AMPHIBIANS AND REPTILES IN THE AOSERP STUDY AREA

by

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for

ALBERTA OIL SANDS ENVIRONMENTAL RESEARCH PROGRAM

Project TF 5.1

May 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 herein is the report on "Amphibians and Reptiles in the AOSERP Study Area".

This interim report was prepared under the Terrestrial Fauna Research Committee (now the Land System) of the Alberta Oil Sands Environmental Research Program, under the Alberta-Canada Agreement of February 1975 (amended September 1977).

Respectfully,

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

A.H. Macpherson, Ph.D
Member, Steering Committee, AOSERP
Regional Director-General
Environment Canada
Western and Northern Region

AMPHIBIANS AND REPTILES IN THE AOSERP STUDY AREA

DESCRIPTIVE SUMMARY

BACKGROUND AND PERSPECTIVE

This research report has been designed to supply information concerning amphibians and reptiles in the study area. Their identification, distribution, development and habitat are effectively studied to reveal what circumstances development of the area will have on them.

Circumstances that may bring about possible damage are outlined, along with recommendations and procedures to enhance habitat reclamation and consequent herptofauna re-establishment.

ASSESSMENT

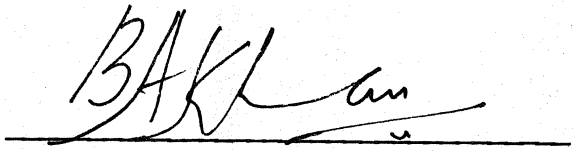
The report entitled "Amphibians and Reptiles in the AOSERP Study Area" was prepared by W. Roberts, V. Lewin, and L. Brusnyk (University of Alberta Museum of Zoology). The report has been reviewed by the Alberta Oil Sands Environmental Research Program, members of the Land System Scientific Advisory Committee, and external referees.

In view of the value of the documents, AOSERP Management recommended that the report have wide distribution and be made available to other AOSERP researchers and the public.

The content of this report does not necessarily reflect the views of Alberta Environment, Environment Canada, or the Alberta

Oil Sands Environmental Research Program. The mention of trade names for commercial products does not constitute an endorsement or recommendation for use.

S.B. Smith, Ph.D
Program Director
Alberta Oil Sands Environmental
Research Program



B.A. Khan, Ph.D
Research Manager
Land System

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONCLUDED)

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

During June, July, and August of 1976 three species of amphibians were found within the Alberta Oil Sands Project area. The wood frog (*Rana sylvatica*) was the most abundant and widespread species and was collected at each of 20 sites examined. Boreal chorus frogs (*Pseudacris triseriata maculata*) and Canadian toads (*Bufo hemiophrys*) were common but found at less than half of the study sites.

All three species had spawned prior to 12 June. Natural ponds and borrow pits were the most frequently used spawning sites. Canadian toads also spawned in flowing water and lake margins. All species had metamorphosed by early August. Wood frogs metamorphosed at a mean snout-vent length of 17.2 mm, Canadian toads at 12.4 mm, and boreal chorus frogs at 13.7 mm. Spawning for each of these species probably does not occur until individuals are in their third summer of life.

Population densities of wood frogs, boreal chorus frogs, and Canadian toads reached estimated maxima of 19.6, 2.3, and 12 per 1000 m^2 during 1977. Maximum densities of all species were found within 50 m of the nearest body of water in moist habitat vegetated by sedges, grasses, horsetails, willows and poplar. Lower densities were found in upland mixed woods and no anurans were found in dry areas with sandy substrate and jack pine forest.

Other amphibian species and reptiles are either absent or only locally abundant.

ACKNOWLEDGEMENTS

This research project TF 5.1 was funded by the Alberta Oil Sands Environmental Research Program (AOSERP), a joint Alberta-Canada research program establishment to fund, direct, and co-ordinate environmental research in the Athabasca Oil Sands area of northeastern Alberta.

1. INTRODUCTION

The Alberta oil sands lie within an area in which the herpetofauna is poorly known. Only a few locality records for four species of amphibians and a single reptilian species exist for northeastern Alberta (Logier and Toner 1961). The Canadian toad (*Bufo hemiophrys*), the boreal chorus frog (*Pseudacris triseriata maculata*) and the wood frog (*Rana sylvatica*) are known from the Fort McMurray area (University of Alberta Museum of Zoology = UAMZ collections). Little is known of the abundance and life histories of these species within Alberta, especially in the northern half of the province.

These species spawn in standing or slowly flowing water as do many amphibians. By periodically visiting a number of potential spawning sites it is possible to record the numbers of adults of each species utilizing the respective sites. It is also possible to determine the type(s) of spawning habitat used, the time of spawning, the duration of larval life, and the time of metamorphosis of the larvae, by making regular periodic visits to those sites. Garter snakes (*Thamnophis spp.*) if present are likely to be found along the margins of amphibian spawning sites as they prey extensively on larvae and small adult amphibians.

Most amphibians and reptiles appear to have well defined home ranges (Porter 1972). Quantitative studies of home ranges have been conducted for the wood frog (*Rana sylvatica*) by Bellis (1965), the chorus frog (*Pseudacris triseriata*) by Kramer (1973, 1974) and the Canadian toad (*Bufo hemiophrys*) by Breckenridge and Tester (1961). Whether or not these anurans are territorial is not known. The tendency for individuals to spend extended periods of time at a given locality permits population estimates to be made by "total" counts, that is, the sum of individuals marked (counted) within a given area. Such counts may be slightly higher than the actual number present within an area at a given time. This overestimate is the result of: (1) counting all (or nearly all) true residents plus a number of

transients; (2) individuals may be counted whose home ranges do not lie completely within the study plots; (3) mortality is not taken into account.

The studies by Breckenridge and Tester (1961), Kramer (1973, 1974), and Bellis (1965) were conducted in relatively small areas and thus provide a limited amount of comparative information with respect to habitat preferences of the species studied. Information on habitat utilization can be obtained by conducting regular periodic censuses of a large number of sample sites selected to include a wide range of habitat types.

The specific objectives of this study are as follows:

1. To determine what species of amphibians and reptiles inhabit the AOSERP study area;
2. To describe the spawning habitats and reproductive phenology of the amphibian species present;
3. To define and describe the habitat types of the amphibian and reptile species;
4. To estimate species numbers and distribution as a function of habitat type; and
5. To identify rare and/or sensitive species in the study area and to discuss their status.

Information derived from the present study will permit the identification of sources of disruption of the life histories and habitat of the resident anurans and provide a basis for reclamation and management strategies beneficial to their re-establishment and maintenance during the post-development period.

2. STUDY AREA

2.1 STUDY AREA FOR REPRODUCTIVE BIOLOGY INVESTIGATIONS

Twenty potential amphibian spawning sites (Figure 1) were selected within the AOSERP study area. The study sites consisted of 10 streams, four borrow pits, three natural ponds, portions of the shoreline of two lakes, and a bog. A brief description and the location of each site is given in Table 1.

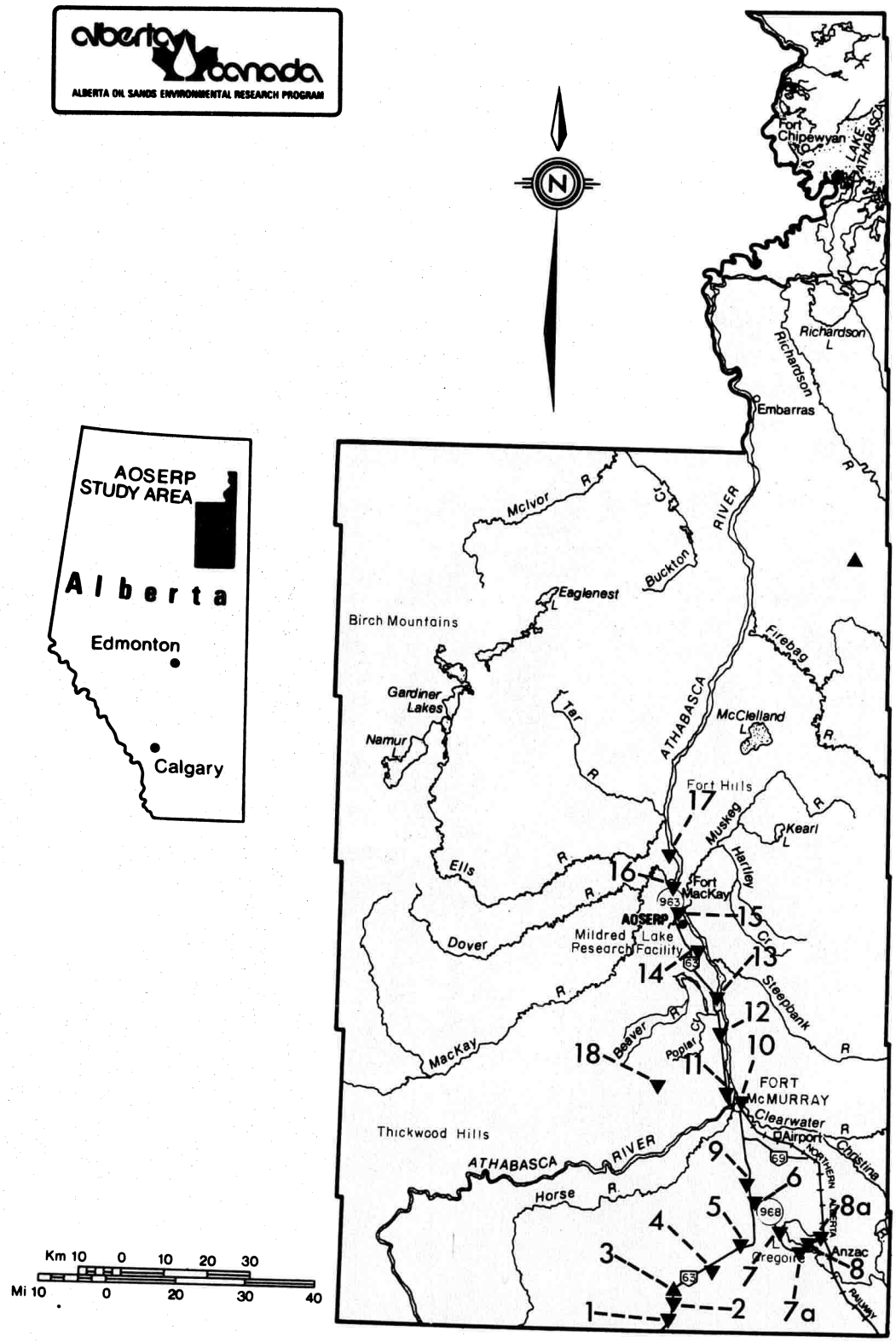

Figure 1. Location of the potential amphibian spawning sites selected within the AOSERP study area during 1976.

Table 1. Description and location of herpetofauna study sites in the Alberta oil sands area

Site No.	Location in relation to Fort McMurray	Description	Rooted aquatic vegetation
1	31 mi. S, 9 mi. W	Natural pond 30 x 60 m	present
2	29 mi. S, 9 mi. W	Stream 3 m wide, 1 m deep	sparse-absent
3	28 mi. s, 8½ mi. W	Backwater on stream 10 m wide	present
4	24 mi. S, 3 mi. W	Borrow pit	present
5	21 mi. S, 2 mi. E	Stream 1 m wide, 0.5 m deep	sparse-absent
6	15 mi. S, 3 mi. E	Borrow pit	present
7	19 mi. S, 7 mi. E	Stream	sparse-absent
7a	21 mi. S, 10½ mi. E	Borrow pit	present
8	20½ mi. S, 11 mi. E	Mouth of Gregoire River, 400 m	absent
8a	20 mi. S, 12 mi. E	Gregoire Lake, shore 400 m	patchy but present
9	11½ mi. S, 2½ mi. E	Stream	sparse-absent
10	1¼ mi. N, ¼ mi. E	Island in Clearwater River	sparse-absent
11	1½ mi. N, ½ mi. W	Stream 3-6 m wide	sparse-absent
12	10½ mi. N, 2 mi. W	Pond of intermittent stream 3 m wide, 1 m deep	present
13	16 mi. N, 3½ mi. W	Borrow pit	present
14	22 mi. N, 6½ mi. W	Mildred Lake (shoreline)	patchy but present
15	27½ mi. N, 9 mi. W	Bog, no open water	mosses
16	30½ mi. N, 9 mi. W	Stream 75 m wide	present
17	36½ mi. N, 10½ mi. W	Natural pond 75 m x 35 m	present
18	2½ mi. N, 11½ mi. W	Natural pond 10 m x 100 m, 2 m deep	present

2.2 STUDY AREAS FOR HABITAT UTILIZATION AND POPULATION DENSITIES

During 1977, 17 sample sites (Figure 2) were selected within the AOSERP study area. All but two of these sites were in contact with bodies of water. Site locations and the type of water body associated with each are given in Table 2.

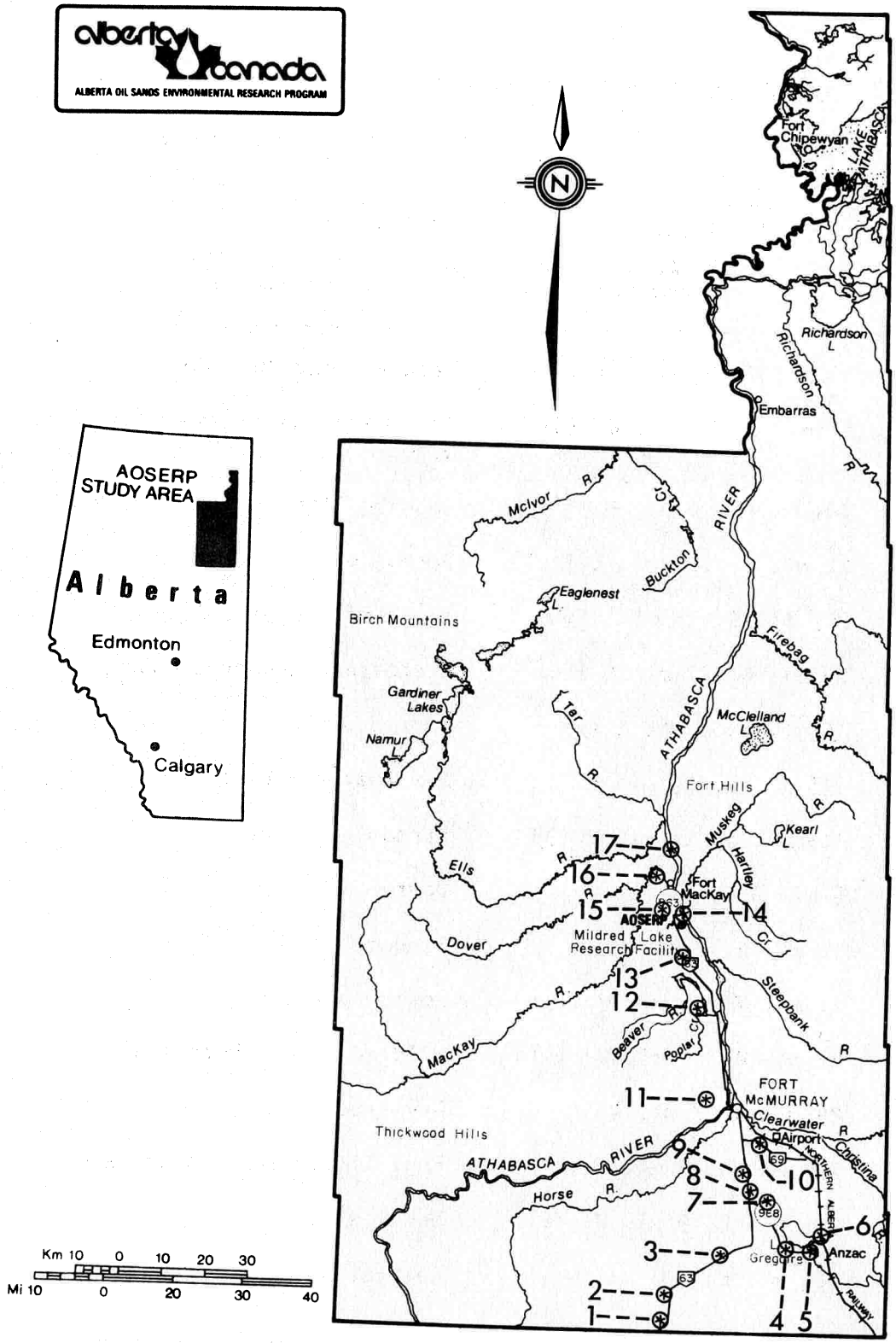

Figure 2. Location of study sites for habitat utilization and anuran population densities within the AOSERP study area during 1977.

Table 2. Locations of anuran habitat sample sites in the Alberta oil sands area during 1977.

Site No.	Location in relation to Fort McMurray	Type of body of water present
1	31 mi. S, 9 mi. W (1)[a]	Natural pond 30 x 60 m
2	28 mi. S, 8½ mi. W. (3)	Back water on stream 10 m wide
3	20½ mi. S, ¼ mi. E	Hanging Stone River - bridge
4	21 mi. S, 10½ mi. E (7a)	Borrow pit
5	20½ mi. S, 11 mi. E (8)	Mouth of Gregoire River
6	20 mi. S, 12 mi. E (8a)	Gregoire Lakeshore, 400 m
7	15 mi. S, 3 mi. E (6)	Borrow pit
8	11½ mi. S, 2½ mi. E	Semi-natural pond
9	11½ mi. S, 2½ mi. E (9)	Stream
10	5 mi. S, 4 mi. E	Borrow pit
11	1¼ mi. N, 2 mi. W	Stream
12	16 mi. N, 3½ mi. W (13)	Borrow pit
13	22 mi. N, 6½ mi. W (14)	Mildred Lake (shoreline)
14	24 mi. N, 7 mi. W	Dry site
15	27½ mi. N, 9 mi. W (15)	Bog, little or no open water
16	30½ mi. N, 9 mi. W (16)	McKay River
17	36½ mi. N, 10½ mi. W (17)	Natural pond

[a]Numbers in parentheses indicate corresponding site number for reproductive biology study conducted in 1976.

3. METHODOLOGY AND PROCEDURES

Twenty potential amphibian spawning sites were selected for sampling during June, July and August of 1976. Each site was visited eight times during the study.

3.1 PHYSICO-CHEMICAL PROPERTIES OF THE WATER

Physico-chemical properties of the water at each site were determined in the field by using a Water Ecology Kit A1368 (Hach Chemical Company, Ames, Iowa). The total hardness in milligrams per litre of calcium carbonate ($CaCO_3$), alkalinity in milligrams per litre of $CaCO_3$, dissolved oxygen and carbon dioxide levels in parts per million, and pH were recorded on the first visit. These attributes were also measured in late July, early August and at the end of August. Water temperatures were recorded on each visit.

3.2 SPAWNING AND DEVELOPMENT

The amphibian species present, and their abundance, were recorded in the following manner. During each visit the observer walked completely around the margins of ponds and borrow pits or for a fixed distance (approximately 400 m) along the margins of lakes or flowing waters. Amphibians observed were identified to species and the numbers of individuals of each were recorded. Individuals were assigned to developmental stages (if larvae) or size classes (if terrestrial) in order to describe their development, time of metamorphosis and growth during their first year of life. The following arbitrary classes were employed: (1) eggs; (2) tadpoles (without limbs); (3) tadpoles with hind limbs present; (4) tadpoles with four limbs present; (5) metamorphosed tadpoles (semi-aquatic or terrestrial with tail still evident); (6) young-of-the-year (tail completely resorbed); (7) yearlings (the smallest size class of subadults or adults); and (8) adults (large individuals presumably in their third or more summer of life).

These classes correspond with the following stages of Gosner (1960):

1 = 1-25; 2 = 26-31; 3 = 32-40; 4 = 41-42; 5 = 43-45; 6 = 46.

The smaller number of classes or stages distinguished by relatively gross differences facilitates the staging of large numbers of larvae in the field.

The head-body lengths (= length) of post-metamorphic frogs and toads were measured to the nearest 0.1 mm according to the method described in Conant (1975). Small subadults were similarly measured, up to and including the time of metamorphosis of young-of-the-year. Young-of-the-year were measured again in late August. Comparison of these data will provide an objective criterion for distinguishing underyearling (class six), yearling (class seven) and older (class eight) individuals.

Subsamples of aggregations of larvae were collected and preserved in 10% formalin. These were later identified to genus using keys in Blair et al. (1968). Specimens of each species and their developmental stages from each site were collected throughout the study and are located in the University of Alberta Museum of Zoology (Accession number 76-31).

3.3 HABITAT DESCRIPTION

At each habitat sampling site three 10 x 100 m plots were established at right angles to the body of water (if present). Where more than one habitat type was present the plots were established so that all habitat types were sampled. Where a body of water was present the following information was recorded: basin morphology, submergent and emergent vegetation present, and temperature. Physico-chemical properties of the water bodies were determined as in Section 3.1. Owing to the large area encompassed by the sample plots only the dominant vegetation types were mapped for each plot.

3.4 HABITAT UTILIZATION AND POPULATION ESTIMATES

A census of each of the sample plots was taken 10 times during the summer of 1977. During each visit the observer walked the plot in a crisscross pattern (see Figure 3). During each visit the following information was recorded on a specially prepared data sheet (see Appendix 10.2): the anuran species present, age, location on the plot, and habitat type with which each individual was associated. Individuals of ages "1" or greater were marked by removal of the phalanges distal to the web on one digit of the left hind foot. The population of adults on each plot was regarded as the total number of individuals so marked.

The sample plots were subdivided by orange surveyor's tape placed at 20 m intervals. Individuals found between the water margin and the 20 m marker were assigned the mean value of 10 m and individuals found between 20 and 40 m markers were assigned the mean value of 30 m, for purposes of calculating the mean distance that each species was found from the water margin during each month of the study.

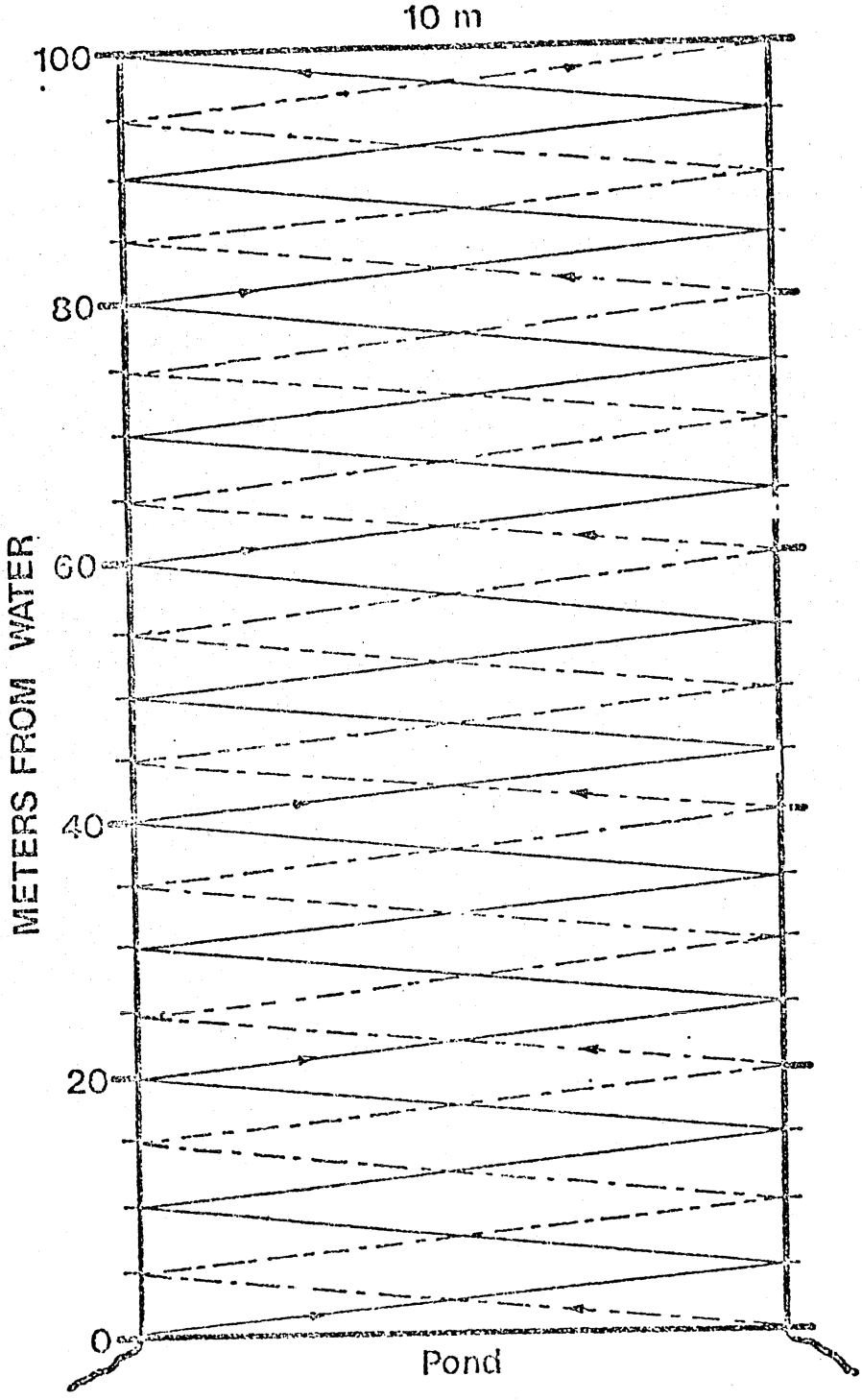

Figure 3. Path taken by observer during each census of study plot.

4. RESULTS

4.1 PHYSICO-CHEMICAL PROPERTIES OF THE WATER

The physical and chemical attributes associated with the potential amphibian spawning sites during 1976 are summarized in Table 3.

4.2 SPAWNING AND DEVELOPMENT

Four hundred and seventy eight adult and subadult amphibians were counted during the 1976 survey. This total was comprised of 225 wood frogs, 207 Canadian toads and 16 boreal chorus frogs. The occurrence of these species and numbers at each study site are given in Table 4.

No spawning pairs or egg masses were found during the present study. Tadpoles were present in all of the known spawning sites during mid June.

Post-metamorphic (= recently metamorphosed) wood frogs were first observed on 30 June (Site 7a). Tadpoles were still present until 4 August (Site 3). Post-metamorphic individuals ranged from 14.5-18.7 ($\bar{X}$ = 17.2) mm head-body length in late July and from 18.2-24.0 ($\bar{X}$ = 20.5) mm by late August. Numbers of young-of-the-year decreased rapidly along the margins of spawning sites following metamorphosis; however, some individuals were still encountered in late August.

Post-metamorphic boreal chorus frogs were first noted on 24 July (Site 6) and metamorphosing individuals (Stage 5) were taken from this site as late as 3 August. Post-metamorphic individuals ranged from 12.6-14.8 ($\bar{X}$ = 13.7) mm in head-body length. Young-of-the-year were not seen along spawning sites shortly after metamorphosis.

Post-metamorphic Canadian toads were first seen on 25 June (Site 11). Tadpoles of this species were present until 7 July (Site 16) at which time they were at the four-leg stage

Table 3. Physico-chemical attributes of study sites.

Site	pH		CO_2 (PPM)		O_2 (PPM)		Total Hardness (mg/L $CaCO_3$)	Total Alkalinity (mg/L $CaCO_3$)	T°C
	Range	$\bar{X}$	Range	$\bar{X}$	Range	$\bar{X}$	Range	Range	Range
1	6.5-8.5	7.5	4-12	8	4-7	4	20-50	30-40	16-24
2	7.5-9.0	8.5	4-24	6	4-9	6	50-180	40-110	11-19
3	6.0-7.5	6.5	8-24	16	4-7	4	30-240	40-50	14-20
4	7.5-9.5	8.5	8-32	13	5-8	6	60-120	10-150	18-23
5	8.0-9.0	8.5	8-16	12	4-9	4	80-160	90-140	15-20
6	7.5-8.5	8.0	12-24	17	4-5	4	190-200	160-220	18-25
7	4.5-9.0	7.0	8-12	10	4-8	4	40-80	20-60	9-20
7a	7.5-8.5	7.5	16-76	18	3-4	3	160-210	220-250	-
8	8.0-9.0	8.5	6-8	8	4-10	4	40-50	50-60	15-21
8a	9.0	9.0	4-8	4	4-10	4	50-80	40-60	-
9	8.0-8.5	8.5	12-16	14	4-9	4	80-130	80-150	14-20
10	8.5-9.0	8.5	8-16	12	4-9	4	50-90	50-100	17-21
11	8.0-9.0	9.0	8-12	10	4-8	4	60-160	40-210	15-21
12	7.5-8.0	8.0	36-50	42	3-6	4	190-250	180-250	15-22
13	9.0	9.0	6-9	8	-	-	150-230	150-220	21-29
14	8.0-8.5	8.5	4-21	-	-	-	170-200	170-180	20-25
15	6.5-7.5	7.0	2-5	3	-	-	110-250	160-230	15-20
16	8.0-9.0	8.5	8-12	10	4-8	6	90-120	90-100	19-21
17	8.0	8.0	-	-	-	-	210	240	21-26
18	9.0-9.5	9.5	-	-	2-8	4	150-200	130-220	24-26

Table 4. The occurrence of adult and subadult amphibians at 20 sites in the AOSERP study area.

Site number	Wood frog		Boreal chorus frog		Canadian toad	
1	11	S[a]				
2	1					
3	13	S				
4	10	S				
5	2					
6	17	S	6	S		
7	21		1			
7a	6	S		S		S
8	27	S			19	S
8a	3				1	
9	9					
10	4				83	S
11	17		3		30	S
12	7	S				
13	5					
14	6		1		33	S
15	7					
16	38	S			12	S
17	33	S	5		4	
18	44	S		S	26	S

[a] S indicates a known spawning site for a species.

and appeared ready to metamorphose. Post-metamorphic individuals ranged from 11.9-13.2 ($\bar{X}$ = 12.4) mm in head-body length. Young-of-the-year Canadian toads had attained head-body lengths of 19.3-28.0 ($\bar{X}$ = 24.8) mm by late August. Young-of-the-year were present along the margins of five spawning sites until late August.

4.3 HABITAT UTILIZATION AND POPULATION ESTIMATES

Nine habitat types were identified within the 17 study sites. The habitat types are ranked in order of decreasing wetness as follows:

1. Water;
2. Sedge fen (*Carex* spp.);
3. Grass meadows (graminae);
4. Willow bog (*Salix* spp.);
5. Aspen poplar forest (*Populus tremuloides*);
6. Black spruce (*Picea mariana*);
7. White spruce (*Picea glauca*);
8. Upland mixed wood (*Populus tremuloides*, *Picea mariana*, *P. glauca*); and
9. Jack pine (*Pinus banksiana*).

The distribution of the habitat types on the sample plots is given in Table 5. Nomenclature follows Moss (1974) (see Appendix 10.3).

The extent to which each habitat type was utilized by each age class of the wood frog during May-August of 1977 is shown in Figure 4. Grass meadows, willow bogs and aspen-poplar areas yielded the highest numbers of wood frogs while none was found in jack pine forests.

The distances from water that members of each age class were found is shown in Figure 5. Young-of-the-year individuals were most common within 40 m of a body of water and never farther from water than 80 m. Yearling and adult wood frogs were most common from 20-60 m from the margin of the closest body of water but were found to range as far as 100 m or more from water.

Table 5. The distribution of habitat types on study plots in the AOSERP study area during 1977.

Site	Distance from water					
	0 m	20 m	40 m	60 m	80 m	100 m
1 a.[1]	Green alder - grasses	White spruce - labrador tea		White spruce - feathermoss		
b.	Green alder - grasses	White spruce - labrador tea - feathermoss				
c.	Green alder - grasses	Jack pine - blueberry		White spruce - feathermoss		
2 a.	Willows - grasses	Upland mixed wood				
b.	Grasses	Fireweed				
c.	Grasses		Willow - bog			
3 a.	Hazel - white birch	Aspen poplar			Birch - poplar	
b.	Willows	White spruce - labrador tea		Birch - poplar		
c.	Upland mixed wood					
4 a.	Aspen poplar					
b.	Upland mixed wood - labrador tea					
c.	Bare ground	White spruce - aspen poplar				
5 a.	Grasses - gravel	Aspen poplar - grasses			Grasses	
b.	Willows - horsetail	Stinkweed - horsetail			Birch - poplar	
c.	Willows - grasses	Grass meadow				
6 a.	Cattail - sedge	Poplar - birch - green alder - willow		Grass meadow	White spruce	
b.	Cattail - willow	Grass - sedges	White spruce - green alder		White spruce	
c.	Cattail - willow	White spruce - poplar			White spruce	
7 a.	Horsetail - grasses	Aspen poplar				
b.	Horsetail - grasses	Aspen poplar				
c.	Horsetail - grasses	Aspen poplar				
8 a.	Willow bog	Regenerating black spruce - labrador tea				
b.	Willow bog	Regenerating black spruce - labrador tea				
c.	Willow bog	Regenerating black spruce - labrador tea				
9 a.	Willow - grasses					
b.	Black spruce - feathermoss					
c.	Black spruce - feathermoss					

Continued ...

Table 5. Concluded.

Site	0 m	20 m	40 m	60 m	80 m	100 m
10 a.	Willow bog	Larch - sedge				
b.	Horsetail - grasses	Larch - sedge				
c.	Wet sedge meadow					
11 a.	Willow - grasses	Aspen poplar				
b.	Grass meadow			Aspen poplar		
c.	Willow - cattail - grasses		Aspen poplar			
12 a.	Willows	Black spruce - feathermoss				
b.	Grasses - poplar saplings		Aspen poplar			
c.	Gravel	Black spruce - feathermoss				
13 a.	Willows - grasses					
b.	Willows - grasses		White spruce - poplar			
c.	Willows - grasses		White spruce - poplar			
14 a.	Jack pine - bearberry				Aspen poplar	
b.	Jack pine - bearberry				Aspen poplar	
c.	Jack pine - bearberry				Aspen poplar	
15 a.	Willows - grasses	Rose - grasses	Willows - grasses			
b.	White spruce - poplar					
c.	Cattail - horsetail	White spruce - poplar				
16 a.	Horsetail - grasses	Natural pond		Black spruce seedlings - feathermoss		
b.	Willows	Natural pond		Black spruce - feathermoss		
c.	Willows	Natural pond		Black spruce - feathermoss		
17 a.	Willows - grasses - horsetail		Aspen poplar			
b.	Horsetail	Horsetail - willow - grasses				
c.	Horsetail - grasses			Aspen poplar		

[a] a, b, and c refer to the plots at each site

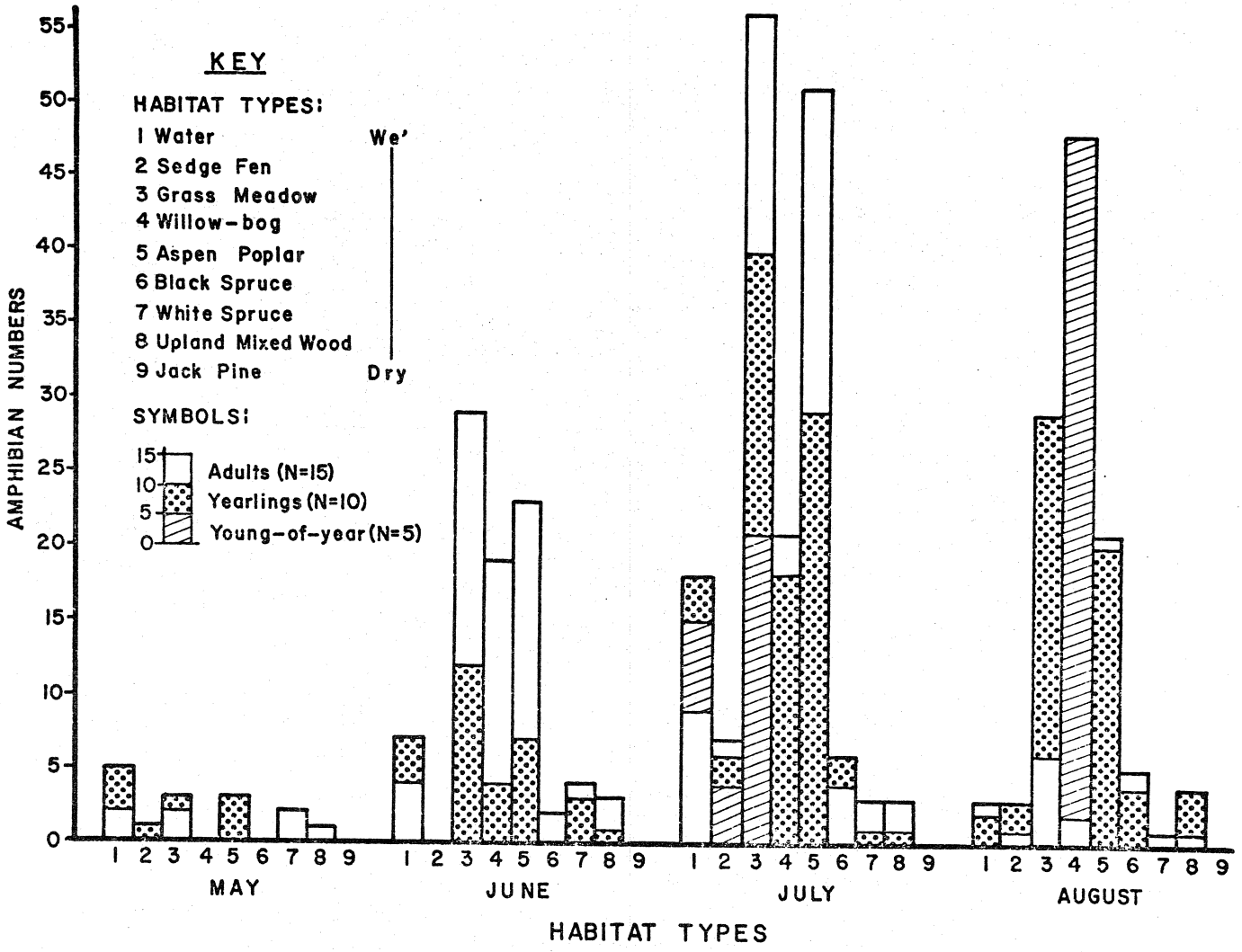

Figure 4. Habitat utilization by wood frogs during May-August 1977.

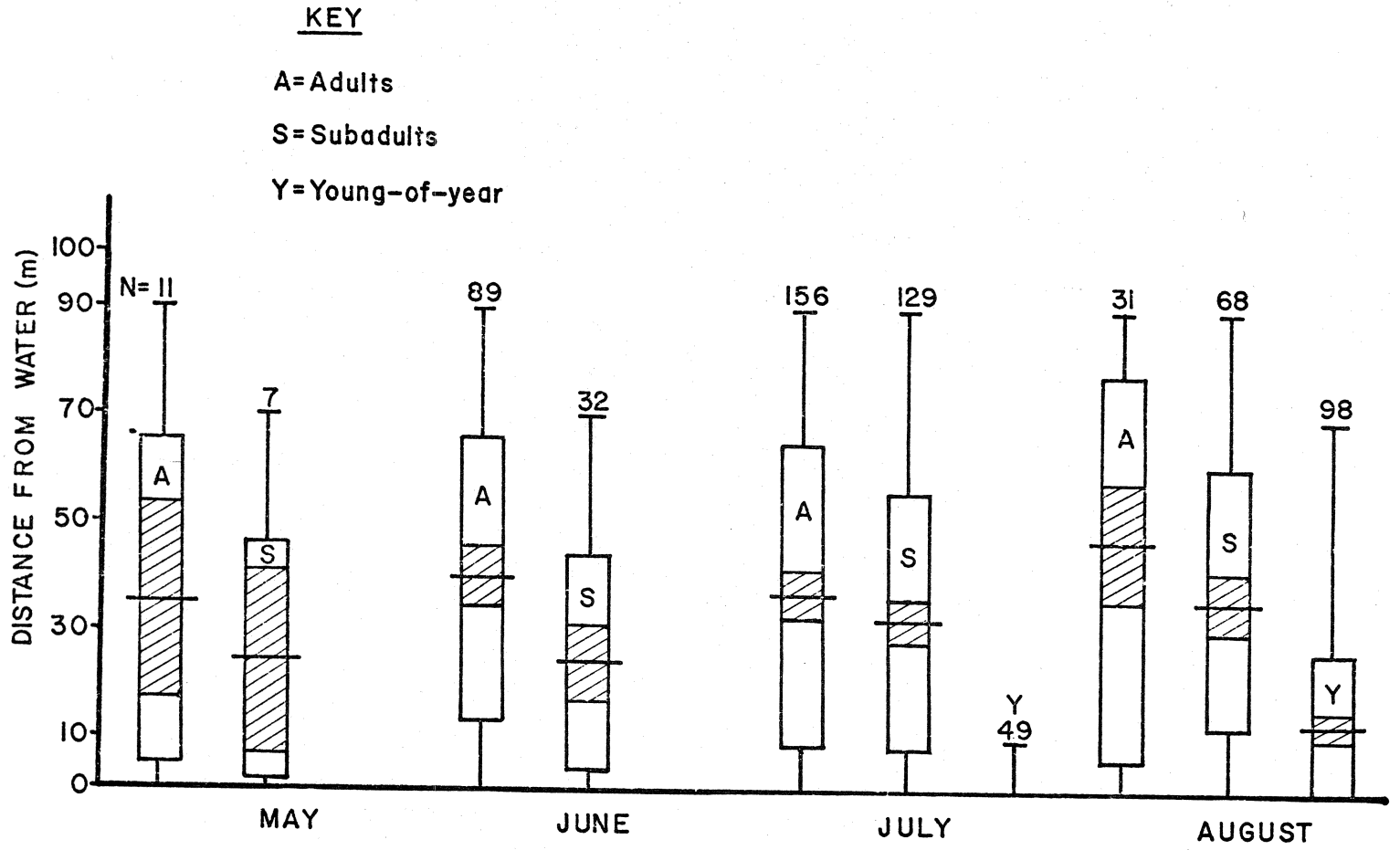

Figure 5. Distance from water that wood frogs occurred during May-August 1977. Two Standard Errors and one Standard Deviation are plotted on each side of the Mean.

Adults were on the average slightly farther from the water than were yearlings. Population densities ranged from 0 to 19.6 individuals (yearlings or older) per 1000 m^2 (Table 6). Densities were highest in grass meadows and poplar forest habitats.

The boreal chorus frog was found most frequently in water, sedge-fen, and grass meadows (Figure 6). None was found in any of the forest habitats. Individuals were seldom found more than 80 m from a body of water (Figure 7). Young-of-the-year were found within 20 m of the water margin. Population densities ranged from 0-2.6 individuals per 1000 m^2. Highest densities occurred along water margins where sedges and grasses were the dominant vegetation.

The Canadian toad was found most frequently in grass meadows and willow bogs (Figure 8). Young-of-the-year were found at the margins of water bodies or in grass meadows. The distance from water at which members of each age class were found is given in Figure 9. Yearlings and adults were found up to 100 m from the water; most individuals being found 40-80 m from water. Young-of-the-year were found within 20 m of water in July and were not seen during August. Population densities ranged from 0-12 individuals per 1000 m^2. Densities of this species were highest in habitat vegetated by grasses, willows, and poplars adjacent to lakes.

Table 6. Densities of amphibians in selected habitat types within the AOSERP study area. Numbers in parentheses indicate maximum estimates.

	Density per 1000 m^2		
	Wood frog	Boreal chorus frog	Canadian toad
Water	(19.6) 2.83	(2.3) 0.45	(12) 0.83
Sedge			
Willow			
Grass			
Horsetail			
Poplar	1.08	0.07	0.16
White spruce			
Black spruce			
Upland mixed wood			
Jack pine	0	0	0

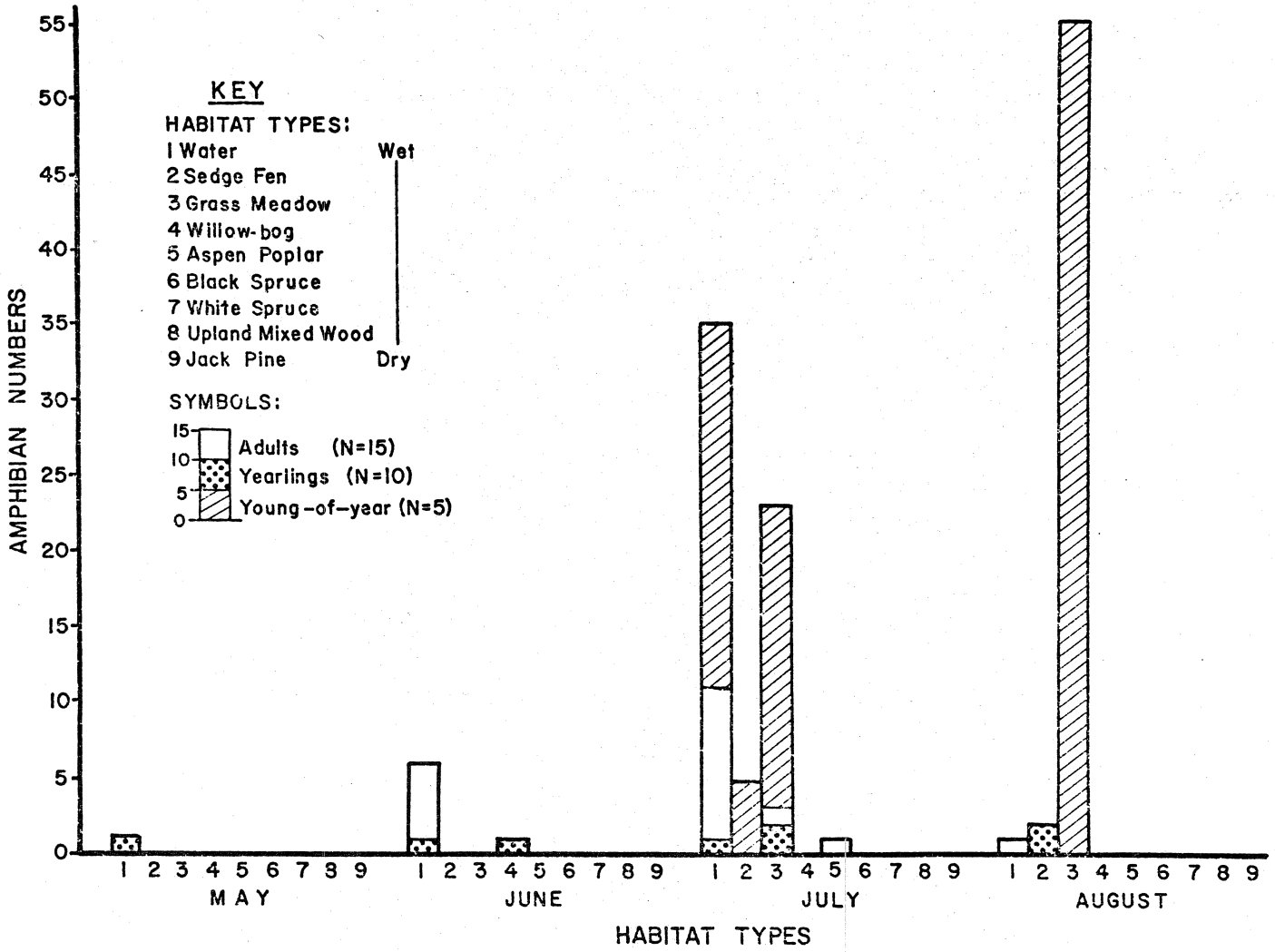

Figure 6. Habitat utilization by boreal chorus frogs during May-August 1977.

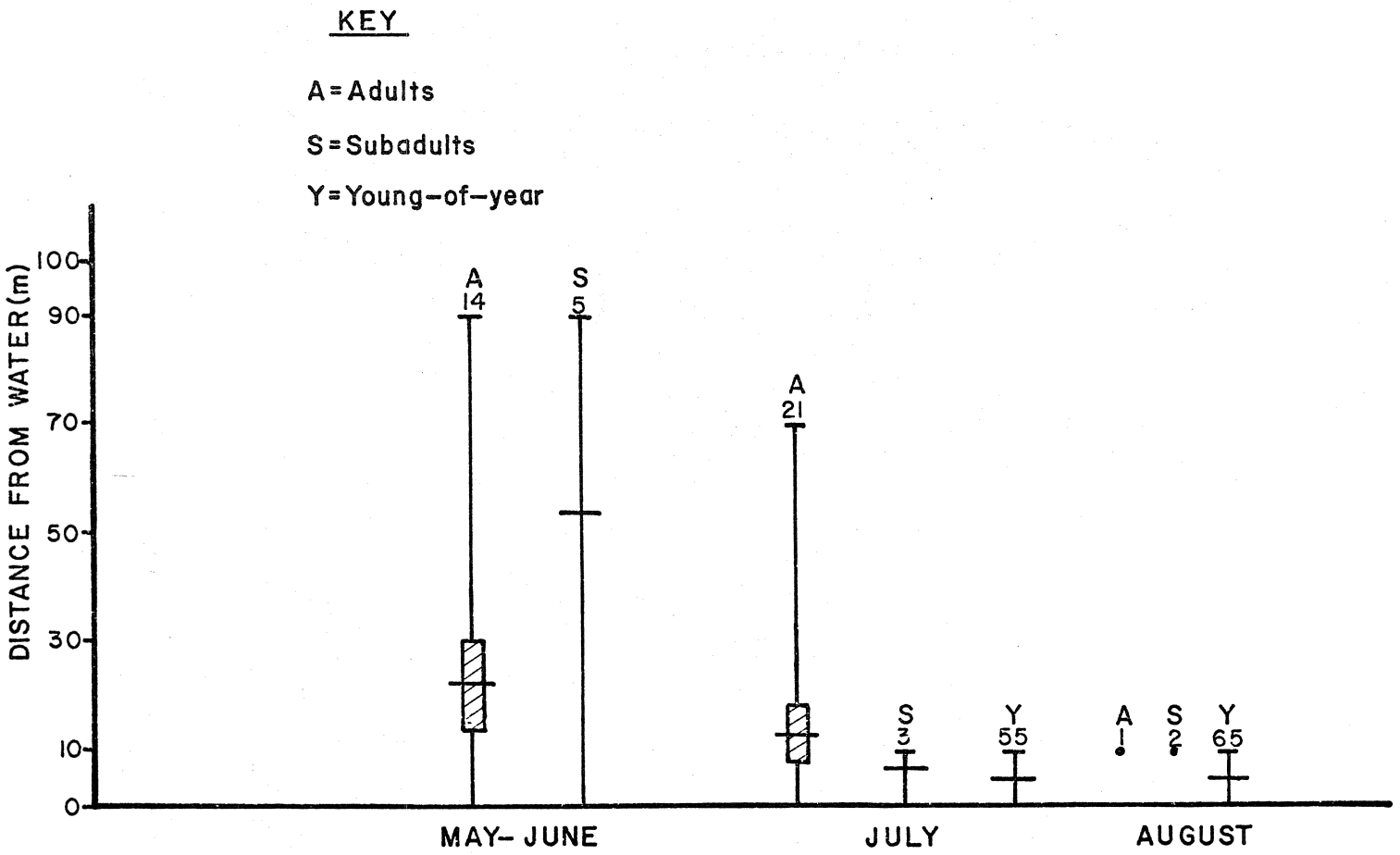

Figure 7. Distance from water that boreal chorus frogs occurred during May-August 1977.

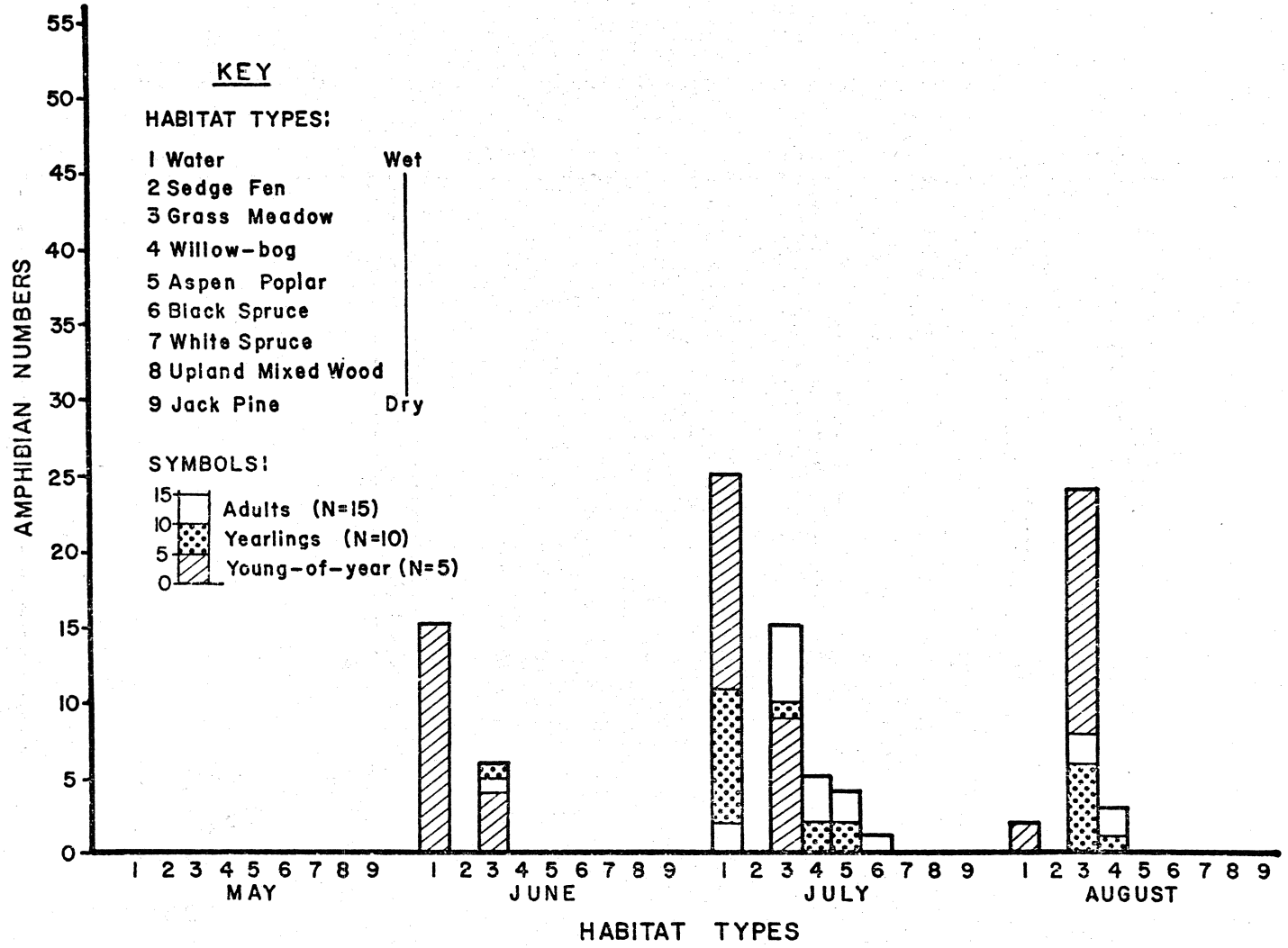

Figure 8. Habitat utilization by Canadian toads during May-August 1977.

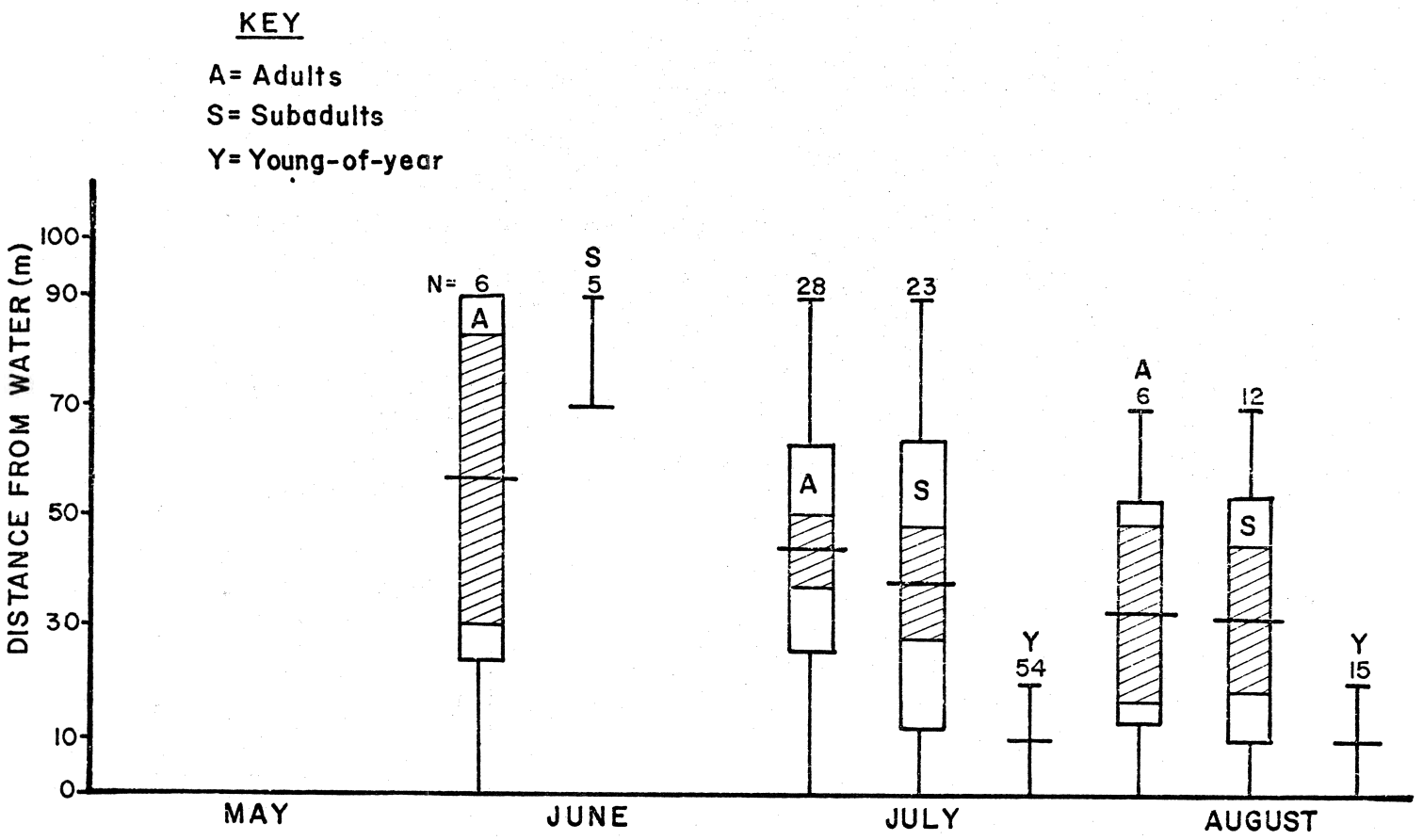

Figure 9. Distance from water that Canadian toads occurred during May-August 1977.

5. DISCUSSION

5.1 SPAWNING AND DEVELOPMENT

The known herpetofauna of the AOSERP study area consists of three anuran species only. The wood frog was present at all sites and spawned in 10 of the 20 sites studied. This species spawned in natural ponds, borrow pits, and a backwater on a stream. Egg masses of this species are attached to aquatic vegetation (Wright and Wright 1949); thus wood frogs are most likely to spawn in standing water where suitable vegetation may be found. Spawning had apparently been completed before the 1976 study was initiated in mid-June. This species spawns as early as March in the southern portion of its range but as late as July in the Northwest Territories (Wright and Wright 1949). Within the study area metamorphosis occurred throughout the month of July and was complete by early August. Metamorphosis elsewhere may occur from late May to mid-September (Wright and Wright 1949) and overwintering of tadpoles may occur at northern latitudes (Bleakney 1954).

Wood frogs metamorphose at a size of 14-22 mm head-body length (Wright and Wright 1949). Post-metamorphic individuals in the present study ranged from 14.4-18.7 mm. Yearlings ranged from 20.4 to 31.0 mm in late June and thus can be readily distinguished from young-of-the-year. Yearlings probably do not spawn. The length of spawning individuals ranges from 29-50 mm for males and 34-56 mm for females (Wright and Wright 1949). Individuals of this size within the study area are almost certainly two or more years old.

Dispersal of post-spawning adults away from the spawning sites occurs but individuals may be encountered near the margins of water bodies throughout the summer. Young-of-the-year also leave the spawning sites shortly after metamorphosis and only small numbers were encountered at these sites during late

August. Wood frogs are terrestrial and are occasionally found far from water in moist wooded areas. They are known to overwinter under leaf litter (Wright and Wright 1949; Hodge 1975) and under logs or stumps.

The boreal chorus frog was seen at seven of the study sites and spawned at three of these. This species spawned in two of the borrow pits studied and in one natural pond. The eggs are laid in small loose clusters attached to vegetation, frequently in temporary ponds (Wright and Wright 1949). Spawning within the study area had been completed prior to 12 June 1976. Spawning is known to occur as early as late March in Indiana (Wright and Wright 1949). Spawning aggregations have been seen as early as late April at Lake Wabamun, Alberta, and chorusing individuals have been heard as early as 3 April 1976 along the Red Deer River near Innisfail (personal observations W.R.). Spawning was underway in the northwestern quarter of Alberta in late May of 1976 (personal observations W.R.) and likely occurred within the study area at that time. Metamorphosis occurred as early as 24 July at Site 6 and was completed at this site shortly after 3 August. Boreal chorus frogs metamorphose at lengths of 7.5-13 mm (Wright and Wright 1949). Post-metamorphic individuals measured during the present study were much larger, averaging 13.7 mm. Other northern Alberta specimens averaged 12.7 mm at, or shortly after, metamorphosis (W. Roberts unpublished data). The relatively large size of boreal chorus frogs at the time of metamorphosis may be the result of development at low temperatures as is true for many poikilotherms (Ray 1961). The size at which young-of-the-year overwinter may be a critical factor affecting their ability to persist during periods of stress. Larger individuals may be more successful in this regard. Yearlings in a number of northern Alberta collections ranged from 15.9-17.3 mm during May. The size of spawning individuals ranges from 21-32 mm

for males and 20-37.5 mm for females (Wright and Wright 1949); thus individuals within the study area probably do not spawn until they are two or more years old. Dispersal of young-of-the-year from spawning sites appears to be rapid as they were only seen at such sites shortly after metamorphosis. Boreal chorus frogs are known to overwinter in Alberta by burrowing under decaying stumps (personal observations W.R.) and into anthills (J. Wolford personal communication).

The Canadian toad was present at nine of the study sites during 1976 and spawned at seven of these. This species utilized the widest variety of spawning habitats including natural ponds, borrow pits, streams and lake margins. The eggs of Canadian toads are laid in long strings and may or may not be associated with vegetation (personal observations W.R.). The long strings of eggs may be less subject to displacement by moving water than the attached spherical or subspherical egg masses of frogs and thus facilitate spawning in waters with a slight current, wave action, and no vegetation. This increases the variety of spawning habitat available to the species; however, egg and tadpole mortality may be higher due to predation and displacement by running water. The fecundity of Canadian toads is higher than that of wood frogs and boreal chorus frogs which may compensate for the mortality arising in the wide variety of spawning habitat utilized. Spawning within the study area had apparently been completed prior to 12 June. Spawning occurred during May along the Red Deer River in 1976 (Roberts unpublished data) and has occurred into mid-June at the same site in previous years. Within the study area, metamorphosis occurred as early as 25 June (Site 11) and continued until early July. The developmental time for this species appears to be unknown. Post-metamorphic individuals of this species range from 9-13.5 mm in head-body length (Wright and Wright 1949). Individuals sampled during the present study ranged from 11.9-13.2 mm. Yearlings ranged from 22.0-29.8 mm in late June and are thus

readily distinguishable from young-of-the-year. Spawning individuals of this species range from 58-68 mm for males and 56-80 mm for females (Wright and Wright 1949); thus it is unlikely that individuals of this species within the study area spawn until they are two or more years old.

Dispersal of adults from spawning sites occurs soon after spawning but individuals may be found along the margins of these sites throughout the summer. Young-of-the-year toads are often found in high numbers along the margins of spawning areas throughout the summer. Lillywhite and Wassersug (1974) regard the aggregating behavior of young-of-the-year boreal toads (*Bufo boreas*) as a retained larval characteristic. Young-of-the-year Canadian toads were abundant along the Red Deer River (a spawning site) in early September of 1976, but were absent after mid-September (personal observations W.R.) probably having buried themselves in suitable substrate for overwintering.

5.2 HABITAT UTILIZATION AND POPULATION ESTIMATES

Wood frogs were most frequently found in grass meadows, willow bogs, and aspen poplar habitat which are the most moist terrestrial habitats available. Heatewole (1961) regards the wood frog as a forest dwelling species and suggests that the shade provided by trees is an important factor in determining habitat selection. He demonstrated experimentally that substrate structure and substrate moisture are important factors governing the selection of microhabitat. Bellis (1962) states that wood frogs are restricted to forested areas, particularly lowland bogs. Shelford (1913) demonstrated that wood frogs prefer an environment with moist air. Marshall and Buell (1955) found that in exposed areas with sparse wood frog populations, the vapour pressure deficit was higher than in shaded tamarack habitat with a dense wood frog population. It thus appears that moisture content of both the substrate and air are important factors in

determining the suitability of habitat types for wood frogs. Tall grasses, willows, and aspen poplars growing in moist soil in low-lying areas provide a favorable environment for wood frogs within the Alberta oil sands area, while much of the forest habitat, especially jack pine, is too dry with respect to substrate moisture and perhaps the humidity of the air.

Heatwole (1961) suggests that the wood frog is less terrestrial than previously thought (see Wright and Wright 1949) and points out that its association with woods and damp leaf litter occurs after woodland ponds dry up. Within the Alberta oil sands area the study sites were associated with more permanent bodies of water. Wood frogs were rarely found at distances greater than 100 m from a water body and most were found within 50 m. Bellis (1962) regards the wood frog as being intermediate between aquatic and terrestrial anurans in its ability to withstand body water loss. Only large wood frogs are found in dry habitats and it is probably the large individuals that emigrate and colonize new areas (Bellis 1962). Larger wood frogs also tended to be further from water during the present study perhaps owing to their greater ability to tolerate body water loss.

The highest population density for this species (19.6 adults per 1000 m^2) was found in an area with a mixture of grasses, willow, and aspen poplar. These plant communities are frequently found individually, mixed, or intergrading with one another adjacent to water bodies. Bellis (1961) found maximum densities of about 17 individuals per 1000 m^2 in tamarack (*Larix laricinia*) and calla lily (*Calla palustris*) habitat.

Boreal chorus frogs were most frequently found near the water margin or in shallow water amongst vegetation. Too few yearlings or adults were found to determine what, if any, habitat type is preferred. Whitaker (1971) regards the chorus frog as a woodland species that occurs most frequently near water, while Stebbins (1966) notes that in the west this species

seems to be primarily an inhabitant of open moist grasslands. Kramer (1974) found that the home ranges of chorus frogs contained breeding pools and that most frogs remained within 100 m of these pools throughout the summer. In Alberta the boreal chorus frog is known from the prairies, aspen parkland, and boreal forest regions (UAMZ collections) but always near water. It is the most widespread amphibian species within Alberta and persists in a wide variety of moist habitat types providing that at least temporary ponds are available for spawning and for development of the tadpoles.

Boreal chorus frogs were found closer to water on the average than the other anuran species present. During June of 1977 nonbreeding individuals were found at a mean distance of 54 m from the water margin. This may be the result of their being found close to their overwintering sites. Unlike breeding individuals they probably do not move immediately to water bodies following emergence in the spring. During July and August most individuals of all age classes were found within 20 m of the water margins. Kramer (1973) notes that while a few individuals may be found over 200 m from breeding pools most are found within 100 m. Individuals may be found buried under leaf litter during the day (Kramer 1973). This may serve as protection against diurnal predators and desiccation. These observations may indicate that this small species is more prone to desiccation than are the larger species.

Insufficient data were obtained to determine population densities on most study plots. Sites 7 and 17 yielded adult population densities of 2.3 individuals per 1000 m^2. Kramer (1974) obtained densities of 0.55 adults per 1000 m^2 from a 33 acre (13.35 ha) study area in Indiana. His data probably include most of the adults present, while estimates from the present study are probably conservative owing to the secretive nature of the boreal chorus frog. Larger numbers of the boreal

chorus frog are assumed to be present based on the numbers heard calling (but seldom seen) during May and June.

The Canadian toad was common at only three of the 17 sites studied. Each of the three sites included poplar forest and grass and two of the three included willows. It is of note that each site was associated with a river or lake rather than a temporary or small permanent pond. Stebbins (1966) states that this species occurs in Transition and lower Boreal life zones (Transition and Canadian life zones of Soper 1964), in the vicinity of lakes and streams. Underhill (1961) and Henrich (1968) regard the Canadian water toad as a water adapted species (i.e. less terrestrial than most bufonids) of prairie ponds and lakes. Breckenridge and Tester (1961) found that this was the only toad species present in habitat vegetated by aspen, willows, bluestem (*Andropogon* spp.), and grasses adjacent to a lake. This species is not a forest inhabitant but resides within damp open areas adjacent to bodies of water. Its association with lakes and flowing water may be owing to its ability to utilize them as spawning and rearing habitat. In such habitat it is subject to a minimum of competitive interactions with other anurans owing to their inability to successfully reproduce there.

Canadian toads are seldom found far from water. Breckenridge and Tester (1961) found that only a few toads were captured in a trap 200 feet (63.3 m) from the water margin while over 80% of the total capture was made within 25 feet (8 m). During the present study most Canadian toads were found within 50 m of the water. Although no significant differences exist from month to month, Canadian toads occurred closer to the water in July than in June and more so in August. This may have been in response to drying of the terrestrial habitat as the summer progressed. Tamsitt (1962) reports migration of this species to water margins at night presumably for water imbibition. Breckenridge and Tester (1961) found no such nightly migration, however; individuals were seldom found sufficiently far upland that they were in particularly dry habitat.

Population estimates for this species reached a maximum of 12 adults per 1000 m^2, only slightly over half of the maximum density for wood frogs. Keheller and Tester (1969) found toads in much greater abundance. This was probably owing to an abundance of excellent overwintering habitat combined with a lack of competition from other anurans along the margins of a prairie lake.

The relative abundance of the three species found during both years of the study may be misleading. The wood frog is certainly widespread and abundant within the study area. This species is the most widely distributed amphibian in North America and occurs farther north than any North American amphibian. Its adaptations to life in cold regions are summarized in Hodge (1976). Canadian toads, however, may be much less abundant than the wood frog as 182 of the 207 adult and subadult Canadian toads seen during 1976 were young-of-the-year. These were found in post-metamorphic aggregations along the margins of spawning sites. In spite of its ability to use the widest variety of spawning habitats (among the three species found here) this species spawned in only seven of the 20 sites studied compared with 10 sites utilized by the wood frog. The boreal chorus frog was heard at or near all of the study sites but spawned in only three of these. Its utilization of temporary ponds and standing bodies of water for spawning sites may reduce the number of potential sites from 20 to 10 for this species. The small size, cryptic coloration, and shy behavior of boreal chorus frogs make them difficult to see and collect even when they are present in large numbers at spawning sites. Since they are a terrestrial species and frequently hide under logs and stones, they are the most difficult to see among the three species present. This species is probably more abundant than our data indicate.

5.3 THE STATUS OF OTHER SPECIES OF AMPHIBIANS AND REPTILES

The apparent absence of other amphibians and garter snakes (*Thamnophis* spp.) within the Alberta oil sands area may be accounted for in two major ways. There may not be any other species present as conditions within this area may not favor their colonization or maintenance. The tiger salamander (*Ambystoma tigrinum*) is known from only a few localities north of Edmonton and the factors limiting its northward distribution are not known. The leopard frog (*Rana pipiens*) is known from north of the Alberta oil sands area (Logier and Toner 1961). The leopard frogs in the Lake Athabasca region may have populated this area by moving northward through Alberta and Saskatchewan following the recession of the Pleistocene glaciers and the disjunct extant populations there at present should be regarded as relict. The factors determining the northern limits of the continuous range of this species within Alberta are not known. The western spotted frog (*Rana pretiosa*) does not likely occur east of the Rocky Mountains and their foothills in Alberta. Records published in Logier and Toner (1961) are based on misidentification of a juvenile wood frog and leopard frog tadpoles (Cook 1964).

Other species may be present but only locally abundant. The western toad (*Bufo boreas*) is known to occur as far north as 56°N in western Alberta and is found in the upper Athabasca watershed (UAMZ collections). Unless there is some barrier to its colonization in the Alberta oil sands area it is almost certainly to be found at least locally along the Athabasca River.

Harper (1931) reports second hand records of the red-sided garter snake (*Thamnophis sirtalis*) from Birch River, Birch Mountain, and Peace Point. F.F. Gilbert (letter dated 3 March 1978, Department of Zoology, University of Guelph, Guelph, Ontario) reports seeing a snake from Kearl Lake north of Fort McMurray. Snakes present within the Alberta oil sands area are most likely red-sided garter snakes as this species is known to occur farther north at Fort Smith (Harper 1931; Hodge 1976). Extreme northern populations of the red-sided garter snake may

exist as relicts of formerly widespread populations that reinvaded this area following the recession of Pleistocene glaciers. However, the northern populations of this species are all found relatively close to the Peace-Athabasca Delta and may have been derived from populations along the upper Peace River (Roberts 1977). The Peace River and its valley provide an avenue of invasion along which feeding areas and overwintering sites are plentiful, and red-sided snakes are locally present downstream downstream to at least Fort Vermilion (UAMZ collections). Downstream migration of snakes along the Peace River probably resulted in the establishment of populations in the Peace-Athabasca Delta region (Figure 10) and may at present contribute to these populations. Migration of snakes upstream from this area via the Birch, McIvor, Muskeg, and Athabasca rivers may have occurred or may be occurring, but at a much slower rate than the downstream migration that resulted in colonization of the Peace-Athabasca Delta area.

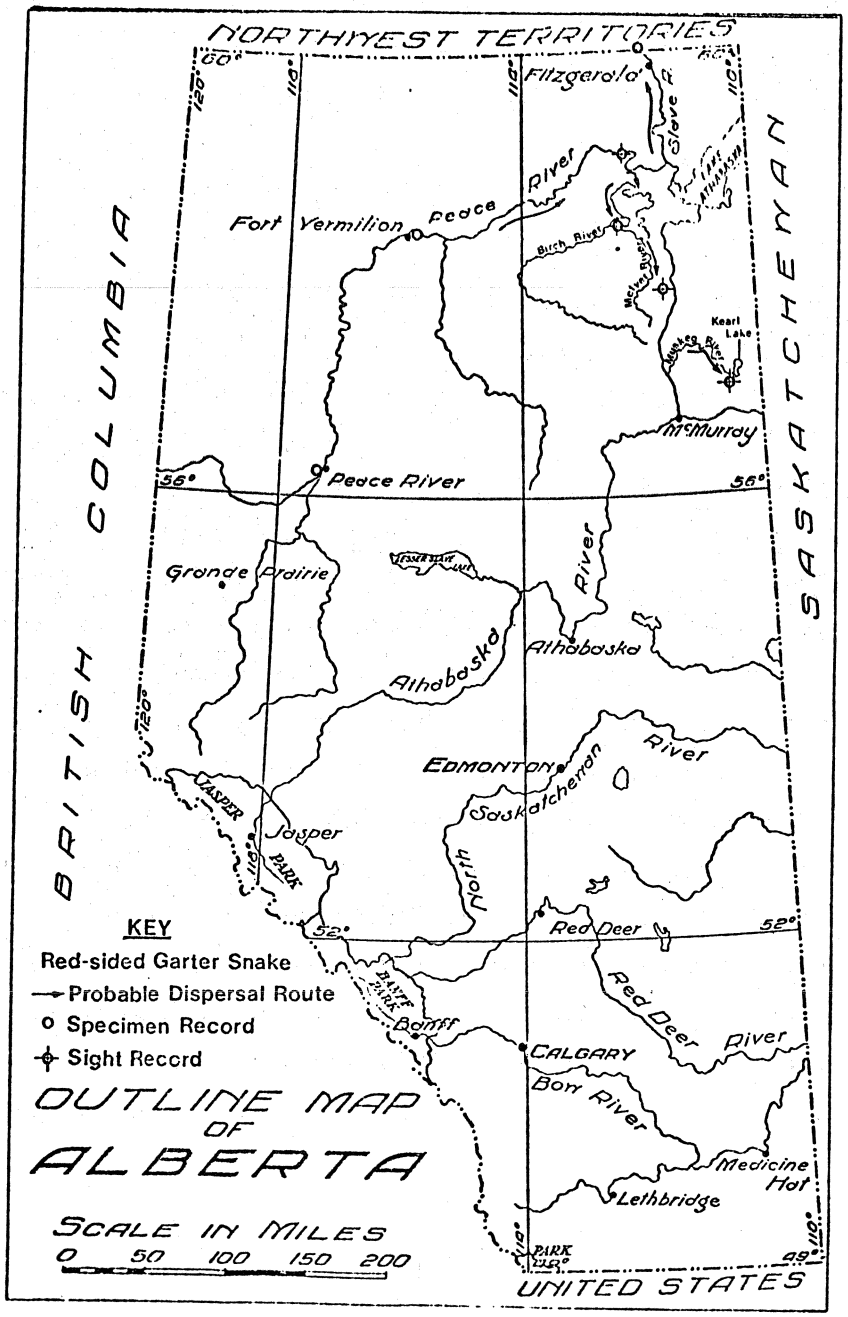

Figure 10. Locality records and probable post-glacial dispersal routes of the red-sided garter snake (*Thamnophis sirtalis parietalis*) north of 56°N.

6. SUMMARY AND CONCLUSIONS

The known herpetofauna of the Alberta oil sands region consists of three amphibian species: the wood frog, boreal chorus frog and Canadian toad, and a single reptile, the red-sided garter snake. The wood frog is the most abundant and widespread species. The amphibian species share a number of life history features. They overwinter in terrestrial sites and spawn in the spring. Larval development is rapid and metamorphosis occurs during the first summer of life. Borrow pits as well as natural ponds appear to be favored as spawning sites over streams and lakes. Subadults and adults are terrestrial; however, most are found within 50 m of a body of water. Highest densities of all species are found in moist habitat, near water, vegetated by sedges, grasses, horsetail, willow, and aspen.

The habitat utilization, population density, and distribution of age classes for each species is schematically summarized in Figure 11. The vegetation profile is based on the frequency of occurrence of dominant species within each 20 m segment of the 48 sample plots adjacent to water. The density values for each amphibian species are based on totals of subadults and adults for all sites and thus represent mean densities. Wood frogs may be found over 100 m from water. However, most are found within 50 m. Small individuals tend to be found closer to water than large ones. Chorus frogs are uncommon at distances greater than 20 m from water and none were found further than 100 m from water. Canadian toads gradually decrease in abundance at distances greater than 40 m from water. No amphibians were found in dry, sandy areas with jack pine forest habitat.

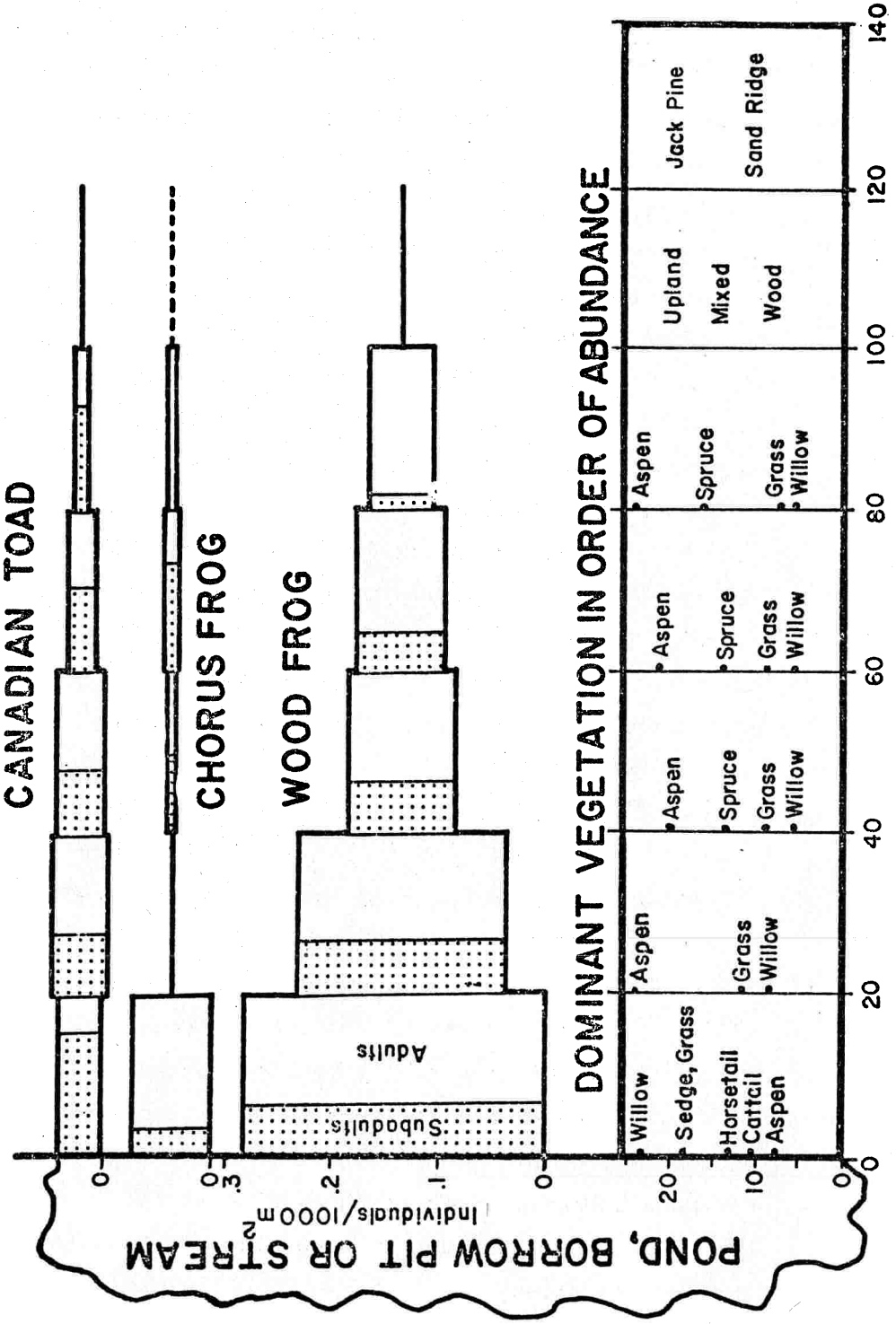

Figure 11. Schematic distribution of amphibians in the AOSERP study area in relation to vegetation and water.

7. IMPLICATIONS AND RECOMMENDATIONS

The following recommendations are directed toward minimizing damage to aquatic habitats and maximizing reclamation of disturbed areas to enhance reestablishment of the local herpetofauna. Extensive mortality of amphibians may result as follows:

1. A decline in water level as a result of draining operations will result in the elimination of spawning and rearing sites if conducted prior to or during the month of May;
2. If such drainage occurs during May-June, egg masses fixed to vegetation or deposited in shallow water will desiccate and be destroyed;
3. If such drainage occurs after May but prior to the end of July, rearing areas for tadpoles will be destroyed resulting in mortality of these larvae;
4. Drainage may result in desiccation of otherwise moist habitat adjacent to bodies of water eliminating the preferred habitat of the amphibians present;
5. Removal of vegetation or overburden within 100 m of water bodies will result in mortality of subadult and adult amphibians owing to loss of cover, moisture, and food organisms; and
6. Removal of overburden adjacent to water bodies will result in elimination of overwintering sites.

If disruption of this habitat is inevitable the following recommendations will enhance habitat reclamation and consequent reestablishment of amphibians:

1. Man-made bodies of water such as ditches and borrow pits are utilized by amphibians as spawning and rearing sites;

2. In order that man-made water bodies provide suitable habitat for recolonization by amphibians they should have the following characteristics: (i) shorelines and bottoms should have gentle rather than steep slopes as revegetation (necessary for egg attachment) is facilitated and warming of the littoral area is more rapid promoting hatching of eggs and subsequent development of the larvae; (ii) revegetation of the shoreline and adjacent uplands with grasses, willow and poplar should be undertaken to provide cover, maintenance of moist habitat and food for invertebrates (amphibian food). These native pioneer species are those with which these amphibians are most frequently found; and (iii) the introduction of silt to water bodies should be avoided as this may reduce light penetration in the water and delay the establishment of rooted aquatic plants. Siltation can also result in suffocation of amphibian eggs; and
3. Disturbance at distances greater than 100 m from water will result in little or no direct mortality of amphibians.

8. NEED FOR FURTHER STUDY

The status of garter snakes within the AOSERP study area remains uncertain. Most of the habitat examined during the last two years apparently lacks adequate overwintering sites for garter snakes. However, our study indicates a large food supply for snakes (amphibians) is available. Isolated sight records exist for (presumably) the red-sided garter snake and it thus constitutes the only reptile species present within the AOSERP study area. As such it is desirable to locate overwintering sites (hibernacula) to determine the size of local populations and derive an understanding of its ecology. Morphometric examination of a series of specimens may provide evidence to aid in determining whether these populations are relict or recently derived from populations along the Peace River.

As the most recent and most precise locality record for garter snakes within the AOSERP study area is at the inlet to Kearl Lake, we propose to visit this area during late April or early May. At this time garter snakes will be concentrated in a large breeding aggregation at the hibernaculum site. This will facilitate enumerating the population and description of the hibernaculum and adjacent habitat. The lack of adequate hibernacula throughout much of the oil sands area precludes its colonization by garter snakes. Identification of such sites is desirable in order that they be protected. Field time for this investigation should take no longer than one week. Costs involved will only be for transportion and food and should not exceed $1000.

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10. APPENDICES

10.1 HYPOTHETICAL LIST OF THE AMPHIBIANS AND REPTILES OF THE AOSERP STUDY AREA

Nomenclature follows Conant (1975) except for *Bufo boreas* and *Rana pretiosa* for which the nomenclature given in Conant et al. (1956) is employed.

Ambystoma tigrinum melanostictum Baird	blotched tiger salamander
Bufo boreas Baird and Girard	western toad
Bufo hemiophrys Cope	Canadian toad
Pseudacris triseriata maculata (Wied)	boreal chorus frog
Rana pipiens Schreber	leopard frog
Rana pretiosa Baird and Girard	spotted frog
Rana sylvatica Le Conte	wood frog
Thamnophis elegans vagrans Barid and Girard	wandering garter snake
Thamnophis sirtalis parietalis Say	red-sided garter snake

10.2 DATA SHEET USED DURING 1977

SITE NO. _____ DATE _____ TIME OF DAY _____ DRY OR WET _____

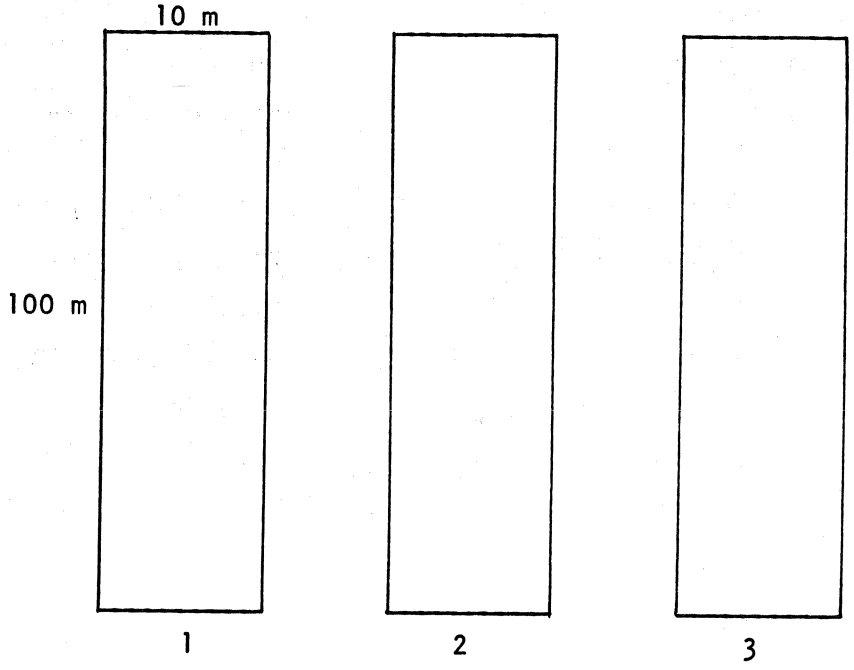
Species	*Age	No. observed	Vocal acitivty
Bufo hemiophrys			
Rana sylvatica			
Pseudacris triseriata			

Water temp. pH ppm O ppm CO

Hardness Alkalinity

Weather

Occurrence of individuals in relation to vegetation.



*Age: 0 egg masses
0+ newly hatched individuals
1+ immatures
2 adults

10.3 COMMON PLANT SPECIES RECORDED ON SAMPLE PLOTS DURING 1977

Nomenclature follows Moss (1974).

Bryophyta	Feathermoss
Equisetum spp.	Horsetail
Larix larcinia (Du Roi) K. Koch	Tamarack
Picea glauca (Moench) Voss	White spruce
Picea mariana (Mill.) BSP	Black spruce
Pinus banksiana Lamb	Jack pine
Typha latifolia L.	Common cattail
Gramineae	Grasses
Carex spp.	Sedge
Populus tremuloides Michx.	Aspen
Salix spp.	Willow
Alnus cispa Pursh	Green alder
Betula papyrifera Marsh.	White birch
Corylus cornuta Marsh.	Beaked hazelnut
Rosa spp.	Rose
Ledum groenlandicum Oeder	Common labrador tea
Vaccinium myrtilloides Michx.	Blueberry
Thlaspi arvense	Stinkweed
Arctostaphylos uva-ursi (L.) Spreng.	Common bearberry
Epilobium angustifolium L.	Fireweed

11. 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 within 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
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.	HE 2.3	Maximization of Technical Training and Involvement of Area Manpower
23.	AF 1.1.2	Acute Lethality of Mine Depressurization Water on Trout Perch and Rainbow Trout
24.	ME 4.2.1	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 Fish 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
47.	TF 1.1.1	A Visibility Bias Model for Aerial Surveys of 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 Data in the AOSERP Study Area
52.	ME 2.3.2	Plume Dispersion Measurements from an Oil Sands Extraction Plant, 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	Self-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.

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

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