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II

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

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NASA-CR. 149432

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16. Abstract

Processing of LANDSAT MSS data for detection of prairie ponds and lakes was completed during this report period. Data coverage included a 36,876 km^2 area in southeastern North Dakota (FWS Survey Stratum # 46) during May and July periods. Cloud coverage limited the May coverage to 87% of the total area. Data analysis was accomplished using three software programs. Details of these programs are discussed. Wetland identification by LANDSAT MSS sensor are compared to visual counts obtained by observers in low flying aircraft during FWS breeding ground surveys. Pond numbers identified by LANDSAT averaged about 20% of these counted visually in the study area. The discrepancy was attributed to the fact that approximately 75% of the ponds in the glaciated prairie region are less than 0.4 ha in size. It is significant, however, that LANDSAT counts accurately reflect trends. Correction factors could be applied to adjust LANDSAT counts to reflect actual conditions.

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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 km^2 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 km^2) of the stratum. Nearly 100 percent (36783 km^2) 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 data 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

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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 sustained 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 km^2 (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 biologists, 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 due 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

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TABLE 1

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

SUMMARY - FREQUENCY DISTRIBUTION OF RECOGNIZED PONDS AND LAKES

BY AREA				BY PERIMETER			
HECTARES		ACRES	FREQUENCY	METERS		FEET	FREQUENCY
0.0 TO 0.40		0.0 TO 1.00	0	0 TO 300		0 TO 984	9819
0.40 TO 0.80		1.00 TO 2.00	9818	300 TO 600		984 TO 1968	6719
0.80 TO 1.20		2.00 TO 3.00	4573	600 TO 900		1968 TO 2952	3133
1.20 TO 1.60		3.00 TO 4.00	2271	900 TO 1200		2952 TO 3937	1698
1.60 TO 2.00		4.00 TO 5.00	1464	1200 TO 1500		3937 TO 4921	707
2.00 TO 2.40		5.00 TO 6.00	994	1500 TO 1800		4921 TO 5905	562
2.40 TO 3.20		6.00 TO 8.00	1330	1800 TO 2100		5905 TO 6890	321
3.20 TO 4.00		8.00 TO 10.00	755	2100 TO 2400		6890 TO 7874	220
4.00 TO 6.00		10.00 TO 15.00	868	2400 TO 2700		7874 TO 8858	151
6.00 TO 8.00		15.00 TO 20.00	569	2700 TO 3000		8858 TO 9842	120
8.00 TO 10.00		20.00 TO 25.00	260	3000 TO 3300		9842 TO 10827	87
10.00 TO 12.00		25.00 TO 30.00	238	3300 TO 3600		10827 TO 11811	70
12.00 TO 16.00		30.00 TO 40.00	243	3600 TO 4200		11811 TO 13780	110
16.00 TO 20.00		40.00 TO 50.00	142	4200 TO 4800		13780 TO 15748	78
20.00 TO 30.00		50.00 TO 75.00	185	4800 TO 5400		15748 TO 17717	51
30.00 TO 40.00		75.00 TO 100.00	111	5400 TO 6000		17717 TO 19685	37
40.00 TO 60.00		100.00 TO 150.00	93	6000 TO 6600		19685 TO 21654	38
60.00 TO 80.00		150.00 TO 200.00	39	6600 TO 7600		21654 TO 24935	30
OVER 80.00		OVER 200.00	92	OVER 7600		OVER 24935	94

TOTAL NUMBER = 24045

TOTAL (SUMMED) FEATURE AREA PER SCENE = 733.41 SQ. KM. = 283.17 SQ. MI.

TOTAL (SUMMED) FEATURE PERIMETER (EDGE) PER SCENE= 16711.48 KM. = 10384.52 MI.

*The surveyed area comprised 15,554 km^2.

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TABLE 2

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

SUMMARY - FREQUENCY DISTRIBUTION OF RECOGNIZED PONDS AND LAKES

BY AREA			BY PERIMETER		
HECTARES	ACRES	FREQUENCY	METERS	FEET	FREQUENCY
0.0 TO 0.40	0.0 TO 1.00	0	0 TO 300	0 TO 984	14870
0.40 TO 0.80	1.00 TO 2.00	14896	300 TO 600	984 TO 1968	9056
0.80 TO 1.20	2.00 TO 3.00	6338	600 TO 900	1968 TO 2952	4054
1.20 TO 1.60	3.00 TO 4.00	3090	900 TO 1200	2952 TO 3937	2315
1.60 TO 2.00	4.00 TO 5.00	2009	1200 TO 1500	3937 TO 4921	1049
2.00 TO 2.40	5.00 TO 6.00	1353	1500 TO 1800	4921 TO 5905	733
2.40 TO 3.20	6.00 TO 8.00	1726	1800 TO 2100	5905 TO 6890	427
3.20 TO 4.00	8.00 TO 10.00	1083	2100 TO 2400	6890 TO 7874	341
4.00 TO 6.00	10.00 TO 15.00	1181	2400 TO 2700	7874 TO 8858	250
6.00 TO 8.00	15.00 TO 20.00	778	2700 TO 3000	8858 TO 9842	228
8.00 TO 10.00	20.00 TO 25.00	391	3000 TO 3300	9842 TO 10827	167
10.00 TO 12.00	25.00 TO 30.00	335	3300 TO 3600	10827 TO 11811	154
12.00 TO 16.00	30.00 TO 40.00	363	3600 TO 4200	11811 TO 13780	188
16.00 TO 20.00	40.00 TO 50.00	237	4200 TO 4800	13780 TO 15748	135
20.00 TO 30.00	50.00 TO 75.00	320	4800 TO 5400	15748 TO 17717	93
30.00 TO 40.00	75.00 TO 100.00	152	5400 TO 6000	17717 TO 19685	73
40.00 TO 60.00	100.00 TO 150.00	125	6000 TO 6600	19685 TO 21654	82
60.00 TO 80.00	150.00 TO 200.00	71	6600 TO 7600	21654 TO 24935	79
OVER 80.00	OVER 200.00	157	OVER 7600	OVER 24935	311

TOTAL NUMBER = 34605

TOTAL (SUMMED) FEATURE AREA PER SCENE = 1364.50 SQ. KM. = 526.83 SQ. MI.

TOTAL (SUMMED) FEATURE PERIMETER (EDGE) PER SCENE= 31837.28 KM. = 19783.68 MI.

*The surveyed area comprised 16,467 km^2.

TABLE 3

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

SUMMARY - FREQUENCY DISTRIBUTION OF RECOGNIZED PONDS AND LAKES

BY AREA			BY PERIMETER		
HECTARES	ACRES	FREQUENCY	METERS	FEET	FREQUENCY
0.0 TO 0.40	0.0 TO 1.00	0	0 TO 300	0 TO 984	1369
0.40 TO 0.80	1.00 TO 2.00	1370	300 TO 600	984 TO 1968	1040
0.80 TO 1.20	2.00 TO 3.00	663	600 TO 900	1968 TO 2952	623
1.20 TO 1.60	3.00 TO 4.00	382	900 TO 1200	2952 TO 3937	421
1.60 TO 2.00	4.00 TO 5.00	261	1200 TO 1500	3937 TO 4921	215
2.00 TO 2.40	5.00 TO 6.00	197	1500 TO 1800	4921 TO 5905	165
2.40 TO 3.20	6.00 TO 8.00	302	1800 TO 2100	5905 TO 6890	95
3.20 TO 4.00	8.00 TO 10.00	160	2100 TO 2400	6890 TO 7874	81
4.00 TO 6.00	10.00 TO 15.00	247	2400 TO 2700	7874 TO 8858	56
6.00 TO 8.00	15.00 TO 20.00	165	2700 TO 3000	8858 TO 9842	52
8.00 TO 10.00	20.00 TO 25.00	95	3000 TO 3300	9842 TO 10827	47
10.00 TO 12.00	25.00 TO 30.00	88	3300 TO 3600	10827 TO 11811	33
12.00 TO 16.00	30.00 TO 40.00	110	3600 TO 4200	11811 TO 13780	61
16.00 TO 20.00	40.00 TO 50.00	66	4200 TO 4800	13780 TO 15748	39
20.00 TO 30.00	50.00 TO 75.00	96	4800 TO 5400	15748 TO 17717	39
30.00 TO 40.00	75.00 TO 100.00	71	5400 TO 6000	17717 TO 19685	20
40.00 TO 60.00	100.00 TO 150.00	65	6000 TO 6600	19685 TO 21654	19
60.00 TO 80.00	150.00 TO 200.00	35	6600 TO 7600	21654 TO 24935	18
OVER 80.00	OVER 200.00	86	OVER 7600	OVER 24935	66

TOTAL NUMBER = 4459

TOTAL (SUMMED) FEATURE AREA PER SCENE = 386.48 SQ. KM. = 149.22 SQ. MI.

TOTAL (SUMMED) FEATURE PERIMETER (EDGE) PER SCENE= 5034.48 KM. = 3128.43 MI.

*The surveyed area comprised 16,531 km^2.

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TABLE 4

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

SUMMARY - FREQUENCY DISTRIBUTION OF RECOGNIZED PONDS AND LAKES

BY AREA			BY PERIMETER		
HECTARES	ACRES	FREQUENCY	METERS	FEET	FREQUENCY
0.0 TO 0.40	0.0 TO 1.00	0	0 TO 300	0 TO 984	5878
0.40 TO 0.80	1.00 TO 2.00	5877	300 TO 600	984 TO 1968	3604
0.80 TO 1.20	2.00 TO 3.00	2469	600 TO 900	1968 TO 2952	1719
1.20 TO 1.60	3.00 TO 4.00	1301	900 TO 1200	2952 TO 3937	1000
1.60 TO 2.00	4.00 TO 5.00	767	1200 TO 1500	3937 TO 4921	394
2.00 TO 2.40	5.00 TO 6.00	564	1500 TO 1800	4921 TO 5905	271
2.40 TO 3.20	6.00 TO 8.00	714	1800 TO 2100	5905 TO 6890	182
3.20 TO 4.00	8.00 TO 10.00	444	2100 TO 2400	6890 TO 7874	143
4.00 TO 6.00	10.00 TO 15.00	466	2400 TO 2700	7874 TO 8858	99
6.00 TO 8.00	15.00 TO 20.00	316	2700 TO 3000	8858 TO 9842	79
8.00 TO 10.00	20.00 TO 25.00	159	3000 TO 3300	9842 TO 10827	57
10.00 TO 12.00	25.00 TO 30.00	138	3300 TO 3600	10827 TO 11811	40
12.00 TO 16.00	30.00 TO 40.00	137	3600 TO 4200	11811 TO 13780	74
16.00 TO 20.00	40.00 TO 50.00	92	4200 TO 4800	13780 TO 15748	47
20.00 TO 30.00	50.00 TO 75.00	118	4800 TO 5400	15748 TO 17717	36
30.00 TO 40.00	75.00 TO 100.00	53	5400 TO 6000	17717 TO 19685	17
40.00 TO 60.00	100.00 TO 150.00	53	6000 TO 6600	19685 TO 21654	16
60.00 TO 80.00	150.00 TO 200.00	29	6600 TO 7600	21654 TO 24935	28
OVER 80.00	OVER 200.00	57	OVER 7600	OVER 24935	70

TOTAL NUMBER = 13754

TOTAL (SUMMED) FEATURE AREA PER SCENE = 479.05 SQ. KM. = 184.96 SQ. MI.

TOTAL (SUMMED) FEATURE PERIMETER (EDGE) PER SCENE= 10332.62 KM. = 6420.69 MI.

*The surveyed area comprised 20,252 km^2.

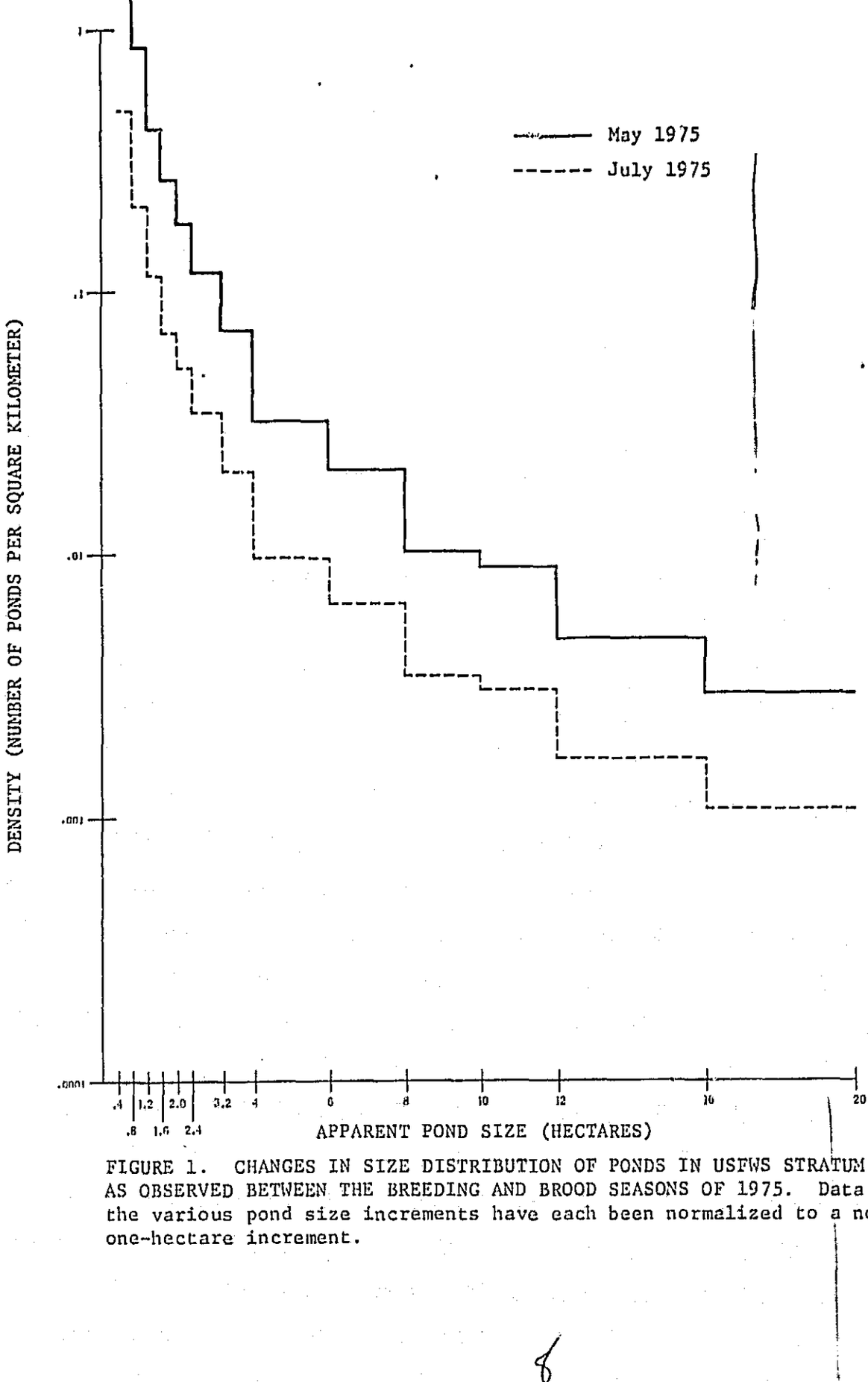

FIGURE 1. CHANGES IN SIZE DISTRIBUTION OF PONDS IN USFWS STRATUM NUMBER 46 AS OBSERVED BETWEEN THE BREEDING AND BROOD SEASONS OF 1975. Data within the various pond size increments have each been normalized to a nominal one-hectare increment.

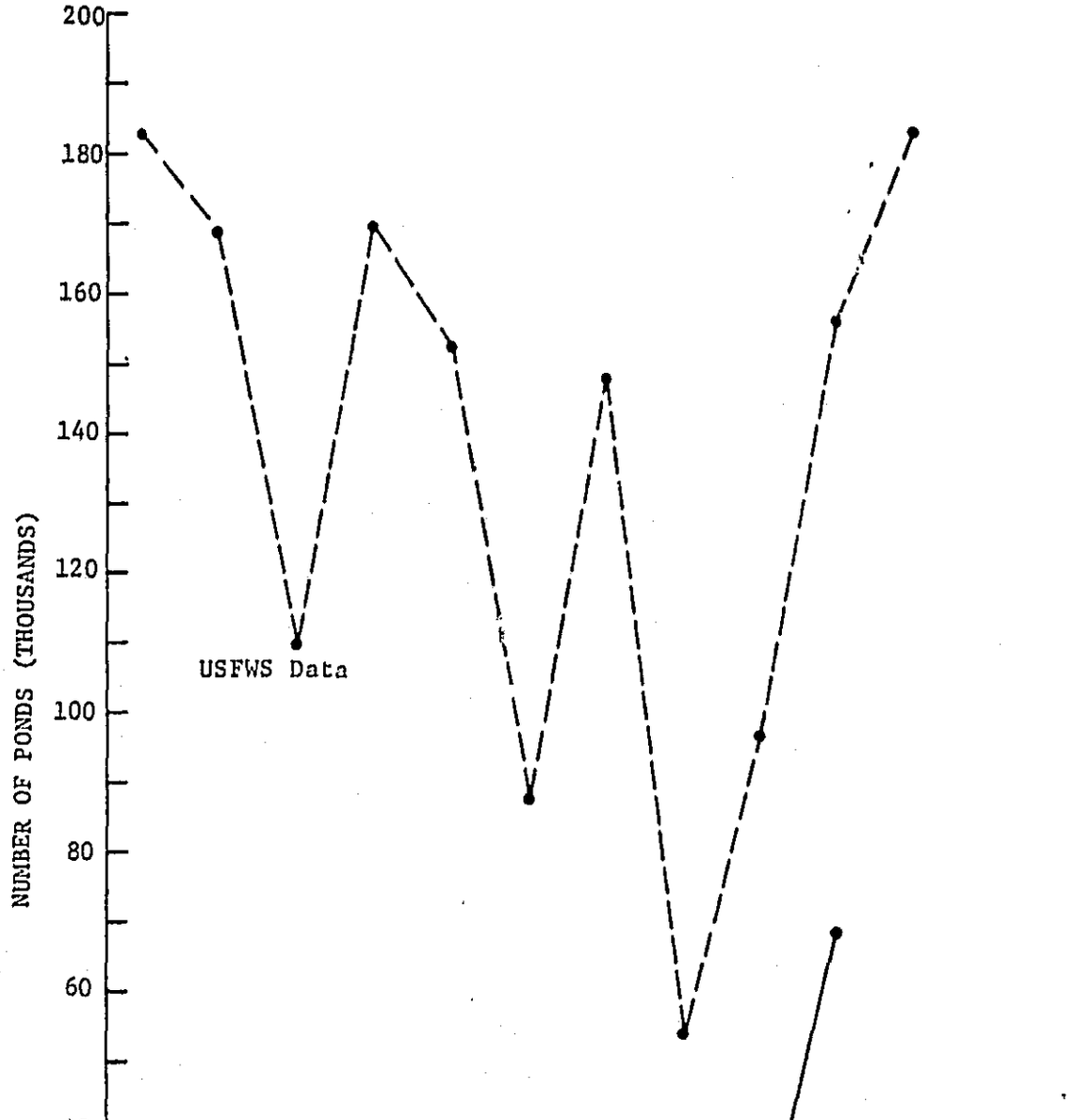

FIGURE 2. NUMBER OF MAY (BREEDING SEASON) PONDS ESTIMATED FOR STRATUM 46 AS DERIVED FROM AERIAL SURVEY DATA OF THE U.S. FISH AND WILDLIFE SERVICE AND FROM LANDSAT DATA.

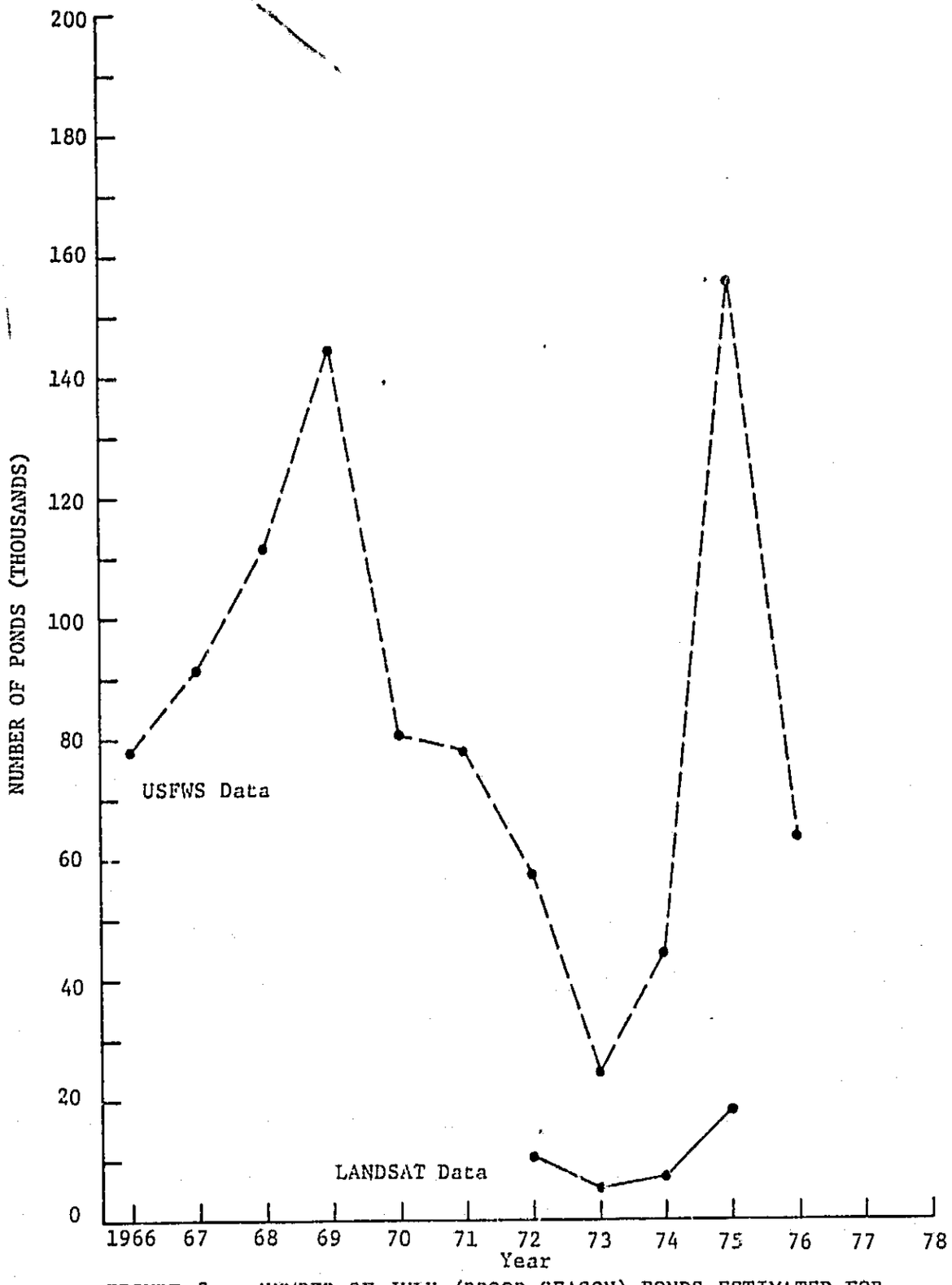

FIGURE 3. NUMBER OF JULY (BROOD SEASON) PONDS ESTIMATED FOR STRATUM 46 AS DERIVED FROM AERIAL SURVEY DATA OF THE U.S. FISH AND WILDLIFE SERVICE AND FROM LANDSAT DATA.