. The 1982 survey was undertaken late in the winter (March 10-19) under poor viewing conditions. Wolf abundance is thought to have been high at the time. Hunting mortality (table 5) for the period 1977-1982 does not appear to have been excessive. Therefore, the low 1982 estimate was probably a result of poor survey conditions and possible high predation. Results of the 1984 survey (Minton[1] pers.

[1] Minton, P. Park Warden, PANP.

TABLE 5

Known[1] moose mortality from hunting adjacent to PANP, 1972-3 to 1984-5.

Winter	Licenced Hunting	Non-licenced Hunting	Total	% of Population[2]	Source
1972-3	N/A	36	36	-	Young et al. 1973
1973-4	N/A	N/A	-	-	-
1974-5	N/A	N/A	-	-	-
1975-6	N/A	N/A	-	-	-
1976-7	N/A	N/A	-	-	-
1977-8	0	0	0	0	Collingwood 1982
1978-9	4	23	27	-	Collingwood 1982
1979-80	10	33	43	-	Collingwood 1982
1980-1	0	26	26	-	Collingwood 1982
1981-2	0	5	5	-	Collingwood 1982
1982-3	1	4	5	0.5	Collingwood 1983
1983-4	6	3	9	-	Collingwood 1984
1984-5	1	0	1	0.1	Ewert and Collingwood 1985

[1] Some mortalities may have gone unreported

[2] % of population as estimated from the aerial survey conducted in the previous winter.

commun.) show a moderate recovery, though not to the level of 1977.

The 1985 ungulate survey in PANP was essentially an elk survey because it covered only the area of best elk habitat, the southern half of PANP. The estimate of moose abundance which arose from the 1985 survey was 827 moose in the southern 1714 km^2 (Collingwood et al. 1985). It appears that moose may have increased from 1982 to 1984 but results from the 1985 survey are inconclusive.

3.3.7.3 Weather Severity

Park staff have monitored the severity of winter weather since 1972-3 (table 6), and have assigned an index value for the relative severity of most winters. According to the assigned index values, 1973-4 and 1978-9 were particularly severe winters. No index value was assigned for 1984-5, but it was a relatively severe winter. High elk hunting mortality (table 3) occurred in 1978-9 and 1984- 5, which were severe winters, and in the mild winter 1980-1. The lowest known elk hunting mortality occurred in 1983-4, a mild winter. Rounds (1975) found in Riding Mountain National Park (RMNP) that the highest moose hunting mortality occurred in severe winters and suggested that a similar relationship may have existed for elk.

TABLE 6

Winter severity for PANP 1972-3 to 1984-5.

Winter	Maximum snow depth (cm)	WSI[1]	Interpretation	Source
1972-3	57.4	918	moderate-severe	Burles 1978
1973-4[2]	80.0	1293	severe	Burles 1978
1974-5	34.0	N/A	mild	Collingwood 1979
1975-6	47.5	610	moderate	Burles 1978
1976-7	29.0	521	very mild	Burles 1978
1977-8	48.5	910	moderate	Burles 1978
1978-9[2]	61.0	1020	severe	Collingwood 1979
1979-80	53.3	645	mild	Sundbo 1980
1980-1	34.5	654	mild	Stefanuk 1983
1981-2	N/A	N/A	N/A	
1982-3	51.1	843	moderate	Stefanuk 1983
1983-4	38.0[4]	N/A	N/A	
1984-5	65.0[4]	N/A	moderate-severe	Anions[3] pers. commun.

[1] Weather severity index (Burles 1978) based upon snow depth, snow density, snow crust and temperature.
[2] Mortality due to starvation observed in these years.
[3] Park Warden, PANP.
[4] Unpublished Data, G. Keesey, Park Warden, PANP, pers. commun.

Severe weather conditions may incline elk to migrate from PANP to neighboring lands in search of food more frequently, or for a longer duration than would be the case during a mild winter. Such behavior would leave elk relatively more susceptible to hunting during severe winters. Although the available data are inconclusive, elk hunting mortality may be directly influenced by winter severity.

Relatively high estimates of moose abundance and elk abundance coincide with the mild winters 1974-5 and 1976-77. A relatively low estimate of elk and moose abundance occurred in 1973-74, a severe winter. Weather conditions have apparently affected the count of elk and moose in the 1974, 1975 and 1977 surveys, but it is not true that aerial surveys have detected the actual impact of weather severity on ungulate abundance. Since aerial surveys for these years were undertaken in early or mid-winter, little if any of the expected mortality due to severe conditions could have occurred by survey time.

Prevailing weather conditions for aerial surveys (table 7) show that relatively high counts were obtained under mild conditions and relatively low counts were obtained under severe conditions. For example the 1974 survey was conducted in cold temperatures (-37°) when the snow was deep (0.71m). That survey produced low counts for both elk and moose. Briscoe and Dolan (1983) showed that aerial survey counts from 1968-1977 were negatively correlated with snow depth in PANP.

TABLE 7

Weather and viewing conditons for aerial surveys, PANP, 1954-1985.

Year	Dates	Max temp(°C)	Min temp(°C)	Snow depth(m)	Visibility	Source
1954	Jan 27-28	-24	-52	0.76	good	Tener 1954
1955	Jan 26-27	-	-	-	good	Tener 1955
1956	Jan 21-25	-	-	1.22	poor	Banfield 1956
1968	Mar 19-27	2	-9	patchy	poor	McGillis and Armbruster 1968
1971[1]	Jan 19-23	-	-	-	-	-
1973	Jan 22-26	9	-21	0.46	excellent	Young _et al_. 1973
1974	Feb 12-16	-2	-37	0.71	fair-good	Galbraith and Millette 1974
1975	Jan 21-Feb 4	-1	-34	0.26	poor-excellent	West _et al_. 1975.
1976	Jan 12-16	-7	-31	0.20[2]	fair	Millette and Galbraith 1976
1977	Jan 31-Feb 8	9	-22	0.29	fair-excellent	Whaley 1977
1982	Mar 10-18	5	-20	0.48	fair-good	Collingwood 1982
1984	Feb 21-Mar 7	8	-27[4]	0.34	-	Minton[3] pers. commun.
1985	Feb 13-15	0	-16	0.66	good-excellent	Collingwood _et al_. 1985

[1] 1971 survey results have been ignored
[2] Burles (1978)
[3] Park Warden, PANP.
[4] Temperatures recorded at Sturgeon Crossing Warden Station.

Weather conditions prior to and during an aerial survey probably influence the survey count by encouraging or discouraging shelter-seeking behavior and movement of elk and moose. For some surveys, weather conditions at the time of the survey have probably had a greater influence than abundance on the survey result. For this reason comparison between yearly survey results should only be made between years of similar survey conditions.

3.3.7.4 Distribution of Elk and Moose within PANP.

Elk range through the southern two-thirds of PANP, with winter concentration at Namekus Lake, the lower Spruce River, Sandy Lake, Rabbit Creek, Flatt Creek, the southern park boundary and the eastern end of Waskesiu Lake (Banfield 1951). Minton[1] (pers. commun.) has analyzed winter aerial survey observations and shown that elk concentrate along the southwestern, southern and southeastern park boundaries in winter. Elk are rarely found north of the trail which runs east-west from Waskesiu Lake to Nesslin Lake, known as the "57" trail.

Moose have been sighted in the northern half of the park more frequently than elk, although aerial surveys from 1968-1977 indicate that 70 percent of moose sightings occurred in the southern half of the park (Briscoe and Dolan 1983). The relative difference in aerial visibility through

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[1] Minton, P. Park Warden, PANP.

northern coniferous vegetation versus southern deciduous vegetation may provide a partial explanation of the difference in apparent moose density. Surveyors records and other historical accounts (Crean 1910) suggest that moose were abundant in all areas of the park.

3.4 SUMMARY OF TRENDS IN ELK AND MOOSE ABUNDANCE.

3.4.1 Elk

Elk were native to the area of PANP prior to settlement, but relative abundance in the park area is unknown. The hunting pressure and habitat loss which accompanied settlement probably had reduced elk to relatively rare status by the time PANP was established in 1927. A provincial ban on elk hunting and the protection of a national park created an environment inside PANP which was favourable to an increase in elk abundance. Predator control, protection and the artificial maintenance of favourable elk habitat by haying and intentional burning probably contributed to an increase in elk abundance which continued until the late 1940's or early 1950's.

During 1949-1961, park policy appears to have changed from an approach which favored an artificially created elk abundance to an approach which favored a more natural condition. The Cookson pasture was excised from PANP in 1949. Predator control, haying and burning ceased. The impact on the elk herd was the removal of a number of factors which acted to increase abundance, and the substitution of factors which reduced abundance. A downward trend resulted, and the elk slaughters and substantial hunting mortality during the same period augmented the decline. The elk slaughters of 1959-1961 probably came at a time when the PANP elk herd was beginning to decline from historic high levels.

The PANP elk herd appears to have remained relatively stable from the period of the elk slaughters until the late 1970's. Aerial surveys from 1982, 1984 and 1985 suggest that there has recently been an abrupt decline in elk abundance. The consistently low estimate which has been produced by the three most recent surveys suggests that the perceived decline may be valid, even though the 1982 and 1984 surveys were conducted relatively late in the winter.

Hunting mortality of 32% of the 1984 population estimate provides a partial explanation for the most recent decline. While habitat loss may have been restrictive at one time, habitat is probably not now limiting at such a low estimated elk abundance. Predation may have contributed to the recent decline, particularly in 1981-2 when wolf numbers were probably at an historic high level in PANP. Winter severity may also have contributed to a decline since mortalities due to starvation were recorded in at least one winter (1978-9) during the period in question.

3.4.2 Moose

Moose are known to have been abundant in the area of PANP prior to settlement; they have likely continued in relative abundance in PANP up to the present. Records show that moose have not been hunted as heavily as elk in PANP, and there is no record, or concern, that favoured moose habitat in PANP is declining.

Occasional extremes in abundance have been recorded for moose although quantitative data regarding such extremes are lacking. A perception that elk actually outnumbered moose during the 1940's was probably the result of gregarious behavior and selection for open habitat by elk.

Aerial surveys suggest that moose numbers may have recently declined but such an interpretation is open to question. The three most recent aerial surveys have not produced evidence of consistent low abundance as has been the case for elk. Moose abundance has probably remained stable, except for a possible recent decline, since the time of the first aerial survey of PANP.

Chapter IV

ANALYSIS OF AERIAL SURVEY DATA

4.1 PURPOSE

The purpose of this chapter is to provide an analysis of elk and moose aerial survey data for PANP. Estimates of density and confidence intervals have been determined from data contained in yearly aerial survey reports. Additional analyses have been applied to survey years when survey conditions and results warrant such treatment. Survey results are analyzed in relation to factors such as weather, timing and snow depth as discussed in Chapter 3.

4.2 SURVEY TECHNIQUE

A general description of survey technique was given in Chapter 2. Table 8 summarizes yearly survey methods. The 1954, 1955 and 1956 surveys differed from all other surveys by the use of a 0.805 km wide transect. In all other surveys a transect width of 0.402 km was employed by surveyors. The 1984 survey sampled approximately 50 percent of the study area whereas all other surveys sampled approximately 25 percent of the study area. The 1968, 1982 and 1984 surveys were conducted relatively late in the

TABLE 8

Summary of aerial survey methods, PANP 1954-1985

Year	Date	Transect width(km)	Average speed(kph)	Height(m)	No. of transects	Total transect area (km²)	Total transect area/ study area
1954[1]	01/27-01/28	0.805	161	91-122	N/A	748.51	0.20
1955[2]	01/26-01/27	0.805	161	91-122	25	890.96	0.24
1956[3]	01/21-01/25	0.805	161	76	25	890.96	0.24
1968[4]	03/19-03/22	0.402	137	122	51	975.67	0.25
1971[5]	01/19-01/23	0.402	145	122	51	975.67	0.25
1973[6]	01/22-01/26	0.402	161	122	51	973.71	0.25
1974[7]	02/12-02/16	0.402	161	122	51	973.71	0.25
1975[8]	01/20-02/04	0.402	161	122	52	976.17	0.25
1976[9]	01/12-01/16	0.402	161	122	52	976.17	0.25
1977[10]	01/31-02/08	0.402	161	122	51	973.71	0.25
1982[11]	03/10-03/18	0.402	145	122	53	993.87	0.26
1984[12]	02/21-03/07	0.402	129	122	105	1952.33	0.50
1985[13]	02/13-02/15	0.402	128	122	24	445.8	0.26

1 Tener 1954.
2 Tener 1955.
3 Banfield 1956.
4 McGillis and Armbruster 1968.
5 Allan and Millard 1971.
6 Young <u>et al</u>. 1973.
7 Galbraith and Millette 1974.
8 West <u>et al</u>. 1975.
9 Millette and Galbraith 1976.
10 Whaley 1977.
11 Collingwood 1982.
12 Minton pers. commun.
13 Collingwood <u>et al</u>. 1985

winter in comparison to the other surveys. The 1976 survey was conducted earlier in the season than all other surveys.

4.3 VISIBILITY BIAS

Underestimation which results from an observer's inability to see and count every animal within the survey area is termed visibility bias. Visibility bias reduces the accuracy of the survey and causes the survey estimate to be low. Caughley (1977) has observed that undercounting is usually serious enough to invalidate the use of an aerial survey as an estimation of absolute abundance, although the survey result may still be useful as an index of population size.

Visibility bias varies according to many factors, including the species behavior and dispersion, observers, weather, habitat type and methodology. LeResche and Rausch (1974) found that observers with current aerial survey experience counted only 68 percent of the moose present in an area under excellent viewing conditions. Hauge and Keith (1981) reported an observation efficiency of 50 percent for aerial surveys of moose from fixed wing aircraft. MacLennen (1975) calculated a "miss factor" for elk in the Porcupine forest of Saskatchewan of 20-40 percent.

Caughley *et al.* (1976) showed that an aerial survey count was sensitive to changes in survey speed, height and width of transect. Visibility bias was increased if airspeed, height and or transect width was increased.

LeResche and Rausch (1974) found that time-of-day and physiography significantly affected visibility count. Norton-Griffiths (1976) showed that observer fatigue (including time-of-day), boredom and airsickness could be responsible for as much as 26 percent of the variation in an aerial survey. Norton-Griffiths (1976) recommended that survey flights should be no longer than three hours in order to minimize visibility bias resulting from observer fatigue.

Caughley *et al.* (1976) and Erickson and Siniff (1963) demonstrated that the use of different observers resulted in significantly different counts. LeResche and Rausch (1974) demonstrated that inexperienced observers saw approximately 20 percent fewer moose than experienced observers under all types of viewing conditions. They recommended that aerial moose surveys should only be conducted by experienced observers under conditions of complete, fresh snow cover.

Weather factors influence ungulate behavior and aerial visibility and thus increase variation between yearly survey results. Severe weather conditions, particularly deep snow and late winter conditions may cause both elk and moose to seek shelter in coniferous or mixed wood areas (Telfer 1970, Trottier and Hutchison 1982), thus reducing aerial visibility and negatively biasing the count. Trottier *et* al. (1983) employed 19 aerial surveys during the winters 1977-8, 1978-9, and 1979-80 in a study of elk and moose habitat selection. They found that late winter surveys produced lower counts than early winter surveys, particularly for elk. This observation was attributed to shelter seeking behavior.

Lynch (1975) showed that variability in winter weather conditions greatly influenced winter counts of moose in Alberta. Lynch found that variability between yearly surveys was reduced when surveys were conducted after the first complete snowfall of the year. Carbyn (1969) recommended that aerial surveys should be standardized with respect to technique, timing and weather severity.

4.4 ELK ABUNDANCE

4.4.1 Trend in Elk Abundance

Elk abundance estimates from aerial survey reports (figure 3) have varied considerably between survey years. An attempt to compare only those surveys conducted under similar snow conditions and at a similar time of the year. produced a comparison among only five survey years.

The 1973, 1975, 1976, 1977 and 1984 surveys (figure 4) were conducted under conditions of less than 0.5 m snow depth, in January and/or February, with a transect width of 0.402 km. Figure 4 demonstrates somewhat less severe

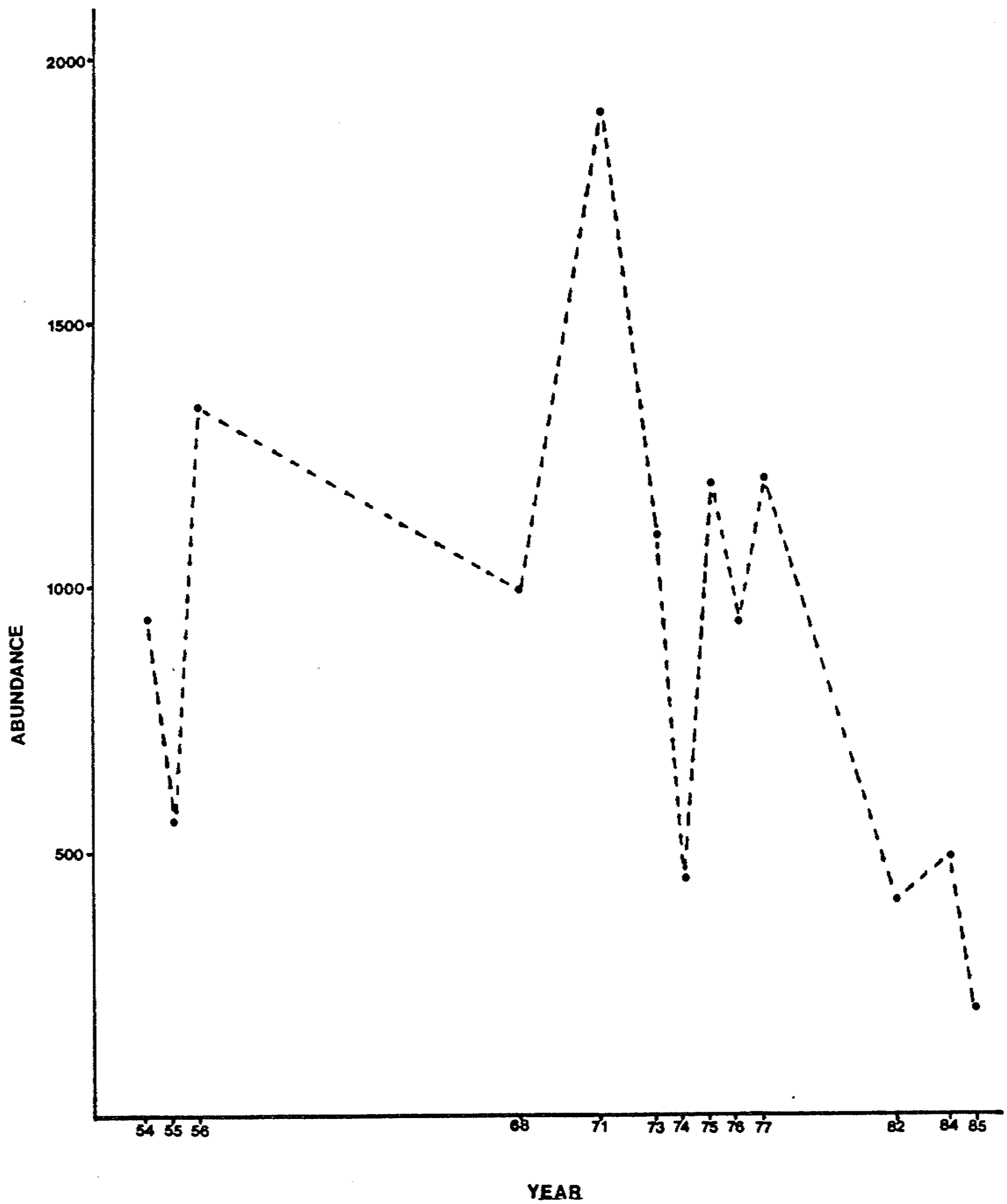

Figure 3: Elk abundance estimates from aerial survey reports.

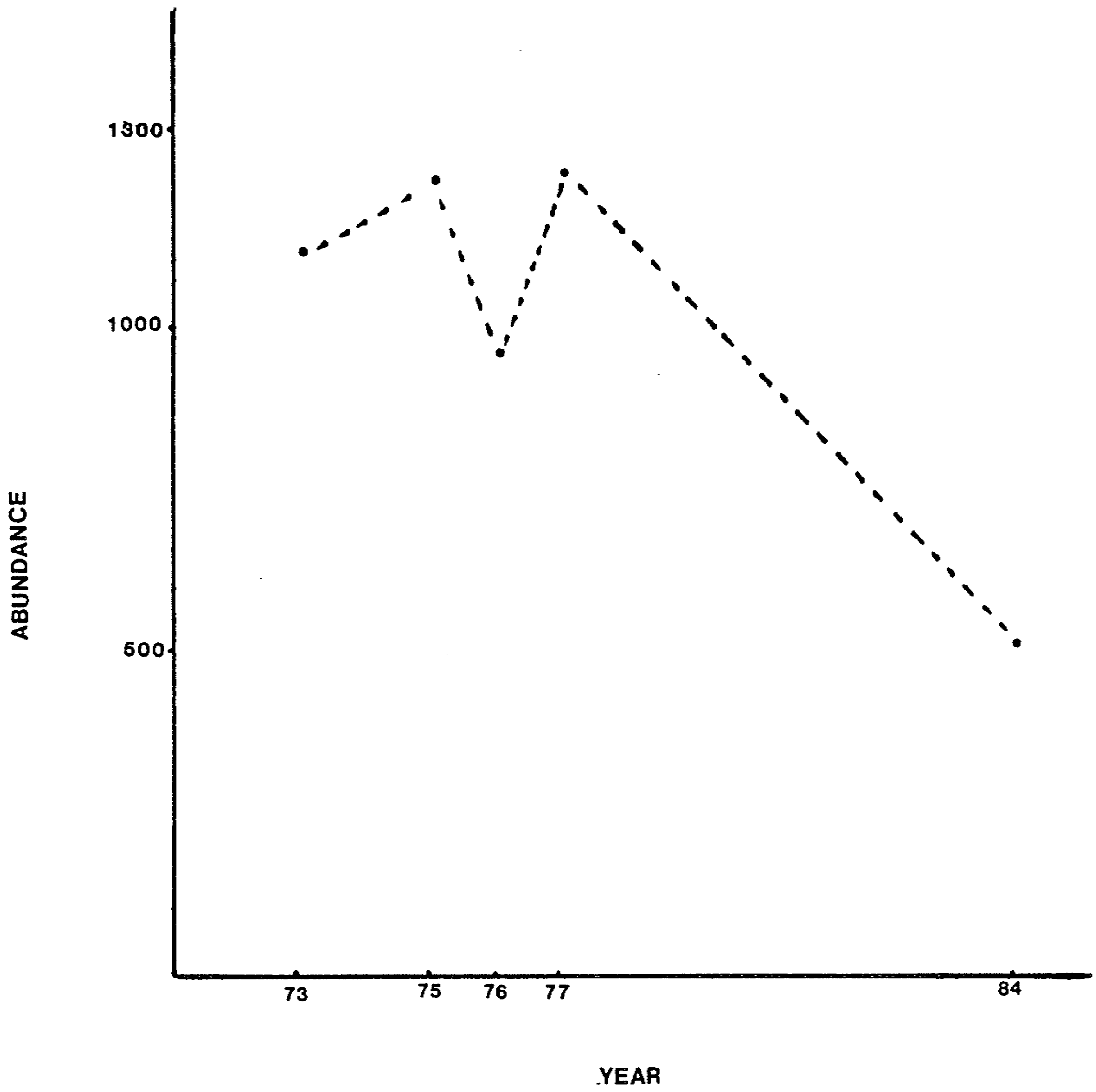

Figure 4: Estimated elk abundance determined from survey reports. surveys conducted in January and February, less than 0.5 m. snow cover.

variation among survey years than Figure 3. Figure 4 suggests that elk numbers have declined from approximately 1000 - 1100 in the late seventies to approximately 500 in the mid-eighties.

Harris (1986) outlined a method for determining the precision of the estimated yearly instantaneous rate of change (r_0), by estimating the coefficient of variation (CV) for a survey. An estimated CV of 76% for PANP elk surveys was derived from 1984 elk data. By regressing the natural logarithm of estimated abundance on time (figure 5), the instantaneous rate of increase (r_0) can be estimated as the slope of the regression line. For PANP elk data $\hat{r}_0$ = -0.0803, therefore the estimated finite rate of increase is approximately - 8.0 % per year.

Where CV is assumed to be 76%, S^2 is estimated (Harris 1986) as:

$$S^2 = \ln (1 \pm CV^2)$$

and the standard error of r_0 is: $SE(r_0) = \sqrt{12 S^2 / nk \ (K^2 - 1)}$

where k = number of years of monitoring,

n = number of surveys/year.

For PANP data the standard error of r_0 was 0.0875. Therefore since r_0 is normally distributed (Harris 1986) there is a probability of approximately 68% that the actual value of r_0 lines in the range ($- 0.1678 \leq r_0 \leq 0.0072$). These data suggest strongly that elk abundance declined over the period 1973 - 1984, with a probability of approximately

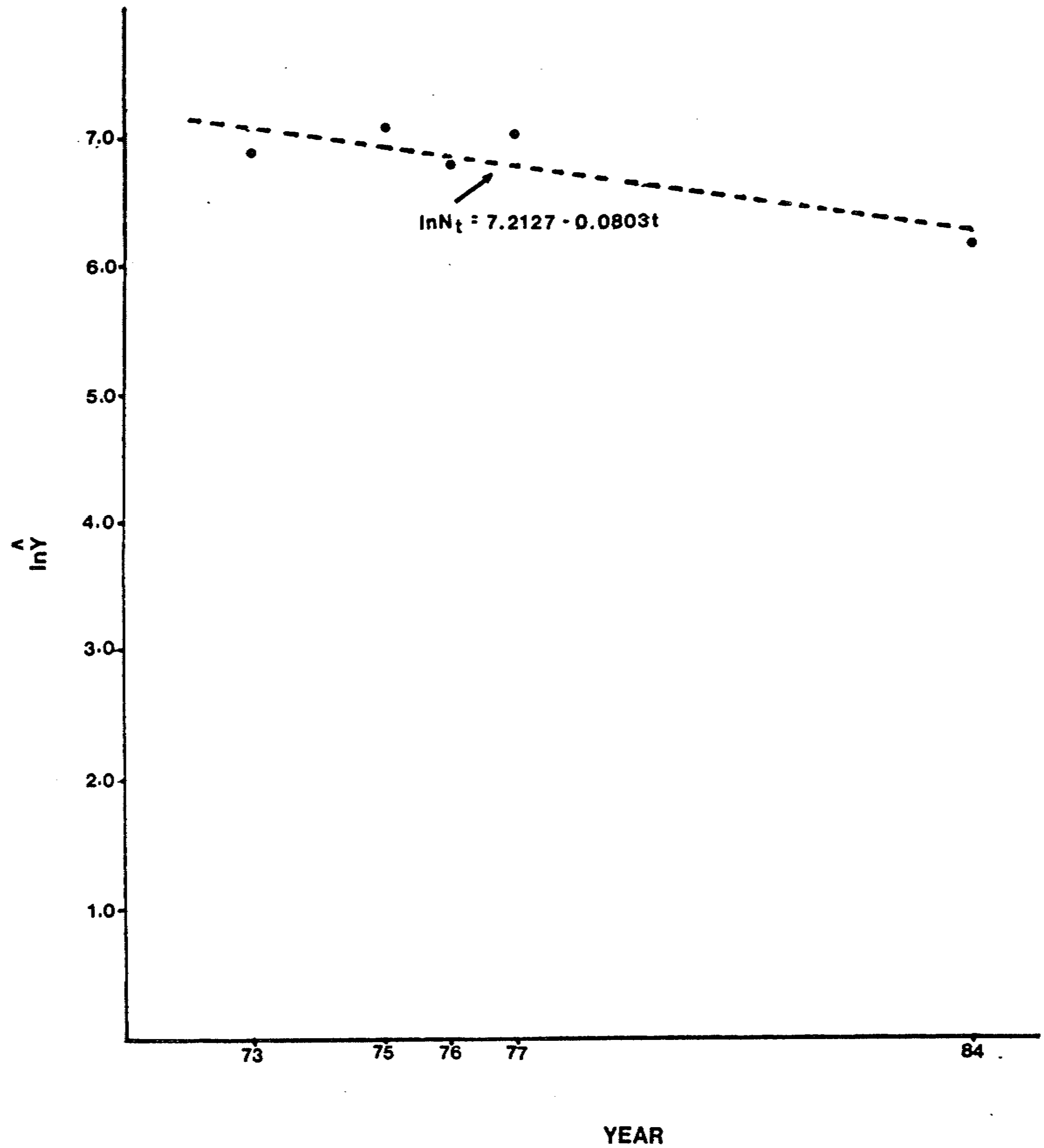

Figure 5: Regression of average elk density on survey year for 5 years of similar survey conditions.

81% that the true r_0 was less than or greater to 0. Harris (1986) suggested that the most efficient means of improving the precision of the estimate of r_0 is by increasing survey frequency.

4.5 CONFIDENCE INTERVALS FOR ELK ABUNDANCE ESTIMATES.

Cochran (1963) and Norton-Griffiths (1978) have outlined a means of determining confidence intervals for unequal transect counts from aerial surveys. The method determines an estimated population total $\hat{Y}$ and an estimated population variance $Var(\hat{Y})$ based on an assumption of random sampling.

Yearly elk abundance estimates and corresponding confidence intervals as determined from Cochran (1963) (table 9) differ from the data offered in Figures 3 and 4, due to the use of a slightly different means of estimating abundance than was used in aerial survey reports. Abundance estimates given in all aerial survey reports excluding 1984 were determined by the formula:

$$\hat{Y} = \text{count} \times \frac{\text{total number of possible transects}}{\text{number of transects sampled}}$$

Estimated population size $\hat{Y}$ from Norton-Griffith (1978) was:

$$\hat{Y} = \text{area of census zone} \times \frac{\text{count}}{\text{total area of transect samples.}}$$

TABLE 9

Estimated elk abundance and confidence intervals for PANP aerial survey data.

Year	Estimate abundance[1]	90% (C.I.[1](%)	95% C.I.[1] (%)
1968	993	±371.4 (37.4)	±445.6 (44.9)
1973	1063	±363.2 (34.2)	±435.3 (41.0)
1974	450	±148.1 (32.9)	±177.5 (39.5)
1975	1330	±452.5 (34.0)	±542.2 (40.8)
1976	933	±352.8 (37.8)	±422.5 (45.3)
1977	1206	±389.4 (32.3)	±466.7 (38.7)
1982	394	±147.3 (37.3)	±176.5 (44.8)
1984	496	±117.5 (23.6)	±140.4 (28.3)
1985[2]	204	±82.9 (40.7)	±100.1 (49.1)

[1] Calculated following the method outlined in Norton-Griffiths (1978).
[2] 1985 survey sampled only the southern 1714 km² of PANP.

Values given in Table 9 include observations made on all transects for each survey year.

The confidence intervals from Table 9 range between ± 23.6% and ± 49.1%. The most narrow (precise) confidence interval was produced by the most intense survey, 1984, in which sampling intensity was twice as great as for all other surveys. The least precise confidence interval (± 49.1%) was produced by the 1985 survey which employed the fewest transects and which produced the lowest count of all surveys.

An examination of aerial survey results shows that only 2.6% of all elk observations occurred in the northern 1630 km^2 of PANP. All other aerial observations occurred south of an east-west line drawn across the park, tangent to the northwest corner of Waskesiu Lake, meeting the eastern boundary approximately 50.4 km (31.5 mi) north of PANP's southeastern corner. This line was arbitrarily chosen to separate the park into sections where elk sightings were common (the southern 2245 km^2) and rare (the northern 1630 km^2). The difference in frequency of aerial elk observations between the southern and northern sections does not absolutely indicate habitat preference, as it may also represent a difference in visibility bias between southern and northern vegetation types.

Elk density estimates (table 10) for the area of relatively common elk sightings (the southern 2245 km^2 of PANP) offer a more reasonable means of comparison with other study areas than estimates determined from sightings over the entire park area. Table 10 includes confidence intervals calculated according to the method outlined by Kingsley and Smith (1981) for systematic samples. This method estimates the standard error of density estimates by using differences among adjacent transects where:

$$S^2 = (1-f) \sum_{i-1}^{n-1} (d_i - d_{i+1})^2 \ / \ (n-1)\ n\ \bar{x}^2(2)$$

and N = no. of transects in the population

n = no. of transects sampled

f = n/N, the sampling fraction

y_i = no. of animals counted in the i^{th} transect

x_i = area of the i^{th} transect

$\bar{y}$ = $\sum_{i=1}^{n} Y_i/n$

$\bar{x}$ = $\sum_{i=1}^{n} X_i/n$

$\bar{Y}$ = mean number of animals per transect

$\bar{V}$ = mean area of all transects

$\hat{R}$ = $y \ / z$ = estimator of true mean density.

d_i = $y_i - \hat{R}x_i$

Confidence intervals determined for the southern portion of the park, calculated according to the method of Norton-Griffith (1978) are narrower than the estimates determined for the whole park area calculated in the same manner (table 9) except in 1982 and 1985 which were years of particularly low counts. Confidence intervals for the southern portion of the park (table 10) are narrower when determined

TABLE 10

Estimated density and confidence intervals for elk in the southern 2245 km^2 of PANP.[1]

Year	Estimated Density (elk/km^2)	90% C.I.[2]	95% C.I.[2]	90% C.I.[3]	95% C.I.[3]
1968	0.443	±0.152 (34.4%)	±0.183 (41.4%)	±0.128 (28.8%)	±0.154 (34.7%)
1973	0.448	±0.144 (32.1%)	±0.173 (38.6%)	±0.108 (24.1%)	±0.130 (29.0%)
1974	0.175	±0.055 (31.6%)	±0.067 (38.0%)	±0.031 (17.8%)	±0.038 (21.4%)
1975	0.553	±0.184 (33.2%)	±0.221 (39.9%)	±0.101 (18.3%)	±0.122 (22.0%)
1976	0.409	±0.144 (35.1%)	±0.173 (42.3%)	±0.125 (30.5%)	±0.150 (36.6%)
1977	0.507	±0.150 (29.7%)	±0.181 (35.7%)	±0.103 (20.3%)	±0.124 (24.4%)
1982	0.172	±0.074 (43.3%)	±0.089 (52.1%)	±0.050 (29.4%)	±0.061 (35.4%)
1984	0.210	±0.048 (22.7%)	±0.057 (27.2%)	±0.034 (16.2%)	±0.041 (19.4%)
1985	0.119	±0.049 (41.4%)	±0.059 (49.9%)	±0.052 (43.4%)	±0.062 (52.4%)

[1] The southern 2245.12km^2 of PANP includes 97.4% of all aerial elk observations fron aerial surveys.

[2] Confidence intervals calculated as in Norton-Griffiths (1978).

[3] Confidence intervals calculated according to the systematic sampling analysis of Kingsley and Smith (1981).

according to the method of Kingsley and Smith (1981) than when determined according to the method outlined by Norton-Griffiths (1978) except in 1985, a year of comparatively low elk abundance.

For some years, confidence intervals appear to be too wide for a resource manager to base decisions upon the aerial survey sample. For example, the 1976 90% confidence interval for $\hat{Y}$, determined by the method of Kingsley and Smith (1980) is $637 \leq \hat{Y} \leq 1198$ elk. Similarly the 1973 survey produces a 90% confidence interval for abundance of $762 \leq \hat{Y} \leq 1248$. A range of 500-600 individuals is a relatively imprecise range for a manger to deal with when considering a population thought to number approximately 1000.

Conversely, some of the confidence intervals offered in Table 10 appear to be acceptable from a management perspective. The 90% interval for 1984 offers managers a range of $395 \leq \hat{Y} \leq 548$ individuals upon which to base a decision. The 1984 estimate was derived from a survey which sampled the study area at twice the intensity of all other surveys.

Based on the past aerial survey data it appears that 90% confidence intervals of ± 20% or less (for example 1975 and 1984) provide the most useful data in terms of assessing population density.

4.5.1 Effect of Excluding Lake Areas from Calculation of Density Estimate.

Because no elk sightings were recorded on the large lakes in the park, an attempt was made to determine the impact of removing the lake areas from density calculations. Density estimates for the southern 2245 km^2 of PANP were calculated excluding the areas of Sandy, Amyot, Namekus, Waskesiu and the Heart lakes from individual transect areas and total survey area, and compared with density estimates which include lake areas (table 11). The impact of excluding the area of the large lakes from density calculations was to increase the density by a factor of approximately 1.04. Confidence intervals were not affected. Overall estimated abundance remained the same.

4.5.2 Sampling

Assumptions in aerial survey sampling are:

i) each observer accurately counts all animals within the sample unit;

ii) each animal has an identical probability of being seen by the observer;

iii) animals are randomly distributed;

iv) conditions and techniques are identical from year to year.

TABLE 11

Effect of the area of large lakes on calculation of estimated densities and confidence intervals.

Year	Estimated Density Excluding Lake Areas (90% C.I.)[1]	Estimated Density Including Lake Areas (90% C.I.)[1]
1968	0.462 ± 0.133(28.8%	0.443 ±0.128 (28.8%)
1973	0.467 ± 0.113 (24.2%)	0.448 ± 0.108 (24.1%)
1974	0.182 ± 0.032 (17.8%)	0.175 ± 0.031 (17.8%)
1975	0.577 ± 0.106 (18.3%)	0.553 ± 0.101 (18.3%)
1976	0.426 ± 0.129 (30.2%)	0.409 ± 0.125 (30.5%)
1977	0.528 ± 0.106 (20.2%)	0.507 ± 0.103 (20.3%)
1982	0.179 ± 0.055 (30.8%)	0.172 ± 0.050 (29.4%)
1984	0.220 ± 0.035 (16.1%)	0.210 ± 0.034 (16.2%)
1985	0.121 ± 0.052 (43.3%)	0.119 ± 0.052 (43.4%)
Total Survey Area	2151.4 km^2	2245.12 km^2

[1] Calculated according to the method of Kingsley and Smith (1981).

Sample units in PANP have been chosen systematically, that is they were selected in an ordered fashion so that the distance between adjacent sample units is constant. Caughley (1977a) explained that systematic sampling is the most efficient way to map ungulate distribution. Cochran (1963) has indicated that because systematically - sampled survey units are spread evenly across a population, survey results may bemore precise than if the survey employed random sampling. Calculation of the standard error from systematically-sampled surveys may lead to a biased standard error if the results are treated in the same fashion as randomly-sampled surveys (Caughley 1977a). Kingsley and Smith (1981) have outlined a method for calculating the standard error of systematic transect surveys which eliminates that bias and improves precision (Section 4.4.2).

Sampling bias is an inaccuracy which results from the non-random distribution of the subject animals and the failure of the survey design to compensate for such a distribution. Gill et al. (1983) stated that the gregarious nature of elk posed a serious sampling problem.

4.5.2.1 Sample Size

A frequency distribution of observed density per transect for PANP aerial survey data would exhibit marked positive skewness, that is, there would be a large number of low density or zero density transects and a low number of high density transects. Cochran (1963) proposed a rule for determining a sample size for populations exhibiting positive skewness wherein the sample would be large enough for application of the normal approximation in determining confidence limits. The rule proposed by Cochran (1963) is that

$$n > 25\ G_i^2$$

where n = sample size

G_i = Fisher's measure of skewness = $\dfrac{E\ (y_i - \bar{Y})^3}{S^3}$.

Assessment of the 1984 aerial survey data for elk (lower 2245 km²) which exhibits the most positively skewed distribution of all years and which supplies the most information presents an n = 21, suggesting that sample sizes are adequate to allow the computation of confidence limits.

The 1984 aerial survey employed approximately twice as many transects as other surveys. Initial inspection of Table 10 indicates that the greater sampling intensity produced a smaller standard error and a correspondingly narrower confidence interval than other surveys. Analysis of the 1984 data as if it sampled at the same intensity as other years (beginning on transect 3 and using only every second transect up to transect 63) produced a density estimate of 0.191. The 90% confidence interval was ± 0.078 (40.9%) and the 95% confidence interval was ± 0.094 (49.2%) (Kingsley and Smith 1981 calculation). Therefore, it is apparent that the increase in sampling intensity for the 1984 survey was effective in reducing the 90% confidence interval from approximately ±41% to approximately ±16%.

Cochran (1963) and Norton-Griffiths (1978) outlined a method for determining the sample size required to yield an estimate of specified precision within specified limits.

The analysis used was:

$$n_0 = \left(\frac{t\,s}{d}\right)^2$$

and

$$n = \frac{n_0}{1 + (n_0/N)}$$

where n_0 = initial estimated sample size

n = estimated sample size

t = absicca of normal curve which cuts off an area α at the tails

S = estimated standard deviation

d = selected margin of error

N = number of available samples.

Analysis of 1985 data suggests that a future sample size of 57 transects will produce a 90% confidence interval of ±20%. An increase in survey effort of 32%, to 75 transects, will produce a 90% confidence interval of ±15%. At a sampling intensity of 50%, 62 transects can be sampled in the southern 2245 km^2 of PANP.

4.5.2.2 Stratification

Cochran (1963), Siniff and Skoog (1964), and Evans et al. (1966) have shown that stratification can be an effective means of reducing the variance of an estimated population total. The 1984 aerial survey employed a large number of transects and presented an opportunity to examine the effect of stratifying the park into areas of internally similar elk density.

The stratification which was employed (figure 6) was approximate and subjective, based upon individual transect densities and known patterns of distribution. The north boundary of PANP was bisected by a perpendicular line dividing each existing transect into east and west portions. Aerial survey maps for 1984 were then examined to allocate the number of elk sighted per transect onto the western or eastern portion of each transect. Areas of relatively high density were identified based upon a subjective assessment of 1984 survey data.

Stratum boundaries were set so as to completely enclose areas of relatively high density. There was a high proportion of transects (80%) in which no elk were sighted.

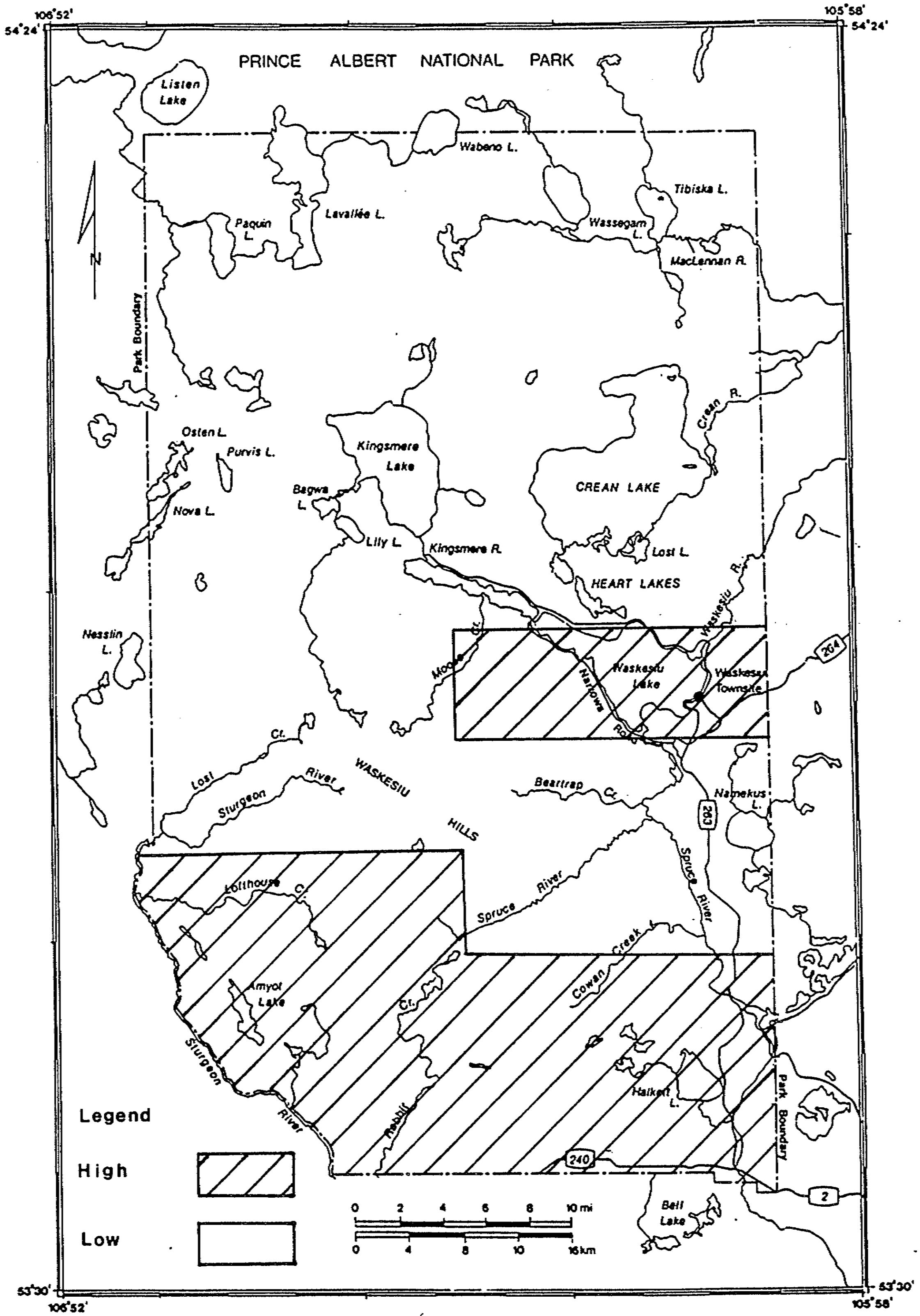

Figure 6: Stratification of PANP into areas of low and high elk density.

Because there were so few transects (20%) in which elk were sighted, only two categories, high and low, were identified. Strata boundaries did not conform to landscape features.

Stratification analysis was performed according to methods outlined by Cochran (1963) and Norton-Griffiths (1978). The area of relatively high elk density was determined to be 1080 km^2, and the area of relatively low elk density was determined to be 2795 km^2. The population estimate ($\hat{Y}$) which resulted from stratification of 1984 data was 450.7 elk with a combined standard error of 57.8863. The 90% confidence interval was $355.5 \leq \hat{Y} \leq 545.95$ (±21.1%). The 95% confidence interval was $337.27 \leq \hat{Y} \leq 564.19$ (±25.2%). Stratification did not greatly improve the precision of the total park abundance for elk compared to the unstratified result for 1984. An accurate stratification based upon habitat boundaries could improve survey precision. If accurate habitat information becomes available stratification may become a viable strategy.

Cochran (1963) outlined a formula for determining the most effective sample size for a given margin of error for a stratified sample under optimum allocation. The formulae

$$n_o = (\Sigma Nn\ sh)^2 \qquad \text{where } V = \left(\frac{d}{t}\right)^2$$

and

$$n = \frac{n_o}{1 + \frac{1}{V}\Sigma Nn\ Sn^2}$$

were employed in determining sample size for a stratified count of elk in PANP, where;

n_o = initial n

n = number of transects needed

N_n = total number of available transects in stratum h

s_n = $\sqrt{\text{Variance of stratum h}}$

d = desired margin of error

t = obscissa of normal curve at area α.

Based on the stratification performed in the 1984 aerial survey data for elk in PANP, a sample size of 156 transects (each transect being one-half the east-west width of PANP) was necessary to provide 90% confidence interval for the estimated population total $\hat{Y}$ of ± 15%. Under optimum allocation, where sample allocation is proportional to the ratio of stratum variances, 95% of the transects should be sampled in the high statum, and 5% of the transects should be sampled in the low statum.

4.6 ELK GROUP SIZE

A comparison was made between average group size of elk observed and estimated density of elk for 1973-1976. The year of highest estimated density (1975) also was the year of highest observed group size. The year of lowest estimated density (1974) was also the year of lowest observed group size. The simple correlation coefficient r = 0.8545 for the relationship between observed group size and density suggests that a direct association exists between the two parameters. In 1974, a severe winter, observers recorded the lowest average group size of the four year period. In 1975, a mild winter, observers recorded the highest average group size of the four year period. Severe weather conditions (temperature, wind, snow conditions) may cause elk aggregations to disperse and bias elk visibility negatively.

4.7 MOOSE ABUNDANCE

Moose abundance estimates from survey reports (table 4, Figure 7), have shown considerable variation between survey years. The survey years 1973, 1975, 1976, 1977, 1984 were chosen for comparison because the surveys from those five years were conducted under similar survey conditions. Abundance estimates for those five surveys (figure 8) exhibit a much less variable trend than for all years taken together. Figure 8 suggests that moose may have declined from approximately 1800 individuals in the late 1970's to approximately 1000 individuals in 1984.

4.7.1 Trend in Moose Abundance

Harris' (1986) method of assessing trend information was applied to moose survey data for 1973, 1975, 1976, 1977 and 1984. A coefficient of variation of 46% was determined from 1984 data. Regression of the natural logarithim of yearly abundance estimates (figure 9) yielded an observed instantaneous rate of increase (r_0) of - 0.0511. The

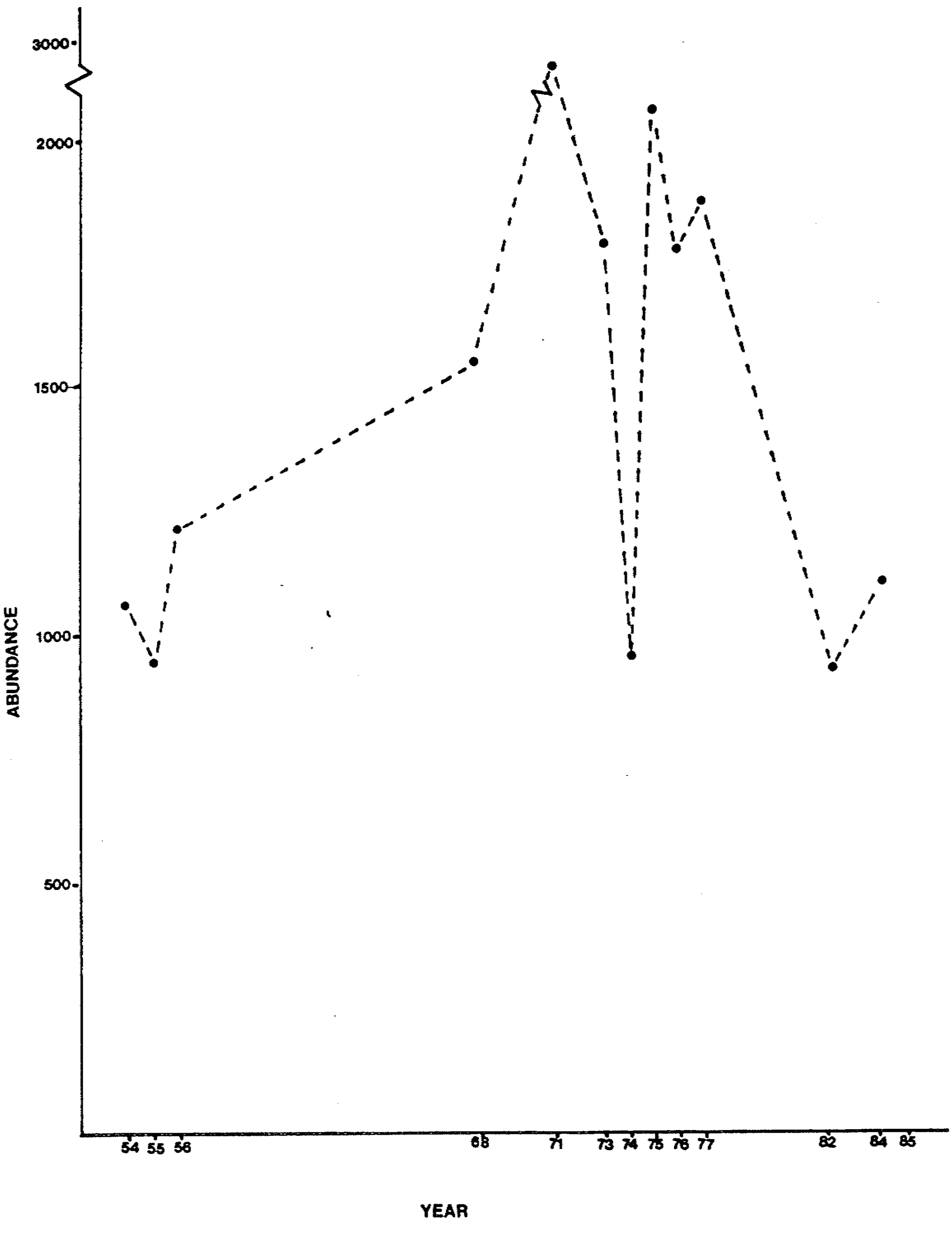

Figure 7: Moose abundance estimates from aerial survey reports.

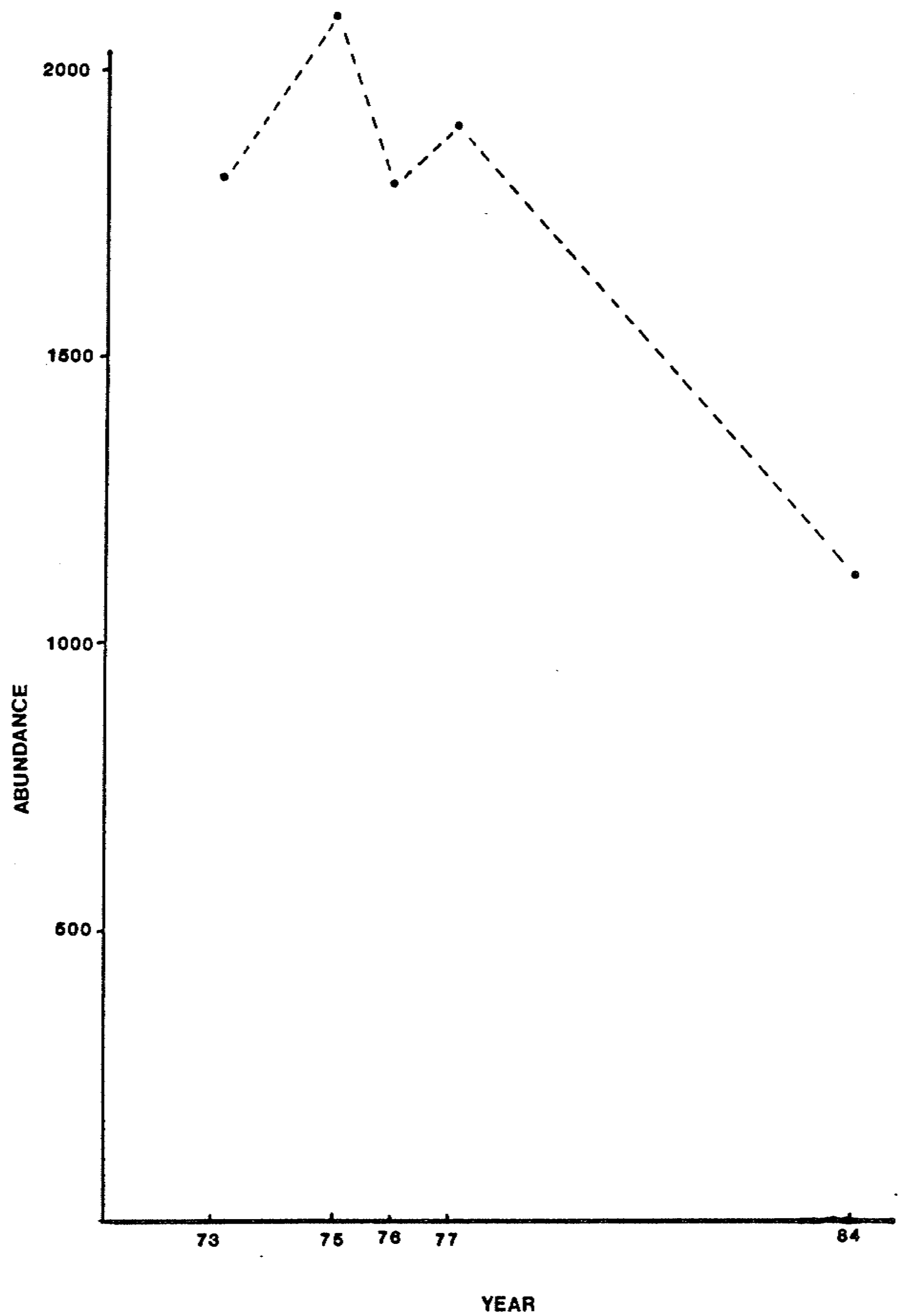

Figure 8: Estimated moose abundance determined from aerial survey reports surveys conducted in January and February, less than 0.5 m snow depth.

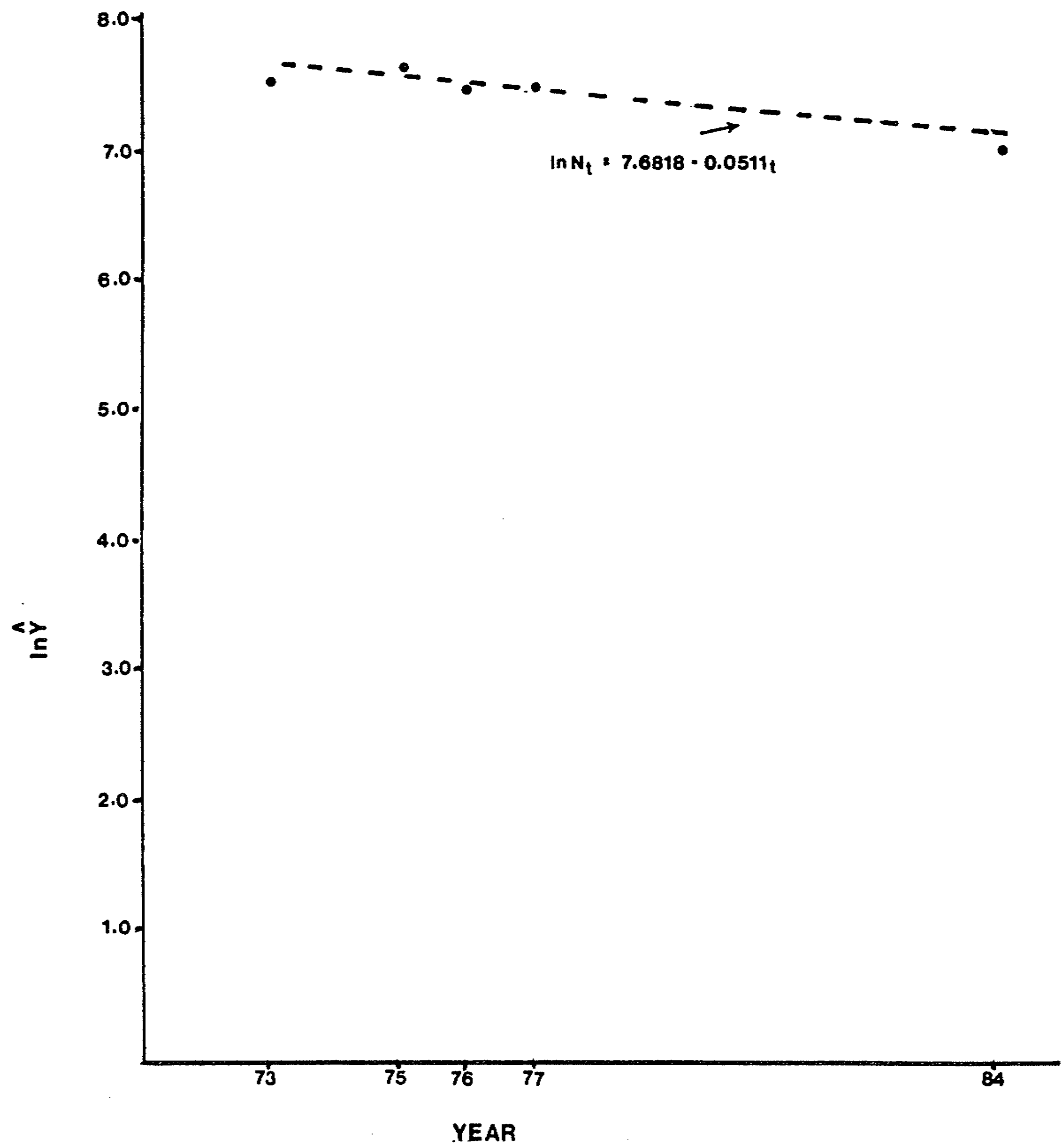

Figure 9: Regression of ln estimated moose abundance on time.

standard error of r_0 was determined to be equal to 0.0568. Thus, there is a 68% probability that the true value of r_0 lies in the range ($-0.1079 \leq r_0 \leq 0.0056$). These data suggest that moose abundance may have declined over the period 1973-1984, however there is appoximately a 22% probability that the true r_0 was greater than or equal to zero.

The latest aerial survey was inconclusive for moose. Unfortunately the 1985 survey result may be biased upwards for moose since the survey sampled only the southern 1714 km^2, an area of relatively high density. The long term trend in moose abundance appears to have been negative, but not as severe as the decline in elk abundance.

4.7.2 Confidence Intervals for Moose Abundance

Estimated abundance and confidence intervals for moose abundance estimates (table 12) were determined following the methods of Norton-Griffiths (1978) and Kingsley and Smith (1981). Intervals calculated according to the method of Norton-Griffiths (1978) ranged between ±11 and ±31% at the $\alpha = 0.10$ level of significance and between ± 13% and ±38% for $\alpha = 0.05$. Intervals calculated following the method of Kingsley and Smith (1981) ranged between ±8% and ±14% for $\alpha = 0.10$ and between ±9% and ±18% for $\alpha = 0.05$.

TABLE 12

Estimated moose abundance, density and confidence intervals for PANP aerial survey data.1

Year	Estimated Abundance	90% C.I.[2]	95% C.I.[2]	Estimated Density[3]	90% C.I.[4]	95% C.I.[4]
1968	1537	±230 (15%)	±276 (18%)	0.3967	±0.0412 (10%)	±0.0494 (12%)
1973	1779	±239 (13%)	±286 (16.1%)	0.4591	±0.0473 (10%)	±0.0567 (12%)
1974	976	±184 (19%)	±220 (23%)	0.2496	±0.0316 (13%)	±0.2496 (15%)
1975	2044	±335 (16%)	±402 (20%)	0.5276	±0.0317 (10%)	±0.0637 (12%)
1976	1770	±316 (18%)	±378 (21%)	0.4569	±0.0495 (11%)	±0.0593 (13%)
1977	1870	±275 (15%)	±330 (18%)	0.4827	±0.0390 (8%)	±0.0467 (10%)
1982	912	±195 (21%)	±234 (26%)	0.2354	±0.0361 (15%)	±0.0432 (18%)
1984	1110	±121 (11%)	±143 (13%)	0.2863	±0.0216 (8%)	±0.0258 (9%)
1985[5]	1869	±582 (31%)	±702 (38%)	0.4823	±0.0680 (14%)	±0.0821 (17%)

[1] determined for the total park area = 3875 km^2

[2] calculation as in Norton-Griffiths (1978)

[3] moose/km^2 estimate abundance = estimated density x 3875 km^2

[4] calculation as in Kingsley and Smith (1981).

[5] The 1985 survey covered only the lower 1714 km^2 of PANP. The result shown is an extrapolation to the entire park area. If the results are related only to the lower 1714 km^2, the population estimate is 827 ± 30% (α=0.05) and the density estimate is 0.4823 ± 0.0758 (16%).
The 1985 survey should not be used in an assessment of trend unless the comparison is made among the southern 1714 km^2 for all years.

Confidence intervals of 90% and 95% fall within an acceptable range of ± 20% or less as established for elk.

Recommended sample size determined from 1984 data, with the goal of producing 90% confidence intervals in a range of ±15% to ± 20%, was 20-26 transects. The sampling approach which has been employed for the PANP moose population has produced adequate results for management purposes.

4.8 SAMPLE SIZES REQUIRED FOR FUTURE TESTS OF SIGNIFICANCE

Eberhardt (1978) and Steel and Torrie (1980) outlined a method of determining the required sample size to detect a specific magnitude of change in a population for a specified power and level of significance. By employing the results from 1984 survey the formula:

$$n_o = \frac{(Z_\alpha \quad + Z\,\beta\,)^2\ S^2}{d}$$

where $Z\alpha$ = the abscissa of the normal curve at the specified a level.

$Z\beta^2$= the abscissa of the normal curve at β where power = 1- β .

n_o = initial sample size

S^2_D = the variance of the difference between 2 means. ℓn independent samples $6^2{}_D = 2\ 6^2$.

d = specified difference of $\hat{Y}_i\ \hat{Y}_i$ it is desired to detect.

was employed in a determination of sample size. Initial sample size was then refined by multiplying by $\frac{\text{error d.f.} \quad +3}{\text{error d.f} \quad +1}$ where error df was equal to 2(n-1).

The chosen sample size was for a one-tailed t-test with α=0.10 and the probability of falsely accepting a null hypothesis equal to 0.20.

A sample size of 78 transects was found necessary to detect a difference of 40% of the standard deviation or approximately 207 moose, in comparison between successive yearly surveys.

A sample size of 62 transects was found necessary to detect a difference of 45% of the standard deviation, or approximately 165 elk, in comparison between successive yearly surveys.

4.9 COMPARISON OF ELK AND MOOSE SURVEY RESULTS

In previous sections it was suggested that elk and moose survey results appeared to vary together, following similar patterns of increase and decrease. A regression of moose density on elk density (figure 10) producing a simple coefficient of correlation (r = 0.98) demonstrates the close association between the two variables. Unless elk and moose populations in PANP have been influenced in an identical fashion by environmental and human factors. then the relationship between elk and moose survey results must reflect the impact of survey conditions. If survey conditions did not affect the counts of elk and moose, then it would be reasonable to expect elk and moose survey result to increase and decrease in a more independent manner.

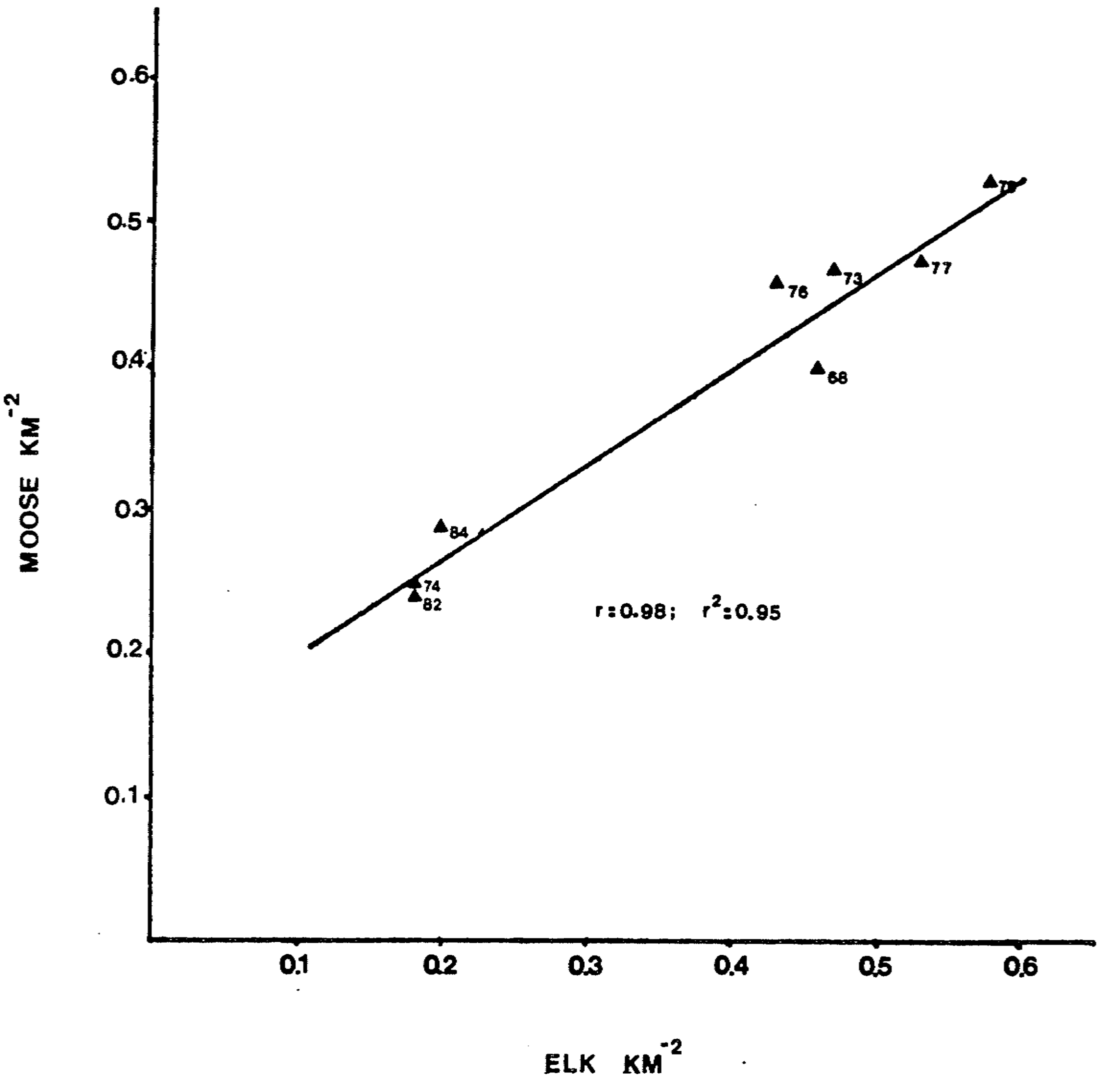

Figure 10: Regression of moose density on elk density, 1968-1984.

Chapter V

DISCUSSION

5.1 SIGNIFICANCE OF ELK IN PANP

The elk population of PANP is an important faunal component of the Southern Boreal Plains and Plateaux Natural Region. The subspecies once ranged throughout central Canada, but is now restricted to a few pockets within Saskatchewan and Manitoba. Preservation of the subspecies and its natural habitat should be considered to be significant on a global scale in view of the relative scarcity of the subspecies and the hunting pressure to which it is subjected throughout its range. The elk population of PANP appears to be undergoing such a rapid decline in abundance that managers may wish to consider taking action to slow or reverse the decline if it continues.

It has been shown that the PANP elk population deviated from a condition of natural regulation throughout the park's history. Fire suppression, intentional ignition of fires, haying, logging, predator control and hunting are the major human influences which have acted upon the PANP elk population. Most recently, hunting has probably exerted the greatest relative influence on the PANP elk population by causing intermittently heavy hunting mortality. Highest loss of elk to hunting has occurred during severe winters, probably reflecting the tendency of elk to travel out of the park in search of food during periods of deep snow cover. Rounds (1975) observed the same relationship in Riding Mountain National Park.

Natural factors which have probably exerted the greatest relative impact on the PANP elk population are severe winter weather, scarcity of food and predation. In the winter of 1978-79, starvation was observed among the PANP elk population demonstrating the combined impact of severe winter weather and decreased food availability. The reportedly abundant wolf population of 1982 (Collingwood 1982) may have exerted unusually high predation on elk and deer in PANP.

5.2 TREND IN ELK ABUNDANCE

Elk were native to the PANP area prior to settlement. During the settlement period elk declined as a result of hunting and habitat loss to the point where they were considered rare in the area. A nationwide ban on elk hunting, combined with the establishment of PANP, allowed local elk abundance to increase. Within PANP, predator control, favourable habitat conditions and protection allowed elk numbers to increase steadily until at least 1942. The elk population of PANP may have reached its greatest abundance by the mid 1950's.

Between 1935 and 1968 several factors which had maintained a high population of elk were reversed. In 1935 hunting for elk was resumed. In 1948, the Cookson Pasture, an important area of elk habitat, was excised from PANP and converted into a community pasture. Predator control ended in PANP in 1954. Intentional burning ceased in 1958. Haying inside the park ceased in 1968. Logging, which may have expanded the favourable elk habitat in the park's southern areas, was phased out and logged areas gradually reforested over this same period.

Fire suppression gradually acted to increase the total forested area in PANP, likely reducing the amount of winter forage and habitat available to elk. The elk slaughters of 1960-1962, combined with high hunting mortality, directly reduced the size of the elk herd. It appears reasonable to suggest that elk numbers began to decline after the mid-1950's as a result of management practices which reduced the amount of favourable elk habitat, restored predation and increased harvest levels.

Elk abundance estimates from 1964-1977 suggest that elk numbered in excess of 1000 individuals. Aerial survey estimates range between 450 and 1330 for surveys taken in 1968, 1973, 1974, 1975, 1976 and 1977. Low estimates obtained during that period (1974 estimated abundance was 450 elk) were probably a result of a late survey date and severe weather at survey time.

Aerial surveys conducted in 1982, 1984, and 1985 produced much lower estimates of abundance than previous surveys. Unfortunately, comparisons between survey years are complicated by differences in the conditions under which surveys were flown. For example, a comparison between the 1982 survey and the 1977 survey would not be meaningful because the 1982 survey was flown in March and the 1977 survey was flown in early February. Additionally there is a gap of 4 years between the two surveys.

In order to assess the most recent trend in elk abundance, surveys which were flown in the months of January and February under snow conditions less than 0.50 m deep were chosen for analysis. Only 5 of the 12 surveys flown since 1968 met the criteria. The trend demonstrated by the five chosen surveys - 1973, 1975, 1976, 1977 and 1984 - was that elk abundance declined at a rate of 8 percent per year between 1973 and 1984.

The greatest decline in elk abundance has occurred since 1977. Severe winter conditions, particularly in the 1978-1979 winter, high hunting mortality (Collingwood 1982) and a high wolf population (Collingwood 1982) may have all contributed to the observed decline. Although the 1985 and 1982 surveys were not included in the trend line analysis because of the conditions under which they were flown, they offer strong corroborating evidence that elk abundance has declined abruptly since 1977. Approximately 76 percent of the decline in estimated abundance for the southern 2245 km^2 of PANP between 1984 and 1985 is explained by known hunting mortality of 156 elk. Employing a 40% miss factor for elk (MacLennen 1975), a maximum elk estimate for PANP could be approximately 445 ± 183 based on 1985 data for the southern 2245 km^2 of PANP. It is important to note that Reed et al. (1986) calculated that a population of no less than 426 elk, in an isolated ecosystem, was necessary to maintain an effective breeding population of 50 individuals and restrict the incidence of inbreeding to one percent. The data suggest that the PANP elk population may have reached a critical level in terms of abundance.

5.3 DISTRIBUTION OF ELK WITHIN PANP

The southern 2245 km^2 of PANP were found to contain approximately 97% of the elk observations from aerial surveys. It is not known for certain if the apparent southern concentration of elk is due to habitat preference or due to a difference in visibility between the predominantly coniferous northern vegetation and the mixed southern vegetation. However, moose have been sighted with greater frequency than elk in the northern section which suggests that if elk existed in the north at moderate population densities, some would have been sighted during the past 10 aerial surveys. It seems reasonable to suggest that the apparent southern concentration is predominantly due to elk habitat preference.

Highest concentrations of elk were found (1) south of a line between the point where the Sturgeon Creek intersects the park's western boundary and the Anglin Lake fire tower, and (2) a small area enclosing the southern end of Waskesiu Lake (figure 6).

5.4 SIGNIFICANCE OF MOOSE IN PANP

Like the elk, the moose is an important faunal component of the Southern Boreal Plains and Plateaux Natural Region. Moose populations in PANP, especially in the northern portion of the park, are relatively contiguous with moose populations outside of the park, therefore the moose population of PANP is not as isolated as the elk population. Unlike the elk, moose are represented widely throughout the Province of Saskatchewan and Canada. Although it is important to preserve moose within PANP in a natural state, the issue of preservation of moose and moose habitat is not as significant as the preservation of elk within the park.

5.5 TREND IN MOOSE ABUNDANCE

Moose were distributed throughout the area of PANP before it became a national park, although population estimates are unavailable. Moose numbers in PANP apparently increased until about 1942 as a result of predator control and landscape management. Large fires in PANP in the 1940's and early 1950's may have afforded new areas of favourable habitat and abundance is thought to have increased in the 1950's. Relatively high hunting mortality may have caused the population increase to slow by the early 1960's. The population may have reached a relatively stable level estimated to lie between 1750 and 2200 individuals from 1960 to 1977.

The most recent aerial surveys suggest that the PANP moose population declined from approximately 1870 individuals in 1977 to 912 individuals in 1982, then increased to 1110 individuals in 1984. The 1985 survey covered only the southern 1714 km^2 of PANP. Extrapolation of the 1985 count to the total park area would be misleading due to the relatively high density of the south. The most recent trend in moose abundance, from 1982 to 1985, is imperfectly understood.

Five aerial surveys which were undertaken in January or February, under conditions of less than 0.50 m snow depth, were analyzed to determine trend. The data indicated that moose abundance declined by 5% per year over the period 1973-1984.

5.6 DISTRIBUTION OF MOOSE WITHIN PANP

The largest observed concentration of moose in PANP occurs in the park's southern half. For aerial surveys, 70% of observations have occurred in the southern half of PANP (Briscoe and Dolan 1983). However it is not certain if this apparent north-south density gradient is real or simply a result of differences in visibility between northern coniferous and southern mixed vegetation. The density gradient for moose is not as severe as for elk,indicating a more uniform distribution of moose throughout PANP.

5.7 ASSESSMENT OF PANP AERIAL SURVEY STRATEGY

The most significant feature of PANP aerial surveys is that monitoring has been an end in itself. No specific objective for moose and elk monitoring has been stated. Managers have been left in the position of being required to monitor populations without having an avenue for assessing results and implementing strategies because there has been no clear direction upon which to base a strategy.

In the absence of a long term strategy, aerial surveys have been independent from one another and information gaps have developed. For example, complete hunting statistics would help to determine the impact of hunting on the PANP elk herd, especially if aerial survey data were available for consecutive years. A request to DPRR officials to implement changes in the elk management strategy would be given added weight by an accurate assessment of the impact of hunting on the herd. Unfortunately this information is not available.

Gaps between survey years have limited the analysis of results. For example, it may have been desirable to test for significant differences in estimated population size between consecutive surveys. Such a method was attempted but was rejected because of the difficulty in interpreting the meaning of a significant decline over a five year interval (elk between 1977 and 1982) as compared to a decline which was not significant over a one year interval (between 1975 and 1976).

Some differences in methods needlessly complicated the analysis of survey results. For example, original data and maps were not stored in a central area, requiring that extra time be spent finding information. Transect locations varied from year to year, requiring that transect areas be measured individually and meaning that surveys differed slightly in number of transects and area surveyed.

The area where the best opportunity exists for improving survey accuracy and precision lies in the timing of yearly surveys. Aerial surveys flown under widely varying weather conditions needlessly muddled the trend analysis. Severe winter weather appeared to produce particularly low-biased counts.

For example, 1974 was relatively severe weather survey which produced a low count. If ungulate abundance was actually affected by the severe winter of 1973-1974, then it would be expected that the 1974-1975 survey would show a reduced count due to mortality in late winter 1973-1974. However, the results were a low 1974 count and a high 1975 count. Weather conditions at the time of the 1974 survey influenced ungulate behavior and increased visibility bias, reducing the accuracy of the survey.

An attempt to examine the results of surveys taken under relatively similar weather conditions produced only five surveys from 1968-1985 for analysis. Criteria were: a snow depth of less than 0.5 m, based on the assumption that snow depth of two-thirds chest height limited mobility for ungulates (Trottier and Hutchinson 1982) and timing of surveys in January or February, based on the assumption that moose and probably elk would shelter in coniferous areas in March (Telfer 1970). Trend line analysis (Harris 1986) was therefore spaced over a 12 year period when in fact it appears that the critical period of decline in the elk herd was between 1977 and 1982. This tended to underestimate the rate of decline.

Confidence intervals determined for elk abundance estimates (table 9) were in the range ±16% to ±52%, generally too wide to form a basis for management decisions.

Confidence intervals for moose abundance levels were narrower than for elk. The present method of surveying appears to offer precision in the range of ± 8-18%, probably sufficient for moose management purposes.

Survey precision was improved by calculation according to the method of Kingsley and Smith (1981). Increased sampling size, as in the 1984 survey, also improved precision. A stratification of 1984 survey results, based on observed transect densities, did not greatly improve precision. Establishment of accurate strata boundaries based upon habitat features may potentially improve precision in future.

Confidence intervals of ±15-20% (α=0.10) were suggested as a goal for future aerial surveys of elk. A sample size of 57 transects covering the southern 2245 km^2 of PANP was projected to produce an abundance estimate for elk with the required precision, based on 1985 data. Analysis of 1984 results suggested that a sample size of 62 transects covering the southern 2245 km^2 of PANP would enable managers to detect a difference of 165 elk, in a one-tailed t-test at the α=0.10 level, between successive surveys.

Moose results for 1984 show that a sample size of 78 transects covering the entire park area will enable managers to detect a difference of 207 moose, in a one-tailed t-test at the α=0.10 level, between successive surveys.

When elk and moose abundance estimates were compared, it was apparent that the two estimates were very closely associated. Therefore, unless environmental factors have affected elk and moose populations in an identical fashion, survey conditions have influenced the count of both elk and moose. Trend analysis may therefore have been impaired by the influence of survey conditions.

5.8 INFORMATION REQUIREMENTS

Critical areas for elk, in particular calving areas and crucial winter habitat, should be identified and considered for protection as zone 1 special preservation areas. As elk abundance declines, protection of critical areas of elk habitat may prove to be an important cornerstone of successful elk management in PANP.

The question of relative visibility between north and south vegetation types in PANP should be resolved. Managers may wish to address this question by experimentally comparing the results of intense quadrat surveys over northern and southern vegetation types with transect surveys over the same areas.The development of 'miss factors' for transect surveys over each vegetation type, and for each species, would allow managers to assess more accurately the absolute abundance of elk and moose in PANP.

Annual harvest data should be collected and compared with annual aerial survey results. This strategy would allow a more specific determination of the impact of hunting on elk and moose.

Weather severity indices are recorded for PANP on a regular basis. If the weather severity index at the time of an aerial survey was recorded within the aerial survey report, managers could assess the impact of weather conditions upon survey results.

The abundance of wolves in PANP has not been recorded regularly. Documentation of wolf abundance estimates, as was the case in 1981-1982, would enable managers to more accurately assess the impact of predation upon elk and moose populations.

Chapter VI

RECOMMENDATIONS FOR MONITORING MOOSE AND ELK

6.1 MONITORING OBJECTIVES IN NATIONAL PARKS

If the absence of human influence is a necessary component of a naturally-regulated population, then it is legitimate to question the need for monitoring. The act of monitoring an ecosystem could be viewed as an unnecessary intrusion into a natural system. Further, a monitoring program may detect a change in abundance without providing information about the cuase of the change.

Leopold (1962) stated "continuous monitoring is the yardstick of success or failure in conservation", yet Caughley (1977) stated "estimates of abundance have no intrinsic value and they should never be considered ends in themselves". It is clear that monitoring is important, but only useful if based upon a logical assessment of management needs. Stelfox and McGillis (1977) suggested that objectives for monitoring should be defined in relation to park and wildlife management objectives.

Parks policy states "natural resources within national parks will be protected and managed with minimal interference to natural processes to ensure the perpetuation of naturally evolving land and water environments and their related species" (Parks Canada 1980). Therefore a primary objective for monitoring in National Parks is to ensure that viable populations of native species continue to exist within a park at natural levels of abundance.

Park policy further states that National Parks can serve as "ecological benchmarks for research into natural processes" (Parks Canada 1980). Therefore, an additional objective for a monitoring program is to acquire knowledge about the ecosystem under consideration both generally, to contribute to knowledge about natural systems, and specifically, to be able to react appropriately in case of an unnatural influence occurring upon the system.

Because wildlife populations in PANP are subject to hunting pressure, monitoring acquires added importance. Houston (1971) recognized that public hunting along the boundaries of a park was a source of ecosystem incompleteness. It is necessary to accept the limitation which hunting imposes upon the objective of natural regulation and monitor and manage the elk and moose of PANP as harvested populations.

A monitoring program for PANP elk and moose populations will only have value if it is included within a management program which identifies sound management objectives for elk and moose. The current status of elk in PANP suggests that such a program should be considered during the upcoming revision of the Park Conservation Plan for PANP.

6.2 AERIAL SURVEY METHODS AND ANALYSIS

6.2.1 Survey Frequency

The average aerial survey frequency in PANP has been approximately one survey every two years, although the timing of surveys has not been regular. A biannual survey strategy creates regular gaps in data which make interpretation of harvest and weather data extremely difficult because the impact of such factors cannot be specifically related to annual abundance. A biannual survey strategy subjects the monitoring program to the risk that if one year's survey is aborted due to unfavourable weather conditions, a gap of 3 or 4 years is created between surveys.

An annual survey strategy will allow annual harvest and weather severity information to be related directly to annual abundance. The trend line analysis suggested by Harris (1986) employs a factor for the number of surveys performed per year in its derivation of the standard error of the rate of increase. Therefore, as the population is surveyed more frequently, the estimate of rate of increase becomes more precise. Surveying at a more frequent rate than annually could improve the precision of trend line analysis, but seasonal variations in viewing conditions would reduce accuracy. The recommended survey frequency is one survey per year, recognizing that operational requirements and weather conditions will cause the actual survey frequency to be less than one survey per year.

6.2.2 Survey type

A systematic transect survey is recommended for PANP. This survey strategy will maintain continuity with previous surveys and also provide the best possible information about ungulate distribution. A quadrat survey could potentially reduce visibility bias. Siniff and Skoog (1964) and Evans et al. (1966) detailed the use of quadrat surveys for moose. However, Caughley (1977) explained that transit time is greater than a transect survey and Caughley (1977a) cautioned that visibility bias is not always reduced in quadrat surveys. A quadrat survey would involve much more flying time than a systematic transect survey plus the added effort of defining quadrat boundaries and strata boundaries. The systematic transect design employed in PANP since 1954 has provided reasonable precision for moose abundance estimates. Systematic transect sampling at a sampling intensity of approximately 50% over the southern 2245 km^2 (62 transects) can produce similar precision for elk abundance estimates.

6.2.3 Precision

Analysis of PANP aerial survey results showed that 90% confidence intervals for abundance estimtes of ±15-20% were practical and adequate for elk and moose management purposes. It is recommended that a sampling intensity be employed which provides such precision.

6.2.4 Analysis

The method of analysis developed by Kingsley and Smith (1981) has been shown to produce a smaller standard error than the method outlined by Norton-Griffiths (1978). This method should be employed in future analysis as it provides more precise confidence intervals and allows analysis which is more sensitive to changes in abundance than the method outlined by Norton-Griffiths (1978).

As the distribution and abundance of elk changes, the appropriate sample size to produce confidence intervals of ±15-20% at the α=0.10 level of significance may change. A yearly assessment of the sample size required to produce the desired level of precision should be undertaken prior to the commencement of the aerial survey. The analysis outlined in section 4.4.4.1 is appropriate to such a determination.

A one-tailed t-test as outlined by Norton-Griffiths (1978) is an appropriate way to test for a significant difference between annual estimates of abundance. The trend line analysis (Harris 1986) outlined in section 4.4.1. provides an effective way to assess medium to long term trends in abundance.

6.2.5 Location of Transects

Transects should be in the same location every year to reduce variability among years and leave open as many options for analysis as possible. Where transects are identical, paired comparisons may be drawn among transects for consecutive surveys.

The first transect should originate on the eastern boundary, 1.8 km (1.125 mi) north of the extreme southeastern corner of the park. This transect would extend west along the southern boundary (excluding the small south eastern corner) and have an area of 14.23 km^2. This approach wold eliminate particularly small transects in the southeastern corner and eliminate the possibility of a 'half-width' transect along the park's southern boundary. Particularly small transects are inefficient because there is a relatively small chance of an ungulate being sighted within the transect, and because small transects increase the variability among transect areas. Increased variability in transect areas can increase the standard error of an abundance estimate. Additional transects should proceed at regular intervals from the initial transect, the length of the interval being determined by the recommended sampling intensity.

6.2.6 Survey Timing

Criteria were developed within this report for comparing among years of similar survey conditions. Those criteria were that the survey should be flown under no less than complete snow cover and no more than 0.5 metres snow depth, during the months of January and February. These criteria allow for a wide range of conditions but it is recommended that they be adopted as criteria for aerial surveys in PANP. A survey should be cancelled if it could not be completed within the recommended time period. Therefore, surveys should have commenced by the second week in February to ensure completion during the allotted time period.

Surveys should not be flown if snow cover is patchy or if the snow depth measured at snow depth stations in PANP exceeds 0.5 metres. Weather severity indices, temperature and windspeed should be recorded for each surveying day. Managers may wish to refine these criteria based upon continued monitoring of weather conditions during aerial surveys.

6.2.7 Survey Speed, Height, and Transect Width

Survey speed, height and transect width should remain unchanged (approximately 130 kph, 122 metres altitude and 0.4 km wide) so that survey methods remain consistent and results are comparable with past years' results.

6.2.8 Observer Efficiency

It has been shown (LeResche and Rausch 1974) that the use of inexperienced observers can reduce survey efficiency. Therefore it is recommended that inexperienced observers receive some training before the actual survey begins. An experienced observer should make a flight over the park to assess survey conditions prior to the commencement of the aerial survey. This observer could be accompanied by an inexperienced observer and the two could make one or two test transects counting on the same side of the aircraft, and compare counts. One new observer per year could be trained in this fashion.

Norton-Griffiths (1976) recommended that survey flights should be no longer than three hours duration in order to minimize visibility bias due to fatigue. Therefore, it is recommended that the length of survey flights be recorded and individual flights be no longer than three hours duration. Morning and afternoon flights should be separated by a reasonable rest period.

Observers should record problems such as fatigue, airsickness and poor visibility so that survey results may be properly interpreted. Observations should be recorded separately for each observer. In this way, potential observer bias may be assessed by comparing counts between observers.

6.2.9 Data Management

Survey maps and field data should be identified and stored in one accessible location so that future investigators may readily access data. Survey observers should be responsible for compiling a data report after each survey, so that the circumstances and conditions of the survey are recorded by the people with the best knowledge. Statistical analysis and storage of survey data may best be handled by a computer. Development of software for performing such analysis may be a suitable project for an independent contractor.

6.3 OPTIONS FOR A MONITORING PROGRAM

Options for monitoring moose and elk in PANP were developed based upon a range of sampling intensities and survey frequencies. The options were developed based on the assumption that a survey of the southern 2245 km^2 of PANP will survey both elk and moose, while a survey of the northern 1630 km^2 of PANP will, for practical purposes, be a moose survey.

Regardless of the chosen option, it is recommended that a survey of elk and moose be conducted in January or February 1989, which samples PANP at a 50% (102 transect) sampling frequency. The reason for this recommendation is that 4 years will have passed since the last aerial survey of the southern area of PANP and 5 years will have passed since the last survey of the northern area of the park. Distribution of elk and moose may have changed over that period, and so an intense survey of the park will be required to update distribution information. Managers will be able to make an informed selection of an appropriate monitoring strategy when they are able to refer to current aerial survey data to assess monitoring needs.

6.3.1 Option 1.

6.3.1.1 Strategy

Conduct an annual, systematic aerial transect survey of PANP based upon a sampling frequency of 50% of the park area (102 transects). Assess the survey strategy at the end of five years.

6.3.1.2 Methods

Beginning with transect 1 (section 6.2.5) construct east-west transects at 0.8 km intervals along the north-south axis of the park. Fly transects in order from south to north.

6.3.1.3 Analysis

Elk abundance can be determined for the southern 2245 km^2 or the total park area. Moose abundance can be determined for the total park area.

6.3.1.4 Expected precision

Confidence intervals for elk for the southern 2245 km^2 at the α=0.1 level should be in the range ±15 - ±20% (Section 4.6.1). Confidence limits for moose abundance estimates at the α=0.1 level can be expected to be smaller than 10%. Tests for significance between annual surveys should detect a difference of 165 elk and 180 moose at the α=0.10 level.

6.3.1.5 Rationale

This type and frequency of survey will provide consistent and precise information about elk and moose trends in abundance. Elk and moose are given equal priority. Survey results can be related to mortality factors.

High quality distribution information will be provided which can be mapped and summarized as an assessment of winter habitat requirements. Regular yearly surveys will ensure that moose and elk monitoring remains a relatively high priority compared with other winter activities.

6.3.1.6 Cost

This option requires approximately 51 hours flying time per year, an estimated capital expenditure of $8,500.00 per year. Approximately 0.2 person years annually will be required to fly the survey.

6.3.1.7 Advantages

This option provides the highest quality of abundance information available about moose and elk.

6.3.1.8 Disadvantages

This option is the highest cost option and it may require three weeks or more to complete the survey.

6.3.2 Option 2

6.3.2.1 Strategy

Conduct an annual systematic aerial transect survey of PANP. Survey the southern 2245 km^2 of PANP at a sampling intensity of 50% (62 transects). Survey the northern 1630 km^2 at a sampling intensity of 25% (20 transects). Assess the monitoring strategy after 5 years.

6.3.2.2 Methods

Beginning with transect 1, construct east-west transects at 0.8 km intervals along the north-south axis of the park, up to transect number 62 (inclusive). Beginning with transect 62, construct transects at 1.6 km intervals up to transect 102 (inclusive). Fly transects in sequence from south to north.

6.3.2.3 Analysis

Elk abundance can be determined from analysis of the southern 2245 km^2. Elk distribution information can be collected from the 20 northern transects. Moose abundance can be determined from all transects, either by using northern and southern areas as separate strata or by simply deriving a total park estimate.

6.3.2.4 Expected Precision

Confidence limits for elk abundance estimates at the $\alpha=0.10$ level will be in the range ±15-20%. Confidence limits for moose abundance estimates at $\alpha=0.10$ will be smaller than ±10%. Tests for differences at the $\alpha=0.10$ level between annual surveys will detect differences of approximately 165 elk and 207 moose.

6.3.2.5 Rationale

This option provides distribution and abundance information for both species at desirable levels of precision. Moose and elk are given equal priority in this approach. Regular annual surveys will give elk and moose monitoring high visibility when winter activities are planned.

6.3.2.6 Cost

This option requires approximately 41 hours of flying annually at an approximate cost of $6,800.00. Approximately 0.15-0.20 person years are required to complete the survey.

6.3.2.7 Advantages

This option provides annual information of a quality similar to option 1 at lower costs and reduced manpower and time requirements.

6.3.2.8 Disadvantages

This survey may require 2-3 weeks to complete.

6.3.3 Option 3

6.3.3.1 Strategy

Conduct an annual systematic aerial transect survey of the southern 2245 km^2 of PANP at a sampling intensity of 50% (62 transects). Conduct regular but not annual surveys of the northern 1630 km^2 area as a check on moose distribution and abundance. Assess survey strategy after five years.

6.3.3.2 Methods

Construct east-west transects for the southern 2245 km^2 as in Option 2. From the results of the 1988-1989 aerial survey, assess the need to survey moose in the northern 1630 km^2 on a biannual or triannual basis, and schedule surveys of the northern area at the selected frequency. Selection of survey frequency can be based on the need to monitor mortality factors in relation to moose abundance. If 1988-1989 data indicate that a mortality factor has affected the herd and should be monitored closely, then an annual survey frequency (Option 1) is recommended. However, if moose abundance appears relatively stable in relation to 1984 data, then biannual or triannual checks on distribution and abundance in the northern section may be satisfactory.

A sampling intensity of 25% (20 transects) is recommended for the northern section.

6.3.3.3 Analysis

Analysis of elk results may be determined as in Options 1 and 2. Moose abundance information for the southern 2245 km^2 can be assessed for trends as in Options 1 and 2. Moose abundance information for the northern 1630 km^2 can be combined with data from the southern 2245 km^2 and can also be treated separately and compared with data from the northern 1630 km^2 from other years.

6.3.3.4 Expected Precision

The precision of the elk estimates and tests will be the same as options 1 and 2. The precision of moose data for the southern 2245 km^2 will also be the same as for options 1 and 2.

Confidence intervals at α=0.10 for the combined estimate of moose abundance will be expected to fall within the range of ±15-20%. Data from the northern 1630 km^2 taken alone, will provide confidence intervals of less than ±25% at the α=0.10 level. Tests for differences between yearly abundance in the northern 1630 km^2 (20 transects) will detect a difference of 130 moose at the α=0.10 level of significance.

6.3.3.5 Rationale

By selecting this option the manager recognizes that monitoring of the PANP elk population is a higher priority than monitoring of moose. This allows the manager to expend the majority of resources on the high priority species and then add a reasonable check on moose abundance and trends for relatively little extra cost.

6.3.3.6 Cost

This option requires an annual base level of 31 hours of flying at a cost of $5,200.00. An additional cost of 10 hours of flying at $1700.00 will be required biannually or triannually. Approximately 0.12-0.15 person years will be required to fly the survey depending on the frequency of northern flights.

6.3.3.7 Advantages

This survey concentrates effort on elk and provides the same level of precision for the southern 2245 km^2 as options 1 and 2. Trends in moose abundance can be closely monitored in the southern section of the park and periodically checked and confirmed in the northern section, at an acceptable level of precision.

6.3.3.8 Disadvantages

Gaps in data collection for the northern section of PANP are the greatest disadvantage of this option. Surveys of the northern section may become irregular due to weather conditions or as a result of the lack of regular funding and committment. Trend line analysis (Harris 1986) for the northern section will be poor relative to other options, but trends may still be closely monitored in the south.

6.3.4 Option 4

6.3.4.1 Strategy

Conduct an annual systematic aerial transect survey of the southern 2245 km^2 of PANP at a sampling intensity greater than 50%, in order to provide an abundance estimate of maximum precision. Conduct surveys of the northern 1630 km^2 as in Option 3. Assess survey strategy after 5 years.

6.3.4.2 Methods, Analysis and Precision

Begin at transect 1 as in Option 1. Construct 75 transects in the southern 2245 km^2 by spacing transect centres 0.65 km apart.

From section 4.4.4.1, it is estimated that a sample size of 75 will produce a 90% confidence interval for elk in the southern area of ±15%. Elk trend data and moose trend data may be analyzed as in Option 3.

6.3.4.3 Rationale

This option would be an attempt to create maximum precision for the high priority species.

6.3.4.4 Cost

This option requires an annual base level of 37.5 hours flying time for the south and additonal costs of 10 hours flight time at selected intervals. Cost for flying the southern portion would be approximately $6200.00 annually, with an additional expense of $1700.00 biannually or triannually. Approximately 0.12-0.15 person years would be required to fly the survey.

6.3.4.5 Advantages

This option has potential to improve the precision of elk abundance estimates by 5% to ±15% at the α=0.10 level.

6.3.4.6 Disadvantages

A major disadvantage of this survey is that transect boundaries will be only 0.25 km apart. Elk and moose which flee from the survey aircraft may flee onto the adjacent transect and be counted twice by observers. Aircraft drift may cause transects to overlap one another, resulting in more double counting. This option may result in decreased survey accuracy.

6.3.5 Option 5

6.3.5.1 Strategy

Design a stratified annual aerial survey of elk based on an accurate map of elk winter habitat in PANP. Include a regular program assessment and review of strata boundaries.

6.3.5.2 Methods

Produce an accurate map of elk winter habitat in PANP. On the map, designate areas of high and low expected elk density, based on habitat preference and known elk distribution. Construct transects or quadrats within high density and low density areas based on optimal sampling (Cochran 1963). Fly the survey annually, and review strata boundaries annually.

6.3.5.3 Analysis

Analysis of a stratified survey was outlined in section 4.6.2.

6.3.5.4 Precision

Precision and accuracy of an optimally allocated stratified survey may be greater than the precision for a systematic transect survey. However, the analysis of 1984 survey results based on a broad stratification of transects did not greatly improve survey precision.

6.3.5.5 Rationale

The intent behind option 5 would be to improve the precision and accuracy of elk abundance estimates and refine knowledge of elk winter habitat preference. Moose abundance would take a very low priority under this option.

6.3.5.6 Cost

Flight time and person years would approximate that required under option 1. An additional cost would be the development of a suitable mapping system, estimated to cost $10,000 to $20,000.

6.3.5.7 Advantages

Under this option, all effort would be concentrated upon the high priority species. Accuracy and precision could potentially be improved over systematic transect surveys.

6.3.5.8 Disadvantages

Moose abundance and distribution acquires a very low priority under this option. Additional flights may be required to assess elk distribution properly. Production of an accurate habitat map is a relatively long term goal so a different survey type may be required in the interim. Trend analysis will be distorted by the use of a different type of survey.

6.4 OPTION SELECTION

It is recommended that option selection should be delayed until the completion of the 50% systematic transect survey recommended for 1988-1989. Monitoring options should be based on management objectives as well as on the availability of manpower and funding. Therefore, management options for elk and moose should be in place before any of the options identified in section 6.3 are selected. The 1988-1989 survey and sections of this report should assist managers in defining a direction for management of elk and moose for the future.

Options 2 and 3 will provide precise, accurate information about elk and moose in PANP which is consistent with previous surveys and therefore permits analysis of long term trends. Options 2 and 3 are moderate cost options which provide for annual assessment of the impacts of mortality factors upon abundance.

Each option includes a review strategy. It must be recognized that a regular review of the monitoring program will allow managers to adapt the monitoring strategy to suit management needs. Changes to park management; for instance a change to active fire management from the current strategy of fire exclusion, may require that elk and moose monitoring proceed under a different strategy from the options identified in this report.

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Appendix A

DATA FROM AERIAL SURVEYS, 1968-1985 PRINCE ALBERT NATIONAL PARK.

Raw Data from 1968 Aerial Survey

Transcect	Area (Km²)	Elk	Moose	Transect	Area (Km²)	Elk	Moose
1-2	14.23	7	13	27-28	19.61	-	10
2-3	14.46	21	9	28-29	19.61	-	8
3-4	15.01	19	15	29=30	19.59	-	9
4-5	15.71	2	12	30-31	19.56	1	3
5-6	17.43	34	21	31-32	19.56	-	5
6-7	17.83	2	8	32-33	19.56	-	2
7-8	18.26	12	8	33-34	19.56	-	2
8-9	18.78	20	10	34-35	19.59	-	3
9-10	19.06	15	14	35-36	19.61	-	1
10-11	19.09	13	16	36-37	19.61	-	3
11-12	19.24	20	21	37-38	19.61	-	2
12-13	19.54	3	4	38-39	19.61	-	-
13-14	19.87	6	13	39-40	19.61	-	5
14-15	20.22	5	7	40-41	19.61	-	5
15-16	20.34	1	9	41-42	19.61	-	10
16-17	20.27	30	13	42-43	19.61	-	-
17-18	19.97	21	14	43-44	19.59	-	4
18-19	19.66	-	7	44-45	19.56	-	7
19-20	19.66	6	12	45-46	19.56	-	5
20-21	19.66	-	6	46-47	19.56	-	5
21-22	19.66	6	9	47-48	19.56	-	1
22-23	19.66	4	10	48-49	19.56	-	2
23-24	19.64	-	15	49-50	19.56	-	5
24-25	19.61	-	5	50-51	19.56	-	7
25-26	19.61	-	9	51-52	19.56	-	2
26-27	19.61	2	1				

ELK COUNTED = 250 MOOSE COUNTED = 387 AREA SURVEYED = 975.67 km²

Raw Data from 1973 Aerial Survey

Transect	Area (Km²)	Elk	Moose	Transect	Area (Km²)	Elk	Moose
1	14.23	20	5	26	19.61	-	6
2	14.23	26	13	27	19.61	2	8
3	14.63	16	12	28	19.61	-	10
4	15.49	5	18	29	19.61	-	13
5	17.25	11	7	30	19.56	-	7
6	17.65	10	16	31	19.56	4	3
7	18.05	4	23	32	19.56	-	-
8	18.61	36	10	33	19.56	-	4
9	19.11	4	9	34	19.57	-	1
10	19.06	2	1	35	19.61	3	1
11	19.11	9	4	36	19.61	-	4
12	19.41	18	1	37	19.61	-	5
13	19.71	17	15	38	19.61	1	10
14	20.17	13	8	39	19.61	-	1
15	20.37	8	7	40	19.61	-	8
16	20.17	20	7	41	19.61	-	1
17	20.22	3	9	42	19.61	-	2
18	19.66	1	4	43	19.56	-	10
19	19.66	3	3	44	19.56	2	13
20	19.66	4	20	45	19.56	-	7
21	19.66	-	9	46	19.56	-	18
22	19.66	-	7	47	19.56	-	16
23	19.61	-	2	48	19.56	-	6
24	19.61	-	11	49	19.56	-	12
25	19.61	5	12	50	19.56	-	5
				51	19.51	-	8

ELK COUNTED =267 MOOSE COUNTED = 447 AREA SURVEYED = 973.71 km²

Raw Data from 1974 Aerial Survey

Transect	Area (Km²)	Elk	Moose	Transect	Area (Km²)	Elk	Moose
1	14.23	1	8	27	19.61	1	7
2	14.23	9	21	28	19.61	-	6
3	14.63	5	12	29	19.61	-	1
4	15.49	12	8	30	19.56	-	3
5	17.25	9	5	31	19.56	-	2
6	17.65	5	8	32	19.56	-	3
7	18.05	7	10	33	19.56	-	1
8	18.61	10	1	34	19.56	-	1
9	19.11	4	9	35	19.61	-	2
10	19.06	7	9	36	19.61	-	-
11	19.11	7	15	37	19.61	-	2
12	19.41	4	7	38	19.61	-	-
13	19.71	3	4	39	19.61	-	1
14	20.17	7	6	40	19.61	-	1
15	20.37	1	8	41	19.61	-	1
16	20.17	2	4	42	19.61	-	2
17	20.22	1	3	43	19.56	10	6
18	19.66	-	4	44	19.56	-	1
19	19.66	1	8	45	19.56	-	5
20	19.66	-	4	46	19.56	-	1
21	19.66	2	-	47	19.56	-	5
22	19.66	2	6	48	19.56	-	5
23	19.61	-	6	49	19.56	-	3
24	19.61	-	2	50	19.56	-	6
25	19.61	-	3	51	19.51	1	6
26	19.61	2	1				

ELK COUNTED = 113 MOOSE COUNTED = 243 AREA SURVEYED = 973.71 km²

Raw Data from 1975 Aerial Survey

Transect	Area (km^2)	Elk	Moose	Transect	Area (Km^2)	Elk	Moose
1	7.12	22	7	27	19.61	-	12
2	14.23	31	22	28	19.61	-	5
3	14.69	22	21	29	19.61	-	13
4	15.34	2	30	30	19.56	-	11
5	17.20	16	22	31	19.56	-	10
6	17.65	22	19	32	19.56	-	6
7	18.00	38	10	33	19.56	-	2
8	18.51	26	21	34	19.56	-	6
9	19.06	10	16	35	19.61	-	-
10	19.06	36	6	36	19.61	-	1
11	19.11	23	10	37	19.61	-	-
12	19.36	4	29	38	19.61	-	6
13	19.71	1	9	39	19.61	-	1
14	20.02	2	16	40	19.61	-	-
15	20.42	8	18	41	19.61	-	-
16	20.27	16	12	42	19.61	-	7
17	19.66	4	8	43	19.61	-	3
18	19.66	6	15	44	19.56	-	1
19	19.66	3	9	45	19.56	17	3
20	19.66	5	14	46	19.56	-	3
21	19.66	8	21	47	19.56	-	11
22	19.66	11	7	48	19.56	-	9
23	19.66	-	5	49	19.56	-	-
24	19.61	-	7	50	19.56	-	5
25	19.61	2	15	51	19.56	-	9
26	19.61	-	17	52	9.76	-	5

ELK COUNTED = 335 MOOSE COUNTED = 515 AREA SURVEYED = 973.71 km^2

Raw Data from 1976 Aerial Survey*

Transect	Area (Km^2)	Elk	Moose	Transect	Area (Km^2)	Elk	Moose
1	7.12	-	16	27	19.61	-	1
2	14.23	29	29	28	19.61	-	5
3	14.69	4	28	29	19.61	-	2
4	15.34	5	10	30	19.56	1	2
5	17.20	11	11	31	19.56	-	9
6	17.65	16	11	32	19.56	-	2
7	18.00	31	18	33	19.56	-	4
8	18.51	2	6	34	19.56	-	-
9	19.06	21	4	35	19.61	-	3
10	19.06	3	8	36	19.61	-	-
11	19.11	-	12	37	19.61	-	3
12	19.36	5	14	38	19.61	-	4
13	19.71	8	18	39	19.61	-	2
14	20.02	19	19	40	19.61	-	3
15	20.42	4	19	41	19.61	-	2
16	20.27	20	2	42	19.61	-	3
17	19.66	28	16	43	19.61	-	6
18	19.66	4	14	44	19.56	-	7
19	19.66	-	4	45	19.56	-	-
20	19.66	2	14	46	19.56	-	8
21	19.66	-	7				
					47	19.56	19.56
22	19.66	5	6	48	19.56	-	19
23	19.61	12	15	49	19.56	-	18
24	19.61	5	6	50	19.56	-	7
25	19.61	-	7	51	19.56	-	10
26	19.61	-	3	52	9.76	-	-

ELK COUNTED = 335 MOOSE COUNTED = 515 AREA SURVEYED = 973.71 km^2

* observations per transect have been inferred from graphical presentation in original report.

Raw Data from 1977 Aerial Survey

Transect	Area (Km²)	Elk	Moose	Transect	Area (Km²)	Elk	Moose
1	14.23	38	11	27	19.61	7	7
2	14.23	1	20	28	19.61	-	9
3	14.63	3	21	29	19.61	-	16
4	15.49	7	12	30	19.56	-	4
5	17.25	15	14	31	19.56	-	9
6	17.65	14	24	32	19.56	-	5
7	18.05	22	14	33	19.56	-	5
8	18.61	20	14	34	19.56	-	3
9	19.11	12	19	35	19.61	-	5
10	19.06	13	13	36	19.61	-	2
11	19.11	9	16	37	19.61	7	2
12	19.41	28	12	38	19.61	-	1
13	19.71	21	17	39	19.61	-	3
14	20.17	7	10	40	19.61	-	2
15	20.37	-	16	41	19.61	-	6
16	20.17	1	17	42	19.61	-	7
17	20.22	3	22	43	19.56	-	3
18	19.66	5	11	44	19.56	-	5
19	19.66	28	9	45	19.56	-	4
20	19.66	15	3	46	19.56	-	4
21	19.66	5	6	47	19.56	1	10
22	19.66	4	8	48	19.56	-	12
23	19.61	8	2	49	19.56	-	6
24	19.61	4	5	50	19.56	-	2
25	19.61	-	5	51	19.51	-	13
26	19.61	5	4				

ELK COUNTED = 303 MOOSE COUNTED = 470 AREA SURVEYED = 973.71 km²

Raw Data from 1982 Aerial Survey

Transcect	Area (Km²)	Elk	Moose	Transect	Area (Km²)	Elk	Moose
1	0.65	-	-	27	19.61	-	2
2	14.23	4	11	28	19.61	-	2
3	14.23	16	7	29	19.61	-	8
4	14.63	8	10	30	19.61	-	2
5	15.49	2	4	31	19.56	-	9
6	17.25	2	11	32	19.56	1	4
7	17.65	12	4	33	19.56	-	3
8	18.05	-	4	34	19.56	-	2
9	18.61	2	8	35	19.56	-	-
10	19.11	4	4	36	19.61	-	3
11	19.06	7	10	37	19.61	-	2
12	19.11	6	18	38	19.61	-	-
13	19.41	2	25	39	19.61	-	6
14	19.71	2	6	40	19.61	-	-
15	20.17	1	1	41	19.61	-	3
16	20.37	-	5	42	19.61	-	1
17	20.17	9	5	43	19.61	-	3
18	20.22	-	7	44	19.56	-	-
19	19.66	2	1	45	19.56	-	-
20	19.66	-	6	46	19.56	-	4
21	19.66	5	2	47	19.56	-	4
22	19.66	7	4	48	19.56	-	1
23	19.66	7	6	49	19.56	-	1
24	19.61	-	5	50	19.56	-	1
25	19.61	-	2	51	19.56	1	1
26	19.61	1	1	52	19.51	-	1
				53	19.51	-	4

ELK COUNTED = 101 MOOSE COUNTED = 234 AREA SURVEYED = 973.71 km²

Raw Data from 1984 Aerial Survey

Transect	Area (Km²)	Elk	Moose	Transect	Area (Km²)	Elk	Moose
1	0.33	-	-	29	20.02	5	8
2	1.31	-	-	30	20.32	10	5
3	7.12	-	-	31	20.42	4	5
4	14.23	12	15	32	20.37	-	9
5	14.23	8	18	33	20.27	1	9
6	14.33	14	11	34	20.27	-	3
7	14.69	4	9	35	20.27	-	7
8	14.74	12	4	36	1971	-	5
9	15.34	14	11	37	19.66	8	13
10	15.59	-	3	38	19.66	-	1
11	17.20	-	11	39	19.66	-	-
12	17.35	7	5	40	19.66	-	7
13	17.65	5	7	41	19.66	-	6
14	17.80	21	12	42	19.66	-	3
15	18.00	15	23	43	19.66	4	4
16	18.26	17	14	44	19.66	-	3
17	18.51	1	24	45	19.66	-	1
18	18.76	7	6	46	19.66	-	2
19	19.06	13	14	47	19.66	-	4
20	19.11	-	17	48	19.61	4	3
21	19.06	1	5	49	19.61	11	4
22	19.01	2	9	50	19.61	10	5
23	19.11	15	13	51	19.61	-	1
24	19.11	17	5	52	19.61	-	4
25	19.36	1	5	53	19.61	-	4
26	19.56	-	9	54	19.61	-	8
27	19.71	-	6	55	19.61	-	5
28	19.76	-	4	56	19.61	1	4

(continued over)

Raw Data from 1984 Aerial Survey (continued)

Transect	Area (km^2)	Elk	Moose	Transect	Area (Km^2)	Elk	Moose
57	19.61	-	5	82	19.61	-	3
58	19.61	-	1	83	19.61	-	-
59	19.61	-	5	84	19.61	-	1
60	19.56	-	11	85	19.61	-	-
61	19.56	-	10	86	19.61	-	-
62	19.56	-	13	87	19.61	-	2
63	19.56	-	-	88	19.56	-	5
64	19.56	-	2	89	19.56	-	4
65	19.56	-	3	90	19.56	-	6
66	19.56	-	4	91	19.56	-	-
67	19.56	-	2	92	19.56	-	1
68	19.56	-	3	93	19.56	-	1
69	19.56	1	5	94	19.56	-	1
70	19.61	-	1	95	19.56	-	3
71	19.61	-	1	96	19.56	-	-
72	19.61	-	1	97	19.56	-	-
73	19.61	-	1	98	19.56	-	9
74	19.61	-	6	99	19.56	-	5
75	19.61	-	-	100	19.56	-	4
76	19.61	-	3	101	19.56	-	10
77	19.61	-	6	102	19.56	-	8
78	19.61	-	1	103	19.56	1	7
79	19.61	4	1	104	19.51	-	9
80	19.61	-	2	105	9.76	-	-
81	19.61	-	-				

ELK COUNTED = 250 MOOSE COUNTED = 559 AREA SURVEYED = 973.71 km^2

Raw Data from 1985 Aerial Survey

Transect	Area (Km²)	Elk	Moose	Transect	Area (Km²)	Elk	Moose
1	14.23	3	26	13	19.76	-	8
2	14.33	3	30	14	20.32	3	5
3	14.74	8	9	15	20.37	-	5
4	15.59	-	10	16	20.27	10	5
5	17.35	-	8	17	19.71	-	2
6	17.80	3	16	18	19.66	-	2
7	18.26	1	17	19	19.66	1	2
8	18.76	3	13	20	19.66	2	1
9	19.11	7	8	21	19.66	-	5
10	19.01	-	12	22	19.66	2	2
11	19.11	2	15	23	19.61	0	1
12	19.56	4	12	24	19.61	1	1

ELK COUNTED = 53 MOOSE COUNTED = 215 AREA SURVEYED = 445.8 km^2