SPECIES DISTRIBUTION AND HABITAT RELATIONSHIPS OF WATERFOWL IN NORTHEASTERN ALBERTA

by

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Canadian Wildlife Service

for

ALBERTA OIL SANDS ENVIRONMENTAL RESEARCH PROGRAM

Project LS 22.1.2

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 "Species Distribution and Habitat Relationships of Waterfowl in Northeastern Alberta".

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,

W. Solodzuk, P.Eng.
Chairman, Steering Committee, AOSERP
Deputy Minister, Alberta Environment

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SPECIES DISTRIBUTION AND HABITAT RELATIONSHIPS OF WATERFOWL IN NORTHEASTERN ALBERTA

DESCRIPTIVE SUMMARY

BACKGROUND AND PERSPECTIVE

This research project was designed to provide the baseline states for waterfowl in the AOSERP study area. In this context, baseline states include: species abundance and diversity, phenology, and habitat relationships for each of the population segments exhitited by waterfowl; as well as spring-staging breeding pairs, broods moulting, and fall-staging. Selected wetlands, representative of the types occurring in the region, were surveyed and categorized according to their relative utilization value by waterfowl.

Specified wetlands in the AOSERP study area are heavily utilized during the spring-staging and fall-staging population segments. Wetlands in the region are not heavily utilized by waterfowl for breeding. Diving ducks utilize oil sands wetlands more extensively than dabbling ducks.

The greatest single source of conflict between waterfowl and oil sands development will be the impact that tailings ponds have on waterfowl. Data presented in this report provide an insight into the most sensitive time of the year during which the most significant contact may occur. Recommendations, specifying methodology to be employed during tailings pond construction and operation which will minimize contact between the tailings pond and waterfowl, are included.

ASSESSMENT

The final report entitled "Species Distribution and Habitat Relationships of Waterfowl in Northeastern Alberta", which was prepared by E. Hennan and B.A. Munson of the Canadian Wildlife Service, has been reviewed and accepted by the Alberta Oil Sands Environmental Research Program.

In view of the value and general application of the data presented in this report to waterfowl management, AOSERP Management have recommended that the report be published as soon as possible. Due to the wide application and interest in the data presented in this report we recommend that this report be given wide distribution.

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ABSTRACT

The objective of the waterfowl segment of the AOSERP/ Avifauna program consisted of determining waterfowl species abundance and diversity and habitat associations.

During waterfowl aerial surveys the length of wetland edge surveyed in 1976 ranged from 373 to 453 km on 65± wetlands. Spring-staging totals for two surveys for this year were 1000 and 3600 ducks. Breeding-pair totals for three surveys ranged from 540 to 870. Two brood surveys revealed 225 and 463 broods; 3590 and 9318 moulting ducks were counted coincidentally. Five fall-staging surveys revealed a total of from 11 000 to 24 000 ducks.

Aerial surveys conducted in 1977 were reduced in number and scope with less than half the number of wetlands surveyed in six surveys.

Oil sands wetlands were more heavily utilized by diving than dabbling ducks.

Analysis of variance for edge type/habitat next-to-edge combinations for diving and dabbling ducks revealed significant associations for both groups of ducks for breeding pairs: dabblers preferred emergent vegetation edge combined with a shrub habitat next-to-edge. Divers preferred, with decreasing preference: emergent vegetation/shrub, wet meadow/coniferous forest, emergent vegetation/wet meadow, and emergent vegetation/mixed forest.

Analysis of spring-staging flocks of both dabblers and divers revealed some preferred habitat associations but these did not prove significant.

Brood and moulter data showed no significant habitat relationships.

Fall-staging divers exhibited significant relationships preferring: open water, shrub/shrub, flooded trees/mixed forest, emergent vegetation/shrub, and shrub/mixed forest.

Fall-staging dabblers exhibited habitat preferences but these were not significant. The preferred wetlands types, in descending order, were: lakes with shallow-marsh aquatics, lakes with deep-marsh aquatics, open lakes, creeks, and rivers.

The significance of individual wetlands in terms of duck numbers and densitites varied throughout the season. However, certain wetlands appeared consistently important: Little McClelland Lake, West Muskeg Lake, Wood Slough, Gordon Lake, Saline Lake, and Algar Lake.

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S. Popowich and B. Chubb drafted the excellent figures incorporated in the text of this report.

The contributions made by L. Hanak, through concern for the quality of the finished product, are gratefully acknowledged.

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1. INTRODUCTION

This is the final report of the Avifauna project LS 22.0[1] to the Alberta Oil Sands Environmental Research Program (AOSERP). The final report incorporates baseline states of avifauna in the AOSERP study area. Because of the tremendous amount of material which must be presented and discussed, the authors have decided to present the data under two separate covers. Waterfowl census and habitat relationships are presented in this volume while data pertaining to terrestrial nongame and upland bird census and habitat relationships are presented in Francis and Lumbis (in prep.).

Previous reports on this sub-project include an interim report submitted on 31 October 1976, in which the objectives and methodology employed in 1976 were discussed together with an outline of the program direction for 1977 and subsequent years. An annual progress report was submitted in April 1977, which provided: (1) short- and long-term objectives of the avifauna program; (2) a description of the AOSERP study area in terms of avifauna concerns; (3) details of the methodology employed; (4) a description of the habitat which were studied; (5) bird density estimates; and (6) interpretation of bird-habitat relationships. A draft final report was submitted in March 1978.

This report deals primarily with the densities, distribution and habitat relationships of waterfowl in the AOSERP study area; included also is a categorization of the surveyed wetlands in terms of relative utilization value (RUV) by waterfowl.

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[1]AOSERP Project LS 22.0 includes the following series of reports:

LS 22.1.1 - Terrestrial game and non game birds.
LS 22.1.2 - Waterfowl.
LS 22.2 - White Pelicans (2 volumes).
LS 22.3.1 - Peregrine Falcon.
LS 22.3.2 - Rare, sensitive and endangered bird surveys.

The focal point of these baseline studies is to provide as complete a list as possible of the presence, distribution, and density of waterfowl together with the habitat requirements of each species, or group of species, as assessed through the correlation of census data with habitat quantification. The goal of the project, therefore, is to ensure that an adequate data base is available to assess and mitigate the potential impact of oil sands development on the avifauna resource and to present informed guidelines to the future direction that land reclamation should take (as it would apply to avifauna).

2. BACKGROUND

Predominantly due to accessibility problems, the Alberta oil sands area (and boreal forest habitats in general) has, until recently, received little attention in terms of purposive avifauna studies. Since 1967, with the advent of large-scale oil sands development by Great Canadian Oil Sands, efforts to assess avian and other wildlife resources have become increasingly intensive.

2.1 WATERFOWL

In 1972-73, Schick and Ambrock (1974) classified the wetlands of the oil sands area according to the Canada Land Inventory system for waterfowl. They also conducted aerial counts of waterfowl during the fall of 1972 and throughout the 1973 season.

In 1975, before the present study, A. Smith and D. Muir (Smith, 1975) counted waterfowl on the same lakes surveyed by Schick and Ambrock (1974), plus several others. (Almost all of these lakes were surveyed in 1976 and 1977 as part of the current study.)

LGL Ltd. Environmental Research Associates conducted intensive migration and breeding studies of waterfowl and wetland-associated species during 1974 and 1975 on and near Syncrude Lease #17 (Sharp et al. 1975, Sharp and Richardson 1976, Ward et al. 1976). Their data provide a comprehensive account of species composition, abundance, and habitat relationships during the early years of habitat disturbance by oil sands development. The conditions encountered during those years can be regarded as transitional; further changes in species composition and bird numbers can be expected as development proceeds. The LGL data will also provide a basis for comparison--qualified according to differences of locations and year of study--of disturbed and undisturbed wetlands.

In addition to the foregoing waterfowl studies connected with the oil sands area, general information on waterfowl in northern Alberta can be found in Peterson (1961), Robbins et al. (1966), Godfrey (1966), Bellrose (1976), and Salt and Salt (1976). Also, the oil sands area is "in line" with the Peace-Athabasca Delta, a major staging area between Arctic breeding ground and southern wintering areas. Information relative to the significance of the Delta with respect to the oil sands can be found in Soper (1951), Nieman and Dirschl (1971), Hennan (1972, 1973, 1974, 1976), and Hennan and Ambrock (1977). Donaghey (1974) assessed waterfowl breeding densities in a boreal forest region near Utikuma Lake, Alberta, 270 km west-southwest of Fort McMurray.

2.2 OBJECTIVES

The objective of the waterfowl segment of the AOSERP/ Avifauna studies was to obtain data on species composition, population densities, and habitat relationships of waterfowl in the oil sands area. This study phase fits into the overall Avifauna program as shown in Figure 1.

The objectives of studies to follow the collection of baseline information include:

1. Examining the effects of direct habitat alteration on avian population densities and species composition; and thus,
2. Assessing the direct impacts of oil sands development;
3. Assessing the impact on avifauna of air- and water-borne contaminants, either through direct exposure or indirectly through the food chain, likely to be introduced by oil sands extraction plants;
4. Assessing the feasibility of predicting avian movements through the development area, in view of potentially hazardous areas such as tailings ponds;
5. Assessing the magnitude of human utilization of the avian resources: consumptive and non-consumptive (in conjunction with the Human Environment Committee): and
6. Designing proposals for incorporation of avian wildlife in reclamation and urban planning.

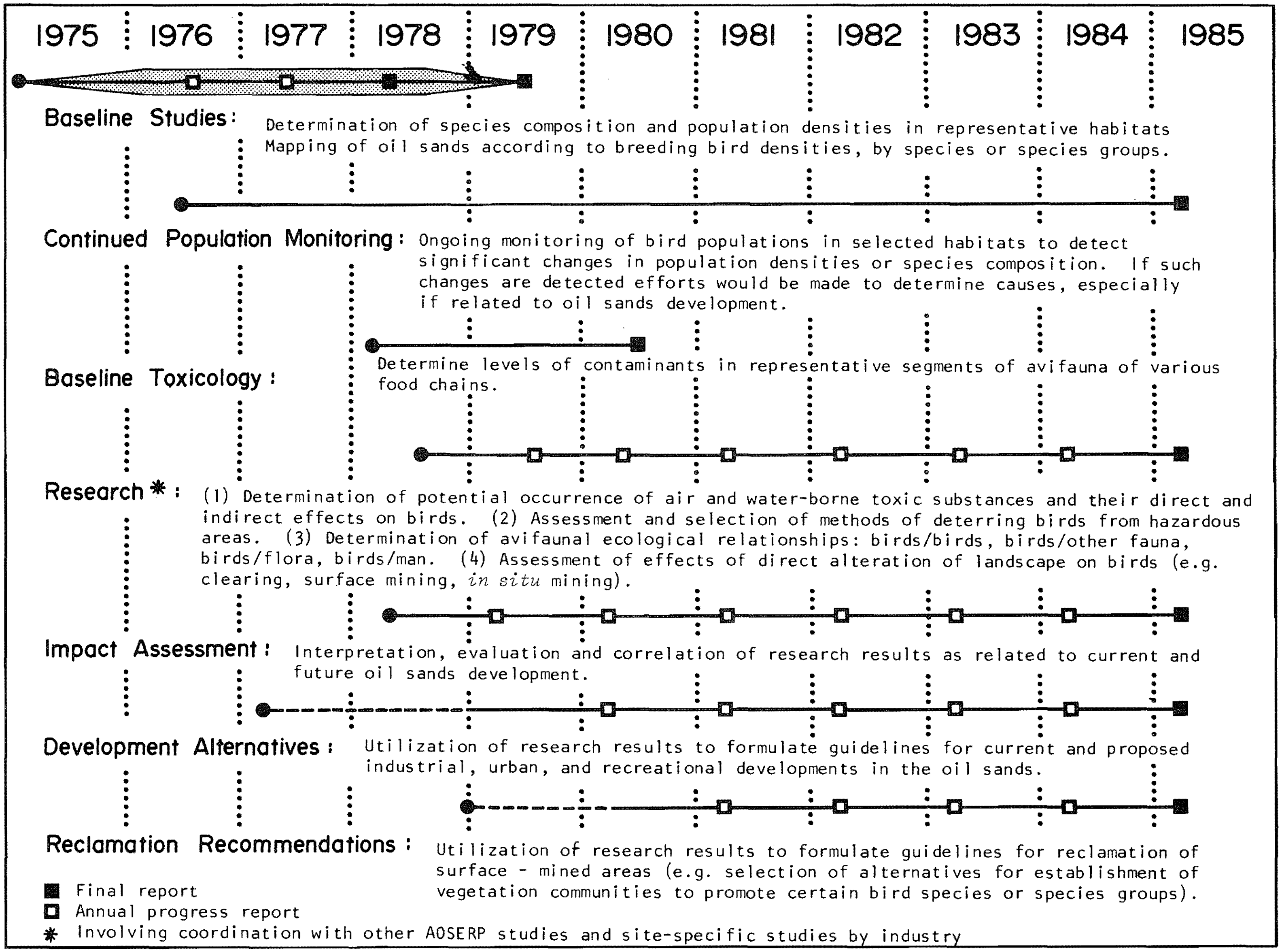


Figure 1. AOSERP/Avifauna: sub-project TF 2.1: revised 10 year program plan.

3. DESCRIPTION OF THE STUDY AREA

The following description is by no means comprehensive, but rather includes those features which may influence avian populations in the oil sands area.

The AOSERP study area (hereinafter called the oil sands) covers approximately 28 000 km^2, extending from 56°15' to 59°00'N Latitude and 110°47' to 112°55'W Longitude, excluding Wood Buffalo National Park (Figure 2). It incorporates most of the 23 000 km^2 of the area known as the Athabasca Oil Sands (Carrigy and Kramers 1974).

The general elevation of the area is roughly 275 to 450 m above sea level (asl). Rising above this platform of lacustrine and alluvial deposits are the unglaciated Birch Mountains (elev. 825 m asl) to the northwest, Stony Mountain (760 m asl) to the south, and Muskeg Mountain (640 m asl) to the east. The Thickwood and Fort Hills (520 and 340 m asl) are located 20 km west and 70 km north of Fort McMurray, respectively. The Athabasca River bearing from the southwest and turning north at Fort McMurray, where it is joined by the Clearwater River from the east, has carved through the platform to an elevation of approximately 235 m asl. Between Grand Rapids, 90 km southwest of Fort McMurray, and Lake Athabasca, 220 km to the north, the Athabasca River drops 165 m. Along this reach, within the AOSERP study area, the Athabasca is fed by a number of tributaries including Beaver, MacKay, Dover, and Ells rivers from the west, and the Steepbank, Muskeg, and Firebag rivers from the east.

A dense distribution of lakes (relative to other portions of the oil sands) occurs in the Birch Mountains (Namur and Gardiner being the largest at 44 km^2 and 54 km^2, respectively) and in the sand hills extending northeast from the Athabasca River 125 km north of Fort McMurray. Elsewhere, large lakes are widely distributed, the major ones being Ronald, McClelland, Algar, and Gregoire (Figure 2). Just beyond the study area, 55 km southeast of Fort McMurray, is Gordon Lake (115 km^2), worthy of mention here because of its significance as a migration stop for waterfowl.

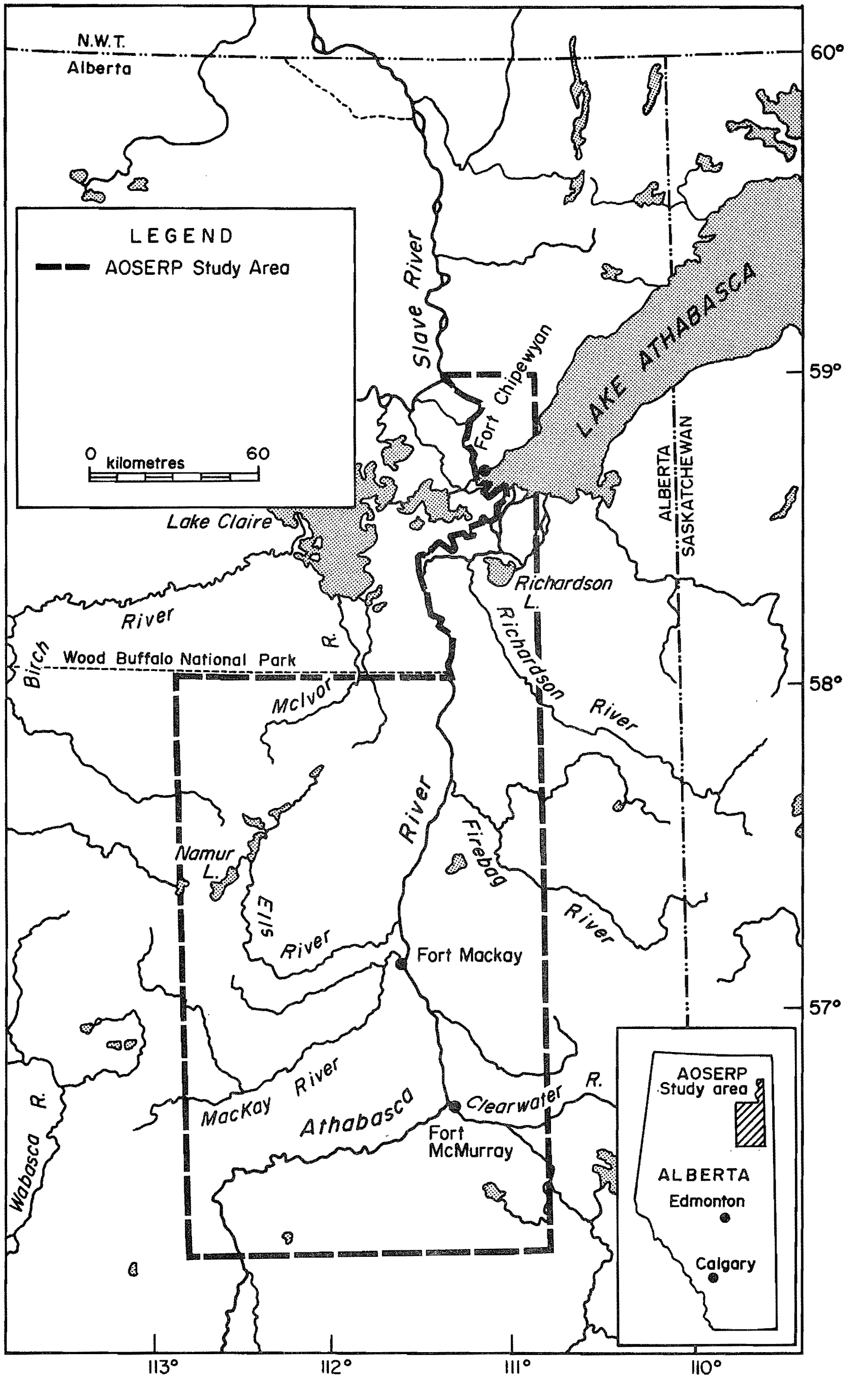


Figure 2. Map of the AOSERP study area.

Additionally, in the oil sands area, there is a scattered distribution of numerous small lakes of various types, from small muskeg-type beaver ponds to lakes with sand beaches surrounded by mixed upland forests.

The vegetation of the area has been described by La Roi (1967). It includes portions of the region known as the boreal-subarctic alluvial lowlands, the boreal-subartic jack pine sand-plains, and the boreal mixedwood (Rowe 1959). A more detailed description of plant communities has been prepared by Stringer (1976) and a forest cover map at a scale of 1 in = 2 mi has been published by the Alberta Department of Lands and Forests (1951). Although there are extensive monotypic vegetation communities, vegetation patterns generally are complex, including numerous combinations of species and age classes. The basic community types include young, intermediate, and mature stands of the following (the relative proportion of mature stands is unknown but may be small due to repeated burnings):

1. Sedge-grass meadows;
2. Willow-bog birch (*Betula glandulosa*) muskeg;
3. Tamarack (*Larix laricina*) muskeg;
4. Black spruce (*Picea mariana*) muskeg;
5. White spruce (*Picea glauca*)-aspen (*Populus tremuloides*) forests;
6. White spruce-balsam poplar (*P. balsamifera*) forest;
7. Aspen forest;
8. Aspen-jack pine (*Pinus banksiana*):
9. Aspen-willow forest;
10. Jack pine forest;
11. Jack pine-alder (*Alnus crispa*) forcest; and
12. Aspen-birch (*Betula papyrifera*)-jack pine-white spruce forest.

There is a general, but not restrictive, correlation of physiographic regions and vegetation communities within the study area, namely: (1) the upland mixed forest communities of the elevated areas (Birch Mountains, Thickwood and Fort Hills): (2) the white spruce-balsam poplar-willow community of the Athabasca River valley; (3) the jack pine stands of the sand hills north and west of the McClelland Lake; and (4) the variable composition muskeg communities over much of the remainder of the study area.

The following climatic and weather data have been extracted from Longley (1967). The study area lies in the cool temperate zone (classification by W. Koeppen) experiencing short cool summers. The mean January temperature is -20^{o}C with an extreme low of -54^{o}C. The mean July temperature is 15^{o}C with an extreme high of 38^{o}C. The average annual snowfall is 152 cm. There is an average of 300 h of sunshine in July and 80 h in January. The average frost-free period is 80 to 100 days.

Approximate sunrise and sunset times at Fort McMurray are as follows (Mountain Standard Time):

	Sunrise	Sunset	Hours of Daylight
21 March	0624	1843	12.25
22 June	0332	2123	18
23 September	0608	1829	12.5
22 December	0901	1546	6.75

Predominant winds (generally light) at the Syncrude plant site are southeast during both winter and summer, but northerly winds occur more frequently in winter than in summer (Atmospheric Environment Service, Environment Canada).

Fort McMurray, located in the valley at the confluence of the Athabasca and Clearwater rivers, is the only major urban center within the AOSERP study area. Established as a Hudson's Bay trading post in 1870, Fort McMurray grew very slowly and sporadically to a town of only 1200 in the early 1960's. Suddenly, with the onset of current oil sands activity, the population leaped to 8000 between

1965 and 1967 and more than doubled to 17 000 in the nine years since Great Canadian Oil Sands (GCOS) began its operations (MacGregor 1974; B. Banas, pers. comm. 1977). The only other communties in the area are Anzac, 39 km south of Fort McMurray, with a current population of 200, and Fort MacKay, 52 km north of Fort McMurray, with a population of 250 (population estimates: B. Banas, pers. comm. 1977).

The GCOS and Syncrude-Bechtel operations currently support staffs of approximately 1000 and 5000 to 7500, respectively, on site at any one time (B. Banas, pers. comm. 1977). Thus, they are population centers in their own right.

Provincial Highway 63 connects Fort MacKay, the GCOS and Syncrude plants, and Fort McMurray to Edmonton 480 km to the southwest.

4. WATERFOWL

4.1 OBJECTIVES AND METHODS

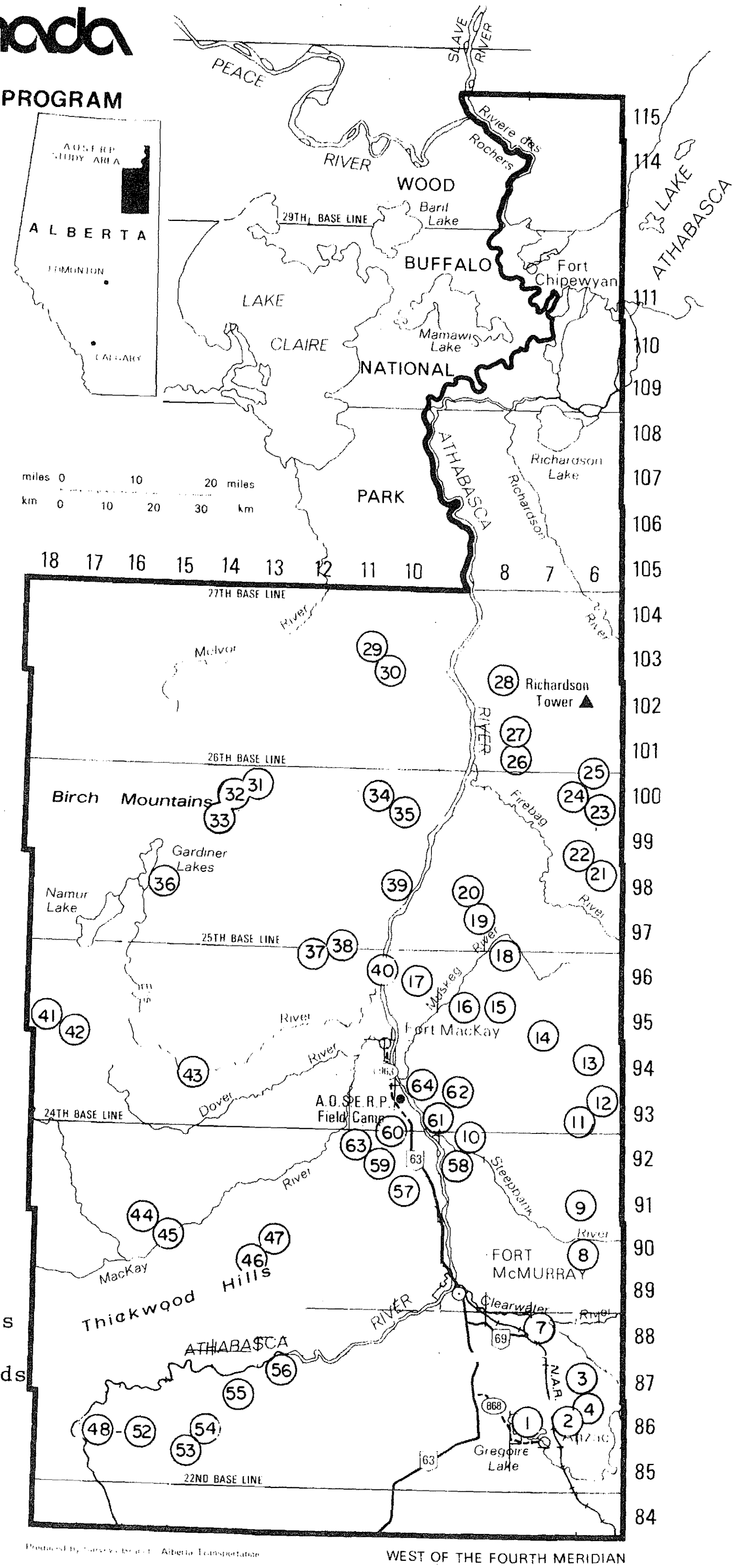
The waterfowl survey program was designed to expand upon data previously collected (see Section 1) regarding waterfowl populations utilizing a variety of wetland types in all portions of the oil sands area. Further, it was designed to provide a more definitive measure of production than had previously been obtained (other than on crown lease #17), and to assess, more accurately, the habitat factors governing selection of wetlands by various waterfowl species.

Wetlands surveyed (Figure 3) were selected for the following combination of reasons:

1. Most had been surveyed previously (Schick and Ambrock 1974; Smith 1975), thus providing a basis for assessment of annual fluctuations;
2. They were distributed throughout the oil sands area (Figure 3), and might therefore provide evidence of differences in waterfowl numbers affected by factors other than local habitat, such as extensive physiographic features; and
3. They provided examples of the various types of wetlands existing in the oil sands (although perhaps not all types).

Waterfowl surveys were conducted in the Peace-Athabasca Delta at intervals corresponding to those conducted in the oil sands. The Delta surveys, part of an on-going monitoring program sponsored by Parks Canada, have been analyzed in a separate report (Hennan and Ambrock 1977); the results ultimately should be assessed conjunctively in order to determine the correlation between Delta populations and movements of birds through the oil sands; this however, was beyond the scope of this report. Delta populations are very significant also in terms of oil sands development because of the potential effects of air and waterborne pollutants.

ALBERTA OIL SANDS
ENVIRONMENTAL RESEARCH PROGRAM
STUDY AREA



◯ Wetland surveyed for waterfowl.

Figure 3. Location of wetlands surveyed for waterfowl in the oil sands area, 1976 and 1977 (see following page for legend).

Figure 3. Concluded.

No.	Name	Location[a]	No.	Name	Location
1	Gregoire L	74D/VT/9257	33	W Baseline Cr	84H/VU/2594
2	Anzac L	74D/VT/9957	34	Square L	74E/VU/6391
3	Kiskatinaw L #1	74D/WT/0066	35	Triangle L	74E/VU/6491
4	Kiskatinaw L #2	74D/WT/0164	36	Gardiner L	84H/VU/1078
5	Gordon L	74D/WT/3564	37	Calumet L	74E/VU/5464
6	Campbell L	74D/WT/2977	38	Lilian L	74E/VU/5660
7	Clearwater/Christina R	74D/VT/9670	39	Athabasca R-3	74E/VU/6570
8	*Round L[b]	74D/WT/0691	40	Athabasca R-2 – Athabasca R-Bit/MacKay	74E/VU/6050
9	*Oval L[b]	74D/WU/0606			
10	Steepbank R	74E/VU/8215	41	Snipe L	84H/UU/9241
11	D-2	74E/WU/0722	42	Dover L	84H/UU/9938
12	Steepbank L[b]	74E/WU/1025	43	Ells R	84H/VU/2233
13	D-1	74E/WU/0934	44	W Muskeg L	84A/VU/1303
14	D-3	74E/VU/9635	45	MacKay L	84A/VU/2301
15	Kearl L[b]	74E/VU/8550	46	Thickwood L	74D/VT/4292
16	Muskeg R-1/Hartley Cr	74E/VU/7146	47	Long L	74D/VT/4593
17	Fishtail L[b]	74E/VU/6947	48	Brule L #1	84A/VT/0558
18	Muskeg R-2	74E/VU/8463	49	Brule L #2	84A/VT/0356
19	Little McClelland L[b]	74E/VU/8267	50	Brule L #3	84A/VT/0252
20	McClelland L	74E/VU/8070	51	Brule L #4	84A/VT/0352
21	C-2	74E/WU/0974	52	Brule L #5	84A/VT/0450
22	C-1	74E/WU/0775	53	Algar L	84A/VT/2042
23	Erp L	74E/WU/0986	54	Little Algar L	84A/VT/2343
24	Audet L	74E/WU/0589	55	Colt L	84A/VT/3365
25	Little Audet L	74E/WU/0691	56	Athabasca R-1	74D/VT/4072
26	Twin L #1	74E/VV/9404	57	Poplar Sl	74E/VU/7210
27	Twin L #2	74E/VV/9305	58	Wood Sl	74E/VU/7413
28	Rich L	74E/VV/9419	59	Beaver Cr Sed Pond	74D/VU/6415
29	Ronald L	74E/VV/6025	60	Ruth L	74D/VU/6715
30	Buckhorn L	74E/VV/6419	61	Steepbank Sl	74E/VU/7021
31	E Baseline L	84H/VU/2996	62	Horseshoe L	74E/VU/6823
32	W Baseline L	84H/VU/2795	63	Mildred L	74E/VU/6424
			64	Saline L	74E/VU/6826

[a]Combination of National Topographic Map Sheet designation and Mercator system.
[b]Surveyed 1976 and 1977.

The wetlands surveyed in 1976 included four in the Birch Mountains, nine in the Athabasca River valley, 10 in the oil sands (other than the above) with less than 60 m of overburden, 23 in the oil sands area (other than the above) with more than 60 m of overburden, and 19 in areas (other than the above) not bearing recoverable oil sands deposits (as delineated by Integ 1973). Two wetlands, Gordon and Campbell lakes, were outside the AOSERP study area.

Of the 65 areas surveyed in 1976, five sections were of rivers (Athabasca, Clearwater, Christina), six were sections of creeks (defined here as streams less than 10 m wide), six were lakes with no emergent vegetation, 42 were lakes with deep marsh aquatics, and six were lakes with shallow marsh aquatics only [see classification by Stewart and Kantrud (1971), for definitions of deep and shallow marsh aquatics]. Of the 54 wetlands excluding rivers and creeks, two were between 6 and 20 ha in size, 38 were between 21 and 200 ha, and 14 were larger than 200 ha.

In 1976 each of the wetlands classified according to "sub-regional" and "local" community types. Sub-regional referred to the general vegetative community of an area extending at least several kilometres in all directions from the wetlands. Local community type referred to the predominant vegetation within roughly 500 to 1000 m of the shore. In addition, wetland edge types were classified during each of the 10 surveys and the lengths of the survey units subsequently were measured on aerial photographs. The categories of each of the foregoing classifications were as follows:

1. Sub-regional Community Types:
   Deciduous forest upland,
   Deciduous forest muskeg,
   Coniferous forest, upland,
   Coniferous forest, muskeg,
   Mixed-forest, upland,
   Mixed-forest, muskeg,
   Shrub muskeg,
   Grass, sedge, forbs-muskeg,
   Recently burned or cleared.

2. <u>Local Community Types</u>:

   As above, but with the addition of "rock".

3. <u>Wetland Edge Types</u>:

   Emergent,
   Dry meadow,
   Wet meadow,
   Mudflat,
   Immature meadow,
   Shrub,
   Coniferous,
   Deciduous,
   Mixed wood,
   Rock,
   Flooded shrub,
   Flooded trees, and
   Sand and/or gravel.

The shoreline for every wetland was described in terms of wetland segments. Each segment of a shoreline was defined by its edge type.

The aerial survey schedule, 1976 and 1977, was as follows:

Survey Type	Survey No.	Date 1976	Date 1977	Aircraft
Spring-staging/Breeding pair	1	10-12 May	12-13 May	Fixed-wing
Spring-staging/Breeding pair	2	27-28 May	26-27 May	Fixed-wing
Spring-staging/Breeding pair	3	11-13 June	11-12 June	Fixed-wing
Production (broods)	4	23-26 June	27-28 June	Helicopter
Production (broods)	5	12-14 July	12-13 July	Helicopter
Fall-staging/Migration	6	19-20 Aug.	22 Aug.	Fixed-wing
Fall-staging/Migration	7	2-3 Sept.		Fixed-wing
Fall-staging/Migration	8	13-14 Sept.	13 Sept.	Fixed-wing
Fall-staging/Migration	9	27-28 Sept.	27 Sept.	Fixed-wing
Fall-staging/Migration	10	8-9 Oct.		Fixed-wing

All but one of the fixed-wing surveys were flown in a Cessna 185 on floats, the exception involved the use of a Citabria/ Champion on floats. Fixed-wing surveys were flown at between 105 and 160 km/h (depending on conditions) and at an average height of 25 m above ground. Surveys were flown between 0730 and 1130 h, and between 1500 and 1900 h. Flights occasionally were cancelled or discontinued due to turbulence, high winds (greater than 25 km/h), or a low, heavy ceiling.

All brood surveys were flown in a Hughes 500 helicopter at a speed of approximately 65 km/h, reduced to as slow as 8 km/h for brood identification and aging. Brood surveys were flown during the three to four hours following sunrise and in the evening between 1700 and 2100 h.

Standard data recorded (on magnetic tape) in 1976 included the wetland name and census segment, data, time, temperature, windspeed, wind direction, cloud cover, precipitation, visibility (a subject assessment--poor, fair, good, excellent; based on lighting and flight speed), edge type, habitat next-to-edge, shoreline topography, water level, and observability (an estimate of the proportion of all birds present that were actually observed--based on visibility, cover type, condition of observers wave action).

In 1977, the standard data recorded during the surveys were reduced to wetland name, date, time of day, temperature, windspeed, wind direction, cloud cover, precipitation, and visibility.

In the spring surveys of 1976 and 1977, waterfowl were recorded by species as pairs, lone males, lone females, and groups according to the numbers of each sex. Other birds and mammals were recorded during all surveys.

In both years broods were recorded according to species, number in brood, and age of brood (Gollop and Marshall 1954). Moulting waterfowl were counted coincidentally with brood surveys.

In the fall surveys of both years, only total numbers of each species were recorded.

In addition to the scheduled aerial surveys, pilots and all AOSERP personnel working in the study area were requested to take note of flocks or broods of identifiable birds moving through or located on wetlands in the oil sands. These data helped to verify patterns of movement and, in the case of migration of geese, swans, and cranes, were the only measure of magnitude and chronology of such movements (since these species were only occasionally observed during aerial surveys).

4.2 RESULTS

4.2.1 Introduction to Census Results

The 1976-1977 census data lend themselves to several levels and formats of analysis. These analyses, listed below, are sufficiently time consuming to warrant future computer treatment.

1. Summary of raw census results from each survey;
2. Adjustments of raw data through;
    - (a) Combination of pairs from different surveys according to optimum census period per species (based on nest initiation data);
    - (b) Incorporation of unidentified ducks;
    - (c) Combination of broods; and
    - (d) Application of observability indices;
3. Summation of adjusted census results by:
    - (a) Region;
    - (b) Sub-regional community type;
    - (c) Local community type;
    - (d) Wetland type and size class;
    - (e) Individual wetland; and
    - (f) Edge type and habitat next-to-edge;
4. Summation of bird densities according to the categories listed in (3); and

5. Summation of other birds recorded during aerial surveys.

In this report, the unadjusted census results will be summarized according to wetland type, wetland edge, and habitat next-to-edge.

Waterfowl aerial surveys were flown in both 1976 and 1977; however, the intensity of the 1977 surveys was considerably less than in 1976. There were fewer surveys flown in 1977 (Figure 3). Only those wetlands identified as possessing suitable habitat for one or more of the population segments of ducks were selected. Therefore, the total numbers of ducks reported in 1977 was considerably less than the numbers reported for 1976. Detailed analysis of census data was, therefore, restricted to those collected during the 1976 surveys.

4.2.2 Chronology

Breakup of the Athabasca River occurs around mid-April while the lakes of the oil sands are usually cleared of ice by the end of April.

In 1976, ducks were first observed on 12 April. Canada Geese (*Branta canadensis*) were observed on 20 April, White-fronted Geese (*Anser albifrons*) and Whistling Swans (*Olor columbianus*) were recorded on 28 April. In 1976, Canada Geese were reported near Fort Chipewyan as early as 8 April and the peak of the spring migration through the oil sands appeared to have occurred between 1 May and 10 May. A second prolonged movement of Canada Geese, occurred between 24 May and 24 June 1976 and probably represented the post-breeding moult-migration of large Canadas from the south (Sterling and Dzubin 1967).

The breeding/nesting period of ducks extended over as much as 10 weeks, depending on the species, weather conditions, and the renesting effort. In 1976 the nesting began as early as 1 April for Mallards (*Anas platyrhynchos*) and ended, for the most party, by the end of the second week of June (scaup, *Aythya affinis*).

Fall-staging and migration extended over a period from mid-August to freeze-up. Differential timing of movements by species and populations was more pronounced than in the spring. Freeze-up in 1976 occurred gradually (freezing at night, thawing diurnally), with a gradual extension of ice during the third week of October. By 23 October 1976, when the last aerial reconnissance was flown, the majority of oil sands lakes were 60 to 90 percent frozen and the Athabasca River had sufficient ice floes to prohibit boat traffic. The data suggest that there was partial exodus of ducks in late August, either a constant population or constant level of immigration and emigration during September, and a major movement in October just prior to freeze-up (Figures 9 to 11). Most Canada and White-fronted geese moved through between 20 August and 17 September 1976, with a peak movement occurring on 7 September 1976 (Figure 10). Snow geese (*Chen caerulescens*) and Whistling Swans passed through the area between 20 September and 10 October 1976, peaking on 4 October (Figure 10).

In 1977, although the scope of the data was significantly reduced, a similar timing of events was noted.

4.2.3 Spring-Staging/Breeding Pairs

Figures 4 and 5 summarize spring staging-migration-breeding pair survey data (See also Table 12). The length of edge censused varied from 403.3 km to 453.5 km; therefore, the data between surveys are not exactly comparable. Such variation occurred through ommission of wetlands due to time (lighting), weather, fuel, or slight modifications in the route. Birds not regarded as indicated pairs were summed as birds in flocks ≤30 and birds in flocks >30. This figure was somewhat arbitrarily chosen in an attempt to separate those ducks which could possibly remain non-breeding residents of the oil sands wetlands from those which were probably enroute to breeding areas farther north. However, both sets of data tend to reveal the same pattern: numerous ducks in early May, followed by

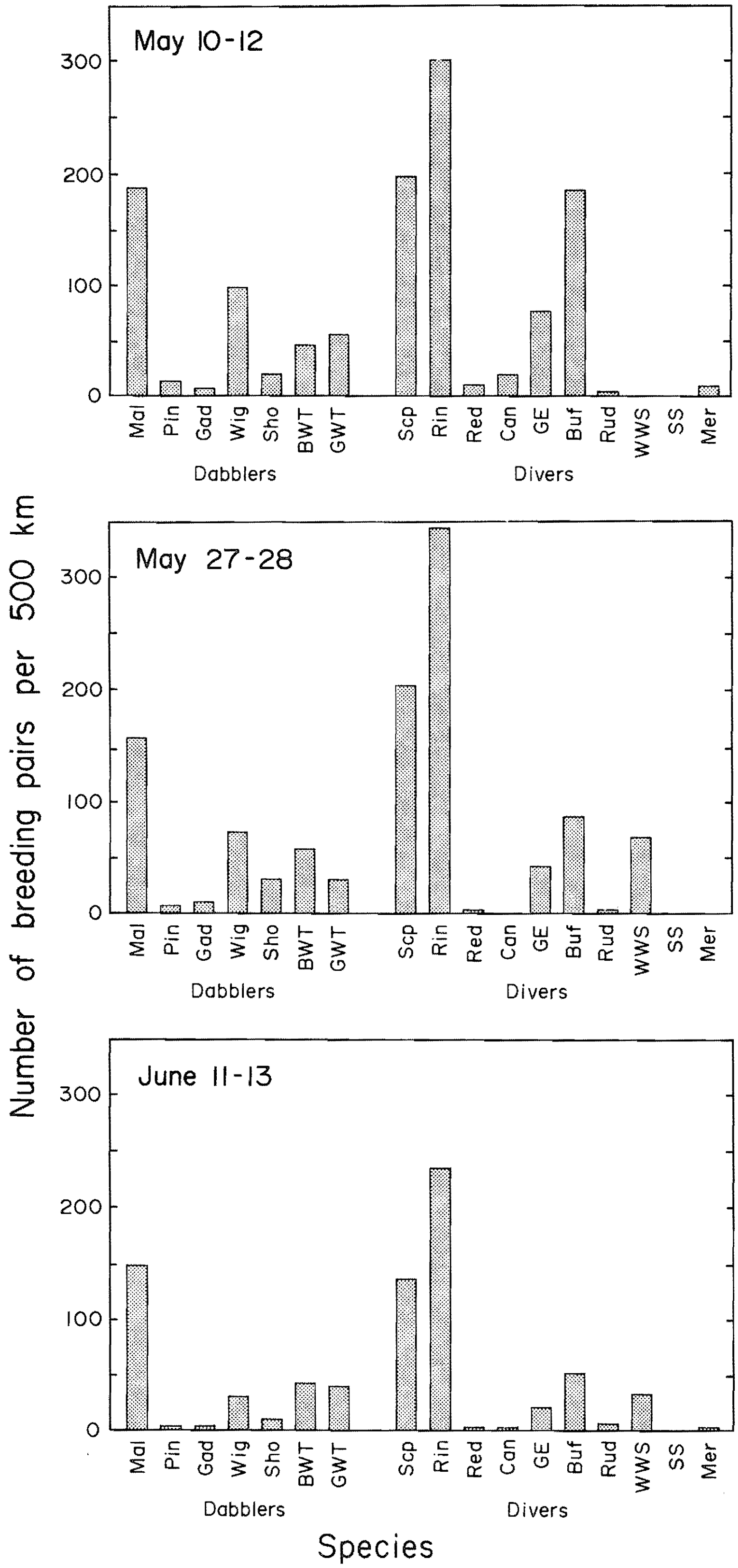


Figure 4. Densities of indicated breeding-pairs on selected oil sands wetlands, May to June 1976.

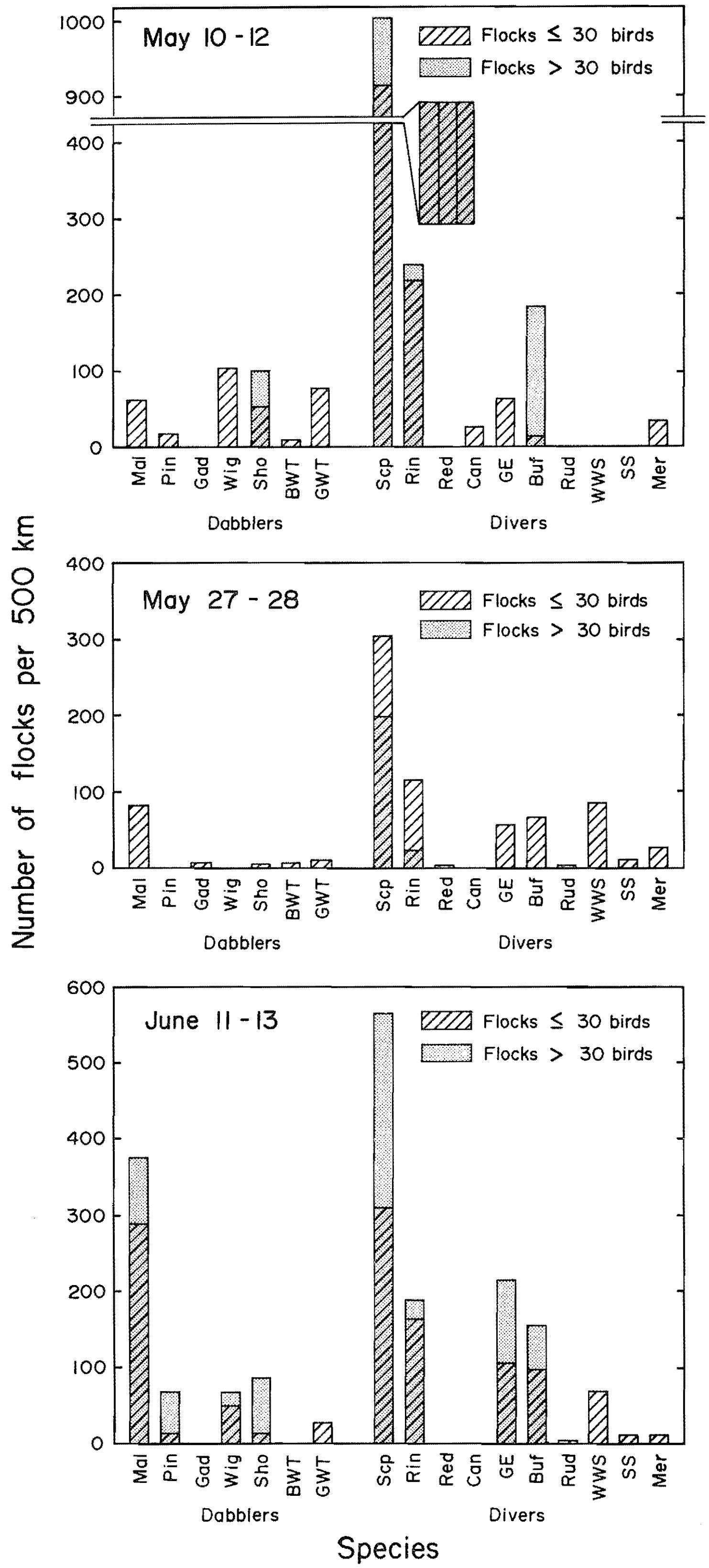


Figure 5. Densities of duck species in flocks on selected oil sands wetlands, May to June 1976.

Table 1. Summary of total ducks as recorded on selected oil sands wetlands--May to June 1976 and 1977.

	1976		1977	
	Total Numbers	% of Total Ducks	Total Numbers	% of Total Ducks
Dabblers				
Mallard	1456	13.3	208	6.4
Wigeon	544	5.0	1	0.03
Green-winged Teal	328	3.0	23	0.7
Blue-winged Teal	250	2.3	31	0.9
Shoveler	230	2.1	35	1.1
Pintail	83	0.8	19	0.6
Gadwall	30	0.3	12	0.4
Unidentified Dabblers	237	2.2	160	4.9
Total Dabblers	3158	28.8	489	15.0
Divers				
Scaup	3585	32.7	309	9.5
Ringneck	1556	14.2	97	3.0
Bufflehead	815	7.4	144	4.4
Goldeneye	386	3.5	103	3.2
Merganser	77	0.7	15	0.5
Canvasback	46	0.4	6	0.2
Redhead	22	0.2	8	0.2
Ruddy	22	0.2	4	0.1
Unidentified Divers	802	7.3	583	17.9
Total Divers	7311	66.6	1269	39.0
Unidentified Ducks	495	4.5	1497	46.0
Total Ducks not Identified	1534	14.0	3255	68.8

a decline in numbers of flocked birds, increasing again in early May, followed by a decline in numbers of flocked birds, increasing again in early June, probably as a result of an influx of post-breeding and non-breeding ducks from the south. Indicated breeding pairs were assessed according to behavioural characteristics of each species (Appendix 6.5).

Table 1 compares the 1976 and 1977 census results for the spring staging/breeding pairs surveys. The three most abundant species, from both years were: Lesser Scaup[1] 33 and 10 percent of total ducks; Mallard, 13 and 6 percent; and Ringneck (*Aytha collaris*) 7 and 4 percent. From these data it is difficult to determine whether any changes or fluctuations occurred in the duck populations for the two years. Difficulties in a strict comparison of data from 1976 and 1977 stem from a reduction in the number of wetlands surveyed in 1977, fewer surveys flown and the substantial number of unidentified ducks in 1977 (69.0 percent of total ducks) compared to 14.0 percent which were present but not identified in 1976 (Table 1).

Table 2 illustrates the species breakdown for all the breeding pair surveys in which the censused ducks were categorized according to the flock criteria and indicated breading pairs (Appendix 6.2). It is interesting to note that, although the scaup to Mallard ratio was approximately 3:1, the total indicated breeding pairs for these two species was essentially similar (scaup 892, Mallard 836--Table 2).

4.2.4 Production and Moulting Ducks

Figure 6 is a summary of the number of ducklings in broods. The results show almost two times as many ducklings were present in

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[1] There are two species of scaup present in the oil sands area: Lesser Scaup (*Aythya affinis*) and Greater Scaup (*Aytha Marila*). Lesser Scaup comprise 99.9 percent of the scaup population in the oil sands area (Ward et al. 1976). Therefore, for the purposes of this report, scaup censused and referred to are considered to be Lesser Scaup.

Table 2. Summary of total ducks in flocks >30, ducks in flocks ≤30, and indicated breeding pairs, as recorded on selected wetlands of the Alberta oil sands, May to June 1976.

Dabblers	Total Ducks		Divers	Total Ducks	
Mallard	1-836)		Scaup	1- 892)	
	2-380)	1456		2-1223)	3585
	3-240)			3-1470)	
Wigeon	1-344)		Ringneck	1- 608)	
	2-140)	544		2- 504)	1556
	3- 60)			3- 444)	
Green-winged	1-232)		Bufflehead	1- 360)	
Teal	2- 96)	328		2- 301)	815
	3- -)			3- 154)	
Blue-winged	1-238)		Goldeneye	1- -)	
Teal	2- 12)	250		2- 173)	386
	3- -)			3- 213)	
Shoveler	1-100)		Merganser	1- 16)	
	2- 70)	230		2- 61)	77
	3- 60)			3- -)	
Pintail	1- 34)		Canvasback	1- 22)	
	2- 49)	83		2- 24)	46
	3- -)			3- -)	
Unidentified	1-216)		Redhead	1- 20)	
Dabblers	2- 21)	237		2- 2)	22
	3- -)			3- -)	
			Ruddy	1- 18)	
				2- 4)	22
				3- -)	
			Unidentified	1- 403)	
Total Dabblers		3158	Divers	2- 399)	802
				3- -)	
			Total Divers		7311

1 - Indicated breeding pairs
2 - Flocks ≤30
3 - Flocks >30

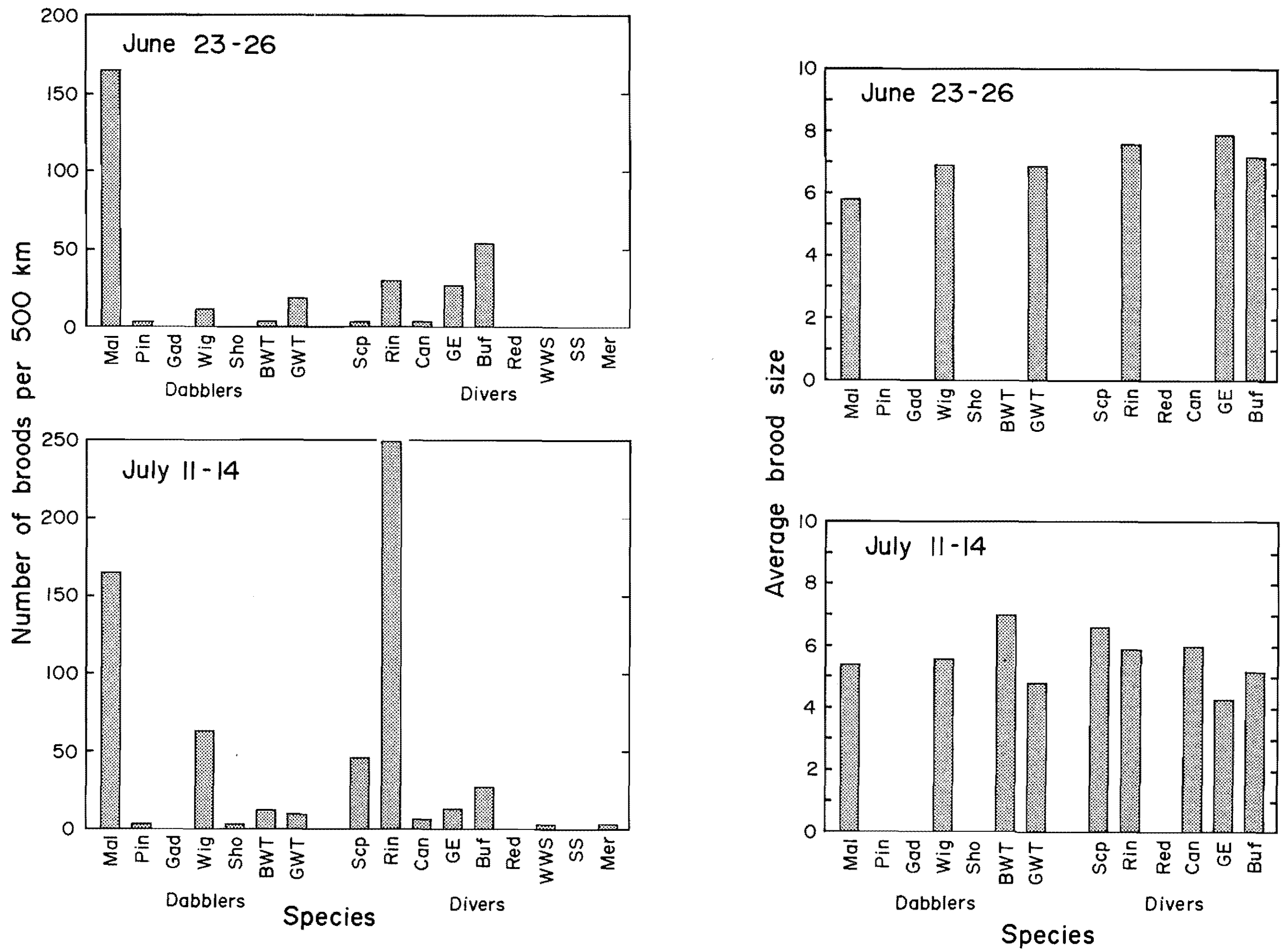

Figure 6. Densities of broods on selected oil sands wetlands, June to July 1976.

the second brood surveys as compared to the initial one (also see Table 13). Many broods counted in the second brood survey of 1976 may have been recounts but there was a substantial number of new broods as indicated by the species breakdown (Figure 6).

The brood-age data for the six species having sample sizes of at least 20 broods were backdated to determine nest initiation periods. The percentages of total successful nests initiated during designated periods are presented in Figure 7. Note that in this, as with all such analyses of brood data, the results are biased in that they do not account for the initiation of unsuccessful nests.

Counts of moulters were not complete in the same sense as other counts; that is, due to concentration of effort on broods, moulters observed were not always recorded. Figure 8 illustrates the concentration of moulters, on a species basis, per 500 km, subject to the above qualificiation (see Table 13).

3.2.5 Fall Staging/Migration

Figure 9 is a summary, by species, of the distribution of ducks which developed during the fall-staging population segment. The first fall-staging survey, 19 to 20 August 1976, revealed numbers of ducks in line with a build-up of "moulting" ducks as recorded during the second brood survey, 11 to 14 July 1976: 14 679 and 9318 ducks, respectively. For possible explanation of the fluctuations which occurred for each species, see interpretive notes in the annotated list (Francis and Lumbis in prep.).

For the fall staging segment, scaup were by far the single most abundant species in both years: 1976, 34 percent of the total ducks; and in 1977, 15.0 percent of the total ducks (Table 3). As in the spring staging, the total unidentified in 1976 (32.0 percent of total ducks censused) was substantially lower than 1977 (70.0 percent of the total ducks censused).

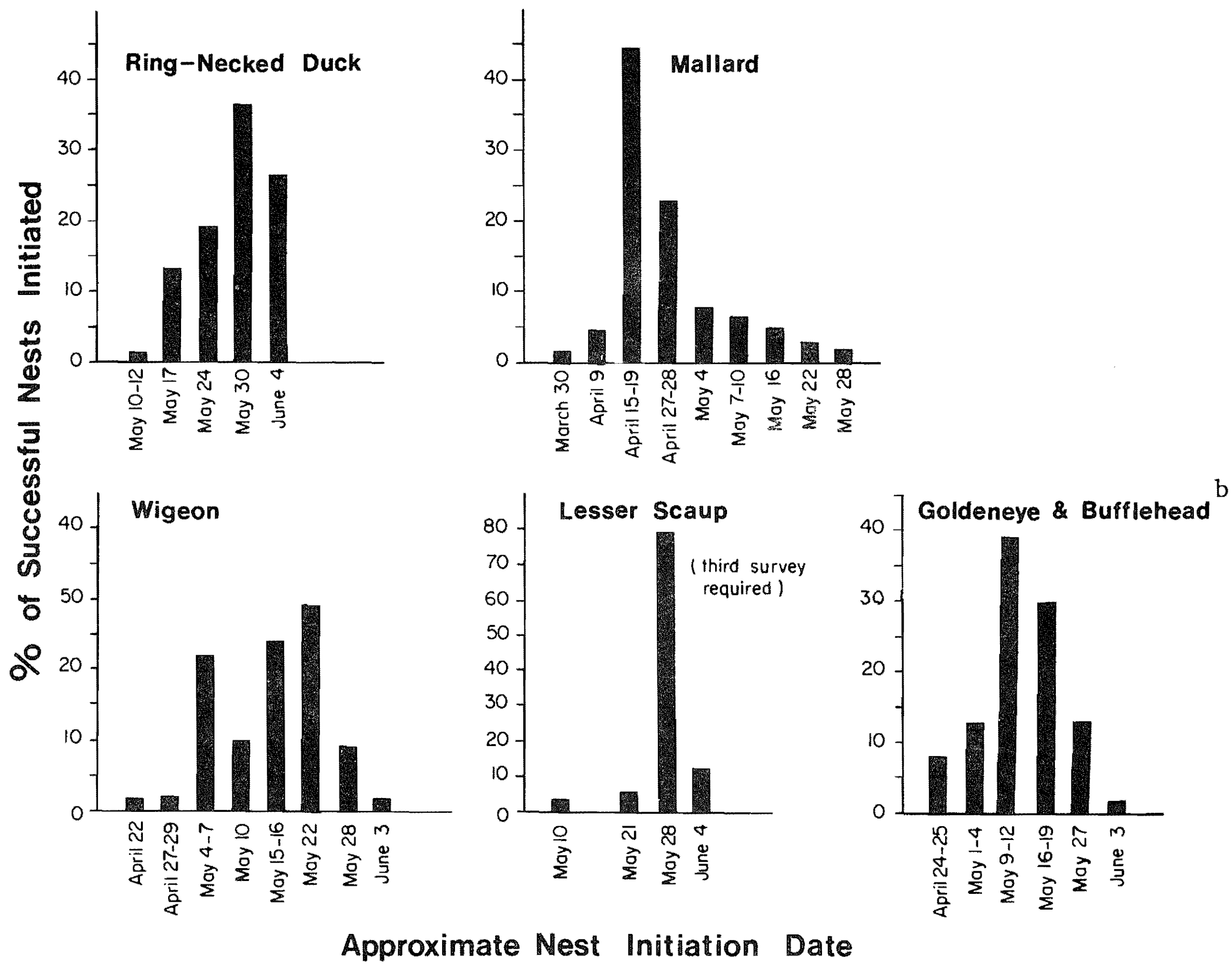

Figure 7. Proportions of total successful nests of five species of duck initiated during designated periods in oil sands wetlands, 1976[a].

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[a] Based on a composite analysis of data from two surveys.

[b] Goldeneye and bufflehead data were combined since their breeding periods were quite similar and because it was often difficult to distinguish between broods of the two species during surveys.

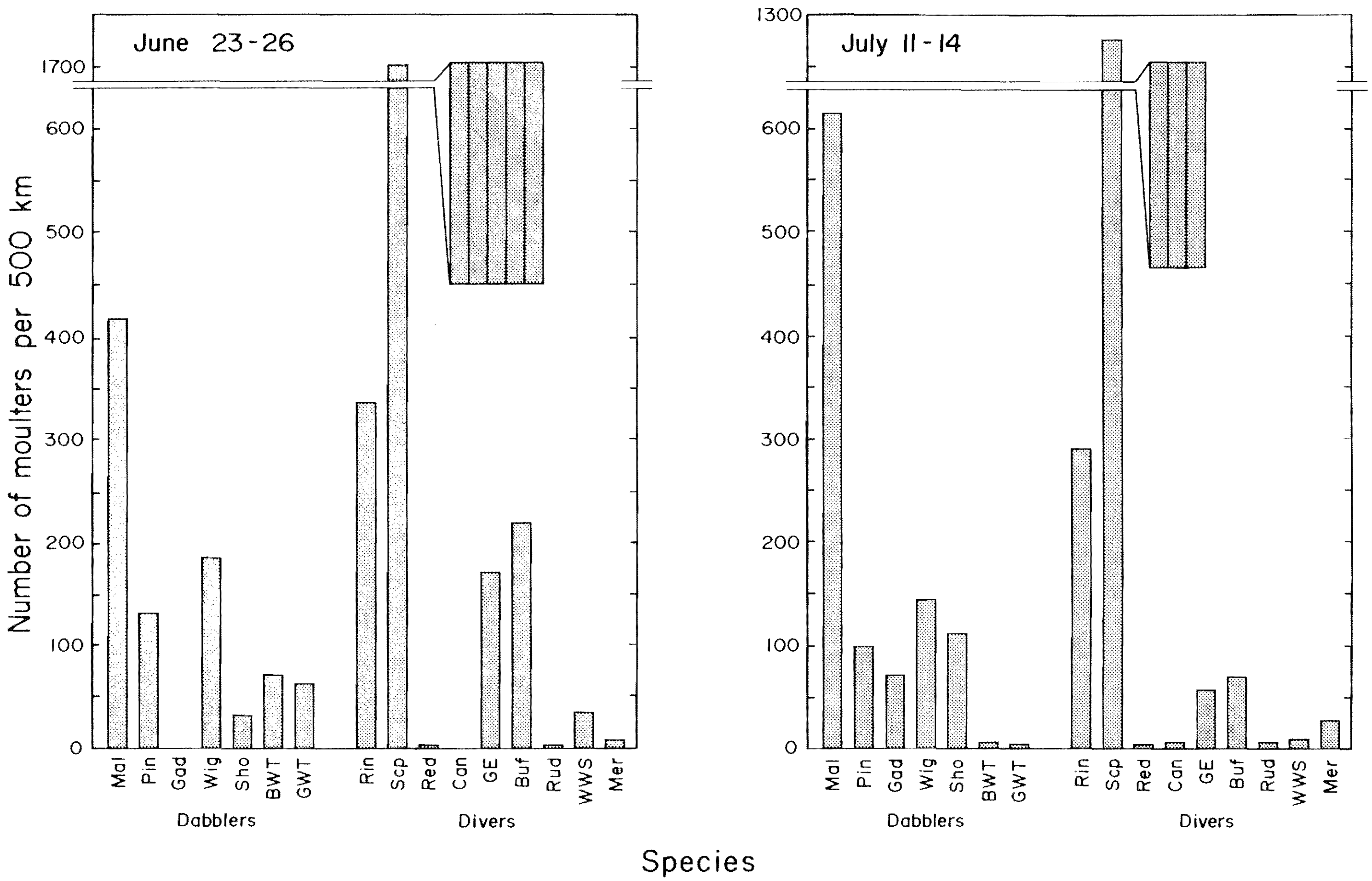

Figure 8. Densities of moulting ducks on selected oil sands wetlands, June to July 1976.

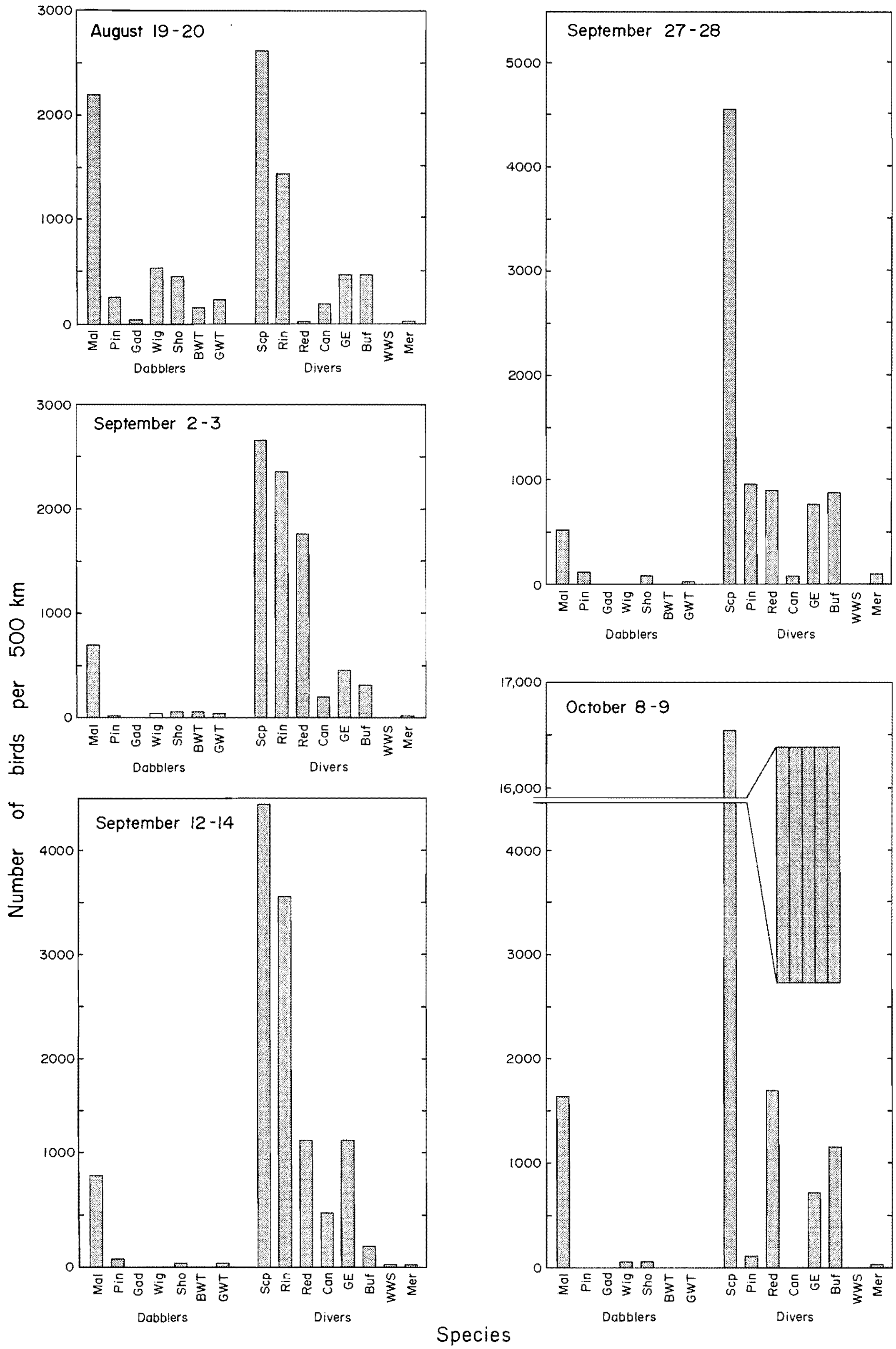

Figure 9. Densities of ducks on oil sands wetlands, August to October 1976.

Table 3. Summary of fall-staging/migration waterfowl census results from selected wetlands in the Alberta oil sands, August to October 1976 and 1977.

	1976		1977	
	Total Numbers	% of Total Ducks	Total Numbers	% of Total Ducks
Dabblers				
Mallard	4 954	6.6	367	3.7
Wigeon	550	0.7	42	0.4
Green-winged Teal	272	0.4	21	0.2
Blue-winged Teal	202	0.3	59	0.6
Shoveler	597	0.8	5	0.1
Pintail	414	0.6	57	0.6
Gadwall	38	0.1	1	0.01
Unidentified Dabblers	5 585	7.4	521	5.3
Total Dabblers	12 614	16.9	1 073	10.9
Scaup	25 530	34.0	1 473	14.9
Ringneck	7 184	9.6	590	6.0
Bufflehead	2 530	3.4	171	1.7
Goldeneye	3 058	4.1	6	0.1
Merganser	141	0.2	-	-
Canvasback	887	1.2	11	0.1
Redhead	4 613	6.1	152	1.5
Ruddy	-	-	-	-
Unidentified Divers	15 068	20.1	4 315	43.5
Total Divers	59 011	78.7	6 718	67.8
Unidentified Ducks	3 522	4.7	2 123	21.4
Total Ducks Not Identified	18 590	32.2	6 438	70.2

Aerial reconnaissance of a portion of the lakes on 23 October 1976 revealed that most were largely frozen over and that very few ducks remained. On the same day there was virtually no open water remaining in the lakers of the Peace-Athabasca Delta, although the major rivers remained open.

4.2.6 Habitat and Ducks

Wetland edge types and habitat next-to-edge were recorded for each wetland segment during each survey. Often several edge types comprised a single segment, but with one type predominating.

The total number of edge segments differentiated in all surveys ranged from 103 to 128. The number of different combin-actions of edge types and habitat next-to-edge (considering only the predominant type in each segment) ranged from 32 to 37 out of a possible 769 combinations.

Table 4 lists the edge types and habitat next-to-edge in order of abundance (total kilometres). The predominant combinations of edge and habitat next-to-edge were emergent/wet meadow, emergent/shrub, wet meadow/coniferous, emergent/mixed forest, coniferous/coniferous, and mixed forest/mixed forest.

Three approaches to the comparison of the unadjusted waterfowl census data with habitat parameters are presented in this report:

1. Total (i.e. all species) waterfowl densities (spring-staging ducks, breeding pairs, broods, moulters, and fall staging ducks) derived from each survey are related to edge type and habitat next-to-edge (Tables 14 to 18). Sample sizes of fewer than 5 km are included but the densitites recorded for such small samples cannot be regarded as representative.

   Edge type and habitat next-to-edge were analyzed separately in regards to preference shown by duck species. The data were subjected to an analysis of variance and in all cases the above relationships

Table 4. Length of edge type and habitat next-to-edge (kilometres) for wetlands surveyed in 1976.

Habitat Type	Total Edge (km)	Total Habitat Next-to-Edge
Emergent (EM)	757.8	6.2
Wet Meadow (WM)	83.6	421.4
Dry Meadow (DM)	42.0	40.5
Immature Meadow (IM)	15.1	14.4
Mud Flat (MF)	75.2	-
Shrub (SH)	112.5	279.0
Flooded Shrub (FS)	25.4	16.3
Flooded Trees (FT)	22.2	1.6
Deciduous Forest (DF)	10.9	39.0
Coniferous Forest (CF)	75.6	177.1
Mixed Forest (MX)	86.0	504.9
Sand and Gravel (SG)	181.2	1.3
Rocks (RX)	28.4	14.2

tested were not significant. However, when the duck species were lumped into two groups--dabblers and divers--and each of these groups compared to the various combinations of edge type and habitat next-to-edge, significant relationships ($p \leq 0.01$) began to appear (Tables 5 and 6);

2. Maximum waterfowl densities for each wetland and each population segment are presented in groups according to wetland type (Table 7). Maximum density refers to the highest density derived from the complement of counts of each population segment. Note that sections of creeks and rivers are treated as complete wetlands; and
3. The relative values of the various oil sands lakes have been assessed according to the total number of waterfowl censused for each population segment. The RUV of a wetland equals the total number of ducks for that wetland, divided by the total for all wetlands in the surveys; the quotient is then multiplied by 100 (Table 8).

The habitat preferences are exhibited by dabbling and diving ducks, in each of the population segments, on oil sands we wetlands, is presented.

4.2.6.1 Spring-staging/breeding pairs. Divers are the most prevalent group of breeding ducks utilizing oil sands wetlands (Tables 1 and 2). These are listed in order of decreasing abundance: scaup, Ringneck, Bufflehead, and Goldeneye. Dabbling ducks do not utilize oil sands wetlands to the same extent as diving ducks; the ratio of divers to dabblers for this population segment was 5:1 (Tables 1 and 2). Dabbling ducks, listed in order of abundance, include: Mallard, Wigeon, Green-winged Teal, Blue-winged Teal, and Shoveler.

Table 5. Densities of breeding pairs of ducks for May to June 1976, on oil sands wetlands, as related to edge type and habitat next to edge combinations.

Edge/Habitat Next-to-Edge Combinations	n	Dabblers Total Breeding Pairs	Dabblers Breeding Pairs/km of Edge	Dabblers Mean Mallard Breeding Pairs	Divers Total Breeding Pairs	Divers Breeding Pairs/km of Edge	Divers Mean Scaup Breeding Pairs
EM/WM	71	4.5	0.9	0.4	6.7	1.2	0.4
EM/SH	27	4.5	2.5	0.8	5.4	2.2	0.8
CF/CF	26	1.0	0.2	0.2	3.0	1.5	0.9
SG/MX	24	0.3	0.04	0.03	0.6	0.1	0.01
MX/MX	24	1.3	0.5	0.2	2.0	0.6	0.2
EM/MX	20	1.4	0.5	0.4	2.0	1.0	0.2
SH/MX	18	2.2	0.5	0.2	2.0	0.5	0.2
WM/CF	18	1.1	0.6	0.2	4.0	2.0	0.8
WM/MX	12	0.8	0.3	0.1	2.3	1.0	0.03

[a] For definition of habitat types see Appendix 6.2.

Table 6. Densities of fall-staging ducks for August to September 1976, on oil sands wetlands as related to edge type and habitat next-to-edge combinations.

Edge/Habitat Next-to-Edge Combinations[a]	n	Dabblers/km	Divers/km
WM/SH	31	34.3	22.0
WM/MX	27	31.3	25.3
EM/MX	36	18.8	11.6
CF/CF	17	17.1	20.0
SH/SH	10	16.9	101.0
EM/SH	43	12.3	37.0
EM/WM	60	7.0	23.8
SH/MX	27	4.6	35.7
PS/MX	16	2.9	17.5
FT/MX	16	0.2	37.7
Middle of Wetlands	45	12.8	134.8

1 [a]For definition of habitat types see Appendix 6.2.

Table 7. Maximum waterfowl densities censused on selected oil sands wetlands, 1976.[a]

Wetland type	Wetland name	DENSITIES (per linear km)				
		Spring staging	Breeding pairs	Broods	Moulters	Fall staging[b]
Creek (CRK)	Muskeg R-1/Hartley Cr	0	0	–	–	–
	Muskeg R-2	0.2	0.2	0.2	0	–
	W Baseline Cr	1.8	0.6	0.3	0.3	13.4[E]
	Ells R	0	0.4	0.2	0.4	–
	Steepbank R	0	0	–	–	–
	MacKay R	0	0.4	0.1	0.1	–
	Mean	0.3	0.3	0.2	0.2	13.4
River (RIV)	Athabasca R-1	2.4	0	–	–	–
	Athabasca R-2	1.1	0.4	–	–	–
	Athabasca R-3	0.7	0.3	0	0	0
	Athabasca R: Bit/MacKay	–	–	–	–	8.0[E]
	Clearwater/Christina R	0.6	0.1	0	0.3	0
	Mean	1.2	0.2	0	0.2	2.7
Open lake (LOP)	Fishtail L	–	–	1.7	3.5	7.9[E]
	Twin L#2	61.3	2.1	1.7	25.4	38.3[E]
	Rich L	3.4	0.7	0.5	1.5	3.4[L]
	Gardiner L	9.3	1.7	0.9	9.4	161.7[M]
	Kiskatinaw L #2	1.4	1.0	0.7	1.4	0.7[L]
	Gregoir L	0.9	0.5	–	–	14.9[L]
	Mean	15.3	1.2	1.1	8.2	37.8
Lake with deep-marsh aquatics (LDM)	Audet L	67.5	3.1	3.0	36.9	172.7[L]
	Little Audet L	9.7	1.4	0.8	3.8	105.1[L]
	Twin L #1	34.6	3.3	0.4	18.3	33.3[L]
	Ronald L	20.5	3.0	0.6	15.1	197.5[L]
	Buckhorn L	4.0	2.7	1.6	16.8	25.1[L]
	Square L	37.9	2.4	1.8	82.9	33.2[E]
	Triangle L	17.1	4.8	1.0	31.9	45.2[E]
	Calumet L	11.9	4.4	2.2	43.1	143.1[L]

continued ...

Table 7. Continued.

Wetland type	Wetland name	DENSITIES (per linear km)				
		Spring staging	Breeding pairs	Broods	Moulters	Fall staging[b]
(LDM continued)	Kearl L	3.5	2.3	0.6	39.0	133.9[L]
	E Baseline L	3.6	0.7	1.1	1.5	9.2[L]
	W Baseline L	5.0	2.9	3.4	37.8	92.6[E]
	Poplar SI	0.3	2.3	0.3	4.5	7.0[E]
	Snipe L	6.0	3.1	1.1	11.1	45.7[E]
	Dover L	4.6	1.4	1.5	9.3	54.8[E]
	Saline L	35.6	10.2	5.0	2.5	341.8[M]
	Horseshoe L	10.7	5.2	2.3	32.6	65.5[E]
	Wood SI	22.9	11.0	6.7	3.8	19.0[E]
	Steepbank SI	7.1	4.5	1.0	3.4	2.6[M]
	Kiskatinaw L #1	2.2	0.9	0.6	0.8	14.2[L]
	McClelland L	16.0	1.2	0.2	4.5	130.8[L]
	C-1	0	0.3	0.3	0.6	4.3[L]
	C-2	2.6	1.7	1.7	3.9	49.1[L]
	Gordon L	16.5	3.4	1.1	13.5	170.6[L]
	Campbell L	3.6	2.6	0.4	3.0	23.4[E]
	Round L	6.6	2.3	1.3	4.8	15.2[E]
	Oval L	5.9	1.2	0.4	5.1	12.2[E]
	Steepbank	0.5	1.3	0.9	0	71.4[L]
	D-1	0	0	0	0.5	6.0[L]
	W Muskeg L	30.4	6.7	10.0	17.0	71.1[L]
	Brule L #1	15.7	4.8	2.1	17.6	38.3[M]
	Brule L #2	1.7	3.9	0	3.9	0
	Brule L #3	1.3	2.5	0.4	2.9	21.3[E]
	Brule L #4	0	0.3	0.3	0.6	3.9[L]
	Brule L #5	1.9	1.5	0	1.1	0.4[E]
	Algar L	72.7	6.4	2.5	255.7	113.6[E]
	Little Algar L	8.2	4.7	0.5	15.0	10.3[E]
	Colt L	-	-	0.9	8.5	0

continued ...

Table 7. Concluded.

Wetland type	Wetland name		DENSITIES (per linear km)				
			Spring staging	Breeding pairs	Broods	Moulters	Fall staging[b]
(LDM continued)	Anzac L		9.6	2.9	2.9	7.3	157.1[L]
	Thickwood L		10.7	2.5	2.9	10.2	24.3[L]
	Long L		2.0	0.9	0.4	1.8	2.0[L]
	Ruth L		1.6	3.7	1.5	10.8	53.5[L]
	Mildred L		2.7	2.2	2.5	0.9	41.1[L]
		Mean	12.6	3.1	1.6	16.4	61.0
Lake with shallow-marsh aquatic (LSM)	Little McClelland L		37.7	10.0	4.0	54.3	456.3[L]
	Erp L		0.3	1.1	1.0	1.2	11.0[L]
	Lilian L		25.0	6.9	3.1	24.4	32.5[E]
	D-2		0	2.0	0.3	0	4.3[E]
	D-3		18.3	8.3	1.1	17.8	15.0[E]
	Beaver Cr Sed Pond		11.1	1.3	-	-	9.5[L]
		Mean	15.4	3.3	1.9	19.6	88.0
	Mean, All types		10.3	2.5	1.4	14.3	57.5

[a]Maximum densities refer to the highest density derived from three surveys in the case of spring-staging ducks and breeding pairs, two surveys in the case of broods and moulting ducks, and five surveys in the case of fall-staging ducks.

[b]E, M, and L mean early, middle, and late, in reference to the period (survey) from which the maximum density value was derived. Early means either of the first two surveys, 19 to 20 August and 2 to 3 September; middle means the survey of 12 to 14 September; and late means either of the last two surveys, 27 to 28 September and 8 to 9 October.

Table 8. Waterfowl numbers and RUB of selected oil sands wetlands, 1976[a].

Wetland type	Wetland name	C.L.I. Classification	Spring staging		Breeding pairs		Broods		Moulters		Fall staging	
			No.	RUV	No.	RUV	No.	RUV	No.	RUV	No.	RUV
Creek (CRK)	Muskeg R-1/Hartly Cr	6	0	0	0	0	–	–	–	–	–	–
	Muskeg R-2	6	1	0	1	0	1	0.1	0	0	–	–
	W Baseline Cr	5-6	14	0.3	8	0.4	2	0.3	4	0	138	0.2
	Ells R	6	0	0	3	0.1	1	0.1	3	0	–	–
	Steepbank R	6	0	0	0	0	–	–	–	–	–	–
	MacKay R	6	0	0	3	0.1	2	0.3	1	0	–	–
	Total		15		15		6		8		138	
River (RIV)	Athabasca R-1	6	20	0.5	0	0	–	–	–	–	–	–
	Athabasca R-2	6	11	0.3	4	0.2	–	–	–	–	–	–
	Athabasca R-3	6	11	0.3	7	0.3	0	0	0	0	0	0
	Athabasca R: Bit/MacKay	6	–	–	–	–	–	–	–	–	3	0
	Clearwater/Christina R	6	8	0.2	1	0	0	0	4	0.1[b]	0	0
	Total		50		12		0		4		3	
Open lake (LOP)	Fishtail L	6	–	–	–	–	10	1.5	30	0.3	85	0.1
	Twin L #2	6	238	5.9	9	0.7[b]	4	0.5	72	0.8	214	0.3
	Rich L	5	46	1.1	8	0.4	4	0.6	21	0.2	30	0
	Gardiner L	6	107	2.6	43	2.1	39	5.5	368	3.9	9559	12.7
	Kiskatinaw L #2	6	1	0	6	0.3	2	0.3	6	0.1	3	0
	Gregoire L	6	13	0.3	9	0.4	–	–	–	–	126	0.2
	Total		405		75		58		497		10007	
Lake with deep-marsh aquatics (LMD)	Audet L	5	614	15.2	55	2.7	29	4.2	488	5.2	1784	2.4
	Little Audet L	5	50	1.2	9	0.4	6	0.9	16	0.2	516	0.7
	Twin L #1	6	106	2.6	18	0.9	1	0.1	83	0.9	233	0.3
	Ronald L	6	215	7.1[b]	36	6.7[b]	8	1.2	230	2.4	7838	10.4
	Buckhorn	5	66	2.2[b]	69	12.8	27	3.9	426	4.5	1269	1.7
	Square L	6	173	4.3	20	1.0	10	1.5	334	3.6	191	0.3
	Triangle L	6	24	0.6	33	1.6	3	0.7[b]	99	1.7[b]	354	0.5

continued ...

Table 8. Continued.

Wetland type	Wetland name	C.L.I. Classification	Spring staging		Breeding pairs		Broods		Moulters		Fall staging	
			No.	RUV	No.	RUV	No.	RUV	No.	RUV	No.	RUV
LDM (continued)	Calumet L	6	20	0.5	28	1.4	11	1.6	150	1.6	1242	1.7
	Kearl L	5	39	1.0	50	2.4	6	0.9	126	1.3	3344	4.4
	E Baseline L	5	22	0.5	9	0.4	9	1.3	11	0.1	151	0.2
	W Baseline L	5	24	0.6	39	1.9	30	4.4	333	3.5	1806	2.4
	Poplar SI	6	2	0.1	29	1.4	2	0.9[b]	29	0.8	68	0.1
	Snipe L	5	45	1.1	50	2.4	13	1.9	86	0.9	1039	1.4
	Dover L	5	66	1.6	31	1.5	22	3.2	146	1.6	1487	2.0
	Saline L	4	132	3.3	128	6.2	63	9.2	28	0.3	5108	6.8
	Horseshoe L	4	40	1.0	89	4.3	30	4.4	458	4.9	1200	1.6
	Wood SI	6	67	1.7	45	2.2	14	6.2[b]	8	0.2	121	0.2
	Steepbank SI	6	22	0.5	26	1.3	5	0.7	11	0.1	13	0[b]
	Kiskatinaw L #1	6	14	0.3	14	0.7	6	0.9	9	0.1	174	0.2
	McClelland L	3M	361	8.9	40	1.9	5	0.7	186	2.0	7693	10.2
	C-1	6	0	0	1	0	1	0.1	2	0	46	0.1
	C-2	6	6	0.1	5	0.2	8	1.2	18	0.2	157	0.2
	Gordon L	2S, 3M	505	12.5	409	19.7	76	11.1	788	8.4	17789	23.7
	Campbell L	5	23	0.6	23	1.1	2	0.3	21	0.2	172	0.2
	Round L	5	46	1.1	32	1.5	8	1.2	59	0.6	327	0.4
	Oval L	6	1	0	8	0.4	3	0.4	29	0.3	158	0.2
	Steepbank L	6	1	0	16	0.8	7	1.5[b]	0	0	653	0.9
	D-1	6	0	0	0	0	0	0	2	0	69	0.1
	W Muskeg L	6	35	0.9	32	1.5	33	4.8	47	0.5	505	0.7
	Brule L #1	5	102	2.5	45	2.2	12	1.7	145	1.5	498	0.7
	Brule L #2	5	4	0.1	11	0.5	0	0	11	0.1	0	0
	Brule L #3	5	4	0.1	10	0.5	2	0.3	9	0.1	113	0.2
	Brule L #4	5	0	0	2	0.1	1	0.1	2	0	14	0
	Brule L #5	5	5	0.1	6	0.3	0	0	3	0	1	0
	Algar L	4, 6	181	4.5	210	10.1	72	10.5	3423	36.5	2812	3.7
	Little Algar L	6	29	0.7	35	1.7	2	0.3	57	0.6	135	0.2
	Colt L	6	-	-	-	-	3	0.4	29	0.3	8	0

continued ...

Table 8. Concluded.

Wetland type	Wetland name	C.L.I. Classification	Spring staging No.	Spring staging RUV	Breeding pairs No.	Breeding pairs RUV	Broods No.	Broods RUV	Moulters No.	Moulters RUV	Fall staging No.	Fall staging RUV
LDM (continued)	Anzac L	6	55	1.4	28	1.4	16	2.3	36	0.4	1315	1.7
	Thickwood L	5	98	2.4	35	1.7	9	1.3	87	0.9	305	0.4
	Long L	5	21	0.5	13	0.6	3	0.4	19	0.2	29	0
	Ruth L	5	21	0.5	57	2.8	13	1.9	159	1.7	1035	1.4
	Mildred L	5	18	0.4	26	1.3	18	2.6	8	0.1	495	0.7
	Total		3257		1822		589		8580		62189	
Lake with shallow-marsh aquatics (LSM)	Little McClelland L	4	99	2.4	62	3.0	16	2.3	214	2.3	2175	2.9
	Erp L	6	1	0	15	0.7	8	1.2	12	0.1	277	0.4
	Lilian L	6	57	1.4	21	1.0	6	0.9	41	0.4	122	0.2
	D-2	6	0	0	9	0.4	1	0.2	0	0	33	0
	D-3	6	35	0.9	26	1.3	2	0.4	32	0.6	76	0.1
	Beaver Cr Sed Pond	-	125	4.1[b]	15	1.8	-	-	-	-	163	0.5[b]
	Total		317		148		33		299		2846	
	Total		4044		2072		686		9388		75183	

[a]Waterfowl numbers = total from all surveys for the designated population segment (spring-staging, breeding pairs, etc.) RUV = (total ducks for the designated wetland / total ducks for all wetlands) x 100. The C.L.I. classification of wetlands (Schick and Ambrock 1974) has been included for comparison.

[b]RUV derived from fewer than the full complement of surveys for the designated wetland and population segment.

Examination of breeding pair data (Table 5) indicates that breeding mallards were present in the same densities as the most prevalent divers, scaup, and Ringneck ducks.

For breeding pairs, the edge type/habitat next-to-edge combination is most preferred; diving ducks prefer emergent vegetation followed by a shrub habitat (3.2 divers/km), the wet meadow/coniferous forest combination (2.0 divers/km), the coniferous forest/coniferous forest combination (1.5 divers/km), emergent/wet meadow combination (1.2 divers/km), emergent/mixed forest combination (1.0 divers/km), and wet meadow/mixed forest combination (1.0 divers/km) (Table 5).

The edge type and habitat next-to-edge combinations preferred by dabbling ducks are listed in Table 5. Emergent/shrub combination (2.5 dabblers/km) and emergent/wet meadow combination (0.9 dabblers/km) were most preferred, with dabbling ducks showing little preference for the remaining combinations.

4.2.6.2 Broods/moulting. None of the edge type/habitat next-to-edge combinations appeared to be significantly favoured by broods or moulting ducks. That is not to say that a relationship does not exist, but only that our survey methods did not detect a significant relationship.

4.2.6.3 Fall staging. Table 6 illustrates the habitat preferences shown by ducks during fall staging on oil sands wetlands. It should be noted that only the preferences exhibited by diving ducks proved significant (p 0.01). Diving ducks were most frequently found in large flocks in the center of the wetland (average 134.8 ducks/wetland). Diving ducks also exhibited a preference for the shrub/shrub combination. Dabbling ducks appeared to prefer an edge consisting of a wet meadow followed by either shrub or mixed forest.

Table 7 allows for a comparison of the intensity of use of wetlands and wetland types, whereas Table 8 provides for a comparison of the total numbers of ducks using each wetland. Thus, a small lake may support fewer total ducks than a large lake and, therefore, have a low RUV. However, the intensity of use of the small lake may exceed that of the large one.

For example, Little McClelland Lake (1 km^2) had an RUV of 3.0 for breeding pairs (62 pairs) and a breeding pair density of 10.0 pairs/km. Meanwhile, Algar Lake (8 km^2), had an RUV of 10.1 (210 pairs), but a pair density of 6.4/km.

Tables 7 and 8 also provide a means of assessing differences in utilization of the various wetlands and wetland types by the five population segments. For example, Triangle Lake had a spring-staging duck density of at least 17.1/km, a breeding pair density of at least 4.8/km, a brood density of at least 1.0/km, a moulting duck density of at least 31.9/km, and a fall-staging duck density of at least 45.2/km. The phrase "at least" applied to all values because these densities were derived from observed birds; that is, they do not account for birds present but not seen, nor do they account for the turnover in use of the wetland as the season progressed.

4.2.7 Geese, Swans, Cranes

Since significant numbers of geese, swans and Sandhill Cranes (*Grus canadensis*) were seen only during their migrations through the oil sands area [the number of nesting Canada Geese (*Branta canadensis*) was virtually neglible] the results of observations of these groups are dealt with separately from other waterfowl. While cranes are not "waterfowl", the similarity of their movements through the oil sands with those of geese and swans warrants their inclusion in this section. The observations reported by all AOSERP personnel were combined to provide an impression of the magnitude, chronology, and distribution of the migratory movements (Figure 10 and 11). All of these impressions were, of course, biased by the distribution of personnel, the dates the observers were in the field, and the amount of effort expended in observing and recording birds. In the latter case, it probably can be assumed that the "efforts" of individuals when in the field were more or less constant. An attempt has been made to avoid duplication of records. Ignoring the spatial distribution

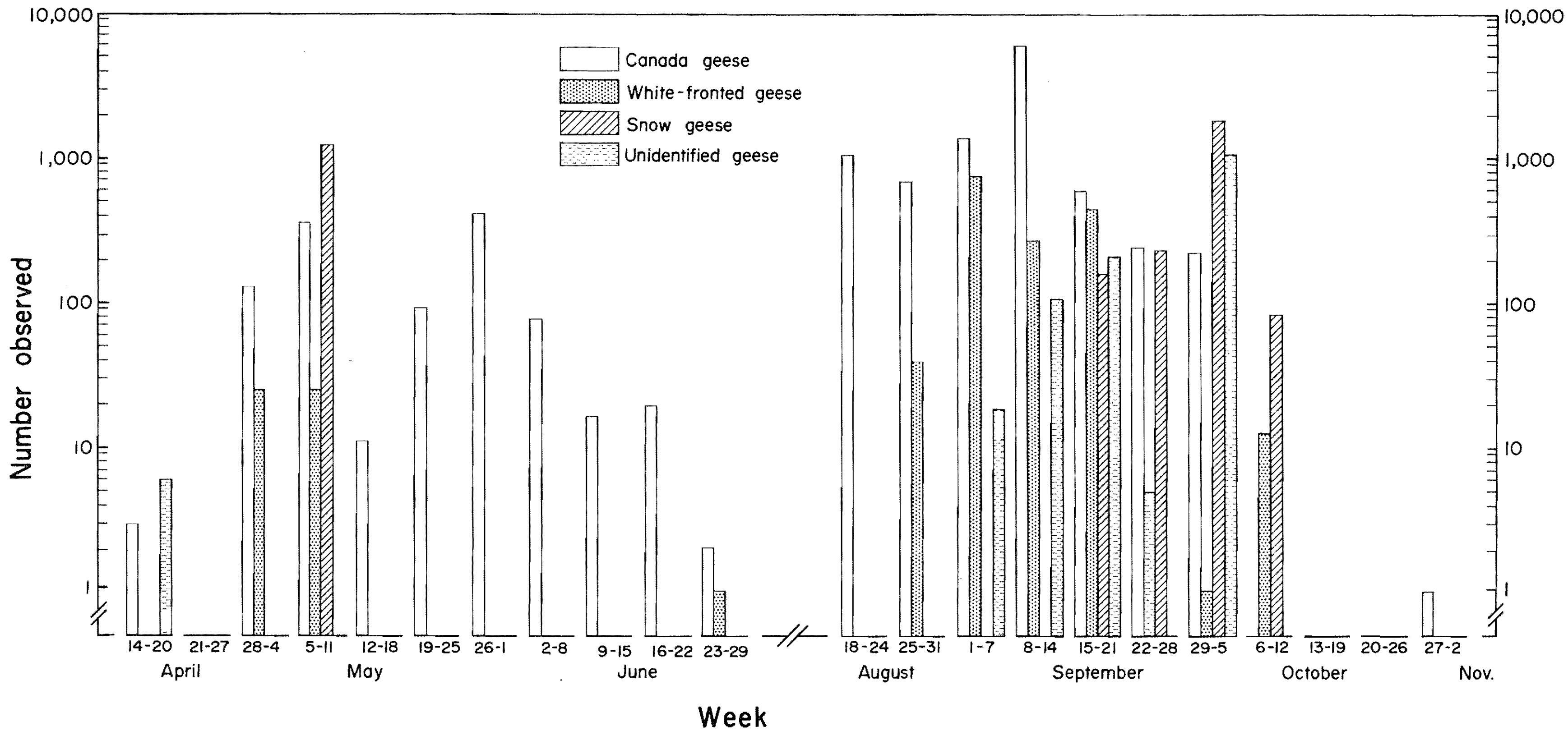

Figure 10. Temporal distribution of geese observations (all species) made in the oil sands area, 1976.

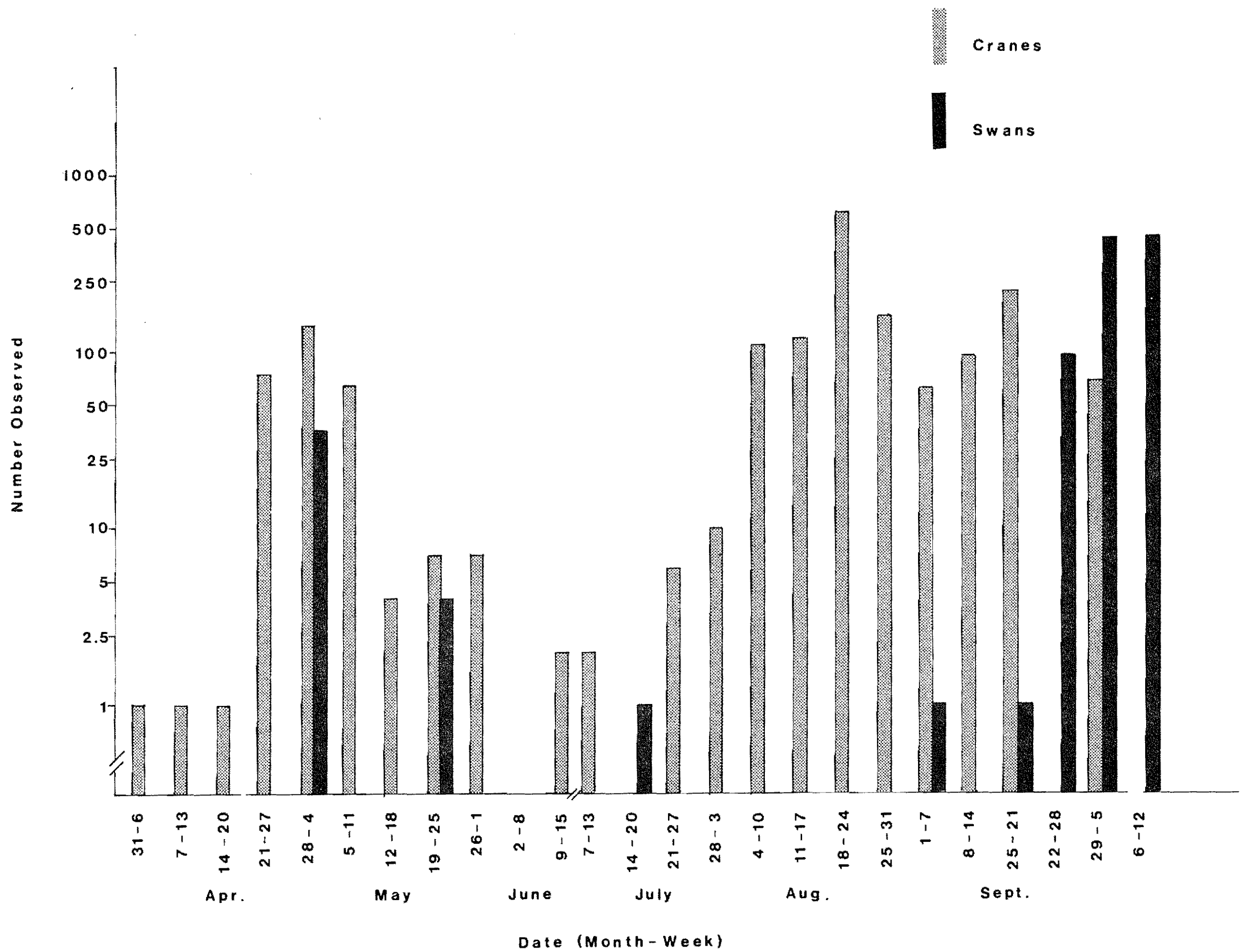

Figure 11. Temporal distribution of swans and cranes in the oil sands area, 1976.

data which are obviously biased by the locations of the observers, Figures 10 and 11 give a good indication of the temporal distribution of the migratory movements through the oil sands in 1976.

4.2.8 Other Species

Table 9 lists the total number of other bird species incidentally identified during the course of waterfowl surveys. The wetlands of the oil sands are well utilized by several of these species of birds, notably the Common Loon (*Gavia immer*), American Coot (*Fulica americana*) in migration, Red-necked Grebes (*Podiceps grisegena*), and gulls, especially Bonaparte's Gulls (*Larus philadelphia*).

4.3 DISCUSSION

Each of the five population "segments"--i.e. spring-staging ducks, breeding pairs, production (broods), moulters, and fall-staging ducks--will be considered in light of:

1. Quality of results;
2. Results of other studies;
3. Edge-habitat types;
4. Wetlands and wetland types; and
5. Relative significance to oil sands wetlands to various waterfowl species.

Portions of the discussion of spring-staging ducks will apply similarly to the other population segments and will not be repeated.

4.3.1 Spring-Staging Ducks

The "spring-staging" data from the third spring-staging/ breeding pair survey (Table 12, Figures 4 and 5: 11 to 13 June) should be ignored as a measure of utilization of oil sands wetlands by migrants. This third survey will have included predominantly post-breeding males or non-breeding ducks of both sexes. These ducks are more accurately included as part of the "moulting segment" (see Section 4.3.2).

Table 9. Total number of other bird species on selected oil sands wetlands, 1976.

Species	Spring Staging	Broods	Fall Staging
Common Loon (*Gavia immer*)	133	130	70
Red-necked Grebe (*Podiceps grisegena*)	181	168	17
Horned Grebe (*Podiceps auritus*)	2	-	-
Western Grebe (*Aechmophorus occidentalis*)	1	-	1
Pied-billed Grebe (*Podilymbus podiceps*)	-	-	1
Unidentified Grebe (*Podiceps* sp.)	55	37	109
White Pelican (*Pelecanus erythrorynchos*)	166	-	-
Great Blue Heron (*Ardea herodias*)	-	1	1
American Bittern (*Botaurus lentiginosus*)	-	18	-
Goshawk (*Accipiter gentilis*)	1	2	-
Rough-legged Hawk (*Buteo lagopus*)	-	-	1
Bald Eagle (*Haliaeetus leucocephalus*)	17	14	33
Marsh Hawk (*Circus cyaneus*)	4	-	16
Osprey (*Pandion haliaetus*)	-	-	1
American Kestrel (*Falco sparverius*)	3	-	-
Unidentified Raptors (*Falconiformes* sp.)	-	1	2
Sandhill Crane (*Grus canadensis*)	33	12	10
American Coot (*Fulica americana*)	495	233	4415
Killdeer (*Charadrius vociferus*)	-	5	-
Common Snipe (*Capella gallinago*)	1	6	-
Unidentified Yellowlegs (*Tringa* sp.)	225	100	23
Unidentified Shorebirds (*Charadriiformes* sp.)	446	41	596
Black-head Gulls[a] (*Larus* spp.)	257	464	172
White-head Gulls (*Larus* sp.)	39	11	53
Unidentified Gulls (*Larus* sp.)	86	7	959
Common Tern (*Sterna hirundo*)	2	-	-
Black Tern (*Chlidonia niger*)	65	32	243
Unidentified Tern (*Sterna* sp.)	1	-	-

[a]Mainly Bonaparte's Gulls (*Larus philadelphia*), but also includes some Franklin's Gulls (*Larus pipixcan*).

The data from the first two survey only (10 to 12 May and 27 to 28 May 1976) do not, however, provide a complete picture of how many ducks of each species used each wetland. One might expect, for example, that many more than 58 to 68 mallards had used the surveyed wetlands, possibly many before the first survey was conducted. Schick and Ambrock (1974) suggested that several thousand waterfowl passed through the area between their weekly surveys. What has been obtained then, is an indication of the order of magnitude of duck utilization of oil sands wetlands during spring migration. The implication of the 1976 figures--1000 to 3500 ducks on 403 to 453 km of shoreline from 65 wetlands is that the oil sands wetlands do not play a major role in the northward migration of ducks. These 1976 numbers were generally low compared to those recorded by Schick and Ambrock (1974), and Smith (1975) during 1973, 1974, and 1975 (Tables 12 and 13). Note, however, figures from previous years increase the interpreted value of these wetlands for spring-staging, but only slightly. Gordon Lake, however, is obviously an important wetland during this period.

It would essentially be impossible to set up a survey sampling system which would include equal and adequate amounts of each type of habitat one would encounter in the wetlands of a region. Rather, one is restricted to simply sampling a number of wetlands representing different general types and assessing the habitat as it is encountered. Thus, samples of various combinations of edge type and habitat next-to-edge are variable and often small. Therefore, one must be selective in extracting meaningful data from Tables 14 through 18. For example, the mean of 9.7 ducks/km on emergent edge back by wet meadow habitat can be regarded as representative since it is derived from the census of 25 segments of such habitat totalling 129 km in length. At the same time, 14.5 km of mudflat edge back by shrub, yielding a mean of 0.6 ducks/km, may not be representative since the 14.5 km sample was derived from only one segment. At that, however, a more evident correlation of waterfowl numbers and edge/habitat next-to-edge types had been expected. It appears that the overall characteristics of the wetland and perhaps its relationship to other wetlands and physiographic features may provide the overriding influences determining waterfowl utiliation. One apparently cannot develop a predictive capability of bird use of oil sands wetlands on the basis of shoreline characteristics alone.

On the basis of more generalized features one can classify a given wetland and obtain some impression of its absolute and relative utilization values (Tables 7 and 8). Thus, a lake with deep-marsh emergent vegetation can be expected to have a mean spring-staging density of 12.6 ducks/km; a lake with shallow-marsh aquatics can be expected to support 15.4 ducks/km; however, it is obvious that there can be considerable deviation from this mean.

The mean density for all wetlands surveyed was 10.3 ducks/km. Those wetlands supporting densities greater than 10.3 are listed in Table 10.

The RUV's in Table 8 are relative only in terms of those wetlands surveyed. Thus, the totals of RUV's for each wetland type are not truly comparable since the types are not equally represented. A method of partially circumventing the problem is to determine the average number of ducks observed on each type of wetland (both surveys combined):

1. Creeks--2.5 ducks per wetland surveyed;
2. Rivers--12.5 ducks per wetland surveyed;
3. Open lakes--81.0 ducks per wetland surveyed;
4. Lakes with deep-marsh aquatics--79.4 ducks per wetland surveyed; and
5. Lakes with shallow-marsh aquatics--52.9 ducks per wetland surveyed.

While this, of course, does not account for the mean size of wetlands of each type, nor the variable sample size, the

Table 10. Oil sands wetlands supporting duck densities greater than the mean for all wetlands surveyed, 1976.[a]

Rank	Spring-staging (mean = 10.3/km)		Breeding pairs (mean = 2.5/km)		Broods (mean = 1.4/km)		Moulters (mean = 57.5/km)		Fall-staging (mean = 57.7/km)	
	Wetland	Number/km	Wetland	Number/km	Wetland	Number/km	Wetland	Number/km	Wetland	Number/km
1	Algar L	72.7	Wood SI	11.0	W Muskeg L	10.0	Algar L	155.7	Little McClelland L	456.3
2	Audet L	67.5	Saline L	10.2	Wood SI	6.7	Square L	82.9	Saline L	341.8
3	Twin L #2	61.3	Little McClelland L	10.0	Saline L	5.0	Little McClelland L	54.3	Ronald L	197.5
4	Square L	37.9	D-3	8.3	Little McClelland L	4.0	Calumet L	43.1	Audet L	172.7
5	Little McClelland L	37.7	Lilian L	6.9	W Baseline L	3.4	Kearl L	39.0	Gordon L	170.6
6	Saline L	35.6	W Muskeg L	6.7	Lilian L	3.1	W Baseline L	37.8	Gardiner L	161.7
7	Twin L #1	34.6	Algar L	6.4	Audet L	3.0	Audet L	36.9	Anzac L	157.1
8	W Muskeg L	30.4	Horseshoe L	5.2	Anzac L	2.9	Horseshoe L	32.6	Calumet L	143.1
9	Lilian L	25.0	Brule L #1	4.8	Algar L	2.5	Triangle L	31.9	Kearl L	133.9
10	Wood SI	22.9	Triangle L	4.8	Mildred L	2.5	Twin L #2	25.4	McClelland L	130.8
11	Ronald L	20.5	Little Algar L	4.7	Horseshoe L	2.3	Lilian L	24.4	Algar L	113.6
12	D-3	18.3	Steepbank SI	4.5	Calumet L	2.2	Twin L #1	18.3	Little Audet L	105.1
13	Triangle L	17.1	Calumet L	4.4	Brule L #1	2.1	D-3	17.8	W Baseline L	92.6
14	Gordon L	16.5	Brule L #2	3.9	Thickwood L	2.0	Brule L #1	17.6	Steepbank L	71.4
15	McClelland L	16.0	Ruth L	3.7	Square L	1.8	W Muskeg L	17.0	W Muskeg L	71.1
16	Brule L #1	15.7	Gordon L	3.4	Twin L #2	1.7	Buckhorn L	16.8	Horseshoe L	65.5
17	Calumet L	11.9	Twin L #1	3.3	Fishtail L	1.7	Ronald L	15.1		
18	Beaver Cr Sed Pond	11.1	Audet L	3.1	Buckhorn L	1.6				
19	Horseshoe L	10.7	Snipe L	3.1	Dover L	1.5				
20	Thickwood L	10.7	Ronald L	3.0	Ruth L	1.5				
21			W Baseline	2.9						
22			Anzac L	2.9						
23			Buckhorn L	2.7						
24			Campbell L	2.6						

[a] Densities are maximums for the individual wetlands, derived from the total complement of surveys for each population segement.

samples are more or less representative and it is believed that the figures are a good indication of the relative value of those wetland types.

If all 65 wetlands surveyed supported an equal share of the spring-staging ducks, each would support 1.5% of the total (i.e. RUV = 1.5). Those wetlands supporting more than 1.5% of the total in 1976 are presented in Table 11. This list corresponds closely, but not exactly, with the foregoing list based on densities. A review of both lists will enhance the assessment of important wetlands.

In the final analysis, it must be remembered that these lists are based on a sampling of wetlands, but that certain wetlands can be considered representative of others of similar type and location. Thus, the relative value and density estimate for Gardiner Lake may be representative of large lakes in the Birch Mountains. Dover and Snipe lakes are expected to be representative of the group of lakes immediately south of the Birch Mountains. Rich Lake is expected to be representative of those lakes in the sand hills in the vicinity of Richardson Tower. All wetlands in the oil sands have not yet been classified according to the various schemes described in Section 4.2: schemes which included consideration of physiographic features, wetland types, sub-regional and local community types, and which might also include traditional migration pathways through the area. During spring migration, as well as during most, if not all other periods of the season, the oil sands wetlands were utilized more by diving than dabbling ducks. The diver:dabbler ratios for spring migrants were 6.3:1 and 7.7:1 (Table 12). The relative observability of species, if known, would probably serve to reduce those ratios somewhat, but it is readily apparent that the oil sands wetlands were favoured by scaup, Ringneck, Bufflehead, and Goldeneye. The ubiquitous Mallard was the most abundant dabbler. By referring to the "raw" data one can get some idea of which

Table 11. Oil sands wetlands supporting duck densities greater than the mean for all wetlands surveyed, 1976.[a]

Rank	Spring-staging		Breeding pairs		Broods		Moulters		Fall-staging	
1	Audet L	15.2	Gordon L	19.7	Gordon L	11.1	Algar L	36.5	Gordon	23.7
2	Gordon L	12.5	Buckhorn L	12.8	Algar L	10.5	Little McClelland L	17.9	Gardiner L	12.7
3	McClelland L	8.9	Algar L	10.1	Saline L	9.2	Gordon L	8.2	Ronald L	10.4
4	Ronald L	7.1	Ronald L	6.7	Wood SI	6.2	Audet L	5.2	McClelland L	10.2
5	Twin L #2	5.9	Saline L	6.2	Gardiner L	5.5	Horseshoe L	4.9	Saline L	6.8
6	Algar L	4.5	Horseshoe L	4.3	W Muskeg L	4.8	Buckhorn L	4.5	Kearl L	4.4
7	Square L	4.3	Little McClelland L	3.0	W Baseline L	4.4	Gardiner L	3.9	Algar L	3.7
8	Beaver Cr Sed Pond	4.1	Ruth L	2.8	Horseshoe L	4.4	Square L	3.6	Little McClelland L	2.9
9	Saline L	3.3	Audet L	2.7	Audet L	4.2	W Baseline L	3.5	Audet L	2.4
10	Gardiner L	2.6	Kearl L	2.4	Buckhorn L	3.9	McClelland L	2.0	W Baseline L	2.4
11	Twin L #1	2.6	Snipe L	2.4	Dover L	3.2	Triangle L	1.7	Dover L	2.0
12	Little McClelland L	2.4	Wood SI	2.2	Mildred L	2.6	Ruth L	1.7	Buckhorn L	1.7
13	Thickwood L	2.4	Brule L #1	2.2	Little McClelland L	2.3	Dover L	1.6	Calumet L	1.7
14	Wood SI	1.7	Gardiner L	2.1	Anzac L	2.3	Dalumet L	1.6	Anzac L	1.7
15	Dover L	1.6	W. Baseline L	1.9	Ruth L	1.9			Horseshoe L	1.6
16			McClelland L	1.9	Snipe L	1.9				
17			Beaver Cr Sed Pond	1.8	Brule L #1	1.7				
18			Thickwood L	1.7	Calumet L	1.6				
19			Triangle L	1.6						

[a] Relative utilization values (RUV's) are based on the total ducks observed in all surveys of a given population segment. RUV = (total for wetland/total for all wetlands) x 100.

wetlands are important to certain species; however, verification of any conclusions regarding traditional use of lakes would require several years of observation.

4.3.2 Breeding Pairs

A more accurate assessment of breeding-pair numbers and densities should include the following analyses as described in Section 4.2. Mathematical adjustments and/or subjective qualification should be considered in terms of: turnover in use of territorial sites; renesting effort; variable observability based on habitat types and duck species; and optimum census period of each species based on brood data (hence, nest initiation dates). These types of data are not available from aerial surveys.

The counts by Schick and Ambrock (1974) and Smith (1975) were adjusted in terms of combining species totals according to their optimum census period. Our unadjusted data, then, are not exactly comparable but will serve in a comparsion of orders of magnitude (Tables 1 and 2). In fact, other than for Gordon Lake, for which our 1976 survey was only partial, the figures are very similar to those for 1975: totals, excluding Gordon Lake but including other lakes surveyed in both years, were 728 and 724 pairs for 1975 and 1976, respectively (Table 1).

The comments regarding correlation of edge types/habitat next-to-edge and spring-staging duck numbers (Section 5.1) apply similarly to breeding pairs. However, for the groups having the largest sample size in terms of both numbers of segments and length of edge censused, namely emergent edge (Table 15), there was consistency in the breeding-pair density: 2.7, 2.2, and 2.1 pairs/km for the three surveys in 1976.

In terms of individual wetlands and wetland types, rather than edge types (i.e. Table 18 vs Table 15), breeding-pair densities ranged from 0 to 11.0/km with an overall mean of 2.5/km. On the average, river habitat supported the lowest pair densities and lakes with shallow marsh aquatics supported the highest. Schick and Ambrock (1974) obtained a mean pair density of 3.8/km (range 0.4 to 15/km) with the dabblers predominating.

A list based on data from Schick and Ambrock (1974) is as follows:

Little McClelland L	(15.0)	Steepbank	(12.1)
Gordon L	(12.5)	Horseshoe L	(09.8)
Saline L	(12.3)	Mildred L	(05.3)

They concluded that the "breeding-pair densities at Gordon, Saline and Horseshoe lakes, and a few smaller wetlands, were comparable to those of prairie wetlands".

By way of comparison with other boreal lakes, Donaghey (1974) reported breeding-pair densities, on ponds, of 3.9 to 6.7/km using a roadside count technique, and 13.1 to 23.6/km, on the same areas, using blind observations. For lakes and streams, using a canoe census technique, densities of 5.0 and 20.0/km and 12.0 to 13.6/km, respectively, were obtained. These results indicate that higher duck densities occur in the ponds, lakes, and streams near Utikuma Lake and/or that the ground census methods were considerably more effective than our aerial methods for counting breeding ducks.

In order to compare surveyed wetlands on the basis of numbers rather than on densities, as was done for the spring-staging component, those wetlands having a RUV greater than "their equal share" (1.5%) are listed in Table 11.

The ratio of divers to dabblers for the breeding pair surveys in 1976 was 1.3:1. This ratio was considerably lower than that for the spring-staging segment. This decline in the ratio of divers to dabblers may be attributed to several sources: the spacing phenomenum of breeding pairs; both diving and dabbling ducks become even less observable from an aircraft during the breeding period; dabbling ducks become even less conspicuous due to plumage and behavioral characteristics; oil sands wetlands are more attractive to spring-staging divers than dabblers and when these birds moved on the ratio would have been reduced. Donaghey

(1974) found equality of numbers or a slight predominance of dabblers on a stream near Utikuma Lake (canoe census). For ponds (roadside and blind observations), the ratio favoured divers.

In this study, the six most common species observed (with more than 50 pairs), based on the probably optimum census period for each species, were: Mallard, Lesser Scaup, Ringneck (*Aythya collaris*), Bufflehead (*Bucephala albeola*), Wigeon (*Anas americana*), and Goldeneye (*Bucephala clangula*).

Donaghey (1974) prepared comparable lists for lakes: Lesser Scaup, Mallard, Wigeon, Bufflehead, Blue-winged Teal (*Anus discors*), Green-winged Teal (*A. crecca*); for streams: Lesser Scaup, Mallard, Wigeon, Green-winged Teal, Blue-winged Teal, Bufflehead; and for ponds: Lesser Scaup, Mallard, Bufflehead, Blue-winged Teal, Green-winged Teal, and Ringneck. The two species of teal probably are much less observable from the air than from canoe or blind. Similarly, some other species are especially secretive [e.g., Ruddy Ducks (*Oxyura jamaicensis*)], or less conspicuous by virtue of plumage [e.g., Gadwall (*Anas strepera*)] and aerial surveys are no doubt biased in this respect. Ideally, ground investigations would improve our assessment of the breeding-pair species composition.

4.3.3 Duck Production

The "accuracy" of the brood surveys is considered to be quite high, based on strict adherence to constraints of flying conditions and times, the excellent quality of helicopter piloting, and the correlation between brood and pair numbers (Tables 12 and 13). Unfortunately, only two surveys were conducted each year and the numerical picture of production was not complete. In retrospect, there obviously were numerous clutches of late (and possibly renesting) species, notably Lesser Scaup, not hatched at the time of the second survey.

If, in terms of edge/habitat next-to-edge types, we accept a minimum of five sample segments with a total sample of 5 km, then the range of observed brood densities (Table 16) was 0.1 to 1.2 broods/km in the first survey and 0.6 to 2.6 in the second survey. Other than shrub/shrub no type was particularly favoured. Of more significance and reliability, once again, were the relationships of densities with individual wetlands and wetland types. In these terms, densities ranged from 0 to 10/km with an overall mean of 1.4/km. As for pairs, lakes with shallow-marsh aquatics had the highest densities and rivers the lowest.

Wetlands supporting densities greater than 1.4 broods/km are listed in Table 10. An anomaly in this list is W. Muskeg Lake, an isolated, circular, muskeg-type lake of approximately 40 ha and 2.7 km of edge. From the authors' experience, this type of lake would not be expected to support the numbers of breeding pairs and broods that it did: 18 and 27, respectively. (Obviously the breeding-pair estimate is low since there were no other adjacent waterbodies, except perhaps small muskeg water pockets only 1 to 3 m in diameter, from which broods could have emigrated.) Schick and Ambrock (1974:30) concluded that "The (oil sands) area's productive capability for waterfowl is low with the exception of a few lakes which become particularly important in lieu of the general limitations of the area". However, this was a generalization since they also state that their brood surveys were inadequate and that "reliable production data is not available".

Donaghey (1974) observed brood densities of 0.6 and 3.9/km on lakes and 1.1 to 1.7/km on streams via canoe census. On ponds he observed 0.1 to 1.2 broods/km via roadside census, and 9.1 to 11.7 broods/km via blind observations. Obviously, blind observations are superior to roadside counts, but how they compare with helicopter surveys is unknown.

Surveyed oil sands wetlands were observed brood numbers (vs densities) yielding relative utilization values greater than

1.5 are listed in Table 11. As with other population segments, this list should be compared with that for brood densities to properly assess the significance of these wetlands.

The ratios of diver to dabbler broods for the two surveys were 0.5:1 and 1.1:1. Unlike the ratios for spring- and fall-staging birds, these ratios cannot be considered as significant due to the influences of census data relative to breeding phenology and of relative observability of the two groups (i.e. diver broods, as a rule, are much more observable than dabbler broods). These influences also apply to inferences regarding the relative abundance of broods of each species. However, it appears safe to conclude that the most common include Mallard, Ringneck, Wigeon, Lesser Scaup, Bufflehead and Goldeneye. This concurs with the breeding-pair data.

4.3.4 Moulting Ducks

The population segment referred to as "moulter" is not, in fact, a discrete group of birds in the same sense as are breeding pairs or broods. "Moulters" include pre-moult, flightless, and post-moult ducks. Such birds are present from the time that the first mallard drakes start to group after breeding. These, along with the non-breeding resident birds of various species, are gradually joined by other resident post-breeding ducks and post or non-breeding ducks from further south (prairies and parklands). This group of "moulting" ducks cannot be separated numerically from the late summer influx of early southward migrants. Thus, the "moulting" population censused in conjunction with brood surveys in essence formed part of a continuum of numbers merging with the breeding-pair component (third survey) and the fall-staging component (Figure 8).

The "moulting-duck" data have, however, been analyzed according to the same method for other population segments (Tables 7 and 8). The figures can be regarded as quite conservative because: (1) moulting ducks, especially when flightless, are relatively inconspicuous in plumage as well as secretive in behaviour; and (2) an unknown portion of moulters went unobserved and/or unrecorded due to concentration of effort on the brood census.

Based on unadjusted data (Table 7), the overall mean density (maximum/wetland) of moulting ducks was 14.3/km. Lakes with shallow-marsh aquatics were favoured (mean = 19.6/km) and rivers and creeks virtually went unoccupied. This is as expected, of course, since the birds are seeking optimum cover at this time. Those lakes supporting more than the mean density of ducks are listed in Table 10.

Those lakes having a relative utilization value greater than 1.5 are presented in Table 11.

The diver:dabbler ratios for moulters observed in the two surveys were 1.5:1 and 7.1:1. An observability bias doubtlessly influenced these ratios. However, in consideration of these surveys along with the subsequent fall-staging, it is again evident that divers are attracted to these lakes in considerably greater numbers than dabblers (Table 11).

The census data (Figure 8) indicate that Ringneck, scaup, Mallard, and Wigeon were the most common moulting ducks. These data should be considered in light of the aforementioned bias. Note also that unidentified dabblers formed 34% and 17% of the dabbler total while unidentified divers constituted 10% and 85% of the diver total. The identification of these ducks may have altered significantly the assessment of the species composition.

4.3.5 Fall-Staging Ducks

As stated for spring-staging, the periodic census of a population undergoing continual immigration and emigration provides provides only a crude estimate of the total waterfowl use of the wetlands surveyed.

The overall mean fall-staging density, based on maximum counts for each wetland, was 57.5 ducks/km (Table 7). Lakes with shallow-marsh aquatics again supported the greatest densities, however, the high mean value (88.0/km) perhaps is not representative of the type since the density of a single, small lake (Little McClelland) raised the mean from what would otherwise have been 14.3/km.

Those lakes supporting duck densities greater than the overall mean are listed in Table 10.

Schick and Ambrock (1974) declared that "The major importance of the area to waterfowl is fall migration; however, use during this period is confined mainly to Gordon and McClelland lakes". The maximum numbers they observed during 1972 and 1973 fall surveys totalled 41 520 and 23 405, respectively. Note that 84% and 44% of these ducks were on Gordon Lake.

In our studies, Gordon Lake was again the most heavily utilized lake (note again that it was only partially surveyed in 1976), but several other areas served as significant staging areas for fall populations. Those areas having relative utilization values greater than 1.5 are listed in Table 11.

One might suspect that the use of some oil sands wetlands by fall migrants, especially late in the season as the "urgency" of the migration is apt to increase, is partially--but only partially--a matter of chance. That is, rather than selecting certain lakes for a stopover, a flock may land on any lake that is along their path of flight. This may explain why, for example, the only period during which Steepbank Lake supported more than the average density of birds was late fall.

The diver:dabbler ratios for five surveys were: 1.5:1, 3.7:1, 6.9:1, 6.7:1 and 12.2:1 (see discussion of moulters). Scaup, Ringneck, Mallard, Redhead, Goldeneye, and Bufflehead were the most numerous fall-staging species. Note that unidentified dabblers and divers constitued a substantial proportion of the total ducks recorded. A species breakdown of the totals for the five fall surveys provides strong evidence of specific temporal migration patterns (Figure 9). Knowledge of these patterns, complemented by analysis of spatial distribution as evidenced in Tables 7 and 8, may have considerable relevance in providing guidelines for oil sands industrial operations, particularly with respect to tailings ponds.

The fall-staging population of the Peace-Athabasca Delta, while highly variable, has been estimated to number as high as 1.2 million ducks under favourable conditions (Hennan 1972). Schick and Ambrock (1974:22) have stated: "Although the major movement out of the Delta is in a southeasterly direction substantial numbers from these flyways [Mississippi and Central] pass through the Fort McMurray region. The degree of fall waterfowl use of this area will depend upon annual fluctuations in Delta populations".

3.3.6 Overview: Ducks

For each population segment a list of the more important oil sands wetlands has been prepared (see preceding sections and Tables 10 and 11). Some wetlands were apparently significant in terms of one population segment but not in terms of others, and some wetlands played a significant role throughout the entire season. In terms of duck densities, Little McClelland Lake was the only area that ranked within the five most important throughout the season. Saline Lake was a major contributor to all but the moulting segment. Algar Lake maintained a moderate density level with the exception of peaking as a moulting area (mainly divers). West Muskeg Lake, surprisingly, maintained a position in the lists and even ranked highest in terms of brood densities. Wood Slough, West Muskeg Lake, Saline Lake, and Little McClelland Lake were most outstanding in terms of densities of breeding pairs and broods.

In terms of total numbers of ducks (vs densities), the evaluation of wetlands changes somewhat although most of the same lakes appear on both lists. Gordon Lake, of course, mainly because of its size, assumes a major role in supporting all population segments. On the other hand, Little McClelland Lake, in spite of its small size, contributed more than "its fair share" (at more than 1.5% of the totals) throughout the season.

The essential sequel to this evaluation of a sample of wetlands in terms of densities and total numbers will be the corresponding classification and mapping of all wetlands in the oil sands area. The factor primarily affecting this classification will be wetland type. However, subsequent data analysis may define the influence of sub-regional and local community types, geographic and physiographic location, and juxtaposition of other wetlands. The inferential mapping process should essentially be one of aerial photograph interpretation with a minimal amount of aerial and ground verification. Four such maps probably will be sufficient in terms of assessing impacts of, and providing guidelines for, oil sands development:

1. Densities:
    a. Incorporated spring- and fall-staging and moulting; and
    b. Incorporated breeding pairs and production.
2. Numbers (RUV'S):
    a. Incorporated spring- and fall-staging and moulting; and
    b. Incorporated breeding pairs and production.

4.3.7 Geese, Swans, and Cranes

The geese and swans which migrate through the oil sands area do not appear to present a significant concern in terms of oil sands development. The occasional flocks which do land on the Athabasca River or on some of the lakes are generally small and their stops are brief. Although this appears to be the norm, a continued surveillance of the type carried out in 1976 (i.e., well-documented incidental sightings from all sources) will serve (at no extra cost) to substantiate such conclusions or, perhaps, provide evidence to the contrary.

The number of Sandhill Cranes which breed in the oil sands has not been adequately assessed; however, incidental sightings of pairs indicated that the overall population was low and widely scattered. The numerous sightings of flocks on or over the cleared portion of the Syncrude lease (Table 9) demonstrates the potential role of such areas in altering the patterns of movements of these birds through the oil sands. The nature of such alteration and its potential effects are still unknown.

4.4 ASSESSMENT AND RECOMMENDATIONS

Relative to other waterfowl production areas [Peace-Athabasca Delta (PAD) and the prairie potholes] the wetlands of the oil sands area do not appear to be important in terms of waterfowl production; however, selected wetlands, notably McClelland and Gordon lakes are heavily utilized by waterfowl during spring- and fall-staging.

At this time we are unable to determine whether McClelland lake is restricted to utilization as a regional staging lake or as a staging lake for migrating waterfowl from the PAD and breeding grounds farther north, or some combination of the above.

We therefore strongly advise against any form of development which will affect the water levels or shoreline habitat of either of these lakes.

We would again emphasize the importance of the PAD both as a waterfowl production area as well as a staging area for birds breeding farther north. Utilization of the PAD varies from year to year, depending upon the continental waterfowl picture and habitat conditions. Therefore, during continental periods of either high populations and/or drought conditions, utilization of the PAD by waterfowl will increase significantly. Therefore, development of any kind which would affect the quality of this area as waterfowl habitat must be avoided if at all possible.

As the oil sands area becomes further developed and the urbanization of Fort McMurray intensifies, the pressure exerted on waterfowl as a result of hunting may require periodic evaluation.

A further important area of concern is the potential hazard to the waterfowl resource created by tailings ponds, the inevitable result of oil sands extraction. The conflict between waterfowl and tailings ponds has received considerable attention in recent years (Schick and Ambrock 1974; Ward et al. 1976). LGL, under contract to Syncrude Canada Ltd., is currently conducting testing of deterrent mechanisms. Our primary concern is therefore directed more toward suggesting guidelines for the construction and filling of tailings ponds which will keep waterfowl utilization of these waterbodies to a minimum.

As previously mentioned, we recognize that the wetlands in the oil sands area do not appear to be prime waterfowl production areas but several of the larger wetlands are heavily utilized by spring- and fall-staging waterfowl. The existence of the following substantial gaps in our present data is also recognized.

1. What is the extent of nocturnal utilization of wetlands by waterfowl in the AOSERP area and therefore what might be the utilization of tailings ponds during darkness, especially considering that the birds would experience difficulty in identifying suitable waterbodies and may take whatever is available;
2. If birds do come into contact with tailings ponds, how will the contaminants affect them, both in the short-term and long-term? Long-term effects may be manifested over several days or weeks, during which time the birds could be hundreds of kilometres removed from the point of contact--especially if the contact occurred during spring and/or fall migration; and

3. Ground verification of aerial survey data was not attempted; therefore, production estimates and habitat relationships must be considered preliminary at best.

It should be noted that no habitat reclamation configuration will completely eliminate attractiveness to all species and, therefore, the suggestions offered can, at best, be a compromise.

We will, therefore, direct our recommendations toward providing suggestions which will render these artifical waterbodies as unattractive to waterfowl as is practically feasible. Our recommendations are based on an analysis of wetland-waterfowl relationships identifying which physical characteristics of the wetland determine it attractive or unattractive to waterfowl.

4.4.1 Recommendations

1. The banks of the tailings pond dykes should be constructed as steeply as possible thereby eliminating gradual shorelines;
2. If the dykes are to be vegetated, utilization of treed vegetation right up to the water edge is strongly recommended;
3. We suggest, as treed vegetation, tall fast-growing poplar and willow species;
4. Ensure that the entire area of the eventual tailings pond is completely devoid of all vegetation in order to eliminate any emergent or projecting vegetation above the water surface. Emergent vegetation of any kind must be avoided;
5. Tailings ponds should be constructed as far removed from drainage courses as is feasible, be of as small a size as is practical, and be square or geometric in shape; and

6. The projected timing for pond filling is to be extended over several years--we strongly recommend that this be reviewed because gradual filling will create artificial shorelines and shallow areas. At this stage of tailings pond construction, two distinct groups of birds may be affected:
   (a) Shorebirds: this group of birds prefers wetlands with open, bare shorelines having a flourishing littoral zone. These birds will, in all probability, be the group which is the most likely to utilize tailings ponds during the early filling stages; and
   (b) Waterfowl: this group of birds is attracted to wetlands with emergent vegetation/shallow marsh aquatics. Banks with a healthy growth of graminaceous plants are attractive to waterfowl. Diving ducks, loons, and grebes prefer large open water areas and mechanical deterrent mechanisms may have to be utilized. Most ducks exhibit a preference for mudflats in which exposed, flat areas, adjacent to the water edge, are heavily utilized for loafing. It is for this reason that gradual filling of tailings ponds, extending over several years, is of concern to us.

Our primary approach to tailings ponds has been one of prevention of contact by waterfowl and we therefore recommend the following schedule for dealing with the problem of birds and tailings ponds:

1. A construction and filling schedule should be devised to ensure that tailings ponds are unattractive to birds;

2. Should birds decide to utilize these wetlands, then adequate deterrent mechanisms must be functional, especially during the peak periods of possible conflict, i.e. spring- and fall-staging;
3. Should all of the above fail, we strongly recommend that floating bitumen be kept at a minimum by restraining booms and continual operation of skimming devices, in case birds do come in contact with tailings ponds. Other potentially demaging constituents of tailings effluents should be controlled prior to introduction into the tailings ponds;
4. We recommend that a monitoring program be established for all tailings ponds, both present and future, to determine the extent of utilization by avifauna: mortality, phenology, and chronology of the bird species affected; and
5. We recommend, that in applicable areas, a clearly defined contingency plan should be determined in the event of dyke failure or oil spillage.

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6. APPENDICES

6.1 RAW DATA TABLES

Table 12. Maximum numbers of spring staging ducks and indicated breeding pairs recorded on selected oil sands wetlands, 1973-1977.

Location	Maximum # of Waterfowl Recorded in Spring					Indicated Breeding Pairs				
	1973	1974	1975	1976	1977	1973	1974	1975	1976	1977
Kearl (Muskeg) L.	529	586	24	37	140	25	22	6	24	17
Little McClelland L.	282	979	72	72	63	72	31	25	30	4
McClelland L.	194	1154	225	360	195	-	63	20	27	-
Audet L.	-	-	234	520	-	-	-	30	24	-
N. Audet L.	-	-	36	36	-	-	-	14	5	-
C-1	-	-	17	0	-	-	-	3	1	-
C-2	-	-	14	6	-	-	-	5	4	-
D-1	-	-	-	0	-	-	-	0	0	-
D-2	-	-	6	0	-	-	-	9	7	-
Oval L.	-	-	312	1	53	-	-	13	6	6
Round L.	-	-	93	30	301	-	-	46	15	17
Campbell L.	52	65	24	12	-	19	17	18	13	-
Gordon L.	5665	5638	3258	429	-	843	393	457	143[1]	-
Gregoire L.	-	-	125	13	-	-	-	25	7	-
Anzac L.	-	-	179	46	-	-	-	27	14	-
Middle Kiskatinaw L.	-	-	12	1	-	-	-	12	3	-
Kaskatinaw L.	-	-	72	14	-	-	-	15	6	-
Poplar Slough	-	-	16	1	14	-	-	11	15	3
Wood Slough	-	-	18	48	105	-	-	9	23	7
Steepbank Slough	40	41	54	22	2	29	30	18	14	1
Mildred L.	246	313	136	17	-	42	32	51	14	-
Horshoe L.	265	59	226	36	92	86	38	37	48	8
Saline L.	624	622	408	101	494	69	87	49	65	14
Ruth L.	113	20	26	11	-	23	13	12	28	-
Long L.	-	-	6	17	-	-	-	3	8	-
Thickwood L.	-	-	42	64	-	-	-	8	15	-
Little Alger L.	-	-	68	27	-	-	-	25	18	-
Alger L.	-	-	303	109	-	-	-	27	93	-
Brule L. - #1	-	-	136	66	-	-	-	18	20	-
Brule L. - #2	-	-	6	4	-	-	-	3	9	-
Snipe L.	-	-	38	43	-	-	-	21	22	-
Dover L.	-	-	38	50	-	-	-	18	15	-
Gardiner L.	-	-	138	74	-	-	-	39	26	-
E. Baseline L.	-	-	62	22	-	-	-	13	4	-
W. Baseline L.	-	-	31	18	-	-	-	6	20	-
Buckhorn L.	-	-	34	66	-	-	-	20	45	-
Triangle L.	-	-	134	24	-	-	-	38	15	-
Lilian L.	-	-	34	40	-	-	-	17	11	-
Calamet L.	-	-	78	20	-	-	-	13	14	-

Table 13. Summary of duck broods and moulting ducks observed on selected wetlands in the Alberta oil sands, 1976.

Survey No.	Survey Date	Length of egde censured (km)	DABBLERS									DIVERS												Unid Ducks	Total Ducks
			MAL	PIN	GAD	WIG	SHO	BWT	GWT	UNID	TOT	SCP	RIN	RED	CAN	GE	BUF	RUD	WWS	SS	MER	UNID	TOT		
Broods																									
1	June 23-26	373.3	124	2	0	9	0	1	13	2	151	1	21	0	2	20	21	0	0	0	0	3	68	6	225
2	July 11-14	384.0	127	2	0	49	2	10	8	8	206	34	157	0	5	10	11	0	1	0	1	6	225	32	563
Average Broods Size (Minimum number broods for calculation = 5)																									
1	June 23-26	373.3	5.8	--	--	6.9	--	--	6.9	--	6.0	--	7.6	--	--	7.9	7.2	--	--	--	--	--	7.5	6.0	6.5
2	July 11-14	384.0	5.4	--	--	5.6	--	7.0	4.8	3.4	5.4	6.6	5.9	--	6.0	4.3	5.2	--	--	--	--	3.6	5.9	3.6	5.5
Moulters																									
1	June 23-26	373.3	368	98	0	139	24	54	48	380	1111	319	960	1	0	128	34	3	27	0	6	159	1638	840	3590
2	July 11-14	384.0	472	75	55	111	85	5	3	163	969	757	224	2	1	44	10	4	7	0	20	5858	6927	1422	9318

Table 14. Densities of spring-staging ducks as related to wetland edge types and habitat next-to-edge on selected oil sands wetlands, 1976.

Edge Type[a]	Habitat next to edge	Survey #1 Number of segments	Survey #1 Length of edge censused[b]	Survey #1 Ducks per km	Survey #2 Number of segments	Survey #2 Length of edge censused	Survey #2 Ducks per km
EM	EM	–	–	–	1	0.6	5.0
EM	DM	2	13.9	2.0	5	15.4	3.8
EM	WM	25	129.1	9.7	20	90.5	4.0
EM	IM	–	–	–	2	7.2	0.3
EM	SH	11	13.2	13.6	5	26.7	1.9
EM	CN	2	6.9	4.3	3	6.0	3.8
EM	DC	2	0.5	0	1	18.8	0
EM	MX	10	35.5	2.0	6	14.9	0.7
EM	FS	2	7.6	0.8	–	–	–
EM	FT	–	–	–	–	–	–
EM		54	206.7	7.6	43	180.1	2.8
DM	DM	–	–	–	–	–	–
DM	WM	–	–	–	1	4.8	10.8
DM	SH	1	8.0	0	–	–	–
DM	CN	1	6.0	0.2	1	1.9	0.5
DM	DC	–	–	–	–	–	–
DM	MX	1	1.4	0	3	6.7	3.3
DM		3	15.4	0.1	5	13.4	5.6
WM	DM	–	–	–	–	–	–
WM	WM	1	0.3	0	1	4.8	3.3
WM	SH	2	4.5	1.8	2	2.9	19.0
WM	CN	6	9.9	29.1	6	14.1	3.1
WM	MX	3	4.7	4.3	4	8.4	1.4
WM	FS	–	–	–	1	1.6	0
WM	FT	1	1.6	0	–	–	–
WM		13	21.0	15.1	14	31.8	4.0
MF	DM	–	–	–	2	2.7	0
MF	SH	1	14.5	0.6	1	1.1	7.3
MF	MX	2	2.1	47.6	2	22.6	0.6
MF		2	16.6	6.5	5	26.4	0.8
IM	DM	–	–	–	–	–	–
IM	IM	–	–	–	–	–	–
IM	MX	2	9.0	12.6	–	–	–
IM		2	9.0	12.6	–	–	–

continued ...

Table 14. Continued.

Edge Type[a]	Habitat next to edge	Survey #1 Number of segments	Survey #1 Length of edge censused[b]	Survey #1 Ducks per km	Survey #2 Number of segments	Survey #2 Length of edge censused	Survey #2 Ducks per km
SH	WM	–	–	–	–	–	–
SH	SH	2	9.8	0.1	1	4.2	0
SH	CN	2	10.7	0	2	15.2	1.1
SH	DC	1	2.3	0	–	–	–
SH	MX	6	19.3	13.1	3	2.9	0
SH		11	42.1	6.0	6	22.3	0.7
CN	CN	10	21.8	25.7	8	21.7	8.6
CN	MX	1	4.8	2.3	3	6.6	1.5
CN		11	26.6	21.5	11	28.3	7.0
DC	CN	–	–	–	–	–	–
DC	DC	3	6.3	10.3	–	–	–
DC	MX	3	4.2	0	2	4.3	0
DC		6	10.5	6.2	2	4.3	0
MX	SH	–	–	–	1	2.7	1.1
MX	CN	–	–	–	–	–	–
MX	MX	8	21.4	7.0	7	23.6	0.2
MX		8	21.4	7.0	8	26.3	0.3
FS	WM	–	–	–	–	–	–
FS	SH	–	–	–	2	1.9	9.5
FS	CN	–	–	–	1	1.0	2.0
FS	DC	–	–	–	–	–	–
DS	MX	2	1.3	0	–	–	–
FS	FT	–	–	–	–	–	–
FS		2	1.3	0	3	2.9	6.9
FT	SH	–	–	–	–	–	–
FT	CN	–	–	–	–	–	–
FT	DC	1	3.2	1.9	–	–	–
FT	MX	1	3.7	96.0	1	3.7	0.3
FT		2	6.9	52.3	1	3.7	0.3
RK	SH	–	–	–	–	–	–
RK	DC	–	–	–	–	–	–
RK	MX	–	–	–	1	8.4	0
RK		–	–	–	1	8.4	0

continued ...

Table 14. Concluded.

Edge Type[a]	Habitat next to edge	Survey #1 Number of segments	Survey #1 Length of edge censused[b]	Survey #1 Ducks per km	Survey #2 Number of segments	Survey #2 Length of edge censused	Survey #2 Ducks per km
SG	DM	–	–	–	–	–	–
SG	SH	–	–	–	–	–	–
SG	CN	2	9.0	0	–	–	–
SG	DC	2	7.5	1.2	–	–	–
SG	MX	9	63.0	1.3	8	55.4	1.0
SG	SG	1	1.3	0	–	–	–
SG		14	80.8	1.1	8	55.4	1.0

[a]EM – Emergent
DM – Dry meadow
WM – Wet meadow
MF – Mudflat
IM – Immature meadow
SH – Shurb
CN – Coniferous
DC – Deciduous
MX – Mixed forest
FS – Flooded shrub
FT – Flooded trees
RK – Rock
SG – Sand and/or gravel

[b]Sample sizes of less than 5 km should probably be ignored.

Table 15. Densities of breeding-pairs of ducks as related to wetland edge types and habitat next-to-edge on selected oil sands wetlands, 1976.

		Survey #1			Survey #2			Survey #3		
Edge type[a]	Habitat next to edge	Number of segments	Length of edge censused[b]	Ducks (pairs) per km	Number of segments	Length of edge censused	Ducks (pairs) per km	Number of segments	Length of edge censused	Ducks (pairs) per km
EM	EM	-	-	-	1	0.6	9.3	1	0.6	6.7
EM	DM	2	13.9	1.7	5	15.4	3.2	1	2.7	3.3
EM	WM	25	129.1	2.9	20	90.5	2.5	21	93.4	2.3
EM	IM	-	-	-	2	7.2	1.7	2	7.2	1.4
EM	SH	11	13.2	8.0	5	26.7	2.7	10	45.5	1.7
EM	CN	2	6.9	1.3	3	6.0	0.5	2	2.4	0
EM	DC	2	0.5	6.0	1	18.8	0.1	2	0.5	0
EM	MX	10	35.5	0.8	6	14.9	1.4	3	4.1	4.4
EM	FS	2	7.6	2.2	-	-	-	1	7.1	2.5
EM	FT	-	-	-	-	-	-	-	-	-
EM		54	206.7	2.7	43	180.1	2.2	43	163.5	2.1
DM	DM	-	-	-	-	-	-	-	-	-
DM	WM	-	-	-	1	4.8	9.8	-	-	-
DM	SH	1	8.0	0.4	-	-	-	2	14.0	0.7
SM	CN	1	6.0	1.0	1	1.9	8.4	-	-	-
DM	DC	-	-	-	-	-	-	-	-	-
DM	MX	1	1.4	0	3	6.7	6.0	-	-	-
DM		3	15.4	0.6	5	13.4	7.7	2	14.0	0.7
WM	DM	-	-	-	-	-	-	-	-	-
WM	WM	1	0.3	3.3	1	4.8	1.0	-	-	-
WM	SH	2	4.5	1.6	2	2.9	6.2	4	6.9	1.0
WM	CN	6	9.9	5.7	6	14.1	1.8	6	12.8	0.9
WM	MX	3	4.7	2.6	4	8.4	0.8	5	11.1	1.3
WM	FS	-	-	-	1	1.6	0	-	-	-
WM	FT	1	1.6	0.6	-	-	-	-	-	-
WM		13	21.0	3.7	14	31.8	1.7	15	30.8	1.1

continued ...

Table 15. Continued.

Edge type[a]	Habitat next to edge	Survey #1 Number of segments	Survey #1 Length of edge censused[b]	Survey #1 Ducks (pairs) per km	Survey #2 Number of segments	Survey #2 Length of edge censused	Survey #2 Ducks (pairs) per km	Survey #3 Number of segments	Survey #3 Length of edge censused	Survey #3 Ducks (pairs) per km
MF	DM	–	–	–	2	2.7	0.7	3	7.5	4.1
MF	SH	1	14.5	0.1	1	1.1	7.3	–	–	–
MF	MX	1	2.1	1.0	2	22.6	0.2	3	24.7	0.5
MF		2	16.6	0.2	5	26.4	0.6	6	32.2	1.3
IM	DM	–	–	–	–	–	–	1	2.9	1.0
IM	IM	–	–	–	–	–	–	–	–	–
IM	MX	2	9.0	1.4	–	–	–	1	3.2	2.5
IM		2	9.0	1.4	–	–	–	2	6.1	1.8
SH	WM	–	–	–	–	–	–	–	–	–
SH	SH	2	9.8	0.1	1	4.2	0	2	9.8	0
SH	CN	2	10.7	0.5	2	15.2	1.7	5	17.6	0.2
SH	DC	1	2.3	1.3	–	–	–	–	–	–
SH	MX	6	19.3	2.5	3	2.9	0.3	8	17.5	0.6
SH		11	42.1	1.4	6	22.3	1.2	15	44.9	0.3
CN	CN	10	21.8	1.9	8	21.7	1.7	10	17.0	1.8
CN	MX	1	4.8	0.6	3	6.6	0.3	1	4.8	0.4
CN		11	26.6	1.7	11	28.3	1.3	11	21.8	1.5
DC	CN	–	–	–	–	–	–	1	1.3	0.8
DC	DC	3	6.3	1.0	–	–	–	1	0.6	0
DC	MX	3	4.2	1.0	2	4.3	1.4	2	6.7	0.4
DC		6	10.5	1.0	2	4.3	1.4	4	8.6	0.5
MX	SH	–	–	–	1	2.7	3.0	–	–	–
MX	CN	–	–	–	–	–	–	1	2.9	3.2
MX	MX	8	21.4	1.8	7	23.6	1.0	9	21.5	0.7
MX		8	21.4	1.8	8	26.3	1.2	10	23.4	0.9

continued ...

Table 15. Continued.

Edge type[a]	Habitat next to edge	Survey #1 Number of segments	Survey #1 Length of edge censused[b]	Survey #1 Ducks (pairs) per km	Survey #2 Number of segments	Survey #2 Length of edge censused	Survey #2 Ducks (pairs) per km	Survey #3 Number of segments	Survey #3 Length of edge censused	Survey #3 Ducks (pairs) per km
FS	WM	-	-	-	-	-	-	-	-	-
FS	SH	-	-	-	2	1.9	12.6	-	-	-
FS	CN	-	-	-	1	1.0	2.0	1	1.0	0
FS	DC	-	-	-	-	-	-	1	0.6	0
FS	MX	2	1.3	2.3	-	-	-	1	18.8	0.1
FS	FT	-	-	-	-	-	-	-	-	-
FS		2	1.3	2.3	3	2.9	9.0	3	20.4	0
FT	SH	-	-	-	-	-	-	-	-	-
FT	CN	-	-	-	-	-	-	-	-	-
FT	DL	1	3.2	4.7	-	-	-	2	3.5	0.6
FT	MX	1	3.7	5.9	1	3.7	2.4	3	8.1	1.1
FT		2	6.9	5.4	1	3.7	2.4	5	11.6	0.9
RK	SH	-	-	-	-	-	-	-	-	-
RK	DC	-	-	-	-	-	-	1	14.2	0.2
RK	MX	-	-	-	1	8.4	0	2	5.8	0
RK		-	-	-	1	8.4	0	3	20.0	0.2
SG	DM	-	-	-	-	-	-	1	1.4	2.1
SG	SH	-	-	-	-	-	-	-	-	-
SG	CN	2	9.0	0.3	-	-	-	-	-	-
SG	DC	2	7.5	0.3	-	-	-	-	-	-
SG	MX	9	63.0	0.1	8	55.4	0.1	6	41.5	0.1
SG	SG	1	1.3	0.8	-	-	-	-	-	-
SG		14	80.8	0.2	8	55.4	0.1	7	42.9	0.1

continued ...

Table 15. Concluded.

[a]EM - Emergent

DM - Dry meadow

WM - Wet meadow

MF - Mudflat

IM - Immature meadow

SH - Shrub

CN - Coniferous

DC - Deciduous

MX - Mixed forest

FS - Flooded shrub

FT - Flooded trees

RK - Rock

SG - Sands and/or gravel

[b]Sample sizes of less than 5 km should probably be ignored.

Table 16. Densities of duck broods as related to wetland edge types and habitat next-to-edge on selected oil sands wetlands, 1976.

		Survey #1			Survey #2		
Edge Type[a]	Habitat next to edge	Number of segments	Length of edge censused[b]	Ducks broods per km	Number of segments	Length of edge censused	Ducks broods per km
EM	EM	1	0.6	1.7	1	0.6	1.7
EM	DM	–	–	–	1	6.4	2.5
EM	WM	16	70.3	0.7	17	83.6	1.4
EM	IM	2	7.2	0.4	1	0.8	1.3
EM	SH	10	46.7	1.2	9	34.8	1.1
EM	CN	1	3.7	0.8	1	0.2	0
EM	DC	1	0.2	0	–	–	–
EM	MX	4	6.3	1.1	9	45.7	1.1
EM	FS	2	9.4	0.6	3	3.5	3.4
EM	FT	1	0.3	3.3	1	7.1	0.8
EM		38	144.7	0.8	43	182.7	1.3
DM	DM	1	3.2	0	–	–	–
DM	WM	–	–	–	–	–	–
DM	SH	–	–	–	1	5.6	0.2
DM	CN	3	13.6	0.4	–	–	–
DM	DC	2	4.5	0.9	2	4.5	3.3
DM	MX	–	–	–	1	8.0	0.1
DM		6	21.3	0.4	4	18.1	0.9
WM	DM	–	–	–	1	3.5	0.3
WM	WM	–	–	–	1	2.3	1.7
WM	SH	4	17.2	0.4	6	12.8	1.3
WM	CN	5	14.4	0.3	8	23.2	0.7
WM	MX	6	13.0	0.8	6	13.6	1.3
WM	FS	–	–	–	–	–	–
WM	FT	–	–	–	–	–	–
WM		15	44.6	0.5	22	55.4	1.0
MF	DM	–	–	–	–	–	–
MF	SH	1	6.0	1.0	–	–	–
MF	MX	–	–	–	–	–	–
MF		1	6.0	1.0	–	–	–
IM	DM	–	–	–	1	3.2	1.6
IM	IM	–	–	–	–	–	–
IM	MX	–	–	–	–	–	–
IM		–	–	–	1	3.2	1.6

continued ...

Table 16. Continued.

Edge Type[a]	Habitat next to edge	Survey #1 Number of segments	Survey #1 Length of edge censused[b]	Survey #1 Ducks broods per km	Survey #2 Number of segments	Survey #2 Length of edge censused	Survey #2 Ducks broods per km
SH	WM	1	7.8	0.8	–	–	–
SH	SH	2	5.5	1.8	5	17.0	2.6
SH	CN	2	6.5	0.3	5	19.8	0.6
SH	DC	–	–	–	–	–	–
SH	MX	6	14.3	0.8	5	11.4	1.2
SH		11	34.1	0.9	15	48.2	1.5
CN	CN	3	4.8	0	5	7.6	1.1
CN	MX	–	–	–	1	1.1	1.8
CN		3	4.8	0	6	8.7	1.1
DC	CN	–	–	–	–	–	–
DC	DC	–	–	–	1	0.6	1.7
DC	MX	4	14.9	0.3	1	5.1	0.8
DC		4	14.9	0.3	2	5.7	0.9
MX	SH	–	–	–	–	–	–
MX	CN	3	3.1	1.0	2	2.5	2.8
MX	MX	5	12.1	0.5	5	10.4	1.3
MX		8	15.2	0.6	7	12.9	1.6
FS	WM	–	–	–	1	0.6	3.3
FS	SH	–	–	–	–	–	–
FS	CN	–	–	–	–	–	–
FS	DC	1	0.3	0	2	1.1	0
FS	MX	6	29.9	0.1	2	2.9	2.8
FS	FT	–	–	–	–	–	–
FS		7	30.2	0.1	5	4.6	2.2
FT	SH	–	–	–	1	3.9	1.0
FT	CN	–	–	–	1	3.7	0
FT	DC	2	1.2	0	–	–	–
FT	MX	1	3.9	0.8	2	3.7	4.3
FT		3	5.1	0.6	4	11.3	1.8
RK	SH	1	14.2	0.6	–	–	–
RK	DC	–	–	–	–	–	–
RK	MX	–	–	–	–	–	–
RK		1	14.2	0.6	–	–	–

continued ...

Table 16. Concluded.

Edge Type[a]	Habitat next to edge	Survey #1 Number of segments	Survey #1 Length of edge censused[b]	Survey #1 Ducks broods per km	Survey #2 Number of segments	Survey #2 Length of edge censused	Survey #2 Ducks broods per km
SG	DM	–	–	–	–	–	–
SG	SH	1	5.6	0	–	–	–
SG	CN	2	2.7	3.0	–	–	–
SG	DC	1	14.5	0	–	–	–
SG	MX	2	15.4	0.1	4	33.3	0.2
SG	SG	–	–	–	–	–	–
SG		6	38.2	0.2	4	33.3	0.2

a
EM – Emergent
DM – Dry meadow
WM – Wet meadow
MF – Mudflat
IM – Immature meadow
SH – Shrub
CN – Coniferous
DC – Deciduous
MX – Mixed forest
FS – Flooded shrub
FT – Flooded trees
RK – Rock
SG – Sand and/or gravel

b
Sample sizes of less than 5 km should probably be ignored.

Table 17. Densities of moulting ducks as related to wetland edge types and habitat next-to-edge on selected oil sands wetlands, 1976.

Edge Type[a]	Habitat next to edge	Survey #1 Number of segments	Survey #1 Length of edge censused[b]	Survey #1 Ducks per km	Survey #2 Number of segments	Survey #2 Length of edge censused	Survey #2 Ducks per km
EM	EM	1	0.6	15.0	1	0.6	36.7
EM	DM	–	–	–	1	6.4	0.3
EM	WM	16	70.3	10.5	17	83.6	21.2
EM	IM	2	7.2	8.8	1	0.8	12.5
EM	SH	10	46.7	26.1	9	34.8	47.0
EM	CN	1	3.7	3.8	1	0.2	0
EM	DC	1	0.2	0	–	–	–
EM	MX	4	6.3	3.3	9	45.7	9.9
EM	FS	2	9.4	8.5	3	3.5	50.0
EM	FT	1	0.3	13.3	1	7.1	35.5
EM		38	144.7	14.8	43	182.7	23.7
DM	DM	1	3.2	3.8	–	–	–
DM	WM	–	–	–	–	–	–
DM	SH	–	–	–	1	5.6	0.4
DM	CN	3	13.6	1.1	–	–	–
DM	DC	2	4.5	27.8	2	4.5	79.1
DM	MX	–	–	–	1	8.0	0
DM		6	21.3	7.1	4	18.1	19.8
WM	DM	–	–	–	1	3.5	0
WM	WM	–	–	–	1	2.3	3.9
WM	SH	4	17.2	3.3	6	12.8	0.5
WM	CN	5	14.4	7.2	8	23.2	3.9
WM	MX	6	13.0	13.6	6	13.6	2.6
WM	FS	–	–	–	–	–	–
WM	FT	–	–	–	–	–	–
WM		15	44.6	7.6	22	55.4	2.5
MF	DM	–	–	–	–	–	–
MF	SH	1	6.0	12.7	–	–	–
MF	MX	–	–	–	–	–	–
MF		1	6.0	12.7	–	–	–
IM	DM	–	–	–	1	3.2	14.1
IM	IM	–	–	–	–	–	–
IM	MX	–	–	–	–	–	–
IM		–	–	–	1	3.2	14.1

continued ...

Table 17. Continued.

Edge Type [a]	Habitat next to edge	Survey #1 Number of segments	Survey #1 Length of edge censused [b]	Survey #1 Ducks per km	Survey #2 Number of segments	Survey #2 Length of edge censused	Survey #2 Ducks per km
SH	WM	1	7.8	36.4	–	–	–
SH	SH	2	5.5	0	5	17.0	21.8
SH	CN	2	6.5	1.8	5	19.8	1.8
SH	DC	–	–	–	–	–	–
SH	MX	6	14.3	1.3	5	11.4	8.2
SH		11	34.1	9.2	15	48.2	10.1
CN	CN	3	4.8	10.4	5	7.6	9.5
CN	MX	–	–	–	1	1.1	0
CN		3	4.8	10.4	6	8.7	8.3
DC	CN	–	–	–	–	–	–
DC	DC	–	–	–	1	0.6	0
DC	MX	4	14.9	4.3	1	5.1	1.0
DC		4	14.9	4.3	1	5.7	0.9
MX	SH	–	–	–	–	–	–
MX	CN	3	3.1	16.1	2	2.5	0
MX	MX	5	12.1	7.3	5	10.4	2.5
MX		8	15.2	9.1	7	12.9	2.0
FS	WM	–	–	–	1	0.6	0
FS	SH	–	–	–	–	–	–
FS	CN	–	–	–	–	–	–
FS	DC	1	0.3	13.3	2	1.1	0
FS	MX	6	29.9	4.8	2	2.9	1.0
FS	FT	–	–	–	–	–	–
FS		7	30.2	4.9	5	4.6	0.7
FT	SH	–	–	–	1	3.9	3.8
FT	CN	–	–	–	1	3.7	0
FT	DC	2	1.2	0	–	–	–
FT	MX	1	3.9	14.9	2	3.7	3.0
FT		3	5.1	11.4	4	11.3	2.3
RK	SH	1	14.2	5.4	–	–	–
RK	DC	–	–	–	–	–	–
RK	MX	–	–	–	–	–	–
RK		1	14.2	5.4	–	–	–

continued ...

Table 17. Concluded.

Edge Type	Habitat next to edge	Survey #1 Number of segments	Length of edge censused	Ducks per km	Survey #2 Number of segments	Length of edge censused	Ducks per km
SG	DM	–	–	–	–	–	–
SG	SH	1	5.6	0.2	–	–	–
SG	CN	2	2.7	4.8	–	–	–
SG	DC	1	14.5	0.3	–	–	–
SG	MX	2	15.4	0.8	4	33.3	9.3
SG	SG	–	–	–	–	–	–
SG		6	38.2	0.8	4	33.3	9.3

[a]EM – Emergent
DM – Dry meadow
WM – Wet meadow
MF – Mudflat
IM – Immature meadow
SH – Shrub
CN – Coniferous
DC – Deciduous
MX – Mixed forest
FS – Flooded shrub
FT – Flooded trees
RK – Rock
SG – Sand and/or gravel

[b]Sample sizes of less than 5 km should probably be ignored.

Table 18. Densities of fall-staging ducks as related to wetland edge types and habitat next-to-edge on selected oil sands wetlands, 1976.

Edge type[1]	Habitat next to edge	Survey #1 Number of segments	Survey #1 Length of edge censused[2]	Survey #1 Ducks per km	Survey #2 Number of segments	Survey #2 Length of edge censused	Survey #2 Ducks per km	Survey #3 Number of segments	Survey #3 Length of edge censused	Survey #3 Ducks per km	Survey #4 Number of segments	Survey #4 Length of edge censused	Survey #4 Ducks per km	Survey #5 Number of segments	Survey #5 Length of edge censused	Survey #5 Ducks per km
EM	EM	1	0.6	45.0	1	0.6	0	1	0.6	266.7	1	0.6	125.0	1	0.6	23.3
	DM	3	14.1	8.5	1	7.4	3.9	1	6.4	5.9	1	7.4	7.0	1	7.4	41.1
	WM	12	69.9	55.9	12	68.1	54.2	12	68.4	46.0	12	68.4	37.0	12	68.1	81.5
	IM	1	0.8	13.8	1	0.8	0	1	0.8	0	1	0.8	16.3	1	0.8	178.8
	SH	8	40.0	31.9	8	32.4	30.6	11	38.4	48.7	9	37.0	12.3	9	35.7	71.7
	CN	1	2.1	11.4	1	3.7	193.2	1	3.7	0.5	1	3.7	105.1	1	3.7	26.8
	DC	-	-	-	-	-	-	1	1.0	700.0	1	1.0	932.0	1	1.0	843.0
	MX	7	11.1	57.2	8	19.1	11.6	7	17.8	5.1	8	18.9	28.6	7	19.5	116.7
	FS	1	7.1	16.8	3	6.9	1.0	3	6.9	1.3	3	6.9	0.1	3	6.9	2.8
	FT	-	-	-	1	7.1	50.8	1	7.1	12.0	1	7.1	6.8	1	7.1	33.1
EM		34	145.7	42.0	36	146.1	41.2	39	151.1	40.4	38	151.8	33.2	37	150.8	79.9
DM	DM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	WM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	SH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	CN	1	2.1	98.6	1	4.8	4.8	1	4.8	3.1	1	4.8	0	1	4.8	0
	DC	-	-	-	1	2.1	28.6	1	2.1	0	1	2.1	0	1	2.1	3.8
	MX	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DM		1	2.1	98.6	2	6.9	11.9	2	6.9	2.2	2	6.9	0	2	6.9	1.2
WM	DM	-	-	-	1	3.5	1.4	1	3.5	1.7	1	3.5	4.3	1	3.5	3.7
	WM	2	2.8	5.7	6	17.8	3.7	6	17.8	1.5	6	17.8	1.6	6	17.8	8.4
	SH	6	13.9	95.0	6	12.5	8.7	6	12.5	107.4	6	12.5	26.3	5	13.8	69.6
	CN	15	35.2	16.8	9	20.8	8.5	8	21.0	3.6	7	19.4	6.5	8	20.5	8.3
	MX	3	5.5	14.2	6	14.1	55.5	6	14.1	58.3	6	14.1	27.9	6	14.7	25.8
	FS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	FT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WM		26	57.4	35.0	28	68.7	16.6	27	68.9	33.0	26	67.3	13.3	26	70.3	23.8

continued ...

Table 18. Continued.

Edge type[1]	Habitat next to edge	Survey #1			Survey #2			Survey #3			Survey #4			Survey #5		
		Number of segments	Length of edge censused[2]	Ducks per km	Number of segments	Length of edge cnesused	Ducks per km	Number of segments	Length of edge censused	Ducks per km	Number of segments	Length of edge censused	Ducks per km	Number of segments	Length of edge censused	Ducks per km
MF	DM	2	2.7	315.9	-	-	-	-	-	-	-	-	-	-	-	-
	SH	1	6.0	45.8	1	6.0	69.0	1	6.0	26.3	-	-	-	1	6.0	5.2
	MX	(2	53.1*	0)	(1	24.0*	0.1)	(1	36.2*	0)	(1	36.2*	0)	(1	36.2*	0)
MF		3	8.7	129.7	1	6.0	69.0	1	6.0	26.3	-	-	-	1	6.0	5.2
IM	DM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IM	-	-	-	1	3.2	5.6	1	3.2	17.5	1	3.2	55.9	1	3.2	55.3
	MX	1	3.2	7.2	1	12.4	38.3	1	2.4	0.8	2	13.7	4.3	2	13.7	9.6
IM		1	3.2	7.2	2	5.6	19.6	2	5.6	10.4	3	16.9	14.1	3	16.9	18.2
SH	WM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	SH	-	-	-	3	4.7	160.6	3	4.7	57.4	2	9.4	18.8	2	3.4	225.6
	CN	4	19.6	10.0	6	23.5	2.7	3	14.8	6.0	5	19.8	2.3	5	19.8	4.3
	DC	1	5.8	112.6	-	-	-	-	-	-	-	-	-	-	-	-
	MX	8	13.7	40.3	6	10.2	62.8	4	7.6	2.4	6	10.3	23.6	4	9.2	104.1
SH		13	39.1	35.9	15	38.4	38.0	10	27.1	13.9	10	39.5	11.8	11	32.4	55.9
CN	CN	8	11.1	26.1	3	3.9	0	2	3.4	1.5	2	1.8	280.0	1	1.0	14.0
	MX	1	4.8	0	1	1.0	25.0	-	-	-	-	-	-	-	-	-
CN		9	15.9	18.2	4	4.9	5.1	2	3.4	1.5	2	1.8	280.0	1	1.0	14.0
DC	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DC	-	-	-	-	-	-	1	0.6	0	1	0.6	0	1	0.6	0
	MX	2	7.6	60.4	2	2.8	0	1	1.4	0	1	1.4	2.1	1	1.4	65.7
DC		2	7.6	60.4	2	2.8	0	2	2.0	0	2	2.0	1.5	2	2.0	46.0
MX	SH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	CN	3	5.8	21.6	4	4.0	11.5	4	4.0	6.3	4	4.0	9.0	2	3.2	0
	MX	4	16.5	6.8	6	15.2	43.4	7	18.1	1.4	6	17.3	1.2	6	20.6	7.0
MX		7	22.3	10.7	10	19.2	36.7	11	22.1	2.3	10	21.3	2.6	8	23.8	6.1

continued ...

Table 18. Continued.

		Survey #1			Survey #2			Survey #3			Survey #4			Survey #5		
Edge type	Habitat next to edge	Number of segments	Length of edge censused	Ducks per km	Number of segments	Length of edge censused	Ducks per km	Number of segments	Length of edge censused	Ducks per km	Number of segments	Length of edge censused	Ducks per km	Number of segments	Length of edge censused	Ducks per km
FS	WM	1	3.1	45.2	1	3.1	27.4	1	3.1	5.2	1	3.1	11.3	1	3.1	25.2
	SH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DC	-	-	-	1	3.7	0	2	0.9	0	2	0.9	0	2	0.9	0
	MX	3	13.6	40.4	1	7.2	45.7	4	12.2	16.6	4	12.5	15.6	4	12.2	23.0
	FT	1	18.8	13.6	-	-	-	-	-	-	-	-	-	-	-	-
FS		5	35.5	26.6	3	13.9	29.8	7	16.2	13.5	7	16.5	13.9	7	16.2	22.2
FT	SH	-	-	-	1	3.9	6.9	1	3.9	17.9	1	3.9	0	1	3.9	11.5
	CN	-	-	-	-	-	-	1	22.5	14.0	-	-	-	-	-	-
	DC	1	3.2	25.0	-	-	-	-	-	-	-	-	-	-	-	-
	MX	2	4.4	33.2	4	25.4	17.4	2	3.7	18.4	4	26.2	25.9	4	26.2	1.7
FT		3	7.6	29.7	5	29.3	16.0	4	30.1	15.0	5	30.1	22.5	5	30.1	3.0
RK	SH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	MX	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
RK		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SG	DM	1	1.4	2.9	-	-	-	-	-	-	-	-	-	-	-	-
	SH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	CN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	DC	-	-	-	1	11.6	10.2	1	11.6	111.6	-	-	-	-	-	-
	MX	5	27.9	4.1	4	14.4	0.4	4	45.7	0.2	7	30.1	27.1	4	21.8	23.5
	SG	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SG		6	29.3	4.0	5	4.8	4.8	5	57.3	22.7	7	30.1	27.1	4	21.8	23.5

continued ...

Table 18. Concluded.

[1]EM - Emergent

DM - Dry meadow

WM - Wet meadow

MF - Mudflat

IM - Immature meadow

SH - Shrub

CN - Coniferous

DC - Deciduous

MX - Mixed Forest

FS - Flooded schrub

FT - Flooded trees

RK - Rock

SG - Sand and/or gravel

[2]Sample sizes of less than 5 km should probably be ignored

*MF-MX. All edge of this type was on the Athabasca River and has not been included in calculating the mean since it was not considered representative of all mudflat edge occurring in the Oil Sands area.

6.2 INSTRUCTIONS FOR WETLAND HABITAT CLASSIFICATION.

Wetland Name or Number:

To correspond with reference maps.

Date of Primary Inspection:

Date on which the basic descriptive data were obtained. Some of these data may be derived during the first or subsequent census surveys.

Location:

Lat. and Long. of approximate center of census area.

Region:

1. Peace-Athabasca Delta
2. Birch Mountains
3. Precambrian Shield
4. Athabasca River Valley
5. Oil sands--other than above--60 m overburden
6. Oil sands--other than above--60 m overburden

Sub-regional Community Type

1. Deltaic
2. Deciduous forest--upland
3. Deciduous forest--muskeg
4. Coniferous forest--upland
5. Coniferous forest--muskeg
6. Mixed forest--upland
7. Mixed forest--muskeg
8. Shrub--deltaic
9. Shrub--muskeg
10. Grass, sedge, forbs--deltaic
11. Grass, sedge, forbs--muskeg
12. Recently burned or cleared

Local Community Type:

Immediately surrounding the water body. Categories as above, excluding deltaic, but including rock-outcrop.

Water Body Type:

1. River: 10 m wide
2. Creek: 10 m wide
3. Lake-open: no emergents
4. Lake--with deep-marsh aquatics (may also have shallow-marsh aquatics)
5. Lake--with shallow-marsh aquatics only. Distribution and density of emergents should be described under "emergents" below.

Size:

In hectares or, in the case of streams, length, and average width in kilometres and metres, respectively.

Depth:

Measure at several points to establish a maximum and estimate an average, in metres. This will not likely be necessary for the larger, recreational lakes for which such data will be available elsewhere.

Bottom Profile:

Shape of the basin

1. Flat
2. Slightly sloping
3. Moderately sloping
4. Steep

Contour:

Shoreline Shape. Determine from an aerial photograph.

1. Regular (e.g. circular))
2. Slightly irregular) a. islands
3. Moderately irregular) present
4. Very irregular) (No.)

Water Source

1. Local drainage: small creeks, springs, general runoff
2. Creeks or rivers--name

Drainage:

Mention if affected by control structures, such as beaver dams, or by natural obstructions.

1. None
2. Creeks or rivers--name

Permanency:

1. Temporary: estimate seasonal duration
2. Semi-permanent (dry in some years
3. Permanent

Bottom Type:

1. Sand
2. Gravel or rock
3. Clay
4. Silt
5. Organic

Turbidity:

Indicate whether determined during disturbed (windy) or undisturbed (calm) conditions. Use paddle or white object and establish "Visibility to x cm".

<u>Submergents</u>:

Dominant species, and sub-dominants when possible. Record general abundance and distribution.

<u>Emergents</u>:

As for submergents. Record approximate width of marginal bands where they occur.

<u>Upland Vegetation</u>:

Dominant species comprising the local community type.

<u>Aquatic Fauna</u>:

General abundance of invertebrates, fish, and amphibians. Record species when known.

<u>Other Factors Affecting Avian Utilization</u>:

E.g. presence of beaver; predators; human activity, etc.

<u>Survey Segment</u>:

Numerical Designation. Where shorelines or edge is consistent throughout, record "Entire".

<u>Date</u>:

Of census survey on which following data were recorded.

<u>Water-Edge Type</u>:

A functional designation; that is, not species dependent. Thus, *Calamagrostis* sp. may be regarded as emergent, wet meadow, or dry meadow, depending on the water level at the time of the survey.

1. Emergent (EM)
2. Wet Meadow (WM)
3. Dry Meadow (DM)
4. Immature meadow (IM)
5. Mudflat (MF)

6. Shrub (SH)
7. Flooded shrub or trees (FS or FT)
8. Deciduous (DEC)
9. Coniferous (CON)
10. Mixed forest (MF)
11. Sand or gravel (S or G)
12. Rock (RK)

Habitat Type Next-to-Edge:

As for "Edge Type". Should include what is considered to be the effective edge; therefore may consist of a series of types.

Shoreline Topography:

1. Flat
2. Slightly sloping
3. Moderately sloping
4. Steep

Water Level:

Relative to shoreline or high-water lines where evident, or relative to various vegetation zones.

Length of Edge Censused:

As measured by aerial photographs. In kilometres.

6.3 WETLAND HABITAT DESCRIPTION FORM

WETLAND NAME OR NUMBER:

DATE OF PRIMARY INSPECTION:

LOCATION:

REGION:

SUB-REGIONAL COMMUNITY TYPE:

LOCAL COMMUNITY TYPE:

WATER BODY TYPE:

SIZE:

DEPTH (MAX./AVE.):

BOTTOM PROFILE:

CONTOUR:

WATER SOURCE:

DRAINAGE:

PERMANENCY:

BOTTOM TYPE:

TURBIDITY:

SUBMERGENTS:

EMERGENTS:

UPLAND VEG'N:

AQUATIC FAUNA:

OTHER FACTORS AFFECTING UTILIZATION:

SURVEY SEGMENT:

	1	2	3	4	5	6	7	8
DATE WATER-EDGE TYPE HABITAT TYPE NEXT-TO-EDGE SHORELINE TOPOGRAPHY WATER LEVEL LENGTH OF EDGE CENSUSED								

COMMENTS:

6.4 WATERFOWL SPRING-STAGING/BREEDING-PAIR CENSUS FORM

WATERFOWL SPRING-STAGING/BREEDING PAIR SURVEY AOSERP/AVIFAUNA

WETLAND NAME OR NO.: ____________ CENSUS SEGMENT: ____________ DATE: ____________ OBSERVER: ____________

VEHICLE: ____________ PILOT: ____________ START TIME: ____________ FINISH TIME: ____________ TEMP. °C: ____________

WINDSPEED (B.S.): ____________ WIND DIR.: ____________ CLOUD (TENTHS): ____________ PRECIP.: ____________ VISIBILITY: ____________

EDGE TYPE: ____________ HABITAT NEXT-TO-EDGE: ____________ LENGTH OF EDGE CENSUSED (KM): ____________ SHORELINE TOPOG.: ____________

WATER LEVEL: ____________ OBSERVABILITY: ____________

	DABBLERS								DIVERS											UNID	GEESE						SWANS
	Mal	Pin	Gad	Wig	Sho	Bwt	Gwt	Unid	Scp	Rin	Red	Can	Ge	Buf	Rud	Wws	Ss	Mer	Unid	DUX	Can	Wf	Unid Dark	Snow	Ross	Unid White	
Pairs																											
Lone Males																											
Lone Female																											
Groups																											
Tot. Ind. Prs.																											
Tot. ≤ 30																											
Tot. > 30																											

continued ...

WETLAND NAME OR NO.: ____________________

	DABBLERS	DIVERS	UNID. DUCKS	TOTAL DUCKS	GEESE	SWANS
TOTAL INDICATE PAIRS						
TOTAL UNPAIRED BIRDS AND BIRDS IN FLOCKS ≤ 30						
TOTAL BIRDS IN FLOCKS > 30						

LOONS	COOTS	GREBES	SHOREBIRDS & RAILS	GULLS	TERNS	PELICANS	CORMORANTS	G.B. HERONS	BITTERNS	S.H. CRANES	RAPTORS	OTHER BIRDS	MAMMALS

6.5 INSTRUCTIONS FOR WATERFOWL SPRING-STAGING/BREEDING-PAIR CENSUS FORM

Wetland Name or Number:

To correspond with map designation and habitat description forms.

Census Segment:

May be the entire shoreline of a water body (record "entire), or a portion therof, if different edge type occur.

Date:

Observer:

Vehicle:

Type of aircraft, e.g. Cessna 185 on floats.

Pilot:

Start Time:

Finish Time:

Temperature °C:

Use aircraft thermometer while on ground.

Windspeed (B.S.):

Beaufort Scale:

0 Calm (1 mph)
1 Lightair (1-3)
2 Light breeze (4-7)
3 Gentle breeze (8-12)
4 Moderate breeze (13-18)

5 Fresh breeze (19-24)

6 Strong breeze (25-31)

7 You shouldn't be flying

Wind Direction:

Use eight points of compass (e.g. NW)

Cloud (tenths):

Precipitation:

1. Nil	a. intermittent
2. Fog	b. light
3. Drizzle	c. moderate
4. Showers	d. heavy
5. Thundershowers	
6. Steady rain	
7. Snow	

Visibility:

General assessment of ability to see, count, and identify birds.

1. Poor
2. Fair
3. Good
4. Excellent

Note that if any of the above conditions, including windspeed, precipitation, and visibility might significantly affect census results according to the judgement to the observer, the survey would be postponed.

Edge-Type:

1. Emergent (EM)
2. Wet meadow (WM)
3. Dry meadow (DM)
4. Immature meadow (IM)
5. Mudflat (MF)
6. Shrub (SH)
7. Flooded shrub or trees (FS or FT)
8. Deciduous (DEC)
9. Coniferous (CON)
10. Mixed (MIX)
11. Sand or gravel (S or G)
12. Rock (RK)

Habitat Next-to-Edge:

As for "edge Type". Should include what is considered to be the effective edge; therefore may consist of a series of types.

Length of Edge Censused:

As measured on aerial photographs. In kilometres May change between surveys, if water levels change.

Shoreline Topography:

1. Flat
2. Slightly sloping
3. Moderately sloping
4. Steep

Water Level:

Relative to shoreline or high water line where evident, or relative to various vegetation zones.

Observability:

An estimate, if possible, of a correction index for ducks based on cover, species characteristics, and time of year. A separate index for dabblers and divers if possible; e.g. dabbler 1.8, divers 1.2.

Pairs:

Observed pairs only. Pairs obviously in groups should be recorded under groups. There will of necessity be some "grey" areas in assessing whether pairs are in fact territorial or flocked and non-breeding. This often applies to lesser scaup and occasionally to shovelers.

Lone Males:

Single drakes only. Drakes in small groups should be recorded under "groups".

Lone Females:

(As for lone males).

Groups:

Record and tally as seen. Examples:

4 = four birds of mixed and/or unknown sex

2/1 = two males, and one female (see total indicated pairs)

5/0 = five males

0/2 = two females

Total Indicated Pairs:

Interpretation pair status depends on the species. The following is to be used as the guide to interpreting census observations, but may be modified pending new information regarding breeding behaviour.

A. <u>Dabblers (all)</u>

1. Observed pair.
2. Lone drake.
3. Drakes in groups of 2 or 3, each drake represents one pair. Note that 3 is, perhaps, a conservative cutoff number for some species, since each drake of larger groups often may represent a pair. The interpretation may be modified according to phenology and location.
4. Groups of 3 to 6 including one hen (during the breeding season of the species).
5. Lone hen: only if no drakes have been seen on the water body and there are no other water bodies being surveyed in the immediate vicinity.

B. <u>Canvasback, Redhead, Ringneck, Ruddy, Merganser, Scoter</u>

As above minus #3 (due to greater chance of there being excess, non-breeding males of these species).

C. <u>Bufflehead, Goldeneye</u>

1. Observed pair.
2. Lone drake.
3. Heterogeneous groups of 3 represent one pair (a sub-adult male will often accompany a pair). Such groups would likely be recorded as <u>?</u>. Do not include lone hens because of similarity in appearance of sub-adult males.

D. <u>Scaup</u>

1. Observed pair.
2. Lone drake.
3. Groups of 2 drakes and one hen represent one pair.

4. Lone hen: only if no drakes have been seen on the water body and there are no water bodies being surveyed in the immediate vicinity.

For remaining species, including geese, swans, and species (or groups) listed on the reverse side of the form, record singles, groups, pairs, colonies, and nests. Record species for the columns, "grebes", "shorebirds and rails", "gulls", "terns", "raptors", and "other birds".

6.6 WATERFOWL BROOD/MOULTER CENSUS FORM.

WATERFOWL BROOD SURVEY AOSERP/AVIFAUNA

WETLAND NAME OR NO.: ____________ CENSUS SEGMENT: ____________ DATE: ____________ OBSERVER: ____________

VEHICLE: ____________ PILOT: ____________ START TIME: ____________ FINISH TIME: ____________ TEMP. °C: ____________

WINDSPEED (B.S.): ____________ WIND DIR.: ____________ CLOUD (TENTHS): ____________ PRECIP.: ____________ VISIBILITY: ____________

EDGE TYPE: ____________ HABITAT NEXT-TO-EDGE: ____________ LENGTH OF EDGE CENSUSED (KM): ____________ SHORELINE TOPOG.: ____________

WATER LEVEL: ____________ OBSERVABILITY: ____________

AGE CLASS	DABBLERS								DIVERS											UNID	GEESE						SWANS
	Mal	Pin	Gad	Wig	Sho	Bwt	Gwt	Unid	Scp	Rin	Red	Can	Ge	Buf	Rud	Wws	Ss	Mer	Unid	DUX	Can	WF	Unid Dark	Snow	Ross	Unid White	
Ia																											
Ib																											
Ic																											
IIa																											
IIb																											
IIc																											
III																											
FLYING																											
TOTAL BROODS																											
MOULTERS																											

WETLAND NAME OR NO.: ________________

TOTALS*	DABBLERS	DIVERS	UNID. DUCKS	TOTAL DUCKS	GEESE	SWANS
Broods Class I						
Broods Class II						
Broods Class III						
Broods Flying						
Broods All Classes						
Moulters						

* The 3 columns are, respectively: total broods; number of yg. in broods of known size; number of broods of known size.

LOONS	COOTS	GREBES	SHOREBIRDS & RAILS	GULLS	TERNS	PELICANS	CORMORANTS	G.B. HERONS	BITTERNS	S.H. CRANES	RAPTORS	OTHER BIRDS	MAMMALS

6.7 WATERFOWL FALL-STAGING CENSUS FORM

WATERFOWL FALL STAGING SURVEY AOSERP/AVIFAUNA

WETLAND NAME OR NO.: ____________ CENSUS SEGMENT: ____________ DATE: ____________ OBSERVER: ____________

VEHICLE: ____________ PILOT: ____________ START TIME: ____________ FINISH TIME: ____________ TEMP. °C: ____________

WINDSPEED (B.S.): ____________ WIND DIR.: ____________ CLOUD (TENTHS): ____________ PRECIP.: ____________ VISIBILITY: ____________

EDGE TYPE: ____________ HABITAT NEXT-TO-EDGE: ____________ LENGTH OF EDGE CENSUSED (KM): ____________ SHORELINE TOPOG.: ____________

WATER LEVEL: ____________ OBSERVABILITY: ____________

	DABBLERS								DIVERS											UNID	GEESE						SWANS
	Mal	Pin	Gad	Wig	Sho	Bwt	Gwt	Unid	Scp	Rin	Red	Can	Ge	Buf	Rud	Wws	Ss	Mer	Unid	DUX	Can	WF	Unid Dark	Snow	Ross	Unid White	
TOTALS																											

WETLAND NAME OR NO.: ____________________

	DABBLERS	DIVERS	UNID. DUCKS	TOTAL DUCKS	GEESE	SWANS
TOTALS						

REMARKS:

LOONS	COOTS	GREBES	SHOREBIRDS & RAILS	GULLS	TERNS	PELICANS	CORMORANTS	G.B. HERONS	BITTERNS	S.H. CRANES	RAPTORS	OTHER BIRDS	MAMMALS

7. 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. 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 Peregrine Falcons (*Falco peregrinus anatum*) in Northeastern Alberta.

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

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