General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.
- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

Produced by the NASA Center for Aerospace Information (CASI)

APPLICATION OF LANDSAT SYSTEM FOR IMPROVING METHODOLOGY FOR INVENTORY AND CLASSIFICATION OF WETLANDS

Dr. David S. Gilmer U. S. Fish & Wildlife Service Northern Prairie Wildlife Research Center

E 7.7-10.0.68 NASA-CR. 149432

in the interest of early and wide digorship semination of Earth Resources Survey Riggiam information and without hability Nos seres ande Derest."

7 January, 1977

Type II Progress Report for Period 1 October to 31 December 1976

Prepared for: National Aeronautics and Space Administration Goddard Space Flight Center Greenbelt, Maryland 20771

(E77-10066) APPLICATION OF LANDSAT SYSTEM N77-16401 FOR IMPROVING METHODOLOGY FOR INVENTORY AND ME AOL CLASSIFICATION OF WITLANDS Progress Report, 1 Oct. - 31 Dec. 1976 (Northern Prairie Unclas Wildlife Research Center) 12 p G3/43 00000

Publication authorized by the Director, U. S. Fish and Wildlife Service

23000

RECEIVED JAN 1 2 1977 SIS/902.6

TECHNICAL REPORT STANDARD TITLE PAGE

1.º Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle		5. Report Date
Application of LANDSAT sys	tem for improving	January 7, 1977
methodology for inventory wetlands.		6. Performing Organization Code
7. Author(s) David S. Gilmer (IN 300) a	and Edgar A. Work, Jr.	8. Performing Organization Report No.
9. Performing Organization Name an		10. Work Unit No.
U. S. Fish and Wildlife Se		
Northern Prairie Wildlife Jamestown, North Dakota 58		11. Contract or Grant No.
Jamestown, North Dakota Sc	5401	S-54049A
		13. Type of Report and Period Covered
12. Sponsoring Agency Name and Ad		Type II Progress Report
Mr. Harold Oseroff, Code 9		1 October 21 December 1077
Goddard Space Flight Cente Greenbelt, Maryland 20771		1 October - 31 December 1977
sieenbert, haryrand 20771		14. Sponsoring Agency Code
15. Supplementary Notes		
16. Abstract		
completed during this repo area in southeastern North July periods. Cloud cover area. Data analysis was a of these programs are disc are compared to visual cou FWS breeding ground survey 20% of these counted visua to the fact that approxima are less than 0.4 ha in st	data for detection of prairie ort period. Data coverage inc n Dakota (FWS Survey Stratum + rage limited the May coverage accomplished using three softwork cussed. Wetland identification unts obtained by observers in ys. Pond numbers identified H ally in the study area. The ately 75% of the ponds in the ize. It is significant, hower . Cor ection factors could be actual conditions.	cluded a 36,876 km ² # 46) during May and to 87% of the total ware programs. Details on by LANDSAT MSS sensor low flying aircraft during by LANDSAT averaged about discrepancy was attributed glaciated prairie region ver, that LANDSAT counts
17. Key Words	18. Distribution	Statement
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages 22. Price
Unclassified	1	13

Type II Progress Report LANDSAT-2

Title: Application of LANDSAT system for improving methodology for inventory and classification of wetlands.

LANDSAT Proposal No.: 23000

GSFC ID No. of P.I.: 300

A. Problems

None to report. Aircraft MSS data mentioned in Paragraph A of the previous progress report were received on 19 October 1976.

B. Accomplishments

The processing of LANDSAT MSS data for the detection of prairie ponds and lakes is now complete. The data processed consisted of observations obtained in May and again in July 1975 throughout a 36,876 km² area in southeastern North Dakota designated by the U. S. Fish and Wildlife Service as Survey Stratum No. 46. Cloud cover was frequently present during May and limited our survey to approximately 87 percent (32020 km²) of the stratum. Nearly 100 percent (36783 km²) of the stratum was monitored during July. The processing of LANDSAT CCT's followed the procedure described in our previous quarterly report. Subsequent to the reformatting of data and recognition training clata analysis was accomplished by the sequential use of three software programs: APSTAT, SORT, and POSORT.

Program APSTAT (Area, Perimeter STATistics) examined the reformatted LANDSAT CCT and used a decision criteria to evaluate each pixel as being either water or nonwater in content. In the current instance, the decision criteria for open surface water was based on water's uniquely low apparent radiance in a near-infrared waveband (MSS-7, 0.8 to 1.1 um). The program then recognized individual water pixels as small ponds and clusters of water pixels as larger ponds and lakes. Subsequently, the geographic position (in UTM coordinates), the area, and the perimeter (land/water edge) of each water feature was computed. The results of these computations with the data for each pond appearing as a separate record were then recorded in the computer's output stream on cards and/or magnetic tape.

The Pond data records generated by APSTAT occurred as a series of data files and within a file in a sequence according to increasing scan line count and increasing pixel count along any scan line. As a convenience for subsequent data editing or information extraction we felt it essential to reorder the pond data records in a logical sequence. Consequently, we utilized a software program known as SORT. This utility program was available through the University of Michigan Terminal System for arranging records from one or more data sets to form a single data set arranged according to one or more attributes of the data. In the present situation the program permitted the merging of multiple data sets (the result of the

Type II Progress Report LANDSAT-2

Title: Application of LANDSAT system for improving methodology for inventory and classification of wetlands.

LANDSAT Proposal No.: 23000

GSFC ID No. of P.I.: 300

A. Problems

None to report. Aircraft MSS data mentioned in Paragraph A of the previous progress report were received on 19 October 1976.

B. Accomplishments

The processing of LANDSAT MSS data for the detection of prairie ponds and lakes is now complete. The data processed consisted of observations obtained in May and again in July 1975 throughout a 36,876 km² area in southeastern North Dakota designated by the U. S. Fish and Wildlife Service as Survey Stratum No. 46. Cloud cover was frequently present during May and limited our survey to approximately 87 percent (32020 km²) of the stratum. Nearly 100 percent (36783 km²) of the stratum was monitored during July. The processing of LANDSAT CCT's followed the procedure described in our previous quarterly report. Subsequent to the reformatting of data and recognition training clata analysis was accomplished by the sequential use of three software programs: APSTAT, SORT, and POSORT.

Program APSTAT (Area, Perimeter STATistics) examined the reformatted LANDSAT CCT and used a decision criteria to evaluate each pixel as being either water or nonwater in content. In the current instance, the decision criteria for open surface water was based on water's uniquely low apparent radiance in a near-infrared waveband (MSS-7, 0.8 to 1.1 um). The program then recognized individual water pixels as small ponds and clusters of water pixels as larger ponds and lakes. Subsequently, the geographic position (in UTM coordinates), the area, and the perimeter (land/water edge) of each water feature was computed. The results of these computations with the data for each pond appearing as a separate record were then recorded in the computer's output stream on cards and/or magnetic tape.

The Pond data records generated by APSTAT occurred as a series of data files and within a file in a sequence according to increasing scan line count and increasing pixel count along any scan line. As a convenience for subsequent data editing or information extraction we felt it essential to reorder the pond data records in a logical sequence. Consequently, we utilized a software program known as SORT. This utility program was available through the University of Michigan Terminal System for arranging records from one or more data sets to form a single data set arranged according to one or more attributes of the data. In the present situation the program permitted the merging of multiple data sets (the result of the utilization of multiple LANDSAT files and CCT's) and the ordering of pond data records in a north to south progression based upon the UTM coordinate system. The ordered output records were stored on magnetic tape.

Program POSORT (POst-SORT) was then utilized to: (1) edit the pond data records based upon specified spatial bounds, (2) compute the area of the bounded space (i.e., the study area), (3) list the ponds occurring within the bounded space, and (4) summarize the frequency of pond occurrence based upon certain size and perimeter criteria. The program was especially written to handle the type of data which resulted from the SORT program and which were unique to this study effort. Basically, program POSORT allowed the editing of data so that only information relative to ponds occurring within USFWS Survey Stratum 46 were analyzed, and it further permitted the substratification of these data. In this context, the program was able to handle a geographic space defined by a closed polygonal figure having as many as 50 vertices. The polygon was specified to the computer in terms of UTM coordinates which identified the desired vertices.

The results of this processing and a preliminary analysis are given in the following section.

C. Significant Results

For the purposes of this study USFWS Survey Stratum No. 46 was subdivided into two parts (substrata). These parts, specified as the "Drift Plain" and "Coteau", were delineated on the basis of physiographic differences. These differences cause wetland densities and type distributions to vary a large degree, between the two substrata. Tables 1 through 4 resulted from software program POSORT and summarize pond data for each of the two substrata and for the May (breeding season) and July (brood season) surveys. A total of 58,650 and 18,213 water features respectively was observed for each of these surveys. Figure 1 illustrates pond size frequency and the seasonal (i.e., May to July) change in pond numbers for Stratum No.46 as a whole. Pond numbers observed during both May and July were well above corresponding periods of the previous several years. May ponds were numerous due to March blizzards which deposited up to 50 cm of snow over parts of North Dakota. April rainfall also produced substantial runoff. The wet conditions delayed farm operations in many areas and no doubt benefited early nesting ducks. The abundant water conditions were substained into July by heavy rains which began on 27 June and lasted into early July. These rains caused severe flooding in the southeastern parts of the state and particularly in the Red River Valley (an area immediately east of Stratum [46]. These rains created inordinately abundant water conditions in much of Stratum 46 particularly in the drift plain portion of that stratum

Over the past several decades estimates of waterfowl breeding populations and production have been made by the U. S. Fish and Wildlife Service using survey information collected from low flying aircraft. Based upon these surveys, estimates of pond numbers for Stratum 46 are shown in Figures 2 and 3. These estimates relate to the most recent ten year

interval and are based on visual observations made along 1738 lineal transect kilometers which make up a total sample area of 350 km² (a 1.0 percent sample). For comparison, pond-number estimates made using LANDSAT data are also included in the figures. In the period 1972 through 1974 LANDSAT was used to survey 16 percent of the stratum and in 1975 in excess of 85 percent of the stratum. From the figures it is apparent that pond numbers tabulated by LANDSAT are much lower than the estimates developed by the USFWS -- amounting on the average to a ratio of about 20 percent. This figure is consistent with findings of several biologist, specifically that between 75 to 85 percent of ponds in the northern prairies are less than 0.4 hectare in size. As a result many prairie ponds go undetected by current satellite sensor systems. It is important to note from Figures 2 and 3, however, that LANDSAT pond counts over the last several years have tracked the trends noted in the USFWS data. By using a correction factor LANDSAT data may have the potential for providing accurate regional waterfowl habitat assessments.

The LANDSAT tabulations of 1975 when compared to USFWS data exhibited a greater relative variation than had previous LANDSAT data. Whereas earlier LANDSAT pond enumerations had ranged between 16 and 22 percent of USFWS estimates, the May 1975 and July 1975 LANDSAT enumerations were 44 and 12 percent respectively of the corresponding USFWS estimates. We attributed these departures to several causes. During May a vast amount of sheet water was present throughout the stratum. Usually such conditions are due to melted snow which has not evaporated or percolated into the soil to the existence of a temporary ice seal. This sheet water in many instances was enumerated by LANDSAT but typically such ephemeral wetlands are not tabulated by the USFWS observers. During July 1975, many wetland basins which would not normally contain water at this time of year did in fact contain water because of the late June rains. Many of these basins would not have been tabulated by LANDSAT because of their small size and/or because of emergent vegetation which would have developed by this date and which occluded the water to the view of the high altitude sensor.

D. Publications

Work, E. A. and D. L. Rebel. 1976. Results of the periodic mapping of prairie surface water features using LANDSAT data: 1972 thru 1974. Prepared for USFWS, USDI Contract No. 14-16-0008-971. Environmental Research Institute of Michigan Report No. 116500-1-F. 36pp + Appendix.

E. Recommendations

None

TABLE 1

SUMMARY OF POND AND LAKE OCCURRENCE AS OBSERVED IN THE COTEAU SUBSTRATUM* DURING MAY 1975.

RES ACRFS FREDUFNCY METERS 0,00 1,00 1,00 1,00 10 900 17 300 0,00 1,00 70 2,00 918 300 17 300 900 900 900 900 900 900 70 900 70 900 70 900 70 295 2,00 10 5,00 900 70 200 994 1500 295 900 70 295 900 700 295 900 700 295 900 700 295 900 700 700 295 900 700 700 295 900 700 700 295 900 700	PERIMETER	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	FEET FF	FRERUENCY
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	0.	81
0.80 10 1.20 2.00 10 3.00 10 3.00 10 3.00 10 3.00 10 3.00 10 3.00 10 3.00 10 2.00 10	¢.	11
1.20 1.60 3.00 7.00	TO 2952	M)
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	ŝ	69
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	617	0
Zur TP 3.20 6.00 T0 8.00 T0 8.00 T0 2100 T710 599 Jur TP 3.20 10 00 T0 15.00 T0 17.00 787 6.00 10 00 T0 15.00 T0 15.00 700 700 787 6.00 10 00 T1 75.00 868 2400 T0 770 787 6.00 10 20 01 70 20 200 70 700 707 8.00 10 20 01 70 260 70 70 70 70 70 8.00 10 20 20 21 20 20 70 </td <td>55</td> <td>۰Q</td>	55	۰Q
3.220 10	TU 6890	321
4 00 10 00 15 00 15 00 15 00 75 00 770 787 6 00 10 00 15 00 15 00 15 00 700 700 787 8 00 10 00 20 01 70 25 00 70 700 885 8 00 10 20 01 70 260 270 70 70 894 8 00 10 20 01 70 260 70 70 894 2 00 10 20 00 71 40 17 260 1082 2 00 10 20 00 10 27 360 10 4200 1378 6 10 10 20 00 10 27 142 14800 1374 0 10 10 10 10 10 10 17 15740 15740 15740 1	78	nu.
6.00 15.00 15.00 70.00 70.00 855 8.00 10.00 20.00 70.00 70.00 854 9.00 10.00 20.00 70.00 70.00 854 0.00 10.00 25.00 70.00 250 984 0.00 10.00 25.00 70.00 25.00 70.00 84 2.00 10 20.00 70.00 70.00 27.00 16.00 10.02 2.00 10 20.00 70.00 70.00 24.00 17.04 27.0 2.00 70 70.00 10.00 10.00 10.00 10.71 26.00 17.04 17.14 2.00 70 20.00 10.00 10.00 17.1 26.00 157.00 157.00 2.00 70 27.00 11.1 54.00 10.157.00 157.00 177.1 2.00 70 17.1 50.00 10.00 00 177.1 54.00 177.1 2.00 70 150.00 10.00 00 10.00<	88	ഹ
8.00 T0 10.00 20.00 T0 25.00 T0 25.00 T0 3300 984 0.00 T0 12.00 75.00 T0 30.00 T0 3600 T0 4200 1181 6.00 T0 20.00 T0 70.00 T0 75.00 T0 17.2 4800 T0 4800 T0 15740 1574 0.00 T0 30.00 T0 75.00 T0 75.00 111 5400 T0 4800 T0 45740 1574 0.00 T0 40.00 T0 75.00 T0 111 5400 T0 4660 1574 0.00 T0 40.00 T0 100.00 10 93 6000 T0 6000 T0 4660 2460 17560	98	NJ.
0,00 TU 12,00 75,00 TU 30,00 TU 30,00 TU 40,00 TU 228 3300 TU 2600 TU 4200 1181 6,00 TU 20,00 TU 30,00 TU 50,00 TU 40,00 TU	108	87
2.00 T0 16.00 30.00 T0 40.00 T0 40.00 T0 20.00 10 1378 6.00 T0 20.00 40.00 T0 50.00 142 4200 T0 4800 1378 0.00 T0 30.00 50.00 70 15.00 17.00 1574 0.00 T0 30.00 75.00 17.00 1574 4800 T0 1574 0.00 T0 40.00 75.00 111 5400 T0 1574 0.01 T0 60.00 101.00.00 171 5400 T0 1771 0.01 T0 60.00 100.01 93 6000 T0 6600 1766 0.01 T0 83 6000 T0 70.00 71 7600 7165	118	70
A,00 TG 20,00 40,00 TG 50,00 1378 0,00 TG 30,00 50,00 TG 75,00 155,00 1574 0,00 TG 40,00 75,00 TG 100,00 171 5400 TG 5400 TG 0,01 TG 60,00 100,00 171 5400 TG 5400 TG 171 0,01 TG 60,00 100,00 171 5400 TG 5400 TG 5400 TG 0,01 TG 60,00 100,00 71 5400 TG 5460 171 0,01 TG 60,00 100,00 73 5400 TG 5460 TG 5460	10 13780	110
0,00 TO 30,00 50,00 TO 75,00 185 4800 TO 5400 1574 0,00 TO 40,00 75,00 TO 100,00 111 5400 TO 5000 1771 0,00 TO 60,00 100,00 TO 150,00 93 6000 TO 6600 1968 0,00 TO 80,00 150,00 TO 200,00 79 6600 TO 7600 2165	157	78
0,00 rD 40,00 75,00 TD 100,00 111 5400 TP 6000 1771 0,00 TD 60,00 100,00 TN 150,00 93 6000 TD 6600 1968 0,00 TD 80,00 TD 200,00 39 6600 TD 7600 2165	177	51
0_00 TO 60_00 100_00 TO 150_00 93 6000 TO 6600 1968 0_00 TO 80_00 TO 200_00 39 6600 TO 7600 2165	961	37
0,00 TD R0,00 150,00 TD 200,00 39 6600 TD 7600 2165	216	38
	0	30
OVER 40.00 OVER 700.00 92 OVER 760	EN 249	44
TOTAL NUMBER = 24045		

4

103P4.52 HI.

If

16711.44 KM.

TUTAL (SUMMED) FFATURE PERTHETER (EDGE) PEP SCENT=

TOTAL (SUMMED) FFATURE ARFA PER SCFNC =

*The surveyed area comprised 15,554 km².

283.17 Sn. HL.

11

733.41 SQ. KH.

ORIGINAL PAGE IS OF POOR QUALITY

TABLE 2

SUMMARY OF POND AND LAKE OCCURRENCE AS OBSERVED IN THE DRIFT PLAIN SUBSTRATUM* DURING MAY 1975.

HFCTAPES AGRES FREQUENCY WETERS FEC FEC FEC 0,0 10 0,0 10 10 0,0 0,0 0,0 0,0 0,0 10 0,0 10 10 0,0 0,0 0,0 0,0 0,0 0,0 10 0,0 10 0,0 0,0 0,0 0,0 0,0 0,0 0,0 11,20 2,00 100 1,00 10 0,0 0,0 0,0 0,0 1,20 2,00 1,00 1,00 1,00 1,00 1,00 0,0 0,0 0,0 1,20 2,00 10 1,00 1,00 1,00 1,00 0,0 0,0 1,20 2,00 17,00 1726 100 1726 100 2905 10 2,00 1726 100 1726 100 1726 100 2905 100 2,00 1726 106 1770 2915 2915 2515 2,00 10 10 10 10 100 1000 10,01 10 10 10 100 17717 10 101 10,00 10	HECTADES AGRES FREQUENCY WETERS FEC FRECLEVCY 0 10 0,40 3,0 11,00 70 0 17 300 10 965 10 10 0,40 3,0 11,00 70 0 17 300 10 960 10 10 960 10 10 960 10 10 10 10	NFC1APES	INA YE	ΕA			RY PERINFIFR	
0 0 0 0 0 0 0 1 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 0 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 1 0 0 0 0 1 0	 10 10 0.40 1.00 11 2.00 14896 300 10 600 984 10 1968 10 2952 20 10 1.00 11 2.00 10 5.00 1050 3937 10 902 1058 10 2952 7055 20 10 1.60 2.00 10 6.00 1056 10 2053 600 10 100 1068 10 2952 7055 20 10 2.00 4.00 10 5.00 2009 1000 10 200 10 100 100 100 100 100 20 10 2.00 10 0.00 11 10.00 1055 100 10 200 10 2057 10 4921 1049 20 10 2.00 10 0.00 10 10.00 1055 100 10 200 10 200 10 200 10 200 10 200 10 200 10 200 20 10 2.00 10 0.00 10 10.00 1055 100 10 200 10 10 10 11011 10 15740 10 10 11011 10 15740 10 10 10 10 10 10 10 10 10 10 10 10 10		цъF		Y343u03A9.	ETER	د لما	FRECLEVCY
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	10 0.4	0 0	1,01	C	ĬĴ	1 U	1487
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	10 0.8	0 1,00	2,00	14896	10	Ę	506
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	20 TO 1.60 3.00 TO 4.00 3090 TO 1200 2957 TO 4921 1049 40 TO 2.40 4.00 TO 5.00 1353 1500 3937 TO 4921 1049 40 TO 2.40 7.00 7.00 TO 6.00 TO 5.00 1353 1500 5905 TO 574 40 TO 3.20 8.00 TO 10.00 TO 12.00 163 700 7574 4.27 20 TO 6.00 TO 0.00 TO 25.00 163 700 774 700 7574 715 60 TO 8.00 TO 20.00 TO 25.00 391 200 TO 200 767 TO 7574 715 60 TO 10.00 TO 25.00 391 300 TO 200 1627 TO 1671 7574 715 60 TO 10.00 TO 25.00 TO 25.00 391 300 TO 200 98.7 TO 1677 315 778 300 TO 300 TO 200 TO 25.00 778 2730 719 717 719 75 70 TO 10.00 TO 25.00 TO 25.00 778 778 774 70 1574 70 70 TO 10.00 TO 25.00 TO 25.00 778 778 700 1574 70 1771 70 95 70 TO 20.00 TO 20.00 TO 20.00 TO 200 10 7717 70 1968 75 70 TO 60.0 10.00 TO 20.00 TO 200 TO 500 19771 70 1968 75 70 TO 60.0 TO 20.00 TO 200 TO 200 TO 2005 TO 1777 70 1771 70 1968 75 70 TO 60.0 TO 10.00 TO 200.00 TO 200 TO 500 17777 70 1771 70 1968 77 71 CO 10 TO 10.00 TO 200.00 TO 200 TO 2005 TO 1777 70 1771 70 1968 77 71 CO 10 TO 10 TO 200.00 TO 200.00 TO 770 7600 21654 77 24035 77 71 CO 10 TO 10 TO 200.00 TO 200.00 TO 770 70 19570 70 1777 70 1968 77 71 CO 10 TO 10 TO 200.00 TO 200.00 TO 700 7050 2054 77 24035 77 71 CO 10 TO 10 TO 200.00 TO 200.00 TO 700 TO 500 2054 70 24035 77 71 CO 10 TO 10 TO 200.00 TO 200.00 TO 700 TO 500 2054 77 24035 77 71 CO 10 TO 10 TO 200.00 TO 200.00 TO 700 TO 500 2054 77 24035 77 71 CO 10 TO 10 TO 10 TO 200.00 TO 700 TO 700 2054 70 7055 77 71 CO 10 TO 10 TO 10 TO 200.00 TO 700 TO 700 TO 700 700 7055 77 71 CO 10 TO 10 TO 10 TO 200.00 TO 70 TO 700 70 700 70 700 70 700 70 700 70 70 7	TU J Z	0 2.00	3.00	6338	5	Ç	402
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	10 1 ⁴ 0	0 3,00	4.00	3090	Ē	11	2315
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	in 2.0	0 4 00	5.00	2009	10	13	104
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	TO 2.4	n 5,00	6.00	1353	2	01	73
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	20 TO 4.00 R.00 TO 10.00 1083 2100 TO 2400 TO 240 TO 7714 TO 850 10 TO 6.00 19.00 TO 25.00 391 2400 TO 2700 794 TO 855 25 10 TO 10.00 25.00 TO 25.00 391 300 TO 300 9848 TO 9848 TO 9848 25 10 TO 10.00 25.00 TO 30.00 335 350 TO 3500 10427 TO 1191 15 10 TO 12 20.00 30.00 TO 40.00 TO 4200 11811 TO 1576 16 10 TO 20.00 50.00 TO 75.00 75.00 75.00 7717 TO 19685 77 10 TO 20.00 10.00 TO 105.00 75.00 77.00 1777 TO 19685 77 10 TO 40.00 170 70 TO 107 00 1777 TO 19685 77 10 TO 40.00 100.00 TO 105.00 125 500 TO 5600 1777 TO 19685 77 10 TO 40.00 100.00 TO 100.00 125 500 TO 5600 1777 TO 19685 77 10 TO 40.00 100.00 TO 200.00 125 500 TO 5600 1777 TO 19685 77 10 TO 40.00 100.00 TO 200.00 157 80 TO 24955 77 10 TO 40.00 170 TO 200.00 157 80 TO 24955 77 10 TO 40.00 100.00 TO 200.00 157 80 TO 24955 77 10 TO 40.00 100.00 TO 200.00 157 80 TO 24955 77 10 TO 40.00 TO 75.00 TO 200.00 157 80 TO 24955 77 10 TO 40.00 TO 75.00 TO 200.00 TO 5600 17777 70 19685 77 10 TO 40.00 TO 75.00 TO 200.00 TO 770 TO 24955 77 10 TO 40.00 TO 75.00 TO 200.00 TO 5600 17777 70 19685 77 10 TO 40.00 TO 75.00 TO 200.00 TO 770 TO 24955 77 10 TO 40.00 TO 75.00 TO 200.00 TO 770 TO 24955 77 10 TO 40.00 TO 75.00 TO 200.00 TO 700 TO	TQ 3.2	n 6.00	8.00	1726	e	Ξ	24
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	10 A.0	0 8,00	10.00	1083	£	Ë	34
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$.00 T0 R.00 I5.00 T1 20.00 778 2700 TG 3000 R65A TO 9842 TO 10.627 .00 T0 12.00 25.00 TO 25.00 331 330 TO 3300 TO 3300 9842 TO 10.627 .00 T0 12.00 25.00 TO 20.00 TO 25.00 10.617 10 13780 .00 T0 20.00 A0.00 TO 75.00 TO 25.00 10.717 TO 11711 .00 T0 20.00 A0.00 TO 75.00 TO 75.00 TO 75.00 17717 TO 15748 .00 T0 20.00 TO 75.00 TO 75.00 TO 75.00 TO 2000 TO 6000 17717 TO 15748 .00 T0 20.00 TO 75.00 TO 105.00 TO 152 000 TO 6000 17717 TO 15748 .00 T0 40.00 TO 75.00 TO 105.00 TO 200.00 TO 6000 17717 TO 19685 .00 TO 40.00 TO 20.00 TO 200.00 TO 6000 TO 6000 17717 TO 19685 .00 TO 40.00 TO 20.00 TO 200.00 TO 6000 TO 6000 TO 24935 .00 TO 80.00 TO 20.00 TO 200.00 TO 200.00 TO 6000 TO 24935 .00 TO 80.00 TO 75.00 TO 200.00 TO 200.00 TO 6000 TO 24935 .00 TO 80.00 TO 20.00 TO 200.00 TO 200.00 TO 6000 TO 6000 TO 24935 .00 TO 80.00 TO 20.00 TO 200.00 TO 200.00 TO 6000 TO 6000 TO 24935 .00 TO 80.00 TO 26.00 TO 200.00 TO 200.00 TO 6000 TO 6000 TO 200.00 TO 24935 .00 TO 80.00 TO 80.00 TO 200.00 TO 200.00 TO 6000 TO 6000 TO 200.00 TO 20035 .00 TO 80.00 TO 80.00 TO 800.00 TO 800 TO 8000 TO 800 TO 200.00 TO 200.00 TO 200.00 TO 700	T.G 6.0	0 10.00	15.60	1161	1U	C F	52
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	<pre>.00 17 10.00 27.00 10 25.00 3391 300 10 3300 9842 TO 1981 .00 10 12.00 25.00 TO 30.00 335 3300 10 3600 10827 TO 11811 .00 10 20.00 10 10 50.00 73.00 3563 3500 10827 TO 11811 .00 10 20.00 TO 40.00 TO 56.00 737.00 15748 TO 17717 .00 10 20.00 75.00 TO 107.00 157 .00 TO 30.00 TO 75.00 1057.00 1572 840 17717 TO 19685 .00 TO 40.00 107.00 TO 206.00 17717 TO 19685 .00 TO 40.00 TO 20.00 TO 200.00 127 .00 TO 40.00 TO 200.00 TO 200.00 TO 200.00 TO 2054 .00 TO 7500 TO 200.00 TO 200.00 TO 200.00 TO 7500 .00 TO 7500 TO 750.00 TO 200.00 TO 7500 TO 7500 TO 7500 .00 TO 7500 TO 750.00 TO 200.00 TO 7500 TO 7500 TO 7500 TO 7500 .00 TO 7500 TO 750.00 TO 200.00 TO 7500 TO</pre>	T. R. 0	0 15.00	20.00	778	10	Ë	~~
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	10 10 0	0 20,00	25.00	391	C	<u>1</u> 2	16
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	-00 10 16:00 30.00 T0 40.00 233 363 3500 T0 4200 13740 T0 15748 13 -00 T0 20.00 T0 75.00 T0 75.00 237 4200 15748 T0 1717 T0 19685 -00 T0 30.00 75.00 T0 100.00 17717 T0 19685 77 7 -01 T0 60.00 100.00 T0 100.00 17717 T0 19685 77 7 -01 T0 60.00 100.00 T0 200.00 17717 T0 19685 77 7 -01 T0 60.00 100.00 T0 200.00 127 000 17717 T0 19685 77 7 -01 T0 60.00 100.00 T0 200.00 15748 7500 100 21654 70 24935 77 7 -01 T0 40.00 150.00 T0 200.00 157 00 100 21654 70 24935 77 7 -01 T0 40.00 150.00 T0 200.00 157 000 17717 T0 19685 77 7 -01 T0 40.00 100.00 T0 200.00 157 000 17717 T0 19685 77 7 -01 T0 40.00 100 00 17017 200.25 77 7 -01 T0 40.00 150.00 T0 200.00 157 40 24935 77 7 -01 T0 40.00 150.00 T0 200.00 157 80 00 17717 70 19685 77 7 -01 T0 40.00 150.00 T0 150.00 157 80 00 17717 70 19685 77 7 -01 T0 40.00 150.00 T0 200.00 157 80 00 17717 70 19685 77 7 -01 T0 40.00 150.00 T0 150.00 157 80 00 17717 70 19685 77 7 -01 T0 40.00 150.00 T0 150.00 157 80 00 17717 70 19685 77 7 -01 T0 40.00 150.00 T0 150.00 157 80 00 17717 70 19685 77 7 -01 T0 40.00 150.00 T0 150.00 157 80 00 17717 70 19685 77 77 77 77 77 77 77 77 77 77 77 77 77	0.00 TO 12.0	0 25,00	30°00	335	O E	01	51
-00 TU 20.00 40.00 TU 50.00 7370 TO 15748 13 -00 TU 20.06 50.00 TO 75.00 320 4800 TO 5400 15748 TO 17717 -01 TO 40.00 TO 75.00 TO 152 5400 TO 600 17717 TO 19685 7 -01 TO 60.00 TO 70 TO 150.00 125 6000 TO 7600 21654 TO 24935 -01 TO 80.00 TO 20.00 TO 200.00 TVER 24935 51 TOVER R0.00 TO 150.00 TS 200.00 157 TO 24935 51 TOVER R0.00 TO 150.00 TS 200.00 157 5000 TO 24935 51 TOVER R0.00 TO 150.00 TS 200.00 157 5000 TO 24935 51 TOVER R0.00 TO 150.00 TS 200.00 157 5000 TO 24935 51 TOVER R0.00 TO 150.00 TO 200.00 TO 24935 51 TOTA R0.00 TO 150.00 TS 200.00 157 5000 TO 24935 51 TOTA R0.00 TO 150.00 TO 200.00 TO 24935 51 TOTA R0.00 TO 150.00 TO 24935 51 TOTA R0.00 TO 150.00 TO 200.00 TO 24935 51 TOTA R0.00 TO 150.00 TO 200.00 TO 24935 51 TOTA R0.00 TO 750.00 TO 750.00 TO 700 TO 70	-00 TU 20.00 40.00 TO 50.00 75.00 237.00 TO 50.00 157.00 TO 17717 -00 TD 30.00 75.00 TO 75.00 320 4800 17717 TO 19685 -00 TD 40.00 170 TO 100.00 1717 TO 19685 -00 TD 60.00 100.00 TO 200.00 -00 TD 60.00 TO 200.00 -00 TO 6000 TO 7600 21654 TO 24935 -00 TD 7600 21654 TO 24935 -00 TO 7600 21654 TO 24935 -01 TD 90.00 TO 200.00 -01 TO 700 TO 6000 TO 200.00 -01 TO 7600 TO 7600 21654 TO 24935 -01 TO 7600 TO 7600 21654 TO 24935 -01 TO 7600 TO 7600 TO 7600 TO 2654 TO 2654 -01 TO 7600 TO 7600 TO 7600 TO 2654 TO 2654 -01 TO 7600 TO 7600 TO 7600 TO 2654 TO 2654 TO 2654 -01 TO 7600	2,00 10 16;0	00°02 0	40.90	363	D	Ľ.	18
-00 TO 30.00 50.00 TO 75.00 320 4800 TO 5400 1574A TO 17717 TO 19685 -01 TO 40.00 75.00 TO 100.00 152 5400 TO 6000 17717 TO 19685 -01 TO 60.00 100.00 TO 200.00 125 6000 TO 7600 21654 7 -01 TO 80.00 150.00 TO 200.00 71 6600 TO 7600 21654 7 -01 TO 80.00 150.00 TO 200.00 157 64035 535 73 -01 TO 80.00 150.00 TO 200.00 157 64035 735 73 -01 TO 80.00 150.00 TO 200.00 157 64035 735 73 -01 TO 80.00 150.00 TO 200.00 157 64035 735 73 -01 TO 80.00 TO 70 LOURER = 34605 70 10 10 10 10 10 10 10 10 10 10 10 10 10	 00 TO 30.00 50.00 TO 75.00 320 4800 TO 50.0 15708 TO 1717 TO 1685 00 TO 40.00 75.00 TO 100.00 152 00 TO 40.00 100.00 TO 5667 TO 21654 TO 2455 00 TO 80.00 TO 750.00 125 00 TO 80.00 TO 750.00 127 00 TO 80.00 TO 7600 21654 TO 2455 7 000 TO 7600 21654 7 000 TO 7600 216545 7 000 TO 7600 21654 7 000 TO 7600	.00.10 20.0	10,01	50°00	237	TO 48	010	13
-00 TO 40.00 75.00 TO 100.00 152 5400 TO 6000 17717 TO 19685 77 -01 TO 60.00 TO 701 TO 150.00 125 6000 TO 7600 19685 TO 21654 72 -01 TO 70.00 150.00 TO 200.00 71 6600 TO 7600 21654 17 24935 7 -01 TO 70.00 150.00 TO 200.00 157 650 73 1654 750 -01 TO 760 150.00 TO 24935 73 -01 TO 760 150.00 TO 24935 74 -01 TO 760 150.00 TO 760 150.00 TO 760 160 160 170 160 160 160 170 160 160 160 160 160 160 160 160 160 16	-00 T0 40,00 75.00 T0 100.00 152 5400 T0 600 17717 T0 19685 -01 T0 60.00 100,00 T0 150.00 125 6000 T0 6600 T0 7600 21654 T0 24935 -01 T0 80,00 150.00 T0 200.00 157 600 T0 7600 21654 T0 24935 -01 T0 80,00 150.00 T0 200.00 157 600 T0 7600 21654 T0 24935 -01 T0 80,00 150.00 T0 200.00 157 600 T0 7600 21654 T0 24935 -01 T0 80,00 T0 7600 21654 T0 24935 -01 T0 80,00 100,00 157 600 T0 7600 21654 T0 24935 -01 T0 80,00 100,00 157 600 21654 T0 24935 -01 T0 80,00 10 7600 21654 T0 24935 -01 T0 80,00 10 7600 21654 T0 24935 -01 T0 80,00 10 7600 21654 T0 24935 -01 T1 80,00 10 10 7600 21654 T0 24935 -01 T1 80,00 10 7600 21654 T0 24935 -01 T1 80,00 10 10 7600 21654 T0 24935 -01 T1 80,00 10 10 7600 21654 T0 24935 -01 T1 80,00 10 10 10 10 10 24935 -01 T1 80,00 10 10 10 10 10 24935 -01 T1 80,00 10 10 10 10 10 10 24935 -01 T1 80,00 10 10 10 10 10 24935 -01 T1 80,00 10 10 10 10 10 10 24935 -01 T1 80,00 10 10 10 10 10 24935 -01 T1 80,00 10 10 10 10 10 24935 -01 T1 80,00 10 10 10 10 10 10 24935 -01 T1 80,00 10 10 10 10 10 10 24935 -01 T1 80,00 10 10 10 10 10 10 10 10 10 10 10 10 1	0° 10 10 20°0	c 50°00	ຕ້	320	TN 54	51 6	ç
.09 TD 60.00 109.00 TU 150.00 125 6000 TO 6600 TO 74685 TO 246935 .00 TO 80.00 150.00 TO 200.00 71 6600 TO 7600 21654 TO 24935 7 .00 FR 80.00 OVER 24935 7 TOVER 80.00 OVER 24935 31 TOTAL NUMBER = 34605 CVER 7600 OVER 24935 31	.09 T0 60.00 109.00 T0 150.00 125 6000 T0 6600 19685 T0 21654 79 24935 .09 T0 80.00 150.09 T0 200.00 71 6600 T0 7600 21654 79 24935 .09 T0 80.00 150.09 T0 200.00 157 6600 T0 7600 21654 79 24935 .00 T0 7600 21654 79 24935 73 .00 T0 7600 21654 79 24935 .01 (8474.00 10 20.00 157 157 1560 10 7600 1058 24935 .01 (8474.00 10 100 100 157 1505 .01 (8474.00 10 100 100 157 1550 100 157 1550, 83 50.41. .01 (8444.00 10 100 100 150 100 150 100 100 150 100 10	0 10 40	0 75 00 TO	2	152	0 T() A()	Ë	7
0.00 TO P0.00 150.00 TO 200.00 71 6600 TO 7600 21654 TO 24935 7 OVER R0.00 OVER 200.00 157 CUER 7600 OVER 24935 31 TOTAL NUMBER = 34605	0.00 TO 80.00 150.00 TO 200.00 71 6600 TO 7600 21654 TO 24935 7 OVER 80.00 OVER 200.00 157 CUER 7600 OVER 24935 31 TOTAL (SHMMED) FEATURE AREA PER SCENE = 34605 OTAL (SHMMED) FEATURE AREA PER SCENE = 1364.50 SO. KR. = 526.83 SO. MI.	.09 70 .60.0	0 100 00 IU	° .	125	0 IO 660	12 úl	۲ <u>۶</u>
FR R0.00 NVER 24935 157 EVER 7600 EVER 24935 3 Total Number = 34605	VFR R0.00 NVER 200.00 157 CVER 7600 NVER 24935 3 TOTAL NUMBER = 34605 (SHMMED) FFATURE AREA PER SCENE = 1360.50 SO. KK, = 526.83 SO. MI.	0.09 TO R0.0	0 150,00 TD	0	11	600 T <u>n</u> 760	1654 19 24	99
TOTAL NUMBER = 3460	ТОТАL NUMBER = 34605 (SHM4ED) FEATURE AREA PER SCENT = 1364.50 SD. KK, = 526.83 30.	FR 80.0	0 UVER	0.	157	VER 760	VER 24	311
· ·	(SHMMED) FFATURE APEA PER SCENT = 1364.50 SD. KK. = 526.83 SD. (SHMMED) FFATURE PERVETED (FROOT)		101	ىـ	= 3460			
	(SHMЧED) FEATURE APEA PER SCENT = 1364,50 \$D. KK° = 526.83 30. (SHMYED) FEATURE PERIVETED (FROOT)							
	(SHMЧED) FFATURE APFA PER SCENT = 1364.50 SO. KK. = 526.83 30. (SHMЧED) FFATURE PERIVETED (ГОСС)		л.					
		TOTAL (SUMPED)	FEATURE PED	VETED LTD.		1		

5

*The surveyed area comprised 16,467 km²

ORIGINAL PAGE IS

TABLE 3

SUMMARY OF POND AND LAKE OCCURRENCE AS OBSERVED IN THE COTEAU SUBSTRATUM* DURING JULY 1975.

химику	- FRFOILE	FREGUENCY DISTRIRUTION OF	RECUGNIZED PONDS AND	S AND LAKES		
		RY AREA			BY PERIMETER	
HECTARES	RES	ACRES	FREDUENCY	HETERS	FEET	FREQUENCY
0 0	0,40	0.0 TO 1.00	0	10	0 TD 984	1369
0 40 TU	0.30	01 10	1379	τŋ	Ţ	1040
0.80 TU	1 1,20	00 TO 7	663	600 TO 900	1968 TO 2952	623
1,20 TO	·	T,T	382	10	11	421
1.60 Tf	1 2,00	1 1	261	10	37 TO	215
2,00 TO	<u> </u>	1 U	197	10	Ŀ	165
2,4U TO	m	.00 TD	302	Τŋ	05 TN	30
	4	Ц	160	10	10 J	18
4 0n TO	9	0 10	247	50	10	56
	¢,	00 IQ	165	TQ 300	1 0	52
	G	7.0 T.U	95	TO 330	10 10	47
•	1 12,00	T :	RR	3300 TO 3600	11 01	33
00.5	91	00 10	110	TQ 420	TO 1	61
0	0 N	00 TN	. 66	TO 480	10 1	39
	20	00 10	96	D T	tn 1	39
	07	00 10	71	TO 600	17717 In 19685	2n
00	9	1 E	65	1 0	ۍ ۲	19
60.00 TO	0 U	00 10	35	760	C 2093	18
UVER	0	UVFP 200.00	86	NVER 7600	NVER 24935	. 66
		TOTAL NUMBER	s 4459			
				-		
						•
TOTAL (S	(зиммер) F	FEATURE AREA PER SCENE	= 386, ab	SQ. KM. = 149	149,22 Sn, MI.	
TUTAL (S	(SUNMEN) F	FEATURE PERINFTFR (C I	(COGE) PER SCENF=	503 <i>4</i> °48 KM° ≖	3128.43 MI.	

*The surveyed area comprised $16,531 \ \mathrm{km^2}$.

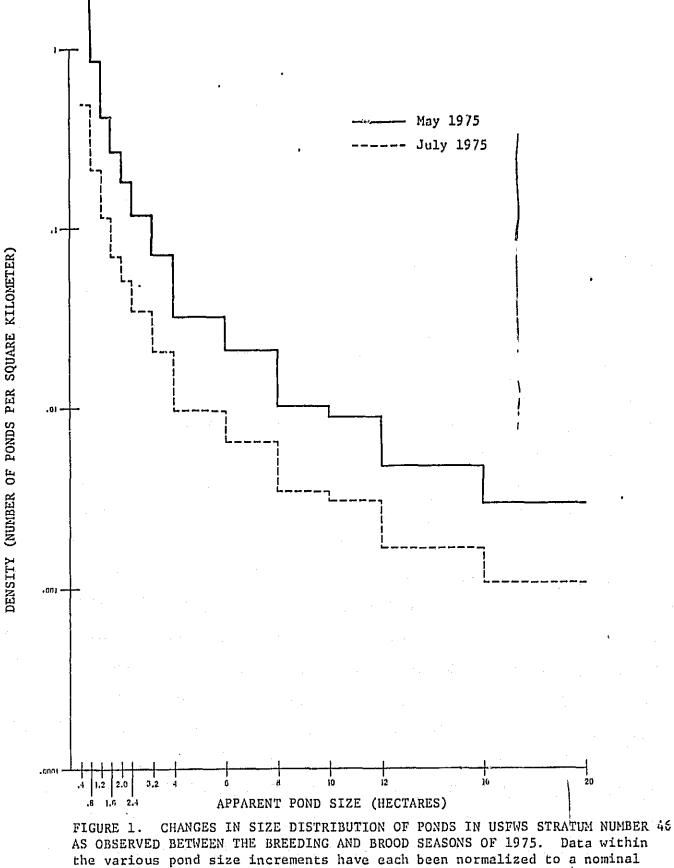
AMARY OF POND AND LAKE OCCURRENCE AS OBSERVED IN THE DRIFT PLAIN SUBSTRATUM* DURING JULY 1975. TABLE 4

		RY AR	Ē			BY PERIMETER	
HECTARE	RES	ACRE	S	FREDUCNCY	METERS	FEET	FREQUENCY
0.0 TU	0,40	0 0 10	1.00	o	TD 30	0 TU 9F	5878
0.40 TO	0,80	.00 T	2,00	5877	TD 60	984 TD 196	3604
, «		00 T	0.0	5769	06 01 0	20C UI 8761	1719
; n				1411			
4 - C				767	11 150	CPC UI 2073	162
2 00 10	2.40	5 00 70	6.00	564	1500 TO 1800	1921 TO 5905	271
		.00 T	8_00	714	0 10 210	5905 TO 689	182
	<u>،</u>	.00 T	-	444	0 10 240	6890 TU 787	143
°,	٩,	.00 T	ហ	466	0 10 270	7874 TU 885	66
	Р, С	5,00 T	ċ	316	0 10 300	8858 TO 984	61
	2	0.00 T	ທ	159	0 TO 330	9842 10 1082	27
	12,00	00 T	30.00	138	0 10 360	10827 TO 1181	C D D
00	ို့စိ	0 00 1	-	137	0 10 420	11811 TO 1378	7.0
S	0	0,00 1	.	26	0 TO 480	13780 TO 1574	7 A 7
,00 T	с,	0,00 1	ທ໌	118	0 TO 540	15748 TO 1771	36
6	0.0	5,00 1	້	53	0 10 600	17717 TO 1968	17
ο	0	00 10	50.	ці Ц	0 TO 66	19685 TO 2165	16
60.00 TO	്	0.00 TN	00	62	0 TN 760	21654 TD 2493	28
DVER	, . .		ð	57	ER 760	QVER 2493	70
		TUT	DTAL NUMBER	= 13754			
	. •						
· .							
TDTAL (S	(SUMMED) F	EATURE AREA	PER SCENE	E = 479.05	SQ. K4. =	184.96 SA. MI.	

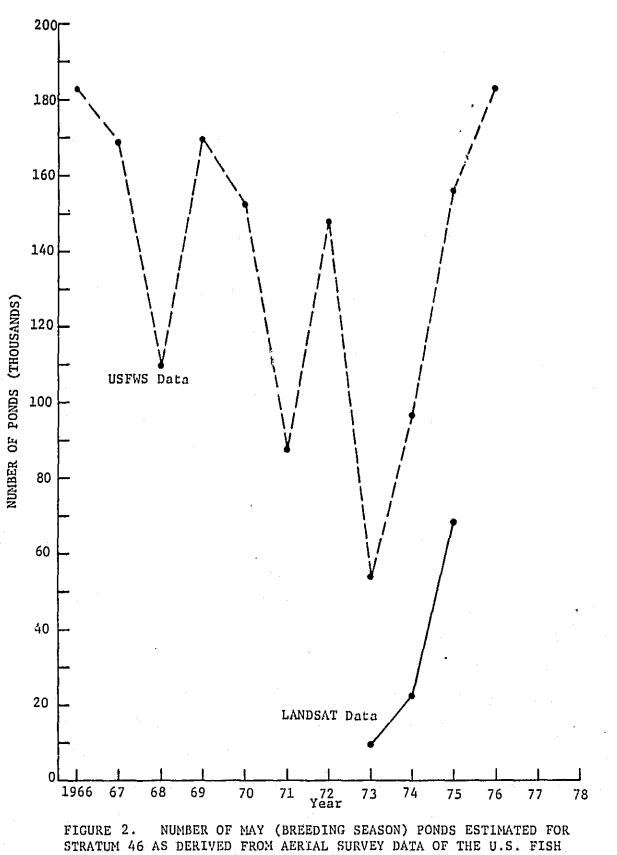
2

*The surveyed area comprised 20,252 km².

ORIGINAL PAGE IS OF POOR QUALITY



one-hectare increment.



AND WILDLIFE SERVICE AND FROM LANDSAT DATA.

