BREEDING DISTRIBUTION AND BEHAVIOUR OF THE WHITE PELICAN IN THE ATHABASCA OIL SANDS AREA

BY

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Environment Canada
Canadian Wildlife Service

for
ALBERTA OIL SANDS
ENVIRONMENTAL RESEARCH PROGRAM

LS 22.2 (TF 2.2)

NOVEMBER, 1979

The Hon. J.W. (Jack) Cookson
Minister of the Environment
222 Legislative Building
Edmonton, Alberta

and

The Hon. John Fraser
Minister of the Environment
Environment Canada
Ottawa, Ontario

Sirs:

Enclosed is the report "Breeding Distribution and Behaviour of the White Pelican in the Athabasca Oil Sands Area".

This report was prepared for the Alberta Oil Sands Environmental Research Program, through its land system, under the Canada-Alberta Agreement of February 1975 (amended September 1977).

Respectfully,

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Chairman, Steering Committee, AOSERP
Deputy Minister, Alberta Environment

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BREEDING DISTRIBUTION AND BEHAVIOUR OF THE WHITE PELICAN IN THE ATHABASCA OIL SANDS AREA

DESCRIPTIVE SUMMARY

BACKGROUND

The potential impact of oil sands development on avifauna can be attributed to:

1. Direct impact--resulting from destruction or contamination of breeding and/or foraging habitat;
2. Indirect impact--resulting primarily from disturbance, which can be attributed to an increased recreational utilization of wilderness areas.

In terms of avifaunal concerns, both forms of impacts will require mitigative measures; however, it is the indirect impacts which may be the most significant, will require the most study, and present the greatest problems in accurately assessing the potential impact on avifauna.

The White Pelican is one of the more sensitive bird species which inhabit the oil sands area. This sensitivity has been manifested by a wholesale desertion of a breeding rookery following a single visitation to the rookery by inquisitive fishermen at a very critical time in the breeding cycle. Identification of critical times in the breeding cycle requires that detailed behavioural investigations must be conducted on this species.

Because of the nature of the impact created by oil sands development (direct and indirect), the necessity for incorporating avian behavioural studies into the Alberta Oil Sands Environmental Research Program became obvious.

The final report on the White Pelican is presented in two volumes:

1. Breeding Distribution and Behaviour of the White Pelican in the Athabasca Oil Sands Area, by R. Beaver and M. Ballantyne; this report; and

2. The Distribution, Foraging Behaviour, and Allied Activities of the White Pelican in the Athabasca Oil Sands Area, by D. Ealey; AOSERP Report 83.

ASSESSMENT

This report incorporates the most current methodology available for the collection and analysis of sound behavioural data. The data collected on breeding behaviour of White Pelicans formed the basis for a thesis prepared in partial fulfillment of the requirements for a Master of Science degree in the Department of Zoology, University of Alberta, by the senior author.

It is the opinion of AOSERP management that both volumes contribute significantly to an understanding of baseline avifauna concerns in the oil sands area.

The Alberta Oil Sands Environmental Research Program is satisfied with the scientific and technical quality of these reports and deems them suitable for wide distribution.

S.B. Smith, Ph.D
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TABLE OF CONTENTS

TABLE OF CONTENTS (CONCLUDED)

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Aerial surveys and ground investigations were conducted in the spring and summer months from 1975 to 1977 on a breeding population of White Pelicans *(Pelecanus erythrorhynchos)* in the Birch Mountains area of northeastern Alberta. In 1975, an undetermined number of White Pelicans bred at Big Island Lake located approximately 20 km northeast of Namur Lake; however, the sighting of only 12 young during a July aerial survey at that location suggested a small breeding flock. Pelicans did not breed successfully at Namur Lake, a previously occupied nesting location, during the course of this study. In 1976 and 1977, White Pelicans established nesting colonies and bred at a rookery site at Birch Lake, located approximately 10 km south of Namur Lake.

Aerial photographs taken at the Birch Lake rookery during the height of the nesting season in late May and early June revealed 140 breeding pairs in 1976 and 70 pairs in 1977. Sixty-eight young were raised to the flying stage in 1976, compared with 55 in 1977, resulting in fledging rates of 0.49 and 0.78 young per nesting attempt in those respective years. Calculated breeding success (number of young raised to the flying stage from estimated total eggs laid) was 22.1 percent in 1976 and 35.7 percent in 1977.

In 1976, an estimated eight to 20 nests were lost to rising water levels induced by beaver *(Castor canadensis)* dams constructed on the outflow channel of Birch Lake. Periodic removal of these dams prevented loss of nests in 1977 to flooding. Mortality during the breeding season included an 11.7 percent loss of eggs and a 19.1 percent loss of young in 1977, the only year for which such data were obtained.

White Pelicans bred only on island sites located in permanent water bodies. The birds nested on flat or gently sloping terrain which provided loose substrates for nest mound

construction. These substrates varied in composition from loose organic soils to gravel with scattered rock. Density and composition of vegetative cover at nesting locations were also variable, being partly modified by the nesting activity of the birds themselves. Pelicans, which were presumably foraging, were observed on water bodies as far as 69 km from the breeding site.

Both adults and young demonstrated varying levels of behavioural responses to disturbances occurring near the rookery. The documentation of these responses and other behaviour is presented in a discussion which considers their implications with respect to the potential effects of development of the Athabasca Oil Sands deposits and the anticipated accelerated recreational use of the Birch Mountains wilderness. Management and reclamation strategies are discussed.

ACKNOWLEDGEMENTS

Special thanks are conveyed to Richard Fyfe and Barry Munson of the Canadian Wildlife Service and Victor Lewin, Department of Zoology, University of Alberta, Edmonton, Alberta, for valuable supervisory support during this study. Additional important field support services were arranged and gratefully received from the AOSERP field office in Fort McMurray as a result of the efforts of Dirk Hadler and Carol Boyle there.

Principal field investigators during the three years of the project were Douglas and Anita Richards, David Ealey, Rick Beaver and Maggie Ballantyne. Ken Zurfluh also provided helpful assistance during the 1977 field season. The co-operation of Marvin Doran, regional Fish and Wildlife Officer, Fort McMurray, Alberta, was greatly appreciated in initially locating the birds and monitoring their subsequent progress.

Bryan Chubb and Susan Popowich of the Canadian Wildlife Service supervised the preparation and production of all drafted figures in this report. Finally, thanks are conveyed to the many considerate field researchers of other AOSERP projects who contributed pelican sightings and timely sharing of their resources.

This research project LS 22.2 (TF 2.2) was funded by the Alberta Oil Sands Environmental Research Program, a joint Alberta-Canada research program established to fund, direct, and co-ordinate environmental research in the Athabasca Oil Sands area of north-eastern Alberta.

1. INTRODUCTION

Although 10 of the 19 known traditional nesting area of White Pelicans *(Pelecanus erythrorhynchos)*[1] have been abandoned in recent decades in Alberta, the breeding population appears to have been stable at least within the last decade (Markham 1978). The most recent information reveals that the Birch Lake rookery harbours approximately 25 percent of the breeding White Pelicans in the province of Alberta (Markham 1978). Other active rookeries include Slave River, Wadlin Lake, Utikuma Lake, Pelican Lake, Lake Newell, Big Island Lake, Coleman Lake, and Beaverhill Lake (Markham 1978). Human encroachment upon the island breeding sites preferred by this species coupled with the destruction of breeding ground habitat have been the two most important factors cited in local population declines recorded in North America during this time (Farley 1919; Behle 1935; Low et al. 1950; Marshall and Giles 1953; Hosford 1965; Sanderson 1966; Anderson and Bartonek 1967; Vermeer 1969, 1970b; Evans 1972; Markham 1978).

An acknowledgement of the potential reproductive failure of White Pelican nesting colonies as a result of human visitations during the critical nesting season has led to the adoption of protective measures by the Province of Alberta. In view of the anticipated development of the Athabasca Oil Sands deposits and an existing lack of knowledge regarding the sensitivity of this particular groups of breeding White Pelicans to various disturbances, initiation of this study was proposed in 1975.

The specific objectives of the study were as follows:

1. Determine habitat requirements for White Pelicans with particular emphasis on critical areas and develop an annotated list of characteristics that define the habitat of this species that will be

[1] In this report, the following references were used in assigning scientific names: birds not native to North America - Peters (1931-1960); North American birds - A.O.U. (1957); mammals - Banfield (1974); flowering plants - Moss (1959).

suitable for mapping potential habitats from air photos and ground surveys. Comment on the extent to which the habitat characteristics can be determined from air photos or ground surveys or a combination of both;

2. Develop a set of ecological maps (scale 1:50 000) for White Pelicans for the Alberta Oil Sands Environmental Research Program (AOSERP) study area indicating production capability with emphasis on critical areas;
3. Work with photo interpreters conducting the vegetation and soils inventory to ensure that the interpretation will be compatible with the preliminary habitat mapping of the wildlife species involved;
4. Determine population structure (age, sex, density), distributions, movements (including dispersal) and biomass for White Pelicans;
5. Determine the relationships of White Pelicans to fish;
6. Examine the hydrological consequences of beaver activities on White Pelicans;
7. Determine the impact of industrial activities, especially disturbance, on White Pelicans;
8. Recommend management alternatives required to minimize adverse effects to White Pelicans during the oil sands development period;
9. Recommend reclamation and management strategies which will enhance White Pelicans in the post-development period; and
10. Conduct a thorough literature review on the above topics.

A separate report (Ealey 1979) discusses the study of those objectives relating to aspects of foraging habitat, behaviour, distributions and allied activities; these aspects will be referred to only briefly in this report. Additionally, a conflict of interests resulted from the objectives pertaining to the study of population structure and breeding behaviour. The former would have required a degree of physical contact with the birds and entailed methods deemed potentially too disruptive to behaviour to be considered feasible. This aspect of the objectives, therefore, remains necessarily unfulfilled, although comments relevant to the topic, as revealed through direct observation and a search of the literature, have been made.

More detailed information of the breeding behaviour of White Pelicans was collected during the course of this study than will be presented in this report. That information is presented in an M.Sc. thesis to be submitted under separate cover to AOSERP (Beaver 1979).

Historic information on the White Pelican rookery[2] at Alberta's Namur Lake is scant. However, it is known that, in the period from 1967 to 1969, as many as 153 breeding pairs per year nested on a small forested island in the northeast end of the lake (Vermeer 1970b). In 1974, 198 breeding pairs of White Pelicans occupied this site (letter dated 18 October 1976 from A.B. Rippin, Regional Wildlife Biologist, St. Paul, Alberta). White Pelicans initiated nesting at Namur Lake in 1975 but deserted their nests when disturbed by local fishermen (conversation in August 1975 with A. Smith, Canadian Wildlife Service employee, Edmonton, Alberta). We conducted an aerial surveillance of the Namur Lake site on 25 July 1975 and confirmed the abandonment of the rookery. Subsequently, 12 young White Pelicans were observed on Big Island Lake (local name), located approximately 20 km by air northeast from the Namur Lake site. It is suspected that this sighting signified a renesting attempt by some of the Namur Lake birds and not an entirely different rookery, but this could not be confirmed.

White Pelicans were observed foraging in the Gardiner Lakes narrows in 1974 and in the Lower and Upper Gardiner Lakes proper in

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[2] A rookery refers to the larger continuous geographic area within which spatially distinct nesting colonies are located.

1975 and 1976 (telephone conversation in September 1976 with Cort Sims, Department of Anthropology, University of Alberta, Edmonton, Alberta). On 25 July 1975 we sighted a total of 111 White Pelicans on Mink and Grew lakes, approximately 65 km southwest of the Namur Lake site. Fifty more pelicans were sighted on the site of the 1976 and 1977 rookery in Birch Lake (assigned name), located approximately 10 km south of Namur Lake; however, it was not determined whether or not the birds were nesting. White Pelicans continued to forage in the Gardiner Lakes in 1977, and foraging activity was also indicated on Eaglenest, Mink, Grew, and Big Island Lakes in 1977 (Ealey 1979).

2. RESUME OF CURRENT STATE OF KNOWLEDGE

In addition to the brief summary of previous investigations conducted in the Birch Mountains area presented in the introduction, a thorough literature search of pertinent topics was made. Relevant literature on White Pelicans, related species, and species with similar ecological requirements has been categorized into various subject interests. Published literature concerned with detailed research on biology and behaviour is rather sparse. Much of the information pertains strictly to casual observations and general notes on occurrence, food habits, breeding grounds, reproductive status, and disturbance of breeding colonies. For reasons of thoroughness, unpublished references were also investigated. A categorized literature summary is provided for reader perusal (Section 9) and may be of some assistance to further investigations of the biology of White Pelicans.

3. THE STUDY AREA

The project study area initially encompassed the areas flown within the adjacent to the AOSERP study area to determine the distribution of White Pelicans. As a result of those surveys, subsequent intensive studies were restricted to a project study area within the Birch Mountains.

3.1 LOCATION AND DESCRIPTION

Located partly within the AOSERP study area (Figure 1), the Birch Mountains terrain comprises a series of uplifted hills ranging from 610 to 870 m above sea level. In traversing the White Pelican project study area (Figure 2) from north to south, elevations decrease from 870 to 460 m above sea level. Within this area are found the highest elevations of the AOSERP study area and the headwaters of the Birch, Mikkwa, Dunkirk, and Ells rivers. The Mikkwa and Ells rivers source from larger lakes in the Birch Mountains: the Mikkwa, from Legend Lake, drains northwest into the Peace River; the Ells, from the Gardiner Lakes, flows south then east to the Athabasca River.

Rowe (1972) includes the Birch Mountains area in the boreal mixedwood forest region. Mixed forests of trembling aspen (*Populus tremuloides*), white birch (*Betula papyrifera*) and white spruce (*Picea glauca*) grow on the better drained slopes and uplands. Black spruce (*Picea mariana*) dominates the more poorly drained areas. Jack pine *(Pinus banksiana)* occurs in the forest cover on drier sandy or till soils but is not extensive. Sparsely forested shrub dominated communities are found on the highest elevations in the northeast corner of the study area and also occur over recently burned landscapes.

Attention has been focused on two areas within the larger project study area: the first, at Birch Lake (local name), is located in the Snipe Creek drainage basin at an altitude of approximately 530 m above sea level; the second includes the lake

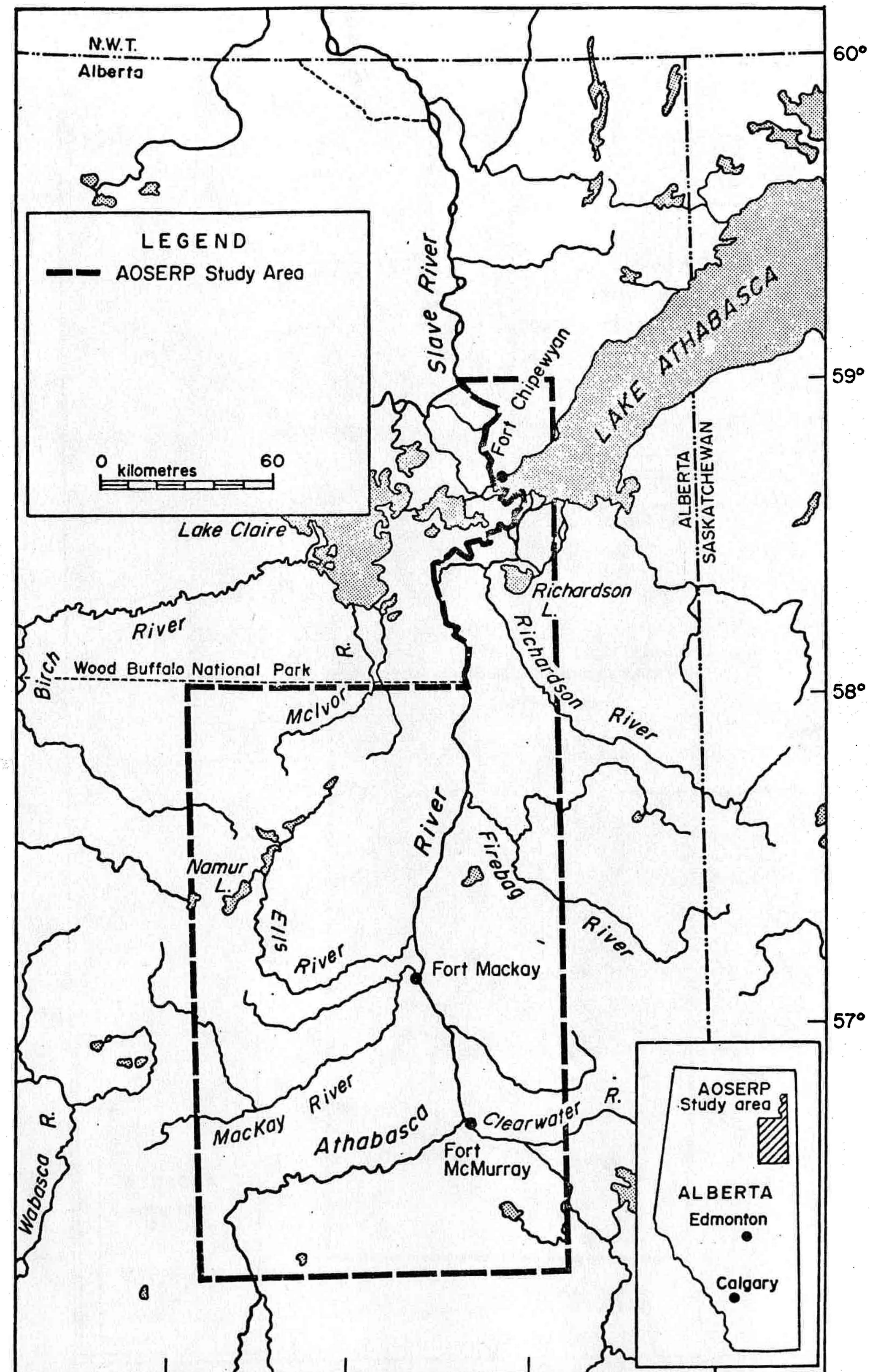

Figure 1. The AOSERP study area.

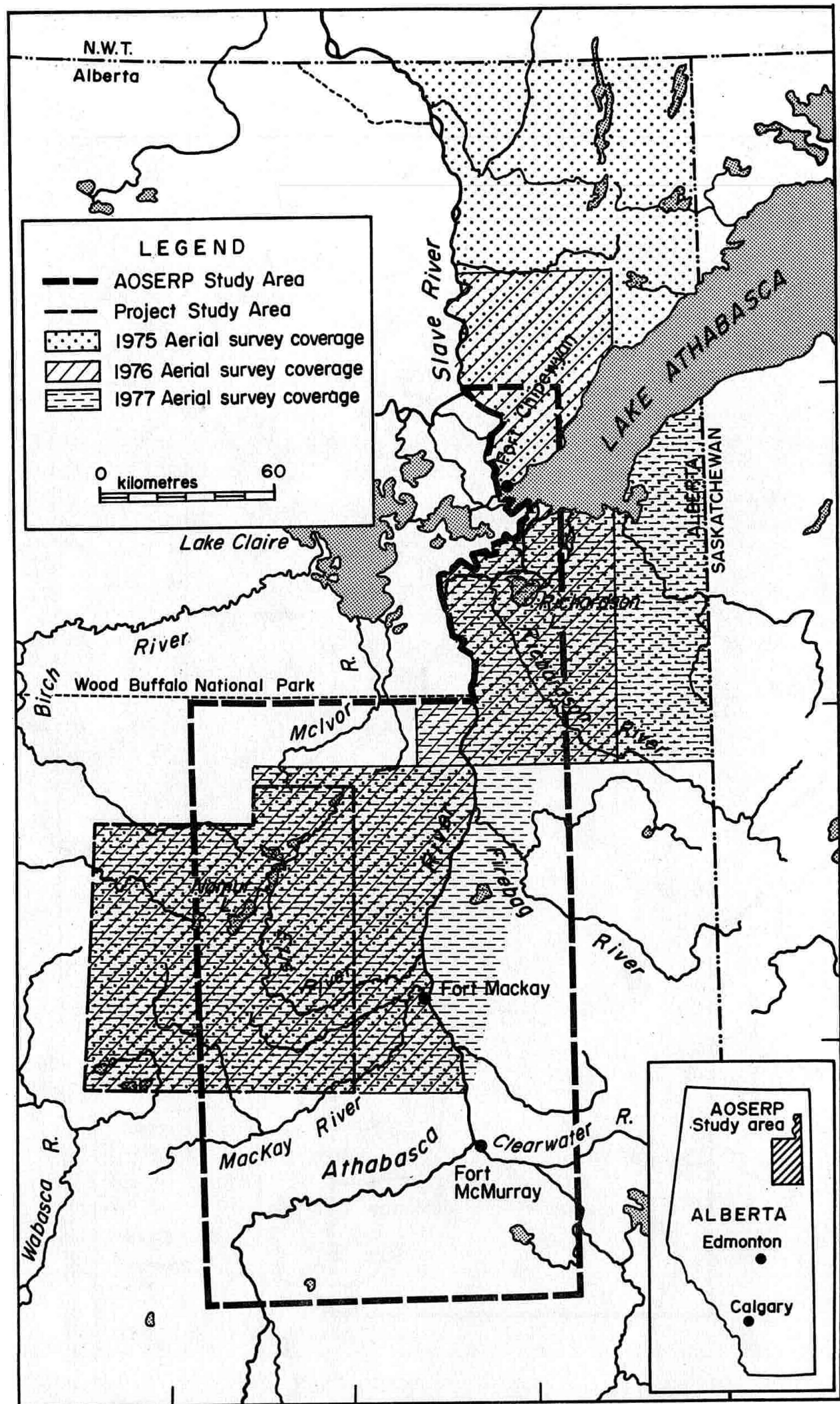

Figure 2. Aerial survey coverage within and adjacent to the AOSERP and White Pelican study areas from 1975 to 1977.

complex forming the headwaters of the Ells River and includes Namur, Gardiner, Big Island (local name), and Eaglenest Lakes, as well as several other unnamed lakes. These lakes are located at higher elevations approximately 720 m above sea level.

Birch Lake, covering an area of approximately 1.7 km^2, is a relatively shallow eutrophic lake which does not exceed 6 m in depth. Located between an abrupt rise in the Birch Mountains to the north and more gradual surrounding relief, the lake is characterized by extensive littoral and marsh vegetation zones. The headwater lakes of the Ells River, by contrast, are surrounded by large hills rising to 100 m above lake levels; their drier shorelines have relatively less expansive littoral zones and emergent vegetation, if not entirely absent, is restricted to a few locations. Available sounding information indicates much deeper basins in these lakes varying from 15 to 60 m at maximum depth (Turner 1968).

4. MATERIALS AND METHODS

The major activities in this study were aerial censusing, ground reconnaissance and behaviour observations at the Birch Lake rookery.

4.1 DISTRIBUTIONS

4.1.1 Early Spring Distribution Survey

An aerial census was flown on 26 April 1977 employing a Cessna 185 float-equipped aircraft. The pilot and one passenger observed as the aircraft flew at altitudes of 100 to 200 m above ground level. Forty-eight lakes and two major flowing water-courses were censused. Larger lakes were surveyed by following shorelines and flying transects while shoreline circuits gave adequate coverage of smaller lakes.

The survey was flown to provide information on the time of arrival and early spring distribution of the Birch Mountain White Pelican population. White Pelicans have been sighted at the rookery site before spring ice has melted at Lavallee Lake in Prince Albert National Park in Saskatchewan (conversation in September 1976 with H. Armbruster, Canadian Wildlife Service employee, Edmonton, Alberta) and also at Pelican Lake in Manitoba (Anderson and Bartonek 1967).

All water bodies censused were classified as frozen, partially ice-free, or ice-free. Numbers and locations of all White Pelicans observed were marked on the same maps (scale 1:250 000) used for the ice cover survey.

4.1.2 Breeding Distribution

An initial aerial survey of a large number of water bodies within the AOSERP study area (Figure 2) was flown during the period from 8 to 27 July 1975. Immediately adjacent areas, east to the Saskatchewan-Alberta border, north to the Northwest Territories-Alberta border, and west to Chipewyan Lake in Alberta, were also surveyed (Figure 2). The technique employed the methods previously described for the spring distribution census and, in addition, helicopters (Hughes 500-C or Bell Jet Ranger) were employed in 1975 only.

Additional surveys of areas within and adjacent to the designated AOSERP study area were conducted in June and July 1976 and July and August 1977 (Figure 2).

Intensive surveys of water bodies within the project study area were conducted on 27 and 28 May, 14 and 17 June, 23 August, and 15 September in 1976. These surveys were repeated in 1977 on the dates of 26 April, 6 May, 8 June, 11 July, 13 and 16 August, and 10 September.

During the survey flights, the number and location of all pelicans sighted were recorded on maps (scale 1:250 000). Suspected breeding locations were additionally surveyed from the ground. The status of each site was recorded as being either presently used as a breeding site, unused at present but used in the past, or unused for breeding either presently or in the past. Evidence of either present or past use for breeding was searched for and included the presence of nesting birds or their young, nest scrapes or mounds, carcasses, and eggshell fragments.

4.2 HABITAT

4.2.1 Breeding Habitat Assessment and Mapping

Periodically, throughout the study, we conducted ground investigations of known rookery sites in the Birch Mountains. The three areas investigated were: a small exposed reef in Birch Lake, a small partially forested island in the north end of Big Island Lake, and another small partially forested island in the northeast end of Namur Lake. During visits to these sites we noted the presence or absence of obvious mammalian predators, distance of the island from the nearest mainland, presence or absence of a loafing bar or spit apart from the main nesting areas, slope of the terrain (in purely descriptive terms), degree of exposure of nesting areas to sun and wave action, substrate composition, and elevation of nesting areas above water. The data were tabulated and compared to observations at other North American rookeries as presented in the literature.

Mapping of the suitability for breeding of water bodies in the breeding distribution area established from aerial and ground censuses was carried out. The mapping (Section 9) was also assisted by interpretation from aerial photographs (black and white and false colour infra-red) in scales varying from 1:31 680 to 1:60 000 taken from the years 1967 to 1977. The mapping and site suitability classifications (Section 9) cover lakes in and adjacent to the project study area. Suitability of water bodies was rated as nil, low, moderate, or optimum based on the conformation of the water bodies to the following habitat characteristics:

1. Nil - Absence of islands and loafing areas. No evidence of present or past use for breeding;
2. Low - Islands present but continuous extent of nesting areas restricted to less than 100 m^2 [1] by the presence of one or more of the following factors: steep slopes (estimated to be greater than 15°)[2]; exposure to wave action; unbroken rocky substrates; and water level fluctuations. The presence of mammalian predators is indicated by ground investigation or by distances of the nesting area less than 100 m from mainland. Loafing areas are absent. There is no evidence of present or past use for breeding;
3. Moderate - Islands are present. Continuous extent of nesting areas from 100 to 200 m^2. Loafing areas present. History of use for breeding may be

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[1] The smallest area used for breeding (133 m^2 Birch Lake) was used to establish lower optimal limits for extent of nesting area.

[2] The estimated greatest gradient of a nesting area observed in the Birch Mountains (at Birch Lake).

evidenced. Water level fluctuations, if evidenced, operate to render habitat unavailable in some years. Otherwise optimum habitat; and

4. Optimum - Islands are present. Continuous extent of nesting areas greater than 200 m^2 and not subject to restricting factors mentioned above. Loafing areas present. Evidence of past and/or present use is present.

As White Pelicans appear to nest in successive years at the same rookeries (Behle 1935; Sanderson 1966; Boeker 1972), areas in the Birch Mountains where documentation and surveys revealed the presence of breeding colonies of White Pelicans were deemed critical.

4.2.2 Water Level Fluctuations

A water level gauge was installed at Birch Lake in July 1977. The gauge was calibrated in 0.01 foot increments; we transformed all readings to centimetres. The gauge was secured in the lake bottom by means of a steel supporting rod to which the gauge was bolted. We endeavoured to take daily water level readings at 2000 h[1] when the weather was calm to avoid innaccurate readings due to waves and wind tides. No readings were taken when waves were present. We began recording water levels on 6 August 1977 and discontinued them after removal of the gauge on 21 September 1977.

Relative changes in the water levels prior to the installation of the gauge were noted. Periodic inspections of inflow and outflow channels were conducted to ascertain the presence or absence of beaver dams which may have influenced observed lake levels.

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[1] All times of day referred to in this report are Mountain Daylight Saving Time.

4.3 POPULATION AND REPRODUCTION

4.3.1 The Breeding Population Census

The breeding population was determined by estimating the number of occupied nests during the peak nesting period then multiplying this figure by two (Lies and Behle 1966; Vermeer 1970b; Boeker 1972). We chose to census aerially, as described by Boeker (1972), rather than by direct visitation to the island, as the latter technique would have flushed the incubating adults. Nest contents, if not damaged by the flushing birds, would have been exposed to the elements or the predatory habits (Schaller 1964; Vermeer 1968; Johnson 1976; Johnson and Sloan 1976) of California Gulls (*Larus californicus*). There were approximately 15 and 25 pairs of California Gulls nesting as breeding associates of the pelicans at the Birch Lake rookery in 1976 and 1977 respectively.

Observations of the White Pelican rookery at Birch Lake indicated a peak in nesting activity varying from mid-May in 1976 to early June in 1977. Based on the observation (Schaller 1964; Knopf 1975a) that nest relief occurs at midday every second or third day during incubation and that otherwise only one pair member is at the nest we chose to survey at 0900 h to avoid enumerating birds that were not on nests. We flew the breeding population (nest) census on 27 May in 1976 and 8 June in 1977. The nest count estimates assumed that all birds counted were on nests and were therefore breeding adults. Adults observed either in the air or on the water in the slides obtained were not enumerated.

A float-equipped Cessna 185 aircraft was used for the flights. Both 55 mm and 200 mm lenses were employed at elevations of 600, 450 and 300 m above ground level. A 35 mm single lens reflex camera (Asahi Pentax) was used.

4.3.2 Breeding Success

We defined breeding success to be the number of young raised to the flying stage expressed as a percentage of the total estimated number of eggs laid. Accurate counts of young pelicans were made immediately prior to their departure from the rookery lake. These counts were made on 21 August 1976 and 23 August 1977. We estimated the total number of eggs laid by multiplying the number of active nests counted on the censuses by a factor of 2.2, the mean clutch size reported for 198 nests at the Namur Lake rookery in 1974 (letter dated 18 October 1976 from A.B. Rippin, Regional Wildlife Biologist, St. Paul, Alberta) and from a sample of six nests at Birch Lake in 1977.

4.3.3 Mortality Factors

Observations from a permanent blind constructed approximately 300 m from the rookery at Birch Lake permitted only a partial count of abandoned nests and eggs, as not all nests and their contents were visible. We noted any apparent nest abandonments, eggs rolled from the nests, and eggs that failed to hatch. Several visits were made to the rookery in August and September 1977, enabling a determination of the number of young that had died, by a carcass count. As the island had been inundated in 1976, we assumed that all carcasses counted were the result of mortalities occurring in 1977 only. No such assessment was made in 1976, however.

4.4 CHRONOLOGIES, BEHAVIOUR, AND MOVEMENTS

A temporary field camp was erected on the east shore of Birch Lake on 20 June 1976. A permanent observation blind was built on the tip of a sedge (*Carex* sp.) and willow (*Salix* sp.) point on the northeast shore, approximately 300 m from the rookery. Observations were conducted with the assistance of either 10X50 power binoculars or a 15-60 variable power spotting scope. Travel to and from the blind was by canoe. Logistic support to the temporary field camp was by Hughes 500-C jet helicopter during the courtship, incubation, and brooding period in order to minimize disruptive influences on the lake itself; thereafter, a float-equipped Cessna 185 aircraft was used.

A floating blind, enabling much closer aproaches to the island, was purchased in 1977 to enhance the detail of behaviour observations. The blind consisted of a hollow wood and fibreglass-reinforced annulus covered with a superstructure of aluminum and canvas to which vegetation was attached. An observer seated inside this structure propelled the blind by wading in shallower water or by operating an electric trolling motor in deeper water. Observation ports of dark nylon screening and the provision of camera lens sleeves allowed the observation and photographing of behaviour details that were not easily viewed from the permanent blind. Three visits were made to the rookery in this apparatus in 1977 during the courtship, incubation, and brooding phases of the reproductive cycle.

During windy or inclement weather, when travel on the lake was impossible, observations were conducted from a hill on the east shore of Birch Lake, using the spotting scope. From the hill, we were unable to see the entire rookery and the number of detailed behaviour observations was reduced additionally by the distance (800 m) involved and heat distortion over the water.

4.4.1 Chronology of Reproductive Events

We noted the dates of spring arrival, initiation of courtship, nest construction and defense, incubation, and hatching for the White Pelicans. The date of cessation of continuous brooding was also noted. Developments of growth and behaviour for maturing young were also recorded from the permanent blind. Dates of migration were inferred from reductions in the number of adults and/or young remaining at the rookery later in the year.

4.4.2 Breeding Behaviour

In 1977, 12 nests were selected to monitor nest relief activities. All nests were visible from the permanent observation blind. Female and male members of each pair occupying a nest were identified by combinations of the following distinguishing criteria (Knopf 1975b):

1. Males are generally larger than females;
2. Bills of females are shorter than males; and
3. Differences in the extent and patterning of presupplemental moult of the head region are evident for individuals.

Nest relief ceremonies and duration of the components of nest relief ceremonies were documented for male and female members of the pair during incubation and brooding.

The observation time schedule was structured to enable viewing of the complete chronology of activities between dawn and dusk. Responses of the birds to disturbances near the rookery occasioned either by our study or local human traffic, as well as naturally occurring events, were noted. An attempt was made to classify the intensity of responses of both adults and young to these disturbances. Some difficulty was experienced in the assessment of alert responses by the birds because alert postures and other motor responses may have been motivated by factors other than fear and these responses were noted in several instances arising from behavioural interactions among the pelicans and gulls at the rookery itself. The evaluation, however, provided an indication of the degree of arousal when disturbances were present near the rookery. Inferences regarding the potential effects of behavioural responses were related to the reproductive phase during which they occurred and the intensity of the responses themselves.

We classified the intensity of the responses to various disturbances that were evident to the observer as follows:

1. None - No apparent reaction as indicated by changes in posturing or movement by any of the birds;
2. Slight - Some birds assume an alert posture with their necks upstretched and look at the source of disturbance. Several birds may move away from the source of disturbance but remain on the rookery or loafing area. Wing flapping may or may not be observed;
3. Moderately Pronounced: Several birds alert. Definite movement off the rookery or loafing area and away from the source of disturbance by some of the birds. Wing flapping is evident; and
4. Pronounced: All birds are alert. All birds move off the rookery or loafing area away from the source of disturbance. Rapid flushing is evident with wing flapping and running observed.

4.4.3 Movements of Adults to and from the Rookery

During each hour of behaviour observations at the rookery, we kept records of the number of adults arriving at or departing from the rookery. The number and flight directions of flocks were also noted as well as the number of birds in such flocks. We were able to establish rates of ingress and egress for the movements of adults to and from the rookery. These rates were examined contemporaneously with the activities of nest relieving and feeding of young, with which they appeared to be associated.

In 1976, 226 h of observation were conducted at the Birch Lake rookery in the period from 23 June to 11 September, covering only the brooding through migration phases of the birds. In 1977 the entire series of events, from spring arrival of adults to their departure in the fall, was studied and entailed 355 h of observation at the rookery. Thus, in total, 581 h were devoted to observations of events at the rookery in 1976 and 1977.

5. RESULTS AND DISCUSSION

5.1 HABITAT

5.1.1 Early Spring Distribution

We observed a total of 33 adult White Pelicans during the 26 April 1977 survey. Twenty-eight pelicans formed a low flying flock over the partially ice-free waters of the upper Ells River and five sat in a small group in the only open water of the outflow channel at Birch Lake. Of the 48 lakes censused, only one was totally ice-free, 19 were partially ice-free, and 28 were still frozen. Both the unnamed watercourse flowing from Eaglenest Lake to the Gardiner Lakes and the Ells River flowing south from the Gardiner Lakes were partially ice-free.

The sighting of White Pelicans in the summer breeding territory before ice had melted in the majority of lakes was significant in that only two concentrations of birds were located: one at a known rookery site; the other near a known foraging area (Ealey 1979). In 1977, White Pelicans did not begin courtship at the Birch Lake rookery until ice had melted by 4 May, approximately 1 wk after the distribution census was flown.

During the period between arriving at the summer breeding grounds and initiating courtship, activities of the earliest arrivals were restricted to open water areas. Certainly, the pelicans could only forage successfully in the open waters then available; however, by arriving before ice had left the waters of the Birch Mountains, they were able to initiate breeding immediately after ice-free waters ensured the security of the rookery site at Birch Lake. Vermeer (1970b) correlated the northern boundary of the breeding distribution for the White Pelican in Canada with the 0°C April isotherm, which suggested the importance of ice in effectively restricting the length of the reproductive season available to this species. We determined that, in the Birch Mountains, the normal ice-free period for lakes lasts from early May to early November, or approximately 185 d. From the time the adult birds begin courtship until all young mature sufficiently to begin migration, approximately 150 d must pass, apparently allowing sufficient time for completion of the reproductive effort given year to year variations in climate.

5.1.2 Breeding Distribution

During the three years of censuses from 1975 to 1977, a total of 1438 White Pelican sightings were recorded throughout the areas surveyed. The vast majority (1416) of these sightings occurred within the White Pelican project study area (Figure 3). In addition, 18 sightings were recorded near the Slave River rapids near Fort Smith and were suspected to be associated with the White Pelican rookery there. Four sightings occurred at Richardson Lake, immediately south of the west end of Lake Athabasca, however, these birds were probably itinerants and not members of a breeding rookery. Reported sightings of White Pelicans by other AOSERP personnel operating in areas not surveyed in this study were rare and the results, therefore, do not indicate significant concentrations of birds in the remainder of the AOSERP study area.

Aerial and ground investigations revealed that only three islands have been used for breeding by White Pelicans throughout the entire AOSERP study area (Figure 4). At Namur Lake, a traditional site abandoned in 1975, nest mounds and eggshell fragments still remained in 1977; however, few pelicans were obseved in the vicinity during the study. The remains of a White Pelican were discovered at the Big Island Lake rookery where 12 young were raised in 1975. Additionally, in 1975, nest scrapes and eggshell fragments were found on the rocky spit extending out from the island there. No breeding has occurred at this latter site since 1975. At Birch Lake, White Pelicans have nested and

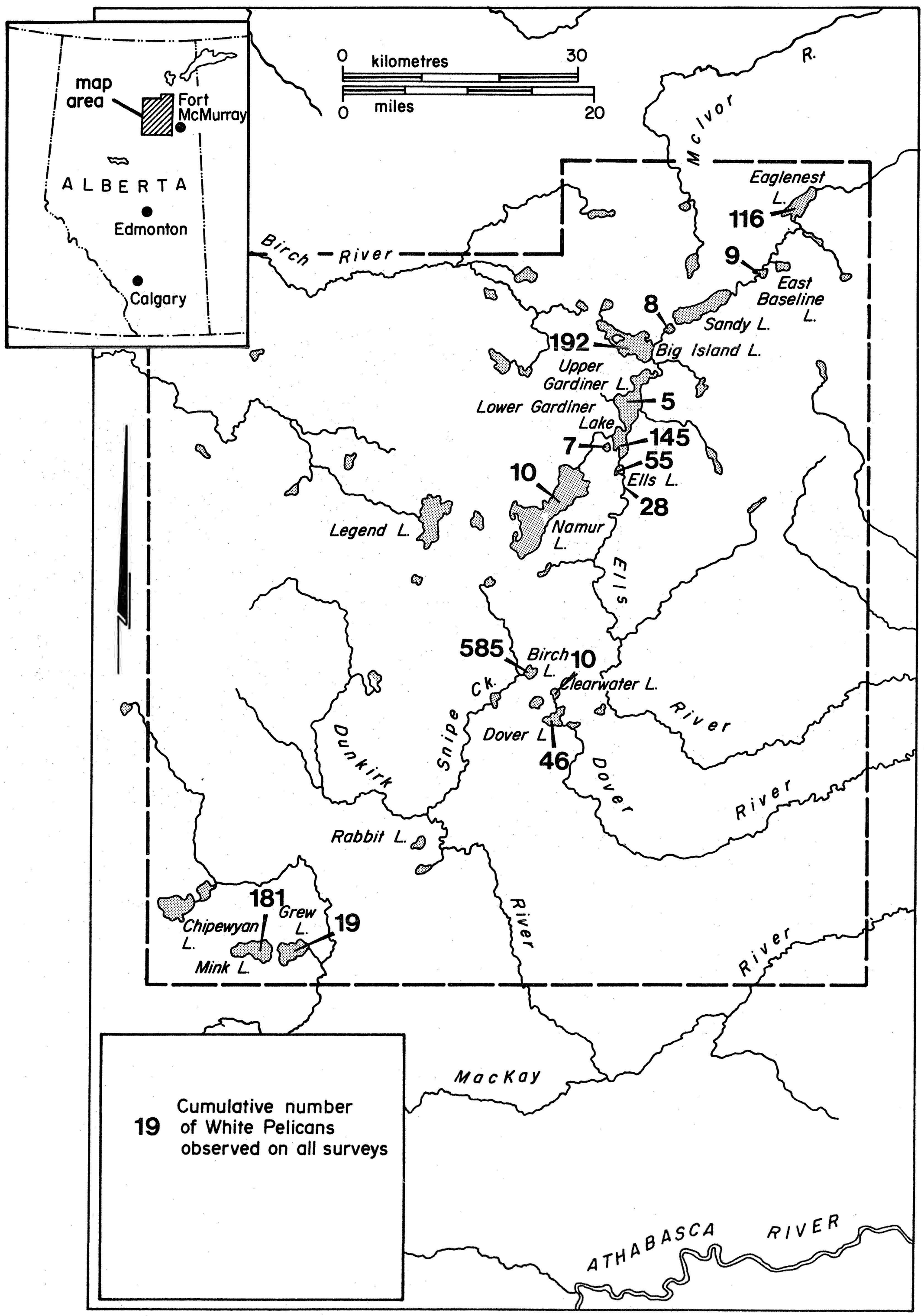

Figure 3. Results of aerial surveys flown within the White Pelican study area from 1975 to 1977.

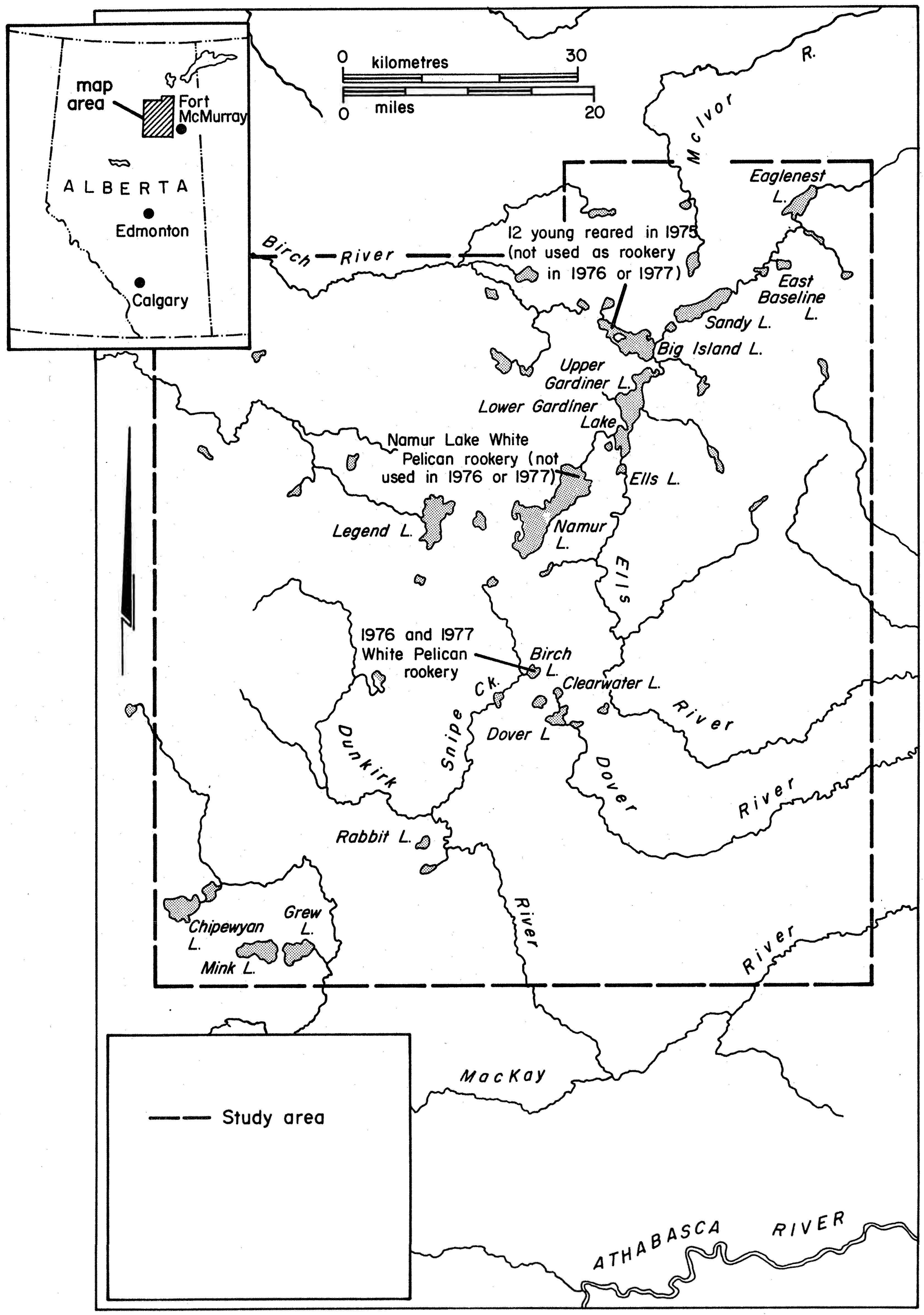

Figure 4. The breeding distribution of the White Pelican in the project study area.

raised young successfully in both 1976 and 1977 and may have used the small island there in years previous to the study although documentation to support this speculation is not available. There was no evidence found, resulting from our investigations, to suggest that White Pelicans bred at other localities in the project study area or in the larger designated AOSERP area.

5.1.3 Breeding Habitat

Characteristically, White Pelicans breed on island sites; however, they have occasionally been found nesting on mainland areas immediately adjacent to the water that were presumably once islands left connected to shore by dropping water levels (Houston 1962; Hosford 1965). Security from mammalian predators has often been cited as one of the benefits derived from the selection of island nesting sites by gregarious bird species (Crook 1965; Ward and Zahavi 1973). The literature indicates that White Pelicans readily recolonize traditional nesting sites rendered temporarily unsuitable by fluctuating water levels (Houston 1962; Hosford 1965; Evans 1972). Predation by canids and other mammals has been noted on larger islands or islands that have been rendered accessible by falling water levels (Carroll 1930; Behle 1935; Vermeer 1970b; Blokpoel 1971; McCrow 1974). Flooding of nesting areas on ephemeral islands is apparently a factor in site abandonment as well (Behle 1935; Houston 1962; Evans 1972).

All of the known rookery sites in the Birch Mountains are island sites located in permanent water bodies. At Big Island Lake (Figure 5), the site consisted of a relatively flat, partly forested island with an attached rock and gravel spit which extended approximately 50 m to the southeast. The island itself was small (less than 5 ha in area) with a mature white spruce and trembling aspen forest cover. A dense shrub layer of raspberry (*Rubus sp.*) covered the entire island. The spit itself was barely

Figure 5. The Big Island Lake rookery.

Figure 6. The Namur Lake rookery.

1 m above water level and subject to wave action on windy days. One pelican skeleton was found on the main body of the island but evidence of previous nesting activity was found on the spit only. The presence of dense shrubbery in the understory and the indicated presence of human activity in the form of an old trapper's cabin here could possibly limit the potential of this island as a breeding site. The exposure of the spit to wave action would be detrimental to nesting efforts there, particularly during windy, inclement weather.

The Namur Lake rookery site (Figure 6) was similar in size and forest cover to the Big Island Lake site, possessing a rock and sand spit which projected eastward from the main body of the island. Here, however, White Pelicans have nested primarily along the southern edge and under the cover of white spruce, the dominant tree species. The understory at the nesting location was dominated by Labrador tea (*Ledum* sp.). White birch covers the east end of the island. A dense successional vegetative growth of raspberry, fireweed (*Epilobium angustifolium*), common nettle (*Urtica gracilis* sp.) and cinquefoil (*Potentilla* sp.) has since sprung up where the pelicans had nested (Figure 7).

Several dead white spruce found at the nesting areas here may have been killed by uric acid conditioned soils as a result of the pelicans' activities. Highest elevations on the island were found at the west end which was approximately 10 m above water level. Slope was gradual toward the lower east end. The area where the pelicans had nested was essentially flat.

Birch Lake (Figure 8), covering an area of approximately 1.7 km^2 is much smaller than either Namur Lake (43.7 km^2) or Big Island Lake (15.8 km^2) (Turner 1968). The Birch Lake rookery, in marked contrast to the two sites previously discussed, was located on a small clay and sand island covered with scattered rocks. The island (Figure 9), subject to periodic flooding by high water levels, is almost completely devoid of vegetation and does

Figure 7. Abandoned nest mounds at the Namur Lake rookery.

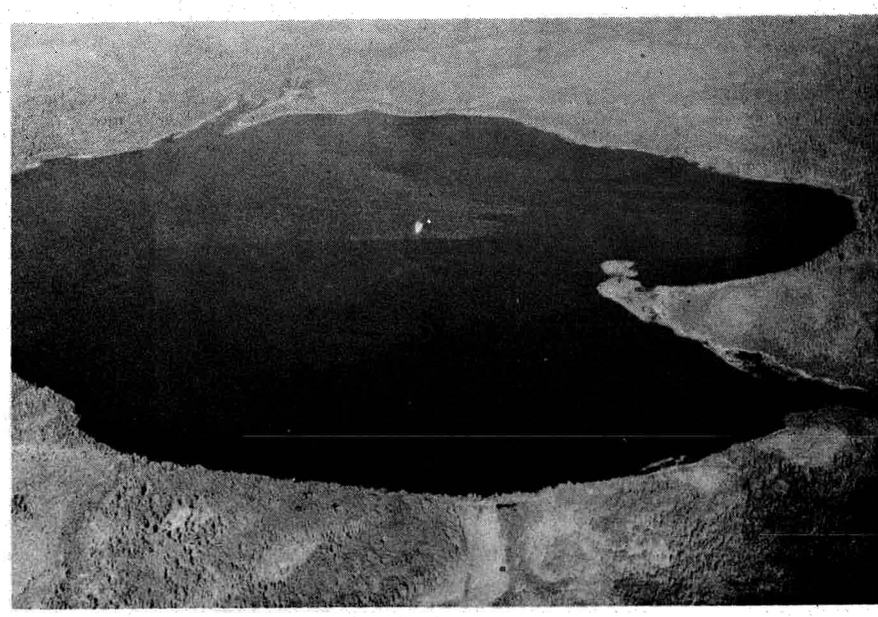

Figure 8. Aerial photograph of Birch Lake.

not rise more than 2 m above lowest water levels. During the lowest lake levels, which were observed in 1977, the island measured 90 m by 23 m and sloped gradually (less than 15°) in all directions from a west-central crown. An ubiquitous growth of water smartweed (*Polygonum amphibium*) surrounded the island with the exception of the eastern tip. Several dead willows on the western tip may have indicated a fluctuating water level in the past as was evidenced by the complete submergence of the island after a late summer rise in lake levels in 1976. The absence of other established vegetative cover may have been due to trampling by the pelicans.

Hardy invading plants such as common nettle, mint (*Mentha* sp.), lambis quarters (*Chenopodium album*), celery-leaved buttercup (*Ranunculus scleratus)*, dock (*Rumex* sp.), cinquefoil and sedges were found scattered on the periphery of nesting areas but were not common. The entire western and northern area of the lakeshore, used as both a loafing and foraging area, was a sedge-willow dominated series of shallow channels and exposed mud bars.

The apparent diversity of island sites chosen by nesting White Pelicans in the Birch Mountains was not unique for the species. A review of breeding habitat preferences demonstrated at other described locations in North America revealed several consistencies in categories we believed were important (Table 1). Nesting substrates of soil, sod, sand, or gravel on gradual slopes appeared to be preferred at all sites. Three of the sites were located on partially forested islands (Namur, Big Island and Lavallee Lakes), two were located on heavily vegetated islands (Chase Lake rookeries), while the remaining five were on depauperate landscapes. The tolerance of nesting White Pelicans to dense vegetative cover therefore appears to be variable. The Chase Lake colonies appeared to have kept an annual growth of marsh elder (*Iva xanthifolia*) from encroaching upon the actual nesting sites by continual trampling (Strait 1973). Trottier and

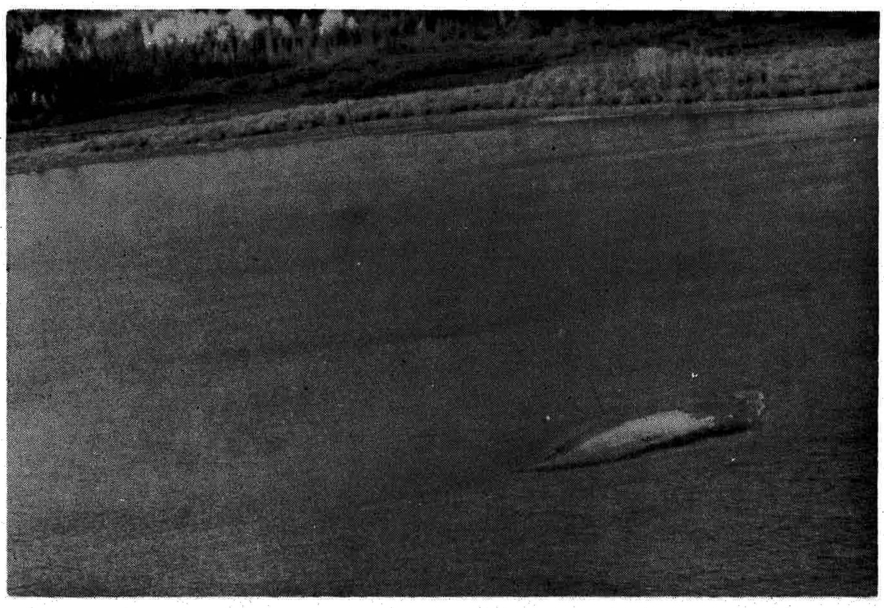

Figure 9. The Birch Lake rookery.

Table 1. A comperison of the characteristics of several described North American White Pelican rookeries.

Rookery Location	Characteristic										Source
	Island	Mainland	Presence of mammalian predators	Distance to nearest mainland (km)	Presence of loafing area	Slope at nesting areas	Exposure of colonies (direction)	Exposure of colonies to waves	Nesting substrate	Estimated elevation of colonies above water level (m)	
Namur Lake, Alberta	Yes	No	None	0.8	Yes	Slight	South	Nil	Organic & fine soils	2	This report.
Big Island Lake, Alberta	Yes	No	None	0.4	Yes	Slight	Open	Moderate	Rock & gravel	1-2	This report.
Birch Lake, Alberta	Yes	No	None	0.3	Yes	Slight	Open	Moderate	Rock & soil	1-2	This report.
Lavallée Lake, Saskatchewan	Yes	No	None	1.0	Yes	Slight	Variable	N.D.[a]	Organic & soil	1-5	Trottier & Breneman (1976).
Stum Lake, B.C.	Yes	No	None	N.D.[a]	Yes	Slight	Open	High	Sand	0-1	Campbell & Frost (1969).
Chase Lake, (1) N. Dakota	Yes	No	None	0.4	Yes	Slight	Variable	N.D.[a]	Gravelled soil	less than 5	Strait (1973).
(2)	Yes	No	None	0.2	Yes	Slight	Variable	N.D.[a]	Gravelled soil	less than 5	Strait (1973).
Gunnison Island, Utah	Yes	No	None	12.0[b]	Yes	Slight	West & East Open	N.D[a]	Loose soil, sod, sand, fine gravel	N.D.[a]	Knopf (1975a).
Hat Island, Utah	Yes	No	None	10.0[b]	Yes	Slight	Open	N.D[a]	Sand, gravel	N.D.[a]	Behle (1935).
Pyramid Lake, Nevada	Yes	No	None	1.6	Yes	Slight	Open	N.D[a]	Loose soil	1-125	Hall (1925).

Symbols:
a N.D. = No Data
b Variable with lake levels

Breneman (1976) reported a similar situation for colonies nesting in common nettle and under forest cover at Lavallee Lake in Saskatchewan. We suspect that, in northern regions at least, colonies established before the growing season prevent the annual vegetation from gaining a foothold through constant trampling and guano deposition. Thus, once established, a rookery site could remain relatively free of vegetation if used every year. The Namur Lake site's invasion by woody perennial shrubs since its abandonment by the pelicans in 1975 may hinder subsequent recolonization of the southeast shore area there.

Though several of the rookery sites investigated in the literature were partially forested or heavily vegetated, there appeared to be understory or adjacent areas free of vegetation near the water that were suitable as loafing areas for White Pelicans. Loafing was a common activity engaged in by the birds at Birch Lake throughout the year and, particularly during the height of aggressive nesting activity, these areas provided a harassment-free staging area for arriving and departing foraging flocks.

White Pelicans do breed on very desolate landscapes exposed to very severe heat conditions and successfully reproduce (Bartholomew et al. 1953). Presumably, the openness of such areas facilitates the initiation of the mobile ground and aerial displays observed during courtship and enhances the high degree of visual and physical stimulation apparently required to stimulate breeding in this social species (Schaller 1964; Knopf 1975a). Open areas also provide unobstructed entrance and exit routes to and from nest locations for arriving and departing birds. Knopf (1975a), in fact, found that driftwood and minor topographic features appeared to partition nesting colonies at Gunnison Island in Great Salt Lake and vegetation may similarly affect the choice of nesting locations.

We found no correlation between the location of colony sites and elevation above water level. Although most colonies were located within a few vertical metres of water level, we suspect that this condition was more a reflection of the choice of smaller islands with gradual sloping terrain. Hall (1925) found White Pelican colonies situated both on the flat beach areas and on the central flat top of Anaho Island in Nevada's Pyramid Lake, the latter location approximately 125 m above lake level.

Certain features, such as minor topographic relief, the density of shrub understories, the permanency of water bodies, the presence of mammalian predators, and the composition of available nesting substrates, were necessarily investigated by ground truthing. Mapping from aerial photographs provided adequate information on the existence of islands, the presence of loafing bars or spits, and the relative density of vegetative cover found on those islands. A discussion of optimum breeding habitats, where pelicans have been known to breed in the past, follows.

1. Namur Lake - Of the four islands located in Namur Lake, only one can be considered as optimum breeding habitat. This island is the traditional site located in the northeast end of the lake. The remaining three islands are deemed too heavily forested, possess estimated gradients in excess of 15° from the horizontal, lack loafing spits or shoreline areas, and are considered too near a potentially disruptive source of human interference in the form of a fishing lodge on the southwest corner of the lake to be considered optimum breeding habitat. Lake levels are probably stable;
2. Big Island Lake - Including the previously mentioned site where pelicans are known to have bred, there are nine islands in this water body.

Two, including the rookery, are considered optimum breeding habitat. The northernmost island in a group of three situated on the south side of the lake, like the rookery, possesses soil and sand substrates, open areas for nesting, gentle slopes less than 15° from horizontal, a loafing spit, and is located well over 100 m from the nearest mainland and is probably, therefore, free of mammalian predators. Of the remaining seven islands, three appear to provide optimum breeding conditions but are located within 100 to 200 m of mainland and could be subject to mammalian predator visitations. Lake levels appear to be relatively stable; and

3. Birch Lake - Although the rookery island is subject to periodic flooding, the availability of optimum breeding habitat in favourable years renders this site a moderately suitable breeding habitat overall. The island is relatively free of vegetation, possesses gradual slopes less than 15° from the horizontal, clay and gravel nesting substrates, and is relatively inaccessible to mammalian predators. A loafing area is present on the island shoreline, near the east and west ends.

For mapping of the suitability of these and other water bodies located within the project study area for White Pelican breeding, see Figure 16 and Table 10. Generally, the lack of islands possessing suitable nesting features is deemed a limiting factor in most lakes and this fact increases the importance of island sites located in the above three water bodies.

5.1.4 Water Level Fluctuations

Water levels during this study began to rise at Birch Lake in the summer in 1976 and by March 1977 had left the rookery island under approximately 15 to 20 cm of ice and water. After removal of a beaver dam blocking the outflow stream in March 1977, lake levels began to drop to the point where the island was exposed once more by the time of the pelicans' return in late April. Beavers reinstalled the dam in May so that, by June, water levels had again risen to the point where some low-lying pelican and gull nests were threatened. The second dam was removed in June before nests were actually flooded and waters receded once again. In July, water levels again began to rise but stabilized. At that time, an investigation of the outflow stream revealed no evidence of a third dam; however, heavy rains had raised the level of Snipe Creek into which the outflow normally drained, precipitating a reverse flow of water from Snipe Creek into Birch Lake. This condition resulted from the gradual stream gradient of the outflow channel.

From 6 August to 8 September 1977, staff gauge readings showed a mean daily water level drop of 0.91 cm for a total drop of 27.1 cm. The last reading, taken on 21 September 1977, revealed a lake level rise of 11.9 cm from the 8 September level. Clearly, the gradual stream gradients, coupled with the activity of Beavers, operate to cause water level fluctuations in Birch Lake. No White Pelican nests were lost to rising water in 1977 but an estimated 8 to 20 were inundated in 1976. High lake levels in successive years would render this island unavailable as a breeding site for both White Pelicans and California Gulls.

5.2 POPULATION AND REPRODUCTION

5.2.1 Population Structure

The discussion in this section of the report has been necessarily restricted to comments on the work of other researchers and therefore some caution is warranted in applying their findings to specific localities.

Very little research has been conducted on the age and sex components of White Pelican populations in North America and much speculation exists regarding the age of first breeding, longevity in the wild, and mortality rates. The most valuable information has resulted from the work of Strait (1973) and Strait and Sloan (1974) which entailed an analysis of band return data for White Pelicans at the Chase Lake rookery in South Dakota. In the absence of any field aging techniques, their approach is, at present, the only feasible method of studying population dynamics. Sex ratios in breeding populations remain unknown, as do mortality and survival rates for the sexes.

The activity of approaching a nesting concentration of pelicans for the purpose of banding young necessitates a certain amount of harassment to both young and attendant adults and this procedure was not undertaken during this study. Behavioural study itself at times required alerting the birds and an attempt was made to limit the amount of additional disturbance. Bearing in mind the potential usefulness of population information in management, however, a brief review of these findings is deemed helpful.

Strait's (1973) calculations indicated a 41 percent mortality rate during the first year of life for the Chase Lake White Pelicans, decreasing to 16 percent in the second year. Thereafter, until the thirteenth year, mortality averaged 21.3 percent but then increased dramatically. The oldest bird recovered was 17 years of age. Leading mortality factors, based on 850 band returns, were: unknown, 52.6 percent; shooting, 25.3 percent; injury, 3.6 percent; disease, 2.8 percent; and entanglement in fishing gear, 2.3 percent. In addition, 7 percent of the bands were returned with no information on cause of death.

Strait and Sloan (1974) calculated an annual adult mortality rate of 21.3 percent by assuming a first breeding age of three years and discounting returns for the last year (age 17) of life. Strait and Sloan (1974), however, stressed the bias incurred through band losses on this long-lived species which tended to indicate inflated mortality rates. Again, caution should be exercised in applying these figures to other rookeries in North America since several factors (migration mortality, starvation, inclement weather, and particularly hunting) could be locally variable.

5.2.2 Size of the Breeding Population

The number of White Pelicans breeding in the Birch Mountains has declined in recent years. In 1974, the breeding population at Namur Lake was estimated at 198 breeding pairs (letter dated 18 October 1976 from A.B. Rippin, Regional Wildlife Biologist, St. Paul, Alberta). No count was available for 1975 when the pelicans were forced from the Namur Lake site but in 1976 the number of breeding pairs nesting had declined to 140 at Birch Lake. In 1977, only 70 breeding pairs were estimated to have nested at Birch Lake. Clearly, the numbers of breeding White Pelicans in the Birch Mountains has declined, at least since 1974.

Employing the results of Strait and Sloan's (1974) Chase Lake investigations, we attempted to explain this decline. By choosing a value mid-way between the 1974 and 1976 breeding pair estimates, we assumed that a breeding population of 170 pairs bred in 1975. We then calculated an annual mean of 127 breeding pairs for the years 1975 through 1977. In 1975 we assumed the 12 young observed at Big Island Lake fledged successfully, while 68 and 55 young fledged at Birch Lake in 1976 and 1977 respectively. These figures resulted in an estimated annual mean fledging rate of 0.36 young per breeding pair. Strait and Sloan (1974) calculated that 39 percent of fledglings survived to an assumed breeding age of three years. If the Birch Lake young had the same survival rate, the recruitment rate for the years 1975 through 1977 was approximately 14 percent, apparently insufficient to offset losses. The breeding population decline in 1975, 1976, and 1977 could have been due to lowered production of young in 1972, 1973, and 1974; unusually high adult mortality in 1975, 1976, and 1977; and/or high mortality of subadult birds produced in 1972, 1973, and 1974. To clarify the reasons for the observed declines, more data than were obtainable were unfortunately required. Strait and Sloan (1974) estimated that a fledging rate of 0.58 young per nest, permitting a 23 percent annual adult pair mortality, was sufficient to stabilize the breeding population at Chase Lake.

5.2.3 Breeding Success

In 1976 and 1977 we estimated that 140 and 70 breeding pairs, respectively, nested at Birch Lake. These counts were obtained from the projection of coloured slides taken at an altitude of 300 m with a 200 mm lens, which gave the best image resolution.

Detail in the slides was not sufficient, however, to allow detection of exposed nests. Based on records of an average clutch size of 2.2 eggs for 198 nests (letter dated 18 October 1976 from A.B. Rippin, Regional Wildlife Biologist, St. Paul, Alberta) at Namur Lake in 1974 and for 6 nests at Birch Lake in 1977, we calculated that 308 eggs were contained in the nests in 1976 and 154 eggs in 1977. Sixty-eight young were raised to the flying stage in 1976 and 55 young in 1977. From these estimations, calculated breeding success was 22.1 percent in 1976 and 35.7 percent in 1977 (Table 2). The fledging rate for the Birch Lake rookery was calculated to be 0.78 young per nest in 1977, an increase from an estimated 0.49 young per nest in 1976. Other fledging rates reported in the literature are as follows: Gunnison Island, Utah, 0.85 young per nest (Knopf 1975a); Chase Lake, North Dakota, 0.58 young per nest (Strait 1973); and 0.54 and 0.39 young per nest at Chase Lake again in different years (Johnson 1976).

Table 2. Breeding success estimates for breeding White Pelicans at Birch Lake in northeastern Alberta in 1976 and 1977.

Estimated number of nests		Estimated number of eggs		Number of young raised to flying stage		Breeding success (percent)	
1976	1977	1976	1977	1976	1977	1976	1977
140	70	308	154	68	55	22.1	35.7

5.2.4 Mortality Factors in Reproduction

More than one factor may have contributed to the observed difference in breeding success rates at Birch Lake between 1976 and 1977. In 1976, flooding of an estimated 8 to 20 nests was an obvious contributing factor. California Gull predation of eggs or young was not observed in either year. Sibling rivalry has been cited as a contributing nestling mortality factor (Strait 1973; Knopf 1975a; Johnson 1976); however, we did not detect this. In contrast, we once watched a feeding of a small begging chick as its larger nest mate slept. Of six nests observed containing two young in 1977, four fledged both chicks. Johnson (1976) did not find a single instance of nests fledging more than one young over a period of three years at Chase Lake. His necropsies of young pelicans commonly showed enlarged gall bladders, indicating starvation.

Flooding of the rookery in August 1976 precluded a carcass count of young pelicans in that year; however, the situation enabled us to subsequently estimate chick mortality in 1977 by such a count when the island remained above water. We collected the remains of 13 deadyoung pelicans (Table 3), 12 of which were nestlings (less than two weeks old) when they died. The thirteenth young died at an estimated age of six to seven weeks. It thus appeared that mortality in prefledged nestlings was considerably higher than for the period after they had left the nest.

Schaller (1964), Greichus and Greichus (1973), Strait (1973), Knopf (1975a) and Johnson (1976) cited infertile eggs, addling due to large clutch size, eggs rolling from the nest, death of one of the adults, nest abandonment, sibling competition, aggression, trampling, morphological defects, disease (parasites included), fluctuating water levels, and bad weather as factors contributing to nest failure and chick mortality.

Table 3. Observed nest failure and mortality factors at the Birch Lake rookery in 1977.[a]

Factor	Number of eggs or young lost
Eggs	
Nest abandonment or eggs rolling from the nest.	7
Failure to hatch (cause unknown)	11
Young	
Unknown	12 (estimated age less than 2 weeks at time of death)[b]
	1 (estimated age older than 2 weeks at time of death)
TOTAL	31

[a] From observations taken at the permanent observation blind and two visits made to the island during August.
[b] Ages estimated by criteria of size and feather development.

Nest abandonments or eggs rolling from the nest accounted for the observed loss of seven eggs at Birch Lake in 1977 (Table 3). The first two untended eggs were observed in an abandoned nest on the periphery of colony E (see later discussion on description of breeding colonies, Section 5.3.4) on 5 June during the early stages of incubation. At that time, an adjacent nester briefly attempted to draw the eggs into its own nest while adding more material to its nest, suggesting as Knopf (1975a) stated, that addling due to clutch supplementation could have been a factor in nest failure. We witnessed no gull predation of abandoned eggs, as has been reported by other investigators (Sanderson 1966; Strait 1973; Knopf 1975a; Johnson 1976), although the eggs remained visible in the same place for several days. The last two untended eggs were observed near colonies A and B on 26 June 1977, soon after hatching had commenced on the island. We could not determine whether the eggs were lost in the late stages of incubation or if they were eggs of a late nesting pelican on the periphery of the colonies. Knopf (1975a) reported that nest abandonment occurred more frequently in the early or late stages of incubation and was more common among peripheral nesters. Of the three remaining egg losses observed in 1977, one appeared to be associated with a late nesting attempt on the periphey of colony A, while the remaining two were observed in colony D. All three eggs appeared to have been displaced rather than abandoned.

From the nests which could be observed from the permanent blind in 1977, a total of 11 incubated eggs failed to hatch (Table 3). Three of these nests contained three eggs each: only one egg hatched from these nests and the resulting chick did not survive. In a fourth nest, another egg failed to hatch after the death of a single hatchling. Adults at all four nests incubated for approximately three weeks after the expected hatching dates. Three of the nests were adjacent to each other in colony C and were finally abandoned over a two day period in late July during the time most other young were leaving their nests. The remaining nest belonged to a late nesting pair which did not desert until 6 August 1977. Knopf (1975a) has also described nest abandonment with colony breakup.

The two remaining eggs of the 11 which were incubated but failed to hatch were from nests in colonies C and D. Each nest fledged one chick. No second young were observed in either nest, nor did the eggs remain visible; it was suspected that they were damaged or destroyed by the nestlings.

5.3 CHRONOLOGIES, BEHAVIOUR, AND MOVEMENTS

5.3.1 Reproductive Chronologies

The first White Pelicans return to the Birch Mountains in late April before spring breakup and congregate on the flowing, open water areas, then gradually move onto the breeding islands as the ice leaves the lakes, generally in early May. Daily ground counts of the number of adult birds present at the rookery over the entire breeding season (Figure 10a, b) in 1977 indicated an early buildup of numbers of birds at the rookery, presumably as newly arrived migrants joined the rookery. After nests had been defended, numbers of adults at the island at any time began to decline as foraging occupied most of their time particularly once young had hatched. Migration in fall further reduced the number of adults observed at the rookery.

The weekly count from 19 to 25 July was omitted due to the presence of large numbers of immature (as determined by plumage characteristics) White Pelicans visiting the island at irregular intervals. The origin of these birds could not be determined, however, the sighting of one banded and non-breeding bird and one banded breeding adult suggested a degree of movement in the summer by immature birds as no banding had ever been carried out on the Birch Mountain population. The phenomenon was similar to a July

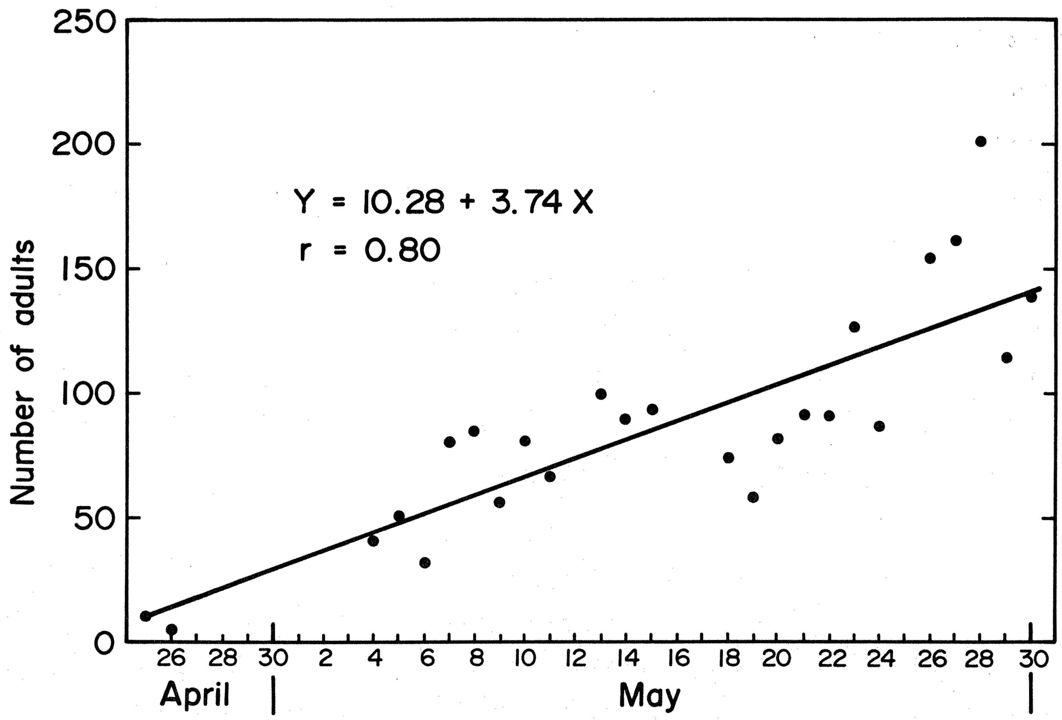

Figure 10a. Daily maximum numbers of adults at the Birch Lake rookery to late May in 1977.

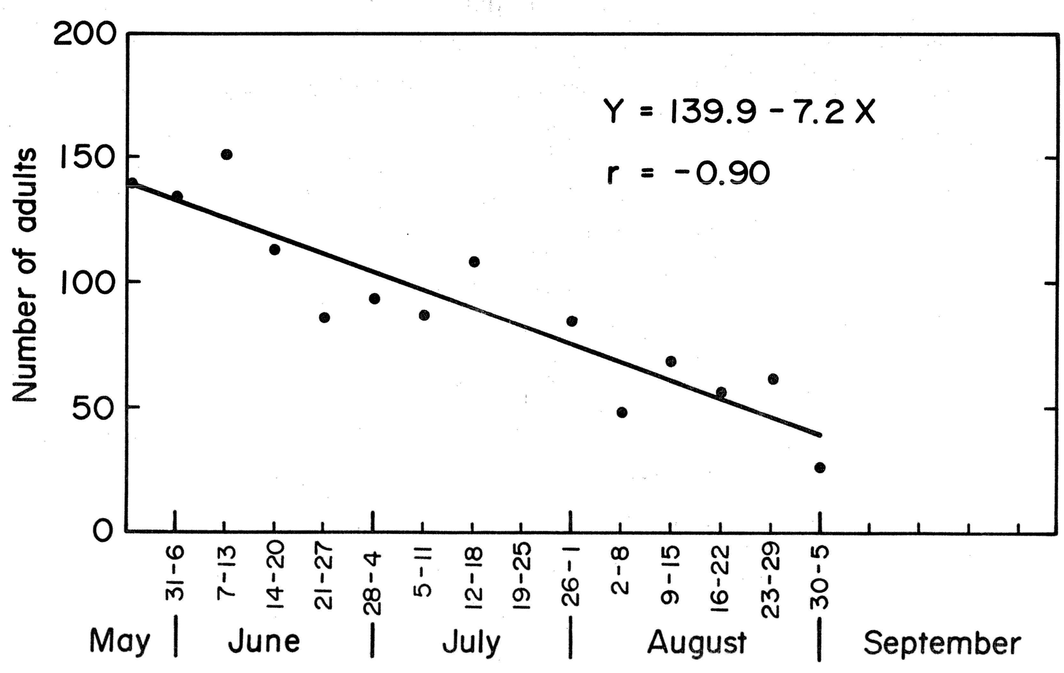

Figure 10b. Weekly maximum numbers of adults at the Birch Lake rookery from late May to early September in 1977.

influx of non-breeding adults observed in 1976. Strait (1973) has determined that Chase Lake juveniles do move northward into Canada from South Dakota in their wanderings.

Extrapolations from Figure 10a and b revealed a possible first spring arrival date of 22 April in 1977. Similarly, the last adults may have left during the week beginning 4 October. Observations in 1976 indicated first spring arrival and last autumn departure dates during the last week of April and last week of September respectively. We interpreted the discrepancy between 1976 and 1977 departure dates to be a measure of the degree of nesting asynchrony among the colonies. First spring arrival dates compare favourably with other rookery locations reported in the literature as follows: Gunnison Island, Utah - 15 March (Knopf 1975a); Great Salt Lake, Utah - 1 April (Behle 1935); Lavallee Lake, Saskatchewan - 26 April (Trottier and Breneman 1976); and Yellowstone Lake, Wyoming - 11 May (Schaller 1964). As previously discussed, timing of ice melt may determine the spring arrival dates for this species in temperate or boreal latitudes.

The height of the nesting activity occurred in late May and early June in 1976, as estimated by backdating from subsequently observed hatching dates and ages of hatched young. In 1977, 92 percent of nests were established during the three week period from 14 May to 3 June although six nests were added to colonies one to three weeks later.

White Pelicans nest in aggregations or colonies which are at least spatially distinct from other colonies in the rookery. Colonies form around a nucleus of first initiated nesting pairs and spread from that point, their ultimate size apparently determined by the number of receptive females present during their formation (Knopf 1975a). Our findings indicated that colonies were not always formed sequentially at the same rookery. Actual colony formation was not observed in 1976 due to a late field season start; however, the observation of four distinct nesting groups in aerial photographs taken on 27 May 1976, and subsequently three distinct age groups of fledgling young, supported the hypothesis that the colonies formed over a period of 20 to 28 d during May. A comparison of the calculated dates of formation for the four colonies in 1976, based on an assumed 29 to 31.5 d incubation period (Bent 1922; Knopf 1975a), estimated ages of young, and allowing one week for colony formation (Knopf 1975a), is presented along with actually observed events for 1977 (Table 4).

At Birch Lake, young were dependent on the adults for a period of 13 to 14 wk. They were first left unattended when 2.5 wk of age, whereafter they left the nest to form aggregations (pods) with other young. Young flew as early as 8 to 9 wk of age but were not capable of sustained flight until approximately 12 wk of age. They appeared to leave the home lake on migration when between 13 and 14 wk old. Physical and behavioural developments for young White Pelicans are presented in Table 5.

We noted some variation in the rate of physical and behavioural development of young from 1976 to 1977. It is not known whether the discrepancy merely represented a range of normal maturational development and growth or whether young actually matured faster in 1976 than they did in 1977. Our inability to document actual hatching dates in 1976 necessitated an estimation of age from a few latest hatched young which may have introduced a bias if those young experienced different growth and development rates, a possibility inferred by Ward and Zahavi (1973), Emlen and Demong (1975) and Knopf (1975a) in discussions of the foraging efficiency of White Pelicans and other synchronously nesting colonial birds. The nutritional aspects of young White Pelican diets remains to be investigated on a temporal basis to confirm this suspicion.

A summary of the reproductive events as estimated in 1976 and observed in 1977 is presented in Figure 11.

Table 4. Colony size and chronology of reproductive events for White Pelicans nesting at the Birch Lake Rookery in 1976 and 1977.[a]

Colony[b]	Size: Number of Nests 1976	Size: Number of Nests 1977	Event: Courtship and Nest Defense 1976	Courtship and Nest Defense 1977	Main Incubation Period 1976	Main Incubation Period 1977	Main Brood Period 1976	Main Brood Period 1977
A	70	28	April 27–May 4	May 11–24	May 4–June 3	May 22–June 21	June 4–June 25	June 22–July 13
B	53	10[c]	N.D.	May 18–26	N.D.	May 26–June 25	N.D.	June 26–July 27
C	13	13	N.D.	May 25–June 4	N.D.	June 4–July 4	N.D.	July 5–26
D	4	11	May 25–June 1	May 26–June 1	June 1–July 1	June 1–July 1	June 25–July 15	July 2–23
E	N.A.[c]	8	N.A.	May 28–June 4	N.A.	June 4–July 4	N.A.	July 5–26

[a] Dates for events not actually observed in 1976 are based on estimates derived from backdating.

[b] Colony designations were assigned to identify spatially and/or temporally separated groups of breeding birds and do not necessarily imply the integrity of colony units from one year to the next.

[c] Symbols: N.D. = No Data; N.A. = Not Applicable.

Table 5. Physical and behavioural development of young White Pelicans at Birch Lake, northeastern Alberta.[a]

Age of Young (weeks)	Physical Description and Behaviour
0-1	Young naked, pink and helpless.
1-2	Aquisition of white down. Young can lift head to feed. Legs and mandibles gray.
2-3	Down covering prominent. Mobility evident, pods begin to form. Begging behaviour pronounced with vocalizations audible at 300 m. Adults no longer brood continuously.
3-4	Down covering appears gray and dirty. Young now walk. Retrice and remige feather sheaths visible.
4-5	Young now walk well. Begin to spend more time away from pod units.
5-6	First young observed swimming and bathing. Primary feathers have erupted approximately 5 to 10 cm[b] from the sheaths. Wing coverts still downy in appearance.
6-7	Wing primaries erupted approximately 15 cm from the sheaths. Young begin to roost overnight away from pods.
8-9	Wing primaries erupted approximately 25 to 30 cm. Tertial feather growth incomplete. Young make first brief flights. Mandibles and feet now yellowish in appearance.
9-10	Young now make flights within confines of lakeshore with occasional soaring.
10-11	Tertial feather growth almost complete. Young fly confidently beyond the confines of the lakeshore.
12-14	Young begin to disperse from the home lake. Migration probably follows immediately.

[a] Adapted from original table in Schaller (1964).
[b] Measurements not made. Estimates based on visual inspection from observation posts using spotting scopes.

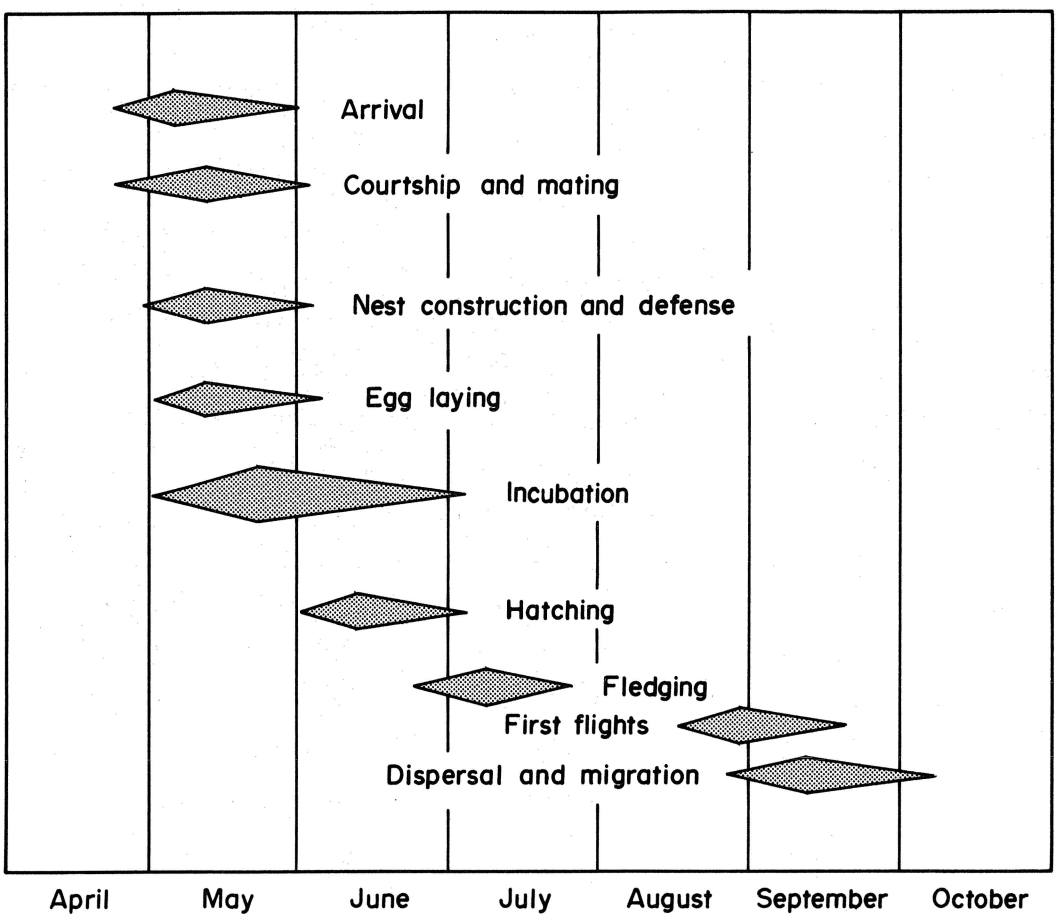

Figure 11. Chronology of events that occurred throughout the breeding season for White Pelicans in northeastern Alberta.

5.3.2. Description of Breeding Colonies

The projection of the colour slides obtained during the aerial census flights revealed four colonies in 1976 and five colonies in 1977 during the height of the nesting season at Birch Lake. Colonies were very closely associated with one another in space but ground observations revealed temporal asynchrony among several of them in both 1976 and 1977. Not all of the available nesting space was used in either year. In 1977, it appeared that not all courting adults eventually paired. In 1977, of a potential 101 pairs observed courting (estimated from 202 courting adults and assuming equal sex ratios in the breeding population), only 70 pairs, or 69.3 percent, nested. The factors underlying the failure of 30.7 percent of the potential pairs to initiate nesting remains unknown but perhaps indicates the presence of subadult birds just approching breeding age or unequal sex ratios in this population. Knopf (1975a) suggested that the number of receptive (adult) females limited colony size and perhaps males do outnumber females in the breeding population.

The areas where colonies formed in 1977 overlapped, but were not superimposed upon the areas chosen in 1976 (Figure 12) and it appeared that, due to the utilization of the larger island area available in 1977, densities of nests were greater in 1976 than 1977. The first colonies in both years formed on the higher available ground and subsequently formed colonies were relegated to lower areas closer to the water line although the first pelicans forming colonies did not choose the highest areas available. Colonies were formed in close proximity to existing colonies but not necessarily nearest the most recently established colony.

5.3.3 Timing of Foraging Movements and Feeding Schedules

Departure of the adult pelicans from the rookery to the foraging areas was observed throughout the day in both 1976 and 1977

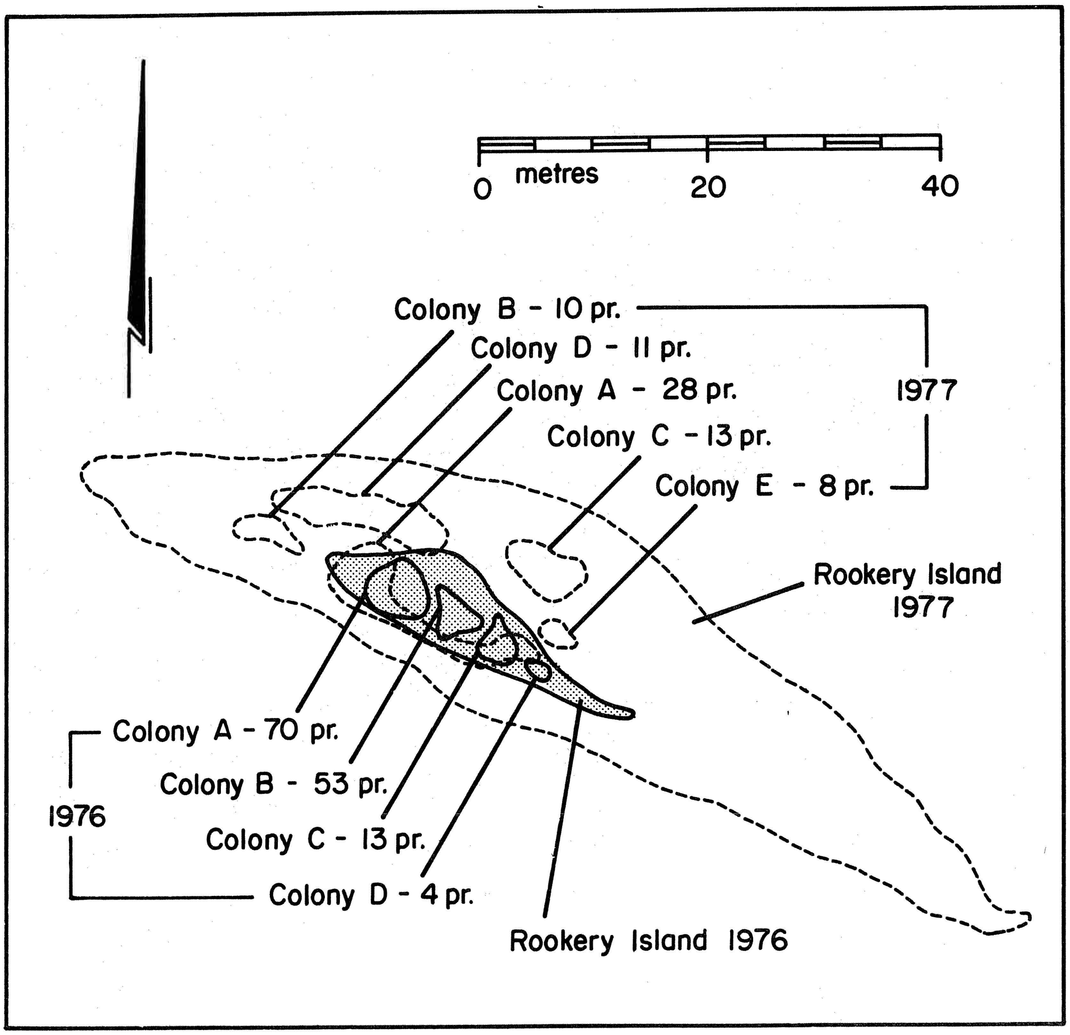

Figure 12. Location and size of nesting colonies of White Pelicans at the Birch Lake rookery in 1976 and 1977.

(Figures 13 and 14). A brief exodus from 0500 to 0600 h followed by a decrease in the rate of departures was also observed. The majority of departures was witnessed in the period from 0800 to 1400 h when the birds appeared to use thermals to gain elevation before embarking to distant areas to the northeast and southwest. In several instances winds appeared to hamper the departure of birds from the lake; more birds appeared to forage at Birch Lake on cool, wet and windy days. We suspect that weather does influence the movement of pelicans. Numbers of birds leaving the rookery appeared to decrease after 1400 h although a third peak was evidenced between 1700 and 1800 h in 1976 and 1800 and 1900 h in 1977.

Peaks in the numbers of pelicans arriving at the rookery from the foraging areas were most evident during the early morning, from 0500 to 0700 h and at midday from 1000 to 1300 h. As with departures, a third increase in arrivals was indicated in the afternoon between 1700 and 1800 h in 1976 and from 1800 to 1900 h in 1977. Numbers of arrivals were observed to decrease thereafter in both years (Figures 13 and 14).

Foraging movements, like breeding, appeared to be synchronized efforts, in fact, most birds arriving at or departing from the rookery did so in flocks. The strategy of social foraging movements in colonial or gregarious bird species has received some attention by other workers (Crook 1965; Ward and Zahavi 1973; Emlen and Demong 1975) and perhaps enhances the efficiency of utilization of widely scattered but locally abundant food resources. Certainly, further study of the foraging biology of White Pelicans would do much to supplement our knowledge of this aspect of behavioural ecology (see Ealey 1979).

At Birch Lake, a typical pattern of departure involved one or more birds leaving the rookery to soar over the shores of the lake where they were joined by others. The resulting flock then flew off to the foraging areas. Mean departing flock size in 1976 was 10.7 (range: 2 to 28) based on 28 flock sightings. Mean departing flock

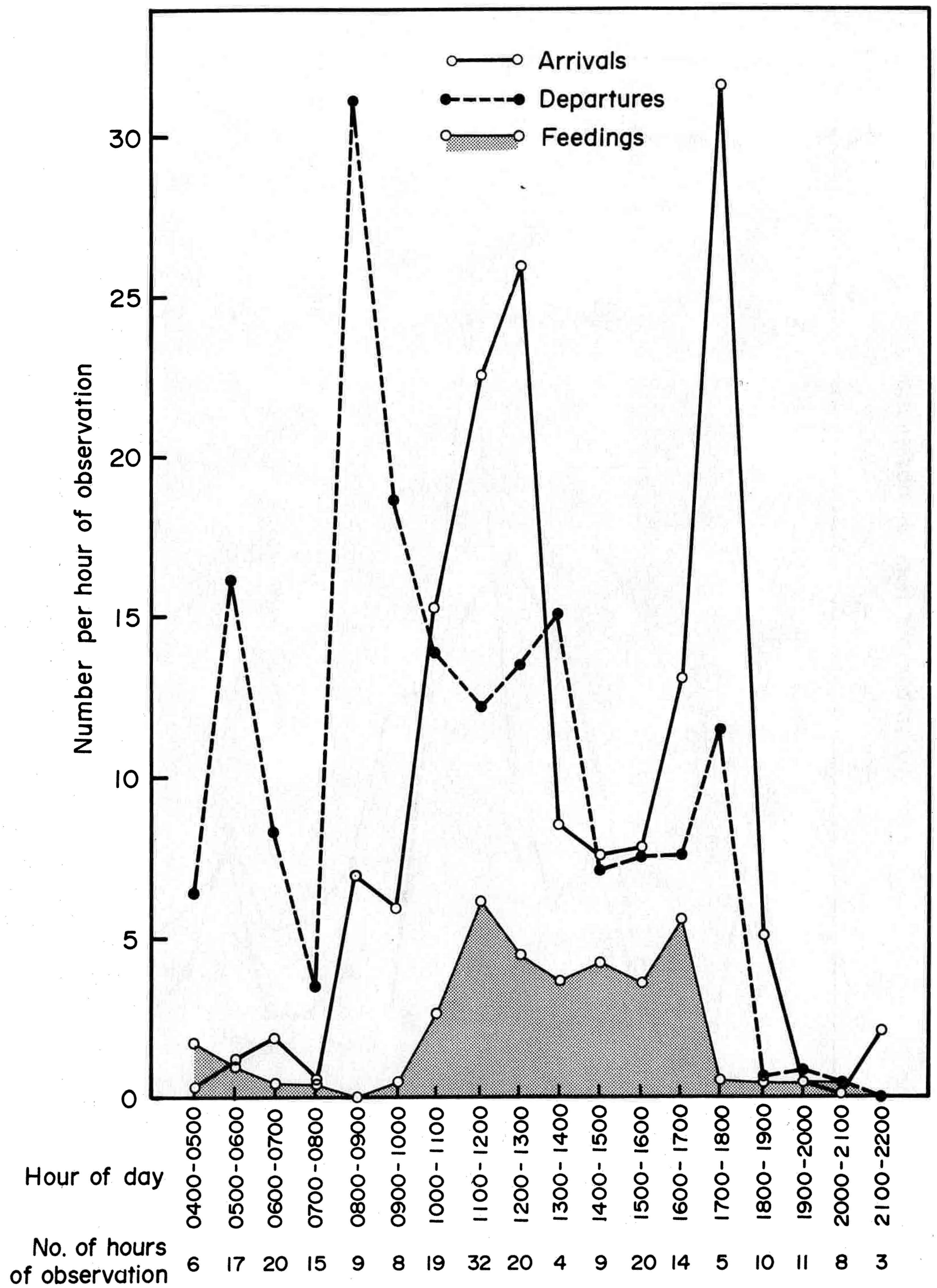

Figure 13. Daily pattern of arrivals and departures of adults and feeding young at the Birch Lake Rookery in 1976.

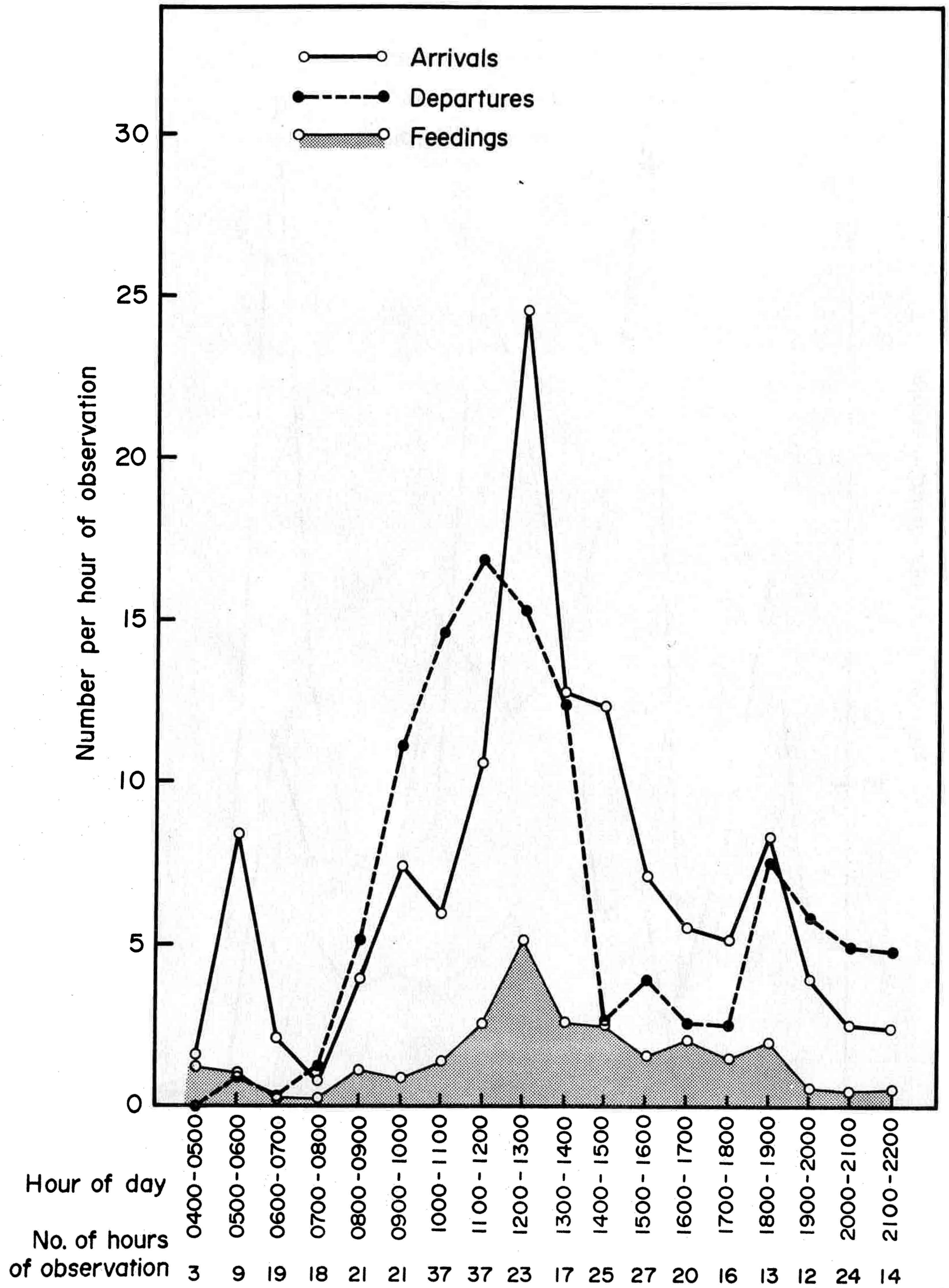

Figure 14. Daily pattern of arrivals and departures of adults and feeding young at the Birch Lake rookery in 1977.

size in 1977 was 6.3 birds (range: 2 to 85) based on 366 flock sightings. Schaller (1964) reported a mean flock size of 2.8 birds from observation of 4416 departures at Yellowstone Lake, Wyoming.

A random sample of 1105 arriving birds in 1976 revealed only 106 single bird arrivals but 999 in 128 separate flocks. Mean arriving flock size was 7.8 birds (range: 2 to 64). In 1977, of 2650 observed arriving birds, only 157 were singles but 2493 arrived in 327 separate flocks. Mean arriving flock size was 7.6 birds (range: 2 to 79). Schaller (1964) reported a mean arriving flock size of 4.8 pelicans based on 4326 observed arrivals.

The larger mean arriving and departing flock sizes in 1976 was probably due to the larger number of breeding birds present in that year. Recruitment of adults by departing flocks was witnessed and this may also have occurred when flocks departed from the foraging areas toward the rookery. This was certainly suggested by the sizes of returning flocks.

The observation of peaks in the numbers of adults returning to the rookery during the early morning hours in both 1976 and 1977 may have indicated nocturnal foraging. Similarly, the increase in the numbers of adults departing from the rookery during the early evening in 1976 would appear to support this speculation. In 1977, at least, White Pelicans were observed foraging nocturnally at the Gardiner Lakes narrows by the authors on several occasions. Nocturnal foraging has also been suggested for White Pelicans at other North American locations (Hall 1925; Schaller 1964).

The adults returned to the rookery to relieve mates on nests or young and to feed their young. An analysis of the rate of feeding of young by adults revealed that most feedings coincided with the influx of adults to the island (Figures 13 and 14). A second peak later in the day suggested that young were perhaps fed twice daily after the parents were relieved of the responsibility of continually brooding their young and both could devote their time to foraging. We were unable to monitor individual young to detemine how often they were fed during the day and whether the rate of feeding changed as they matured. Schaller (1964) was able to mark individual young at Yellowstone Lake and concluded that nestlings (less than three weeks of age) were fed at least four times a day, usually during the early morning and toward evening, and that older young were fed less frequently, perhaps only once a day. Greichus et al. (1976) found that captive-raised young White Pelicans voluntarily reduced their food intake around the age of six weeks from 1400 g to 600 g, shortly after peaks in growth weights were achieved. We suspect, therefore, that several feedings were given daily to nestlings up to three weeks of age. After this age, young did not require continual brooding and both parents were free to forage. Until six weeks of age when maximum weights are probably achieved, we suspect that young were fed at least twice a day and once per day thereafter.

5.3.4 Nest Relief Activity

Due to the late start in 1976, very little information concerning nest reliefs was obtained. In 1977, however, we began to monitor specific nests during colony establishment and were able to collect data on nest relief ceremonies during the incubation and brooding phases. Initially, pair members usually could not be distinguished unless they were observed together and size used as the criterion of identification, females being generally smaller than males. As the presupplemental moult progressed, each adult acquired distinctive head plumages, making it possible to recognize individuals of a nesting pair.

The exchange of nesting duties usually involved a "ceremony". Behaviours previously exhibited by courting and nest-building pelicans continued to be displayed during nest reliefs. These behaviours included "uprights" and "head swaying", termed "recognition displays" by van Tets (1965) and "bows", "nest indications" and "nest material presentations", considered by van Tets (1965) and Schreiber (1977) to signal nest site ownership although caution is recommeded in implying homologies for described behaviour. The amount of time devoted to the activities varied, as did the apparent intensities of the ceremonies. In some instances, the nesting pelican vacated the nest after cursory "uprights" were exchanged while, in other cases, the pair "grunted", "bowed", presented nest materials, and performed "uprights" and "head swaying" for several minutes, both before and after nesting duties were exchanged. As the season progressed, relief ceremonies became less intense and ceased as nests were left untended with the young forming pods.

During incubation, pair members appeared to relieve nest mates on an average of once every day, in contrast with Schaller's (1964) observations of reliefs every other day at Yellowstone Lake; however, interruptions to consecutive daily observation of monitored nests were experienced as a result of bad weather and some spculation exists regarding scheduling of nest relief activity at Birch Lake. Schaller (1964) and Knopf (1975a, 1976) reported that nest reliefs increased to once a day after the chicks hatched and this scheduling was the case at Birch Lake also. When the chick were approximately 2.5 wk old, relief frequency may have increased to twice daily with each parent feeding the young. Nest reliefs continued at this frequency until after nests were left untended.

When the adults ceased continuous brooding and the young wandered from their nests we could no longer monitor the pairs but it appeared, from the number of adults counted at the rookery each day, that the frequency with which the parents visited their young declined to once per day when the young were 8 wk old. Schaller (1964) also observed this frequency.

Nest reliefs at Birch Lake were witnessed throughout the day but were most common during the late morning and early afternoon in 1977 for which such data were obtainable. These peaks

(Figure 15) coincided with peaks in the number of adults returning to the rookery (Figure 14). On occasions when we observed two reliefs at a nest in one day, the second relief occurred in the early evening, coinciding with a second smaller peak in the number of arrivals.

Nest reliefs were timed from the arrival of the relieving pelican at the island until its mate had left the nest. We further analyzed the nest reliefs in three divisions: the first from the arrival of the relieving bird until the initiation of the relief ceremony; the second from the initiation of the relief ceremony until the mate left the nest; and the third from the initiation to completion of the nest relief ceremony itself. A comparison of the first two divisions during incubation and brooding is presented in Table 6. No significant difference was observed between the mean relief times of incubating and brooding birds as measured by this technique. A comparison of males and females showed no correlation between the sex of the pelican relieving or being relieved and the duration of the relief ceremony (Table 7). Of potential importance in the following discussion was the observation that the contents of the nest were not left exposed or untended for appreciable lengths of time (mean times were less than 1 min during incubation and brooding for both males and females).

5.3.5 Responses to Present Levels of Human Activity

During the course of this study, an attempt was made to subjectively classify behavioural responses of incubating and brooding adults and their young to various disturbances related to our study or existing human activity in the study area. We felt that, by familiarizing ourselves with responses of the birds which indicated alertness and, therefore, potential abandonment of the rookery, some interim recommendations could be suggested which would minimize disruptions deemed potentially detrimental to the breeding success of these birds.

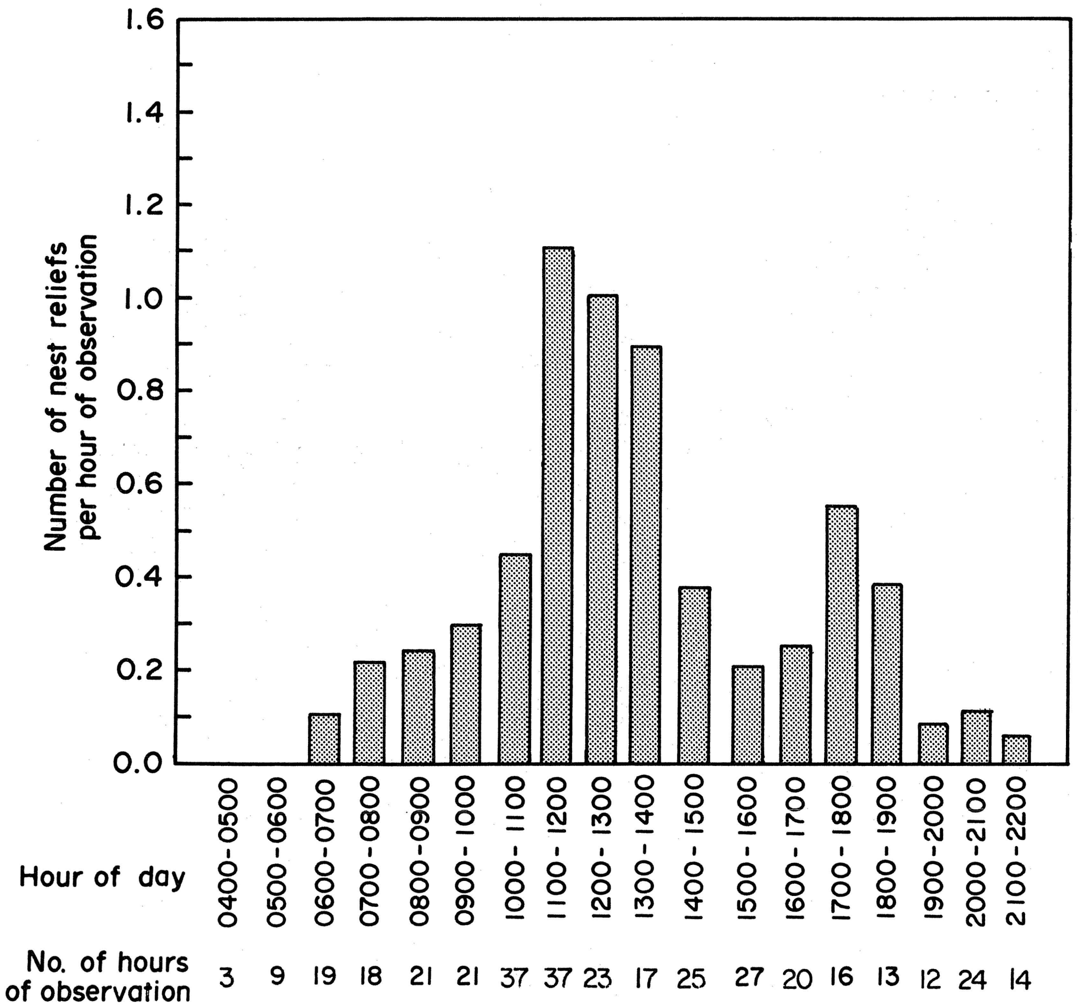

Figure 15. Daily pattern of nest reliefs at the Birch Lake rookery in 1977.

Table 6. Comparison of the nest relief times for incubating and brooding adults in 1977.

Relief Chronology	Relief Time (minutes[a])			
	Incubating		Brooding	
	Mean	S	Mean	S
From arrival of relieving bird to initiation of relief ceremony.	3.83(11)[c]	3.07	7.45(9)[b]	9.62
From initiation of relief ceremony to completion of relief (one bird off nest and mate on nest).	0.52(23)	1.25	0.51(15)[b]	0.41

[a] Symbols: S = One Standard Deviation;
[b] Means are not significantly different as determined by t tests ($P > 0.2$).
[c] Number in parentheses is sample size.

Table 7. Comparison of the nest relief times for male and female members of the pair in 1977.

Relief Chronology	Relief Time (minutes[a])			
	Males relieving females		Females relieving males	
	Mean	S	Mean	S
From initiation to completion of relief ceremony (one bird off nest and mate on nest).	0.56(24)[c]	0.80	0.39(25)[b]	0.40

[a] Symbols: S = One Standard Deviation;
[b] Means are not significantly different as determined by t tests ($P > 0.1$).
[c] Number in parentheses is sample size.

Postures indicative of heightened alertness by White Pelicans include looking around with the neck stretched upright, sudden stretching movements, especially wing flapping, silent flight away with no take-off displays, and ultimately rapid flushing (Schaller 1964; Knopf et al. 1975; van Tets 1965). These reactions are similar to those observed for Brown Pelicans by Schreiber (1977) and may be diagnostic for most species in the pelican family. Young White Pelicans which are able to fly demonstrate identical responses to the adults, whereas young not able to fly appear to form dense clusters in response to pending danger while exhibiting the typical alert "head-up" posture. The proximity of nesting colonies and neighbouring birds within colonies and the visually oriented communication patterns of White Pelicans probably influence the degree of response and the number of birds involved as much as the nature of the disturbance and the timing during the reproductive cycle at which the disturbance occurs.

Visits by researchers to a permanent blind located approximately 300 m from the rookery elicited no adult response until July, when most adults had completed incubation; thereafter, such visits precipitated varying degrees of response by the adults but the majority of visits continued to elicit no response (Table 8). Young did not, and perhaps could not, demonstrate responses to these visitations until they had left their nests at approximately three weeks of age; thereafter, although no responses were observed in the majority of instances (Table 9), some pronounced responses were observed.

Approaches by researchers in a canoe less than 300 m from the rookery appeared to elicit relatively more intense reactions from both adults and their young (Tables 8 and 9) although early data from periods prior to hatching are lacking for incubating adults. The floating blind, in which approaches closer than 100 m were made, elicited only slight responses if any at all, although only three tests were made with the apparatus and conclusive

Table 8. Levels of observed responses of adult White Pelicans to current level of human activity near the rookery during the 1976 and 1977 breeding season.[a,b]

Types of Disturbance	Level of Adult White Pelican Response[c] at Estimated Closest Approach by Disturbance																								
	Less than 100 metres					100 - 300 metres					300 - 500 metres					500 - 1000 metres					Greater than 1000 metres				
	M	Jn	Jl	A	S	M	Jn	Jl	A	S	M	Jn	Jl	A	S	M	Jn	Jl	A	S	M	Jn	Jl	A	S
Observers																									
1) Floating Blind	n(2)[d]		SI(1)																						
2) Permanent Blind											n(38)	n(45)	n(75)	n(69)	n(11) mp(1)										
Aircraft																									
1) Single engine i) cruising overhead or to one side											n(1)	n(1)					n(5)		mp(1)		SI(1)	n(2)		n(2)	
ii) landing																	n(1) SI(1) mp(1)	n(1) SI(4) mp(2) p(2)	mp(4) p(4)	p(1)					
ii) takeoff																	mp(2)	SI(4) mp(4) p(2)	SI(1) mp(3)	mp(1) p(1)					
2) Twin engine																n(1)									
3) Jet Helicopter																					SI(1) mp(1)	n(1) SI(1)	SI(2)	mp(1)	
4) Unidentified (heard but not seen included)																							n(1) SI(1)		
5) Jet planes																					n(6) SI(2)	n(2) SI(1)	n(2) SI(1)	n(4) SI(1)	n(1) SI(1)
Human Intruder in Canoe				p(1)				n(2) SI(2)	SI(1) p(1) mp(1)	p(1)	n(38)	n(45)	n(72) SI(1) mp(2)	n(62) SI(1) mp(4) p(2)	n(10)	n(1)									
Other (loud noises eg. generators, camp construction, wolves howling)																n(3)	n(1)	n(1)	n(1)	n(1)				n(1)	

a Adapted from original table in Johnston-Beaver (1978).
b Time of season: M=May; Jn=June; J1=July; A=August; S=September.
c Symbols: n=none; S1=slight; mp=moderately pronounced; p=pronounced.
d Number in parentheses is the number of observed responses.

Table 9. Levels of observed responses of young White Pelicans to current levels of human activity near the rookery during the 1976 and 1977 breeding seasons.[a,b]

	Levels of Young White Pelicans Response[c] at Estimated Closest Approach by Disturbance																			
	Less than 100 metres				100 - 300 metres				300 - 500 metres				500 - 1000 metres				Greater than 1000 metres			
Type of Disturbance	Jn	J1	A	S	Jn	J1	A	S	Jn	J1	A	S	Jn	J1	A	S	Jn	J1	A	S
Observers																				
1) Floating Blind		S1(1)[d]																		
2) Permanent Blind									n(45)	n(75)	n(69)	n(11)								
Aircraft																				
1) Single engine																				
i) cruising overhead or to one side															p(1)				n(2)	
ii) landing														n(1) S1(3)	p(5)	p(1)				
iii) takeoff														n(1) S1(3)	p(1)	mp(1) p(1)				
2) Jet Helicopter																	n(1)	S1(1)	p(1)	
3) Jet Planes																	n(3)	n(1) S1(2)	n(3) S1(1) mp(2) p(1)	n(1) S1(1)
Human Intruder in Canoe			p(3)			S1(1)	S1(2) mp(1) p(3)	p(1)	n(45)	n(75)	n(51) S1(2) mp(12) p(4)	n(7) S1(1) mp(2) p(1)			p(1)					
Other																				
(loud noises e.g. generators, camp construction, wolves howling)														n(1)	p(1)					

a Adapted from original table in Johnston-Beaver (1978).

b Time of season: Jn = June; J1 = July; A = August; S = September.

c Symbols: n = none; S1 = slight; mp = moderately pronounced; p = pronounced.

d Number in parentheses is the number of observed responses.

response levels remain to be established. Additionally, approaches in the floating blind were always made gradually so that the birds were not suddenly presented with an unfamiliar stimulus.

On a relative basis, the most pronounced reactions of adults and young were observed in response to aircraft (Tables 8 and 9). In June, when most adults were either incubating eggs or brooding young, moderately pronounced reactions were observed in response to take-offs and landings by a single-engine Cessna 185 aircraft at distances from 500 to 1000 m from the island. Responses of adults appeared to become more pronounced after they had completed brooding young in July and August. We purposely did not land floatplanes on Birch Lake during the courtship and colony formation (in May) phases of reproduction in order to eliminate the possibility of abandonment by the breeding birds. Adults, however, were observed to respond slightly to aircraft flying in the vicinity at estimated altitudes or distances greater than 300 m during these periods (Table 8).

Responses of young White Pelicans to aircraft activity appeared to increase in intensity after they had left the nest and achieved a degree of independence in July and August and, in contrast to the adults, displayed more pronounced reactions to high flying commercial jets during this period (Tables 8 and 9). Pronounced responses of young also occurred when a single-engine Cessna 185 took off from or landed on the lake from 500 to 1000 m from the rookery during the postfledging period as well (Table 9). Landings of this type of aircraft at these distances appeared to be less disruptive to adults than take-offs (Table 8), whereas young did not appear to demonstrate different response intensities as measured by our technique although the number of tests were limited. Responses of adults and young to various other observed disturbances are also presented in Tables 8 and 9; however, discussion of these is hampered by lack of a sufficient number of observations.

It was apparent that both adults and young were alarmed by certain activities occurring near the rookery although a large number of observations is lacking for all types of disturbances, particularly during the earlier phases of the reproductive cycle. Further study is indicated here if more exact threshold response levels are to be determined.

The observation of moderately pronounced levels of response to various disturbances was viewed as being potentially detrimental to the breeding success of White Pelicans. Direct approaches to the nesting area by boaters or people on foot have apparently resulted in several site abandonments in the past (Farley 1919; Behle 1935; Low et al. 1950; Marshall and Giles 1953; Hosford 1965; Sanderson 1966; Anderson and Bartonek 1967; Vermeer 1969, 1971; Evans 1972; Knopf et al. 1975; Johnson and Sloan 1976).

Even temporary abandonment of nests results in conditions which enhance mortality of eggs or young and often results in the reproductive failure of entire colonies if disturbance is prolonged. These conditions include breakage of eggs by flushing adults or young, predation of nest contents by gulls and exposure of eggs and nestling young to extreme environmental conditions. Our results show that adults normally do not leave nests exposed for periods much longer than 1 min even during a nest relief which doubtlessly limits the opportunity for nest predation by gulls and overheating or chilling of their eggs or young.

Subsequent renesting attempts by disturbed White Pelicans have not been adequately documented to determine the degree of compensation afforded by such a strategy but it is suspected that prolonged disturbances at sites used by breeding White Pelicans would preclude renesting attempts there. Our observations indicated that levels of responses sufficient to be of concern could be evoked by the following types of disturbance (Table 8 and 9).

1. Approaches by canoe at estimated distances less than 1000 m. Approaches at distances greater than 300 m are potentially disruptive after young have left their nests at approximately three weeks of age.
2. Overflights by single-engined aircraft (Cessna 185) at estimated distances less than 500 m. Such overflights do not appear to be disruptive to adults until their young have left the nests;
3. Take-off and landings of both single-engined light planes (Cessna 185) or jet helicopters (Hughes 500-C) at estimated distances less than 1000 m from the rookery. There were indications of disturbed behaviour at distances greater than 1000 m, however thresholds were not clearly established; and
4. Overflights of commercial jet airplanes at estimated altitudes greater than 1000 m. Young appeared to demonstrate more pronounced reactions here than adults.

We were unable to detect the degree, if any, of accommodation to the various types of disturbance observed during the course of this study or whether there was heightened sensitivity resulting from prolonged disturbance over a number of years. It appeared, however, that during incubation breeding adults were reluctant to leave their nests in response to disturbance. The apparent increase in responsiveness to disturbance by adults after they ceased brooding their young probably reflected a decrease in motivation to remain with the nest once young had left them. Young pelicans, until they had attained the age of at least two weeks, were incapable of demonstrating detectable alarm responses but, with the attainment of mobility, readily reacted to human related disturbance and, in fact, were observed to huddle in response to the nearby presence of potential avian predators such as Common Ravens (*Corvus corax*), Bald Eagles (*Haliaeetus leucocephalus*) and Goshawks

(*Accipiter gentilis*). Such responses by the young were apparently adaptive, given their inability to flee as readily as adults and were more pronounced in response to a given distubance than were the responses of adults.

6. SUMMARY AND CONCLUSIONS

During the spring and summer months from 1975 to 1977, studies were conducted in the designated oil sands study area of northeastern Alberta, investigating the breeding distribution, habitat and behaviour of White Pelicans. Aerial surveys revealed that the birds bred only in the Birch Mountains area. Subsequent investigations, employing both ground and aerial reconnaisance, enabled the collection of pertinent data in the project study area located in the Birch Mountains.

White Pelicans arrived at the breeding grounds before ice had left the majority of water bodies in the spring; concentrations of birds were observed on or near available open water, areas thought to provide critical foraging habitat at that time of year. White Pelicans were also observed in advance of spring break-up at the rookery site subsequently used.

White Pelicans nested only on low lying islands in permanent water bodies in the project study area. Characteristically, the islands used possessed gradually sloping terrain, nesting substrates of loose soil, gravel, sand, clay, or forest litter. Loafing areas of mud, sand, rock, or gravel bars or spits were located immediately adjacent to the nesting areas as part of the islands themselves. Vegetative cover on nesting sites varied from sparse to partly forested with sparse shrub understories. Trampling activity by the breeding birds and probably conditioning of soils by excrement were thought to affect ground and forest cover on rookeries.

An estimated 140 breeding pairs established nests on a small sparsely vegetated island in Birch Lake in 1976. In 1977, only an estimated 70 breeding pairs established nests at the same site. Reasons contributing to the observed reduction in the breeding population estimates were thought to be related to prior lowered reproductive success and/or high moratlity of adults and subadults at the Namur Lake rookery as late as 1975 and recurrent flooding of the nesting site at Birch Lake.

White Pelicans established nests in four spatially separate breeding colonies in 1976 and five colonies in 1977. Asynchrony of reproductive events varied as much as one month among colonies in 1976 and two weeks in 1977. In both years, the first established colony was located on the higher ground and contained the greatest number of nests. Estimated colony sizes varied from four to seventy nests.

Breeding success estimates, calculated from estimates of the total number of eggs laid and counts of the number of young raised to the flying stage, were 22.1 and 5.7 percent in 1976 and 1977 respectively. The loss of an estimated 8 to 20 nests to high water levels in 1976 was thought to be a major contributing factor to the reduced breeding success observed in that year. Other contributing mortality factors, for which only 1977 data were collected, demonstrated an 11.7 percent loss of eggs and a 19.1 percent loss of young, primarily during the nestling period when young were less than two weeks old. Nest abandonment, eggs rolling from the nest, and failure of eggs to hatch accounted for egg losses. Causes of chick mortality could not be determined but appeared to be more frequent among nestlings than fledged young.

Reproductive chronologies of observed pairs indicated an incubation period lasting approximately 30 d and a subsequent continuous brooding period of from two to three weeks duration. Thereafter, parents left their chicks unattended for increasingly longer periods of time, returning only to feed them. Young left the nests when they were two to three weeks old and joined social aggregations (termed pods) of similar aged young. Throughout the day, young pelicans remained intermittently in pods until they were approximately five to seven weeks of age, thereafter roosting alone in the overnight period. Young first bathed at five to six weeks of age and made their first short flights when eight to nine weeks old.

Adults departed from the rookery toward the foraging areas primarily during the midday period of the daylight hours observed and similarly returned at midday to either feed their young or relieve mates on nests. No demonstrably significant differences in the mean elapsed times for nest relief ceremonies were observed between incubating and brooding adults or male and female members of the pair. Pair members could be distinguished by size difference, males being generally larger than females, and other morphological characteristics. Males possessed longer bills than females and, during the presupplemental moult of the head region, individual plumage characteristics were evident.

Reactions of both adults and young to various disturbances near the rookery, including aircraft movements, canoes, and other human related activites, appeared to vary in the degree of response elicited, depending on the timing during the reproductive season when the disturbance occurred, the type of disturbance and the estimated distance of the disturbance from the birds. Pronounced alert responses were recorded to both aircraft and humans in canoes although clear response threshold distances were not established for various other forms of disturbance.

Breeding adults on nests appeared reluctant to leave their nests during incubation and brooding. However, after this period had passed, there were more inclined to leave the rookery when disturbed. Young pelicans were incapable of locomotion until they were approximately two to three weeks of age and did not demonstrate discernible alarm responses until that age; thereafter, young would cluster together and move away from the source of disturbance. Young in this latter age group appeared to react in a more pronounced manner than adults to identical disturbance situations.

Young White Pelicans dispersed from the home lake approximately two weeks after they first flew and probably began migration immediately. This period marked the abrupt end of the dependent phase and adult parents responded by migrating shortly thereafter. Asynchrony of reproductive events among the breeding colonies at the rookery resulted in a protracted migration departure scheduling varying from early September to mid-October.

7. MANAGEMENT AND RECLAMATION RECOMMENDATIONS

7.1 DURING THE OIL SANDS DEVELOPMENT PERIOD

The breeding habitat of the only known breeding concentration of White Pelicans in the entire designated oil sands study area is probably not threatened by practises presently employed to extract oil from the oil sands. In the Birch Mountains area, overburden thicknesses in excess of 152 m would limit a feasible recovery of bitumen to an in situ mode of operation which would entail probable environmental constraints of land clearing, groundwater regime alteration and surface water contamination (Integ 1973). Additionally, the power requirements of such operations would entail additional impacts as a result of easement routings. Periodic service and maintenance visits would also be anticipated to such sites, requiring undetermined modes of transportation. Integ (1973) also identified the Birch Mountain Lakes area as potentially valuable for recreation purposes; we agree that planning for the optimum utilization of this area be carried out, recognizant of the potential conflicts with critical or sensitive wildlife species and habitats. The reclamation and management recommendations in this section are based, then, on probable development scenarios in the identified project study area relating to the establishment of in situ extraction plants and recreational use of the Birch Mountains.

At present, the technology of in situ modes of bitumen extraction is in the experimental stages. Anticipated operations would apparently involve the liquification of viscous bitumen by chemical or physical manipulations, possibly requiring energy supplies to power the preparation facilities. Land clearing operations involved in site preparation, storage area construction, and power easement routings would not be potentially detrimental to White Pelicans unless they occurred near the shores of lakes utilized by White Pelicans for foraging or breeding. The danger of abandonment of breeding locations in apparent response to distubance near such locations has been indicated although specific disturbances associated with in situ site exploration, construction, operation and maintenance have not been conducted.

The potential for disruption of breeding habitat exists where in situ operations would affect water levels in lakes and the quality of water in those lakes or drainages which they are part of. It is particularly important, then, that due consideration be given to the effect on water levels of lakes used as water supplies for such operations and the construction of storage ponds near drainages of these lakes where White Pelicans are known to breed. Seepage of processed bitumen or the chemicals used in its recovery into a water body used by White Pelicans could conceivably curtail its use by the birds. Noise levels generated by pressure equipment at in situ sites or the presence of aircraft used to access them are deemed potentially disruptive to breeding White Pelicans and it is therefore recommended that such sites not be located within 2 km of a known rookery site. This distance is deemed sufficiently removed to allow the undisturbed functioning of nesting White Pelicans and their young.

Of primary importance in addressing the disturbance mediated reproductive failure of White Pelicans in the Birch Mountains area is a consideration of the anticipated accelerated use by people pursuing recreational activities. Our behavioural data suggest that light aircraft flying over a breeding site during the critical reproductive season, beginning 1 April and ending 15 October, at altitudes less than 500 m, may cause undue alarm to the birds. Similarly, landings or take-offs of such aircraft within 2 km of a known rookery are not recommended during this critical period.

Direct approaches by persons on foot or in boats at breeding locations are not recommended. Authorization should be required for such approaches which are closer than 1 km from a known rookery during the critical reproductive season beginning 1 April and ending 15 October.

Disturbance to nesting White Pelicans and their young can be kept to a minimum within the above stated distances by researchers who have a knowledge of the stage of the reproductive cycle for a given rookery. The management recommendations as outlined are intended, however, to prevent the abandonment of breeding sites caused by intrusions of uninformed members of the public. Certainly, the dangers of reproductive failure are highest during the period up to the time young are two to three weeks of age. Thereafter, they can be left alone for longer periods without consequence.

Harassment of young White Pelicans has been considered a potential indirect cause of mortality throughout the period of dependence (Hall 1925; Behle 1935; Bartholmew et al. 1953; Johnson and Sloan 1976). Heat stress, trampling, gull predation, and chilling are cited as the probable causative agents of disturbance-related egg and chick mortality. Certainly, these problems would not be factors if the birds were left alone. Adoption of the access restrictions outlined in this report would do much to eliminate unnecessary disturbance.

There is much that could be done in addition to preserving unmolested breeding sites. Improvement of the Birch Lake rookery by eliminating the beaver impoundments which flood the island periodically or actual reconstruction of the island itself could ensure the perpetuation of this site. The partial clearing of sections of suitable island breeding sites at other lakes would further enhance their suitability as nesting locations. The encroachment of woody perennial shrubs at rookery sites abandoned in the past may affect the subsequent recolonization of the site and partial clearing would solve the problem. The availability of a number of alternate nesting locations has probably enabled successful production after years of abandonment due to the disturbance or flooding of nest islands in the Birch Mountains. The continued maintenance of suitable alternate island breeding sites could be accomplished through such habitat manipulation in conjunction with restriction of human access. This approach is deemed both feasible and desirable.

The breeding White Pelicans of the Birch Mountains are a unique component of the wilderness forest and lake system found there. The prime attractions of this scenic area have been identified as trophy sport fishing, canoeing, and other related outdoor activities (Integ 1973). Development of the area's recreational potential need not preclude the continued presence there of this species.

7.2 RECOMMENDATIONS OF GENERAL SCIENTIFIC IMPORTANCE

The detailed study of a species that has demonstrated a marked sensitivity to human encroachments is difficult. Traditional and very useful methods for obtaining reliable population statistics are difficult to apply to a study of White Pelicans in that they require an undesirable degree of contact with the birds. It is thought, however, that, with the application of scientific study guidelines as outlined in this report and others (Knopf et al. 1975; Johnson and Sloan 1976), disruptive disturbance can be kept to a minimum and allow the collection of much useful information. When possible, banding efforts should be conducted during the period that all young have been hatched and the majority are between the ages of two to four weeks. The degree of asynchrony existing among colonies at a particular rookery will, of course, determine the timing of banding efforts. At such times, young are not sufficiently mobile to escape and trample one another nor are they as susceptible to gull predation, chilling, exposure, or becoming lost. Adults do not appear to abandon young when disturbed.

Banding and marking studies could provide the following pertinent data which are now found to be lacking:

1. Information regarding sex ratios in the breeding population and sex related mortality rates;
2. Age of maturity;
3. Dispersal patterns; and
4. Migration routes and wintering areas and some indication of migration related mortality.

Population dynamics studies, in conjuction with continued monitoring of breeding population statuses and reproductive successes, would do much to enhance the present management criteria for this long-lived species.

In this report, we have attempted to make recommendations based on the available knowledge of the responses of the birds to observed incidental disturbance. It should be clear that hiatuses in the data base exist, particularly in the documentation of clear threshold response distances for nesting White Pelicans and their young. The information gathered as a result of this study, while providing useful interim management guidelines for a specific situation, could be greatly improved with more observations in controlled situations where noise levels, distances, and the type of disturbance are known. The available data could be very useful in designing further studies.

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9. APPENDIX

Fifty water bodies located within and adjacent to the project study area were assigned site numbers. The suitability of these water bodies was categorized on a scale rating the breeding potential from nil to optimum as outlined in Section 4.2.1 of this report. These ratings are presented in Figure 16 and Table 10.

9.1 LITERATURE SUMMARY

9.1.1 Status of Continental Breeding Population

Fischer 1974; Vermeer 1970b, 1975; Markham 1978.

9.1.2 Factors Affecting Distribution and Breeding Success

Bailey 1935; Behle 1935; Blokpoel 1971; Carroll 1930; Carson 1966; Evans 1972; Farley 1919; Fischer 1974; Greichus and Greichus 1973; Houston 1962; Hosford 1965; Hall 1925; Johnson 1976; Johnson and Sloan 1976; Knopf 1976; Knopf et al. 1975; Lies and Behle 1966; Low et al. 1950; Marshall and Giles 1953; McCrow 1974; Strait 1973; Sanderson 1966; Vermeer 1968, 1969, 1970b, 1970c, 1971, 1975.

Also

Brown and Urban (1969) and Brown et al. (1973) presented factors affecting distribution of the Great White Pelican (*Pelecanus onocrotalus)*, a related African species. Emlen and Demong (1975) presented data on the colonially nesting Bank Swallow (*Riparia riparia)* which suggested that synchronized breeding enhanced social foraging efficiency. Gillet et al. (1975) studied the effects of human disturbance on egg and chick mortality in the Glaucous-winged Gull (*Larus glaucescens*), a colonially nesting species. Greichus et al. (1976) illuminated several of the afflictions and their treatment of captive-raised young White Pelicans.

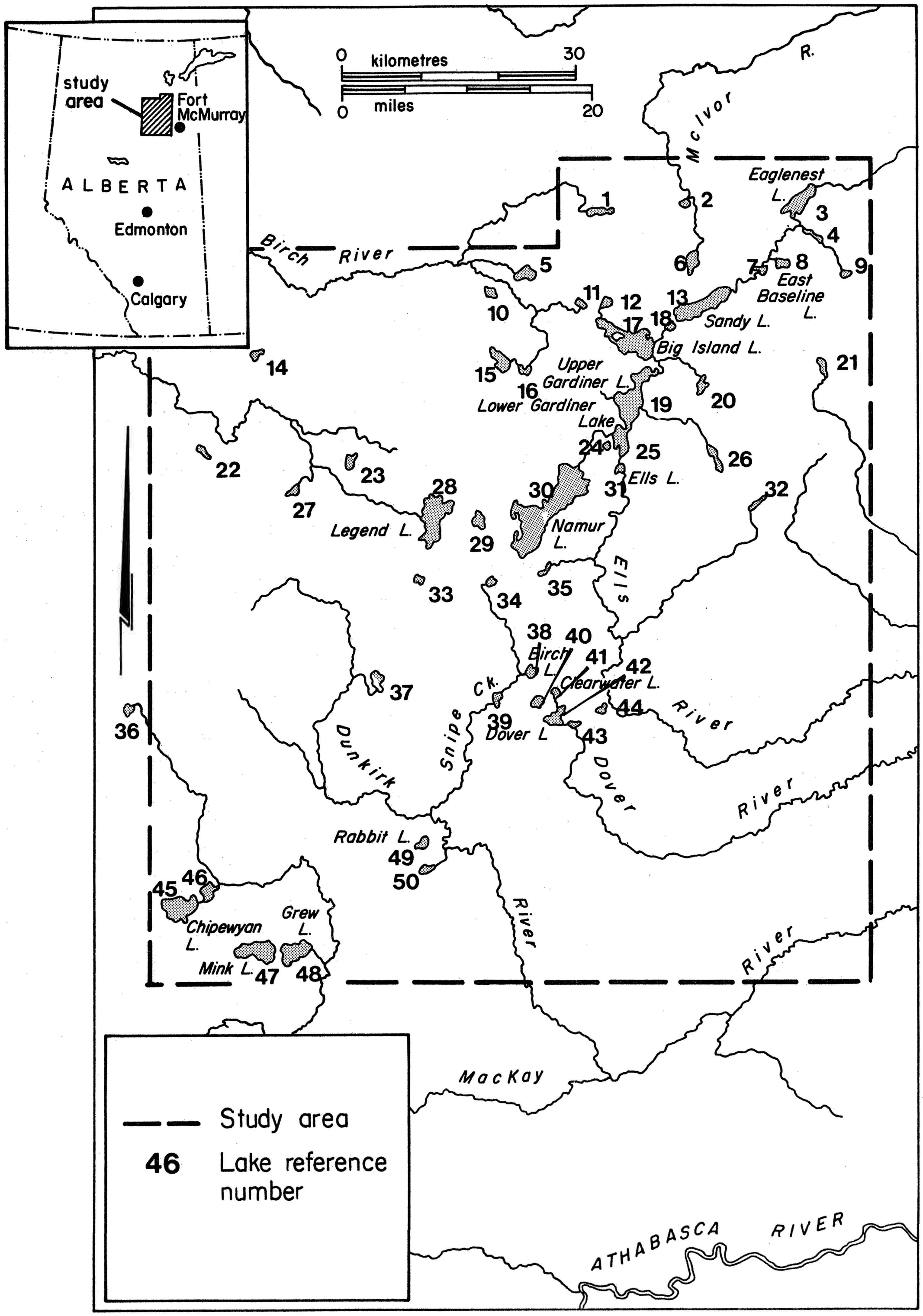

Figure 16. Map of the project study area showing lakes evaluated for White Pelican breeding potential.

Table 10. Breeding potential for White Pelicans of lakes evaluated within the project study area.[a]

Site Number	Breeding Potential[b]	Site Number	Breeding Potential
1	n	26	n
2	n	27	n
3	n	28	n
4	l[c]	29	n
5	m[c]	30	o
6	n	31	n
7	n	32	n
8	n	33	n
9	n	34	n
10	n	35	n
11	n	36	n
12	l	37	n
13	l	38	m
14	n	39	l
15	n	40	n
16	n	41	n
17	o	42	l
18	l	43	n
19	m	44	n
20	n	45	n
21	n	46	n
22	n	47	n
23	n	48	n
24	n	49	n
25	l	50	n

[a] Site numbers correspond to those indicated on Figure 16.

[b] Symbols: n = nil; l = low; m = moderate; o = optimum;

[c] Not ground truthed.

9.1.3 Site Specific Records and Observations

Many of the articles investigated dealt with local observations and were informative in that comparable data were collected in a number of cases. These records have been categorized by name or locality.

A. Canadian Sites

(i) Numar Lake, Alberta

Beaver 1977; Beaver and Ballantyne 1977; Bishoff and Fyfe 1976; Ealey 1979; Vermeer 1969.

(ii) Miquelon Lake, Alberta

Farley 1919.

(iii) Lavellee Lake and Other Saskatchewan Rookeries

Houston and Street 1959; Houston 1962; Trottier and Breneman 1976; Trottier 1977; Vermeer 1970a, 1970b, 1970c.

(iv) Manitoba

Hosford 1965; Vermeer 1970b.

(v) Stum Lake, British Columbia

Campbell and Frost 1969.

B. United States Sites

(i) Chase Lake and Other North Dakota Sites

Johnson 1976; Johnson and Sloan 1976; Stewart 1975; Strait 1973.

(ii) South Dakota

McCrow 1974.

(iii) Great Salt Lake, Utah

Behle 1935; Knopf 1975a; Low et al. 1950.

(iv) Nevada

Bond 1940; Hall 1925; Marshall and Giles 1953; Mills 1925.

(v) Yellowstone Lake, Wyoming

Schaller 1964.

9.1.4 Breeding Site Requirements and Descriptions

Beaver and Ballantyne 1977; Behle 1935; Campbell and Frost 1969; Farley 1919; Houston 1962; Hosford 1965; Johnson 1976; Knopf 1975a, 1976; Low et al. 1950; Marshall and Gile 1953; McCrow 1974; Snaderson 1966; Stewart 1975; Trottier and Breneman 1976; Vermeer 1970b, 1975.

Also

Crook (1965) hypothesized that colony site preference for many bird species depended both on predator inaccessiblity and abundant food resources, the latter being most efficiently explotied by recruiting type behaviours. Din and Eltringham (1974) described the tree nesting habitats of the Pink-bakced Pelican (*Pelecanus rufescens*) in Uganda. Emlen and Demong (1975) suggested that a relationship existed btween colony location and the nature of the food supply used by Bank Swallows. Finally, Ward and Zahavi (1973) presented arguments to support the hypothesis that, for many colonial nesting bird species, food availability, not predation, is more important in determining the location of the colony.

9.1.5 General Biology

Bailey 1935; Bent 1922; Palmer 1962; Salt and Wilk 1966; Salt and Salt 1976; van Tyne and Berger 1976. The last reference dealt with the pelican family in general.

Also

Brown et al. (1973) discussed the reproductive biology of the Great White Pelican at Lake Shala, Ethiopia. McCrow (1974) contributed similar information for White Pelicans in South Dakota.

9.1.6 Population Structure and Dynamics

McCrow 1974; Strait 1973; Strait and Sloan 1974.

9.1.7 Physiology and Anatomy

Bartholomew et al. 1953.

Also

Burton (1977) promoted muscle mechanics as the primary agent responsible for pouch expansion in Brown Pelicans (*Pelecanus occidentalis*) whereas Schreiber et al. (1975) ascribed a hydraulic mechanism to the same function.

9.1.8 Description of Eggs

Behle 1935; Evans 1969; Greichus and Greichus 1973; Palmer 1962.

9.1.9 Moulting and Plumages

Behle 1935; Knopf 1975a; Palmer 1962.

Also

Baxer and Urban (1970) and Brown and Urban (1969) observed plumages of the Great White Pelican in Africa. Din and Eltringham (1974) described the plumage changes of adult and young Pink-backed Pelicans in Africa.

9.1.10 Pesticide Monitoring

Anderson et al. 1969; Greichus and Greichus 1973; Knopf and Street 1974; Vermeer and Reynolds 1970.

Also

Strait (1973) measured eggshell thickness but not the actual pesticide residue levels themselves.

9.1.11 Migration Routes and Winter Range

Houston 1967, 1968; Low et al. 1950; Marshall and Giles 1953; Palmer 1962; Strait 1973; Vermeer 1970a, 1975; Ward 1924.

Also

Urban and Jefford (1977) provided the first data on dispersal of marked juvenile Great White Pelicans from Lake Shala, Ethiopia.

9.1.12 Spring Arrival Dates

Beaver and Ballantyne 1977; Behle 1935; Houston and Street 1959; Knopf 1975a, 1976; Schaller 1964; Trottier and Breneman 1976.

9.1.13 Rare Breeding Records and Recolonization Attempts

Behle 1935; Carroll 1930; Hatfield 1973; Ryder and Grieb 1963.

9.1.14 Food Habits and Foraging Observations

Bartholomew et al. 1953; Behle 1935; Bond 1940; Brown and Graham 1953; Cottam and Uhler 1937; Cottam and Williams 1939; Greichus et al. 1976; Hall 1925; Johnson 1976; Low et al. 1950; Marshall and Giles 1953; Mills 1925; Stewart 1975; Trottier 1977.

Also

Brown and Urban (1969) and Brown et al. (1973) presented diet information for the Great White Pelican in Africa. Henderson (1975) investigated feeding rites in Glaucous-winged Gulls. Lowe and Lowe (1976) observed attempted predations of juvenile Silver Gulls (*Larus novaehollandia)* by Australian Pelicans (*Pelecanus conspicillatus)*.

9.1.15 Behaviour

Beaver and Ballantyne 1977; Cottam and Williams 1939; Knopf 1975a, 1976; Low et al. 1950; Mills 1925; Strait 1973; Schaller 1964; van Tets 1965.

Also

Brown and Urban (1969) and Brown et al. (1973) studied the breeding behaviour of the Great White Pelican in Ethiopia. Burke and Brown (1970) presented observations on patterns of species received similar attention in Uganda from Din and Eltringham (1974). Henderson (1975) studied the role of the chicks' begging behaviour in parental feeding behaviour in Glaucous-winged Gulls. Robert and

Ralph (1975) studied the behavioural responses to disturbance of Western Gulls in California. Schreiber (1977) discussed maintenance behaviour and communication patterns of the Brown Pelican in Florida.

Three additional papers, more theoretical in their treatments, discussed the adaptiveness of social behaviours of various bird spcies (Crook 1965; Emlen and Demong 1975; Ward and Zahavi 1973).

9.1.16 Management Recommendations

Most of the articles in this category acknowledged the sensitivity of White Pelicans to disturbance during the nesting season and recommended that casual human visitations to the breeding sites be curtailed. Included were: Beaver and Ballantyne 1977; Fischer 1974; Greichus et al. 1976; Houston 1966; Johnson and Sloan 1976; Knopf et al. 1975; Lies and Behle 1966; Vermeer 1970c, 1971, 1975.

10. AOSERP RESEARCH REPORTS

1.		AOSERP First Annual Report, 1975
2.	AF 4.1.1	Walleye and Goldeye Fisheries Investigations in the Peace-Athabasca Delta--1975
3.	HE 1.1.1	Structure of a Traditional Baseline Data System
4.	VE 2.2	A Preliminary Vegetation Survey of the Alberta Oil Sands Environmental Research Program Study Area
5.	HY 3.1	The Evaluation of Wastewaters from an Oil Sand Extraction Plant
6.		Housing for the North--The Stackwall System
7.	AF 3.1.1	A Synopsis of the Physical and Biological Limnology and Fisheries Programs whithin the Alberta Oil Sands Area
8.	AF 1.2.1	The Impact of Saline Waters upon Freshwater Biota (A Literature Review and Bibliography)
9.	ME 3.3	Preliminary Investigations into the Magnitude of Fog Occurrence and Associated Problems in the Oil Sands Area
10.	HE 2.1	Development of a Research Design Related to Archaeological Studies in the Athabasca Oil Sands Area
11.	AF 2.2.1	Life Cycles of Some Common Aquatic Insects of the Athabasca River, Alberta
12.	ME 1.7	Very High Resolution Meteorological Satellite Study of Oil Sands Weather: "A Feasibility Study"
13.	ME 2.3.1	Plume Dispersion Measurements from an Oil Sands Extraction Plant, March 1976
14.		
15.	ME 3.4	A Climatology of Low Level Air Trajectories in the Alberta Oil Sands Area
16.	ME 1.6	The Feasibility of a Weather Radar near Fort McMurray, Alberta
17.	AF 2.1.1	A Survey of Baseline Levels of Contaminants in Aquatic Biota of the AOSERP Study Area
18.	HY 1.1	Interim Compilation of Stream Gauging Data to December 1976 for the Alberta Oil Sands Environmental Research Program
19.	ME 4.1	Calculations of Annual Averaged Sulphur Dioxide Concentrations at Ground Level in the AOSERP Study Area
20.	HY 3.1.1	Characterization of Organic Constituents in Waters and Wastewaters of the Athabasca Oil Sands Mining Area
21.		AOSERP Second Annual Report, 1976-77
22.		Alberta Oil Sands Environmental Research Program Interim Report to 1978 covering the period April 1975 to November 1978
23.	AF 1.1.2	Acute Lethality of Mine Depressurization Water on Trout Perch and Rainbow Trout
24.	ME 1.5.2	Air System Winter Field Study in the AOSERP Study Area, February 1977.
25.	ME 3.5.1	Review of Pollutant Transformation Processes Relevant to the Alberta Oil Sands Area

26.	AF 4.5.1	Interim Report on an Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
27.	ME 1.5.1	Meteorology and Air Quality Winter Field Study in the AOSERP Study Area, March 1976
28.	VE 2.1	Interim Report on a Soils Inventory in the Athabasca Oil Sands Area
29.	ME 2.2	An Inventory System for Atmospheric Emissions in the AOSERP Study Area
30.	ME 2.1	Ambient Air Quality in the AOSERP Study Area, 1977
31.	VE 2.3	Ecological Habitat Mapping of the AOSERP Study Area: Phase I
32.		AOSERP Third Annual Report, 1977-78
33.	TF 1.2	Relationships Between Habitats, Forages, and Carrying Capacity of Moose Range in northern Alberta. Part I: Moose Preferences for Habitat Strata and Forages.
34.	HY 2.4	Heavy Metals in Bottom Sediments of the Mainstem Athabasca River System in the AOSERP Study Area
35.	AF 4.9.1	The Effects of Sedimentation on the Aquatic Biota
36.	AF 4.8.1	Fall Fisheries Investigations in the Athabasca and Clearwater Rivers Upstream of Fort McMurray: Volume I
37.	HE 2.2.2	Community Studies: Fort McMurray, Anzac, Fort MacKay
38.	VE 7.1.1	Techniques for the Control of Small Mammals: A Review
39.	ME 1.0	The Climatology of the Alberta Oil Sands Environmental Research Program Study Area
40.	WS 3.3	Mixing Characteristics of the Athabasca River below Fort McMurray - Winter Conditions
41.	AF 3.5.1	Acute and Chronic Toxicity of Vanadium to Fish
42.	TF 1.1.4	Analysis of Fur Production Records for Registered Traplines in the AOSERP Study Area, 1970-75
43.	TF 6.1	A Socioeconomic Evaluation of the Recreational Fish and Wildlife Resources in Alberta, with Particular Reference to the AOSERP Study Area. Volume I: Summary and Conclusions
44.	VE 3.1	Interim Report on Symptomology and Threshold Levels of Air Pollutant Injury to Vegetation, 1975 to 1978
45.	VE 3.3	Interim Report on Physiology and Mechanisms of Air-Borne Pollutant Injury to Vegetation, 1975 to 1978
46.	VE 3.4	Interim Report on Ecological Benchmarking and Biomonitoring for Detection of Air-Borne Pollutant Effects on Vegetation and Soils, 1975 to 1978.
47.	TF 1.1.1	A Visibility Bias Model for Aerial Surveys for Moose on the AOSERP Study Area
48.	HG 1.1	Interim Report on a Hydrogeological Investigation of the Muskeg River Basin, Alberta
49.	WS 1.3.3	The Ecology of Macrobenthic Invertebrate Communities in Hartley Creek, Northeastern Alberta
50.	ME 3.6	Literature Review on Pollution Deposition Processes
51.	HY 1.3	Interim Compilation of 1976 Suspended Sediment Date in the AOSERP Study Area
52.	ME 2.3.2	Plume Dispersion Measurements from an Oil Sands Extraction Plan, June 1977

53.	HY 3.1.2	Baseline States of Organic Constituents in the Athabasca River System Upstream of Fort McMurray
54.	WS 2.3	A Preliminary Study of Chemical and Microbial Characteristics of the Athabasca River in the Athabasca Oil Sands Area of Northeastern Alberta
55.	HY 2.6	Microbial Populations in the Athabasca River
56.	AF 3.2.1	The Acute Toxicity of Saline Groundwater and of Vanadium to Fish and Aquatic Invertebrates
57.	LS 2.3.1	Ecological Habitat Mapping of the AOSERP Study Area (Supplement): Phase I
58.	AF 2.0.2	Interim Report on Ecological Studies on the Lower Trophic Levels of Muskeg Rivers Within the Alberta Oil Sands Environmental Research Program Study Area
59.	TF 3.1	Semi-Aquatic Mammals: Annotated Bibliography
60.	WS 1.1.1	Synthesis of Surface Water Hydrology
61.	AF 4.5.2	An Intensive Study of the Fish Fauna of the Steepbank River Watershed of Northeastern Alberta
62.	TF 5.1	Amphibians and Reptiles in the AOSERP Study Area
63.	ME 3.8.3	Calculate Sigma Data for the Alberta Oil Sands Environmental Research Program Study Area.
64.	LS 21.6.1	A Review of the Baseline Data Relevant to the Impacts of Oil Sands Development on Large Mammals in the AOSERP Study Area
65.	LS 21.6.2	A Review of the Baseline Data Relevant to the Impacts of Oil Sands Development on Black Bears in the AOSERP Study Area
66.	AS 4.3.2	An Assessment of the Models LIRAQ and ADPIC for Application to the Athabasca Oil Sands Area
67.	WS 1.3.2	Aquatic Biological Investigations of the Muskeg River Watershed
68.	AS 1.5.3 AS 3.5.2	Air System Summer Field Study in the AOSERP Study Area, June 1977
69.	HS 40.1	Native Employment Patterns in Alberta's Athabasca Oil Sands Region
70.	LS 28.1.2	An Interim Report on the Insectivorous Animals in the AOSERP Study Area
71.	HY 2.2	Lake Acidification Potential in the Alberta Oil Sands Environmental Research Program Study Area
72.	LS 7.1.2	The Ecology of Five Major Species of Small Mammals in the AOSERP Study Area: A Review
73.	LS 23.2	Distribution, Abundance and Habitat Associations of Beavers, Muskrats, Mink and River Otters in the AOSERP Study Area, Northeastern Alberta
-	--	Interim Report to 1978
74.	AS 4.5	Air Quality Modelling and User Needs
75.	WS 1.3.4	Interim report on a comparative study of benthic algal primary productivity in the AOSERP study area

76. AF 4.5.1 An Intensive Study of the Fish Fauna of the Muskeg River Watershed of Northeastern Alberta
77. HS 20.1 Overview of Local Economic Development in the Athabasca Oil Sands Region Since 1961.
78. LS 22.1.1 Habitat Relationships and Management of Terrestrial Birds in Northeastern Alberta.
79. AF 3.6.1 The Multiple Toxicity of Vanadium, Nickel, and Phenol to Fish.
80. LS 22.3.1 Biology and Management of Peregrin Falcons (*Falco peregrinus anatum*) in Northeastern Alberta.
81. LS 22.1.2 Species Distribution and Habitat Relationships of Waterfowl in Northeastern Alberta.
82. LS 22.2 Breeding Distribution and Behaviour of the White Pelican in the Athabasca Oil Sands Area.
83. LS 22.2 The Distribution, Foraging Behaviour, and Allied Activities of the White Pelican in the Athabasca Oil Sands Area.

These reports are not available upon request. For further information about availability and location of depositories, please contact:

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