A Report
on the 1976 U.S. Fish and Wildlife Service
35mm Aerial Photography Program
on the Alaskan North Slope

by

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for

Office of Special Studies
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I. INTRODUCTION

Background

As a result of the pending development of oil reserves in Naval Petroleum Reserve #4 (PET 4) on Alaska's Artic North Slope, the Office of Special Studies, U.S. Fish and Wildlife Service (USFWS) - Alaska Area began, in 1976, a multi-year study to determine the effects of PET 4 petroleum development on waterbirds and wetlands.

A five-year study by Bergman et al., 1976, in the adjacent Prudhoe Bay oil field (Point Storkersen) indicated that North Slope wetland regimes characterized by the emergents Arctophila fulva and Carex aquatilis were important to resident (breeding) waterbird populations. It was also reported that oil development altered drainage patterns that resulted in changes in emergent and marginal vegetation (1) (2). However, attempts to document these effects have been mostly ineffective due, in part, to the lack of available equipment and techniques to monitor large areas and identify vegetation changes over time. As a potential solution to this problem for the PET 4 Study, Dr. Milton W. Weller, Head, Department of Entomology, Fisheries and Wildlife at the University of Minnesota and project leader, initiated the purchase of a 35mm aerial photography system patterned after the Montana 35mm Aerial Photography System developed by Meyer, 1973 (3). In addition, a temporary biological technician with extensive experience in remote sensing was employed to develop and operate the program.

35mm Aerial Photography System

The 35mm aerial photography system offers the on-the-ground resource manager a cost effective and practical means of obtaining land and water resource information. Functionally, these systems are geared to reconnaissance, detection and limited mapping operations with the advantages of simplicity of operation, economy, flexibility and a fast turnaround.

The Canon F-1 system (Figure 1), purchased for USFWS includes the following items: Canon F-1 body, motordrive unit, outside battery pack (handle), 28mm (wide angle), 50mm and 135mm (telephoto) lenses, remote shutter release, Luna Pro (Gossen) hand-held light meter, 1A (haze) and Wratten #12 (yellow) filters. A side mount (Figure 2) was constructed by, and purchased from, the University of Minnesota Institute of Agriculture,

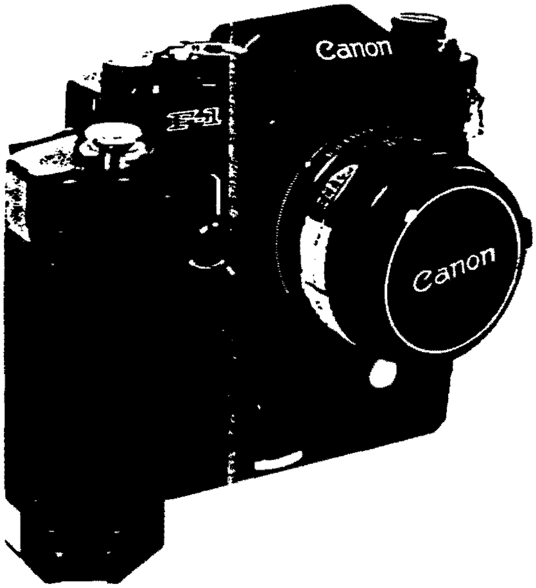

Figure 1. Canon F-1 Camera with motordrive unit, outside battery pack, and 50mm lens taped on infinity (RSL photo).

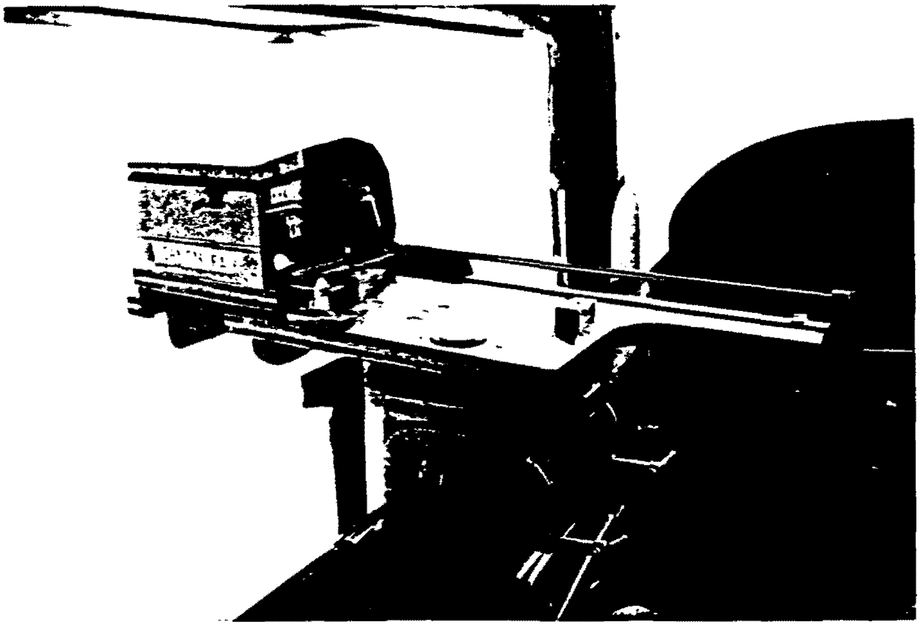

Figure 2 35mm camera side mount used on the North Slope during 1976 (RSL photo).

Forestry and Home Economics Remote Sensing Laboratory (RSL) for obtaining near vertical photography.

Objectives

The objectives for the 1976 aerial photography program include:

1. Carry out overflights to determine the optimum film/filter/scale combination(s) and season for detection and separation of *Arctophila fulva* and *Carex aquatilis* in particular, and other tundra vegetation.
2. Carry out overflights to determine optimum scales for assessment of the effects of oil exploration (rolligon tracks) and development (well sites, etc.).
3. Carry out overflights to obtain complete small scale coverage of Point Storkersen study area for the purpose of constructing a photo mosaic.
4. Carry out overflights of selected key vegetation areas on Point Storkersen for preparation of baseline vegetation maps.
5. As time and funding permit, carry out overflights on the Colville River Delta and Teshekpuk Lake areas for the purpose of establishing baseline vegetation data on these areas.

II. METHODS

Aerial Photography

Overflights of Point Storkersen were conducted primarily of the pond area east of Big Lake and of Phalarope Lake (Figure 3). These areas were selected because of their well developed *Arctophila fulva* and *Carex aquatilis* beds, and therefore, provided excellent sites for both film/filter/scale tests and for 35mm vegetation plot mapping. Both color infrared film and color film were tested at scales of 1:3000, 1:6000, 1:12000 and 1:25000. All of these tests were conducted with a side mount and Cessna 206 contracted from Sea Airmotive at Deadhorse. In addition, the entire Point Storkersen area was photographed with Kodacolor II film at a scale of 1:25000. Photographic operations for this overflight were conducted through the cargo hatch (belly hole) of a Beaver flown by James King, USFWS flyway biologist.

On the Colville River Delta 1:12000 Ektachrome X coverage was obtained of 31, one-half mile square vegetation plots. These plots were

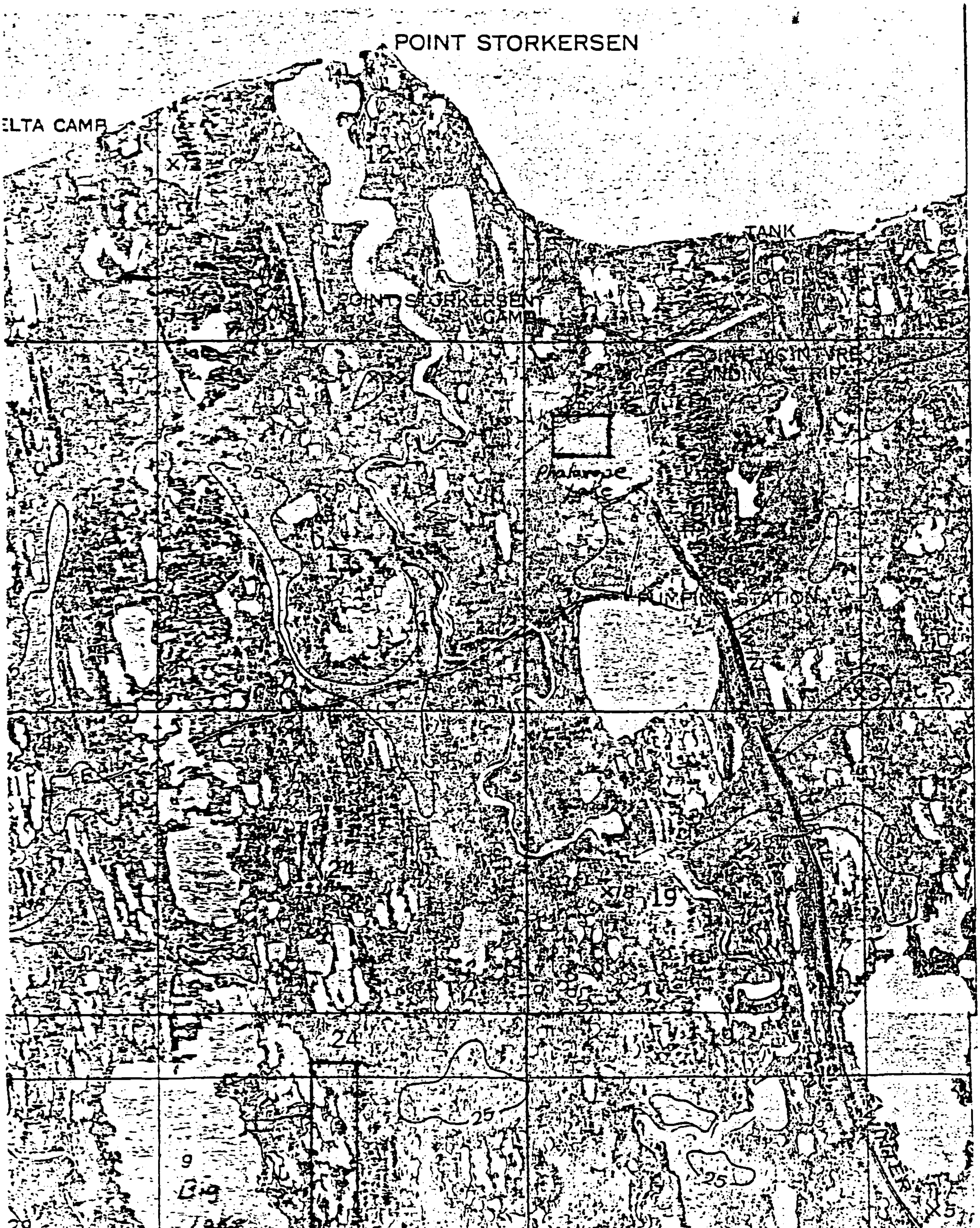

Figure 3. • Xeroxed 1:24000 orthophotomap of the Point Storkersen Study Area showing location of vegetation photo plots at Phalarope Lake and Big Lake.

randomly located within transects previously used for aerial census of large birds. The photo plots were to provide a statistical approach to determining vegetation changes on the delta over time. In addition, 1:12000 Ektachrome X coverage was obtained of Helmericks Island. Extensive ground truth was available for this area and would provide good signature-feature correlation for Colville River vegetation.

A synopsis of the 1976 aerial photography program is presented in Table 1.

Flight Planning

Flight plans were constructed using 35mm coverage and exposure interval tables developed by the University of Minnesota Institute of Agriculture, Forestry and Home Economics Remote Sensing Laboratory (RSL)(Figures 4 and 5). Exposure intervals were selected so as to obtain 60% endlap (40% forward gain) on sequential photographs. Flight lines for Point Storkersen projects were ruled on 1:24000 orthophotomaps and for the Colville River Delta on 1:63360, USGS quadrangles.

Films and Exposures

The four basic Kodak films employed in 1976 overflights were true color films, Ektachrome X and Kodacolor II and color infrared films(CIR), Ektachrome IR-Type 2236 and Aerochrome IR-Type 2443. Kodacolor II is a color negative film for production of prints and the others are color positive (reversal) films for production of slides. Ektachrome X, Kodacolor II, and CIR Type 2236 were purchased over the counter, but the Aerochrome IR-Type 2443 is only available in extremely large quantities (35, 150 foot rolls) and was purchased through the RSL.

Camera exposure settings were determined with a hand-held Luna Pro lightmeter. During side mount operations, readings were taken vertically on the shadow side of the aircraft to avoid fuselage reflection. During overflights with the Beaver, readings were taken through the cargo hatch. Typical exposure settings on the North Slope were f4-f5.6 at 1/500 sec. for CIR film (ASA100) and f2.8-f4 at 1/500 sec. for Ektachrome X (ASA64) and Kodacolor II (ASA80).

Color films were exposed through a 1A haze filter and the CIR films were exposed through a #12 (Wratten equivalent) yellow filter.

Recording

All flight data including date, film, filter, scales, time of photography, location, exposures, weather, and flight problems were recorded on

Table 1. Synopsis of Aerial Photography Overflights for 1976

Date	Location	Mount	Film/Filter	Scale	Roll #	Shutter Speed	Lens (mm)	Purpose
6/26/76	Point Storkersen	Side	Kodacolor II/1A Ektachrome X/1A CIR-Type 2443/12	1:25000 1:6000 1:6000	A B Camera mal-function	1/500 sec	50	Camera Equipment Test
7/28/76	Phalarope Lake Big Lake	Side	Ektachrome X/1A CIR-Type 2236/12 Ektachrome X/1A CIR-Type 2236/12	1:12000 1:12000	1,2	1/500 sec	50	Film/Filter/Scale Test
7/28/76	Phalarope Lake Big Lake	Side	Ektachrome X/1A CIR-Type 2236/12 Ektachrome X/1A CIR-Type 2236/12	1:6000 1:6000	3,4	1/500 sec	50	Film/Filter/Scale Test
7/28/76	Phalarope Lake Big Lake	Side	Ektachrome X/1A CIR-Type 2236/12 Ektachrome X/1A	1:3000 1:3000	5,6 7	1/500 sec	50	Film/Filter/Scale Test
7/30/76	Colville River Delta	Side	Ektachrome X/1A CIR 2443/12	1:12000 1:12000	8 9	1/500 sec	50	Helmericks Island Bird Sanctuary
7/31/76	Phalarope Lake Loon Lake	Bottom (Belly)	Ektachrome X/1A	1:12000	10	1/500 sec	50	Belly mount test
8/1/76	Point Storkersen	Bottom (Belly)	Kodacolor II/1A Ektachrome X/1A	1:25000 1:25000	11,12,13,14 15	1/500 sec	50	Complete photo coverage of Point Storkersen
8/3/76	Point Storkersen	Side	Ektachrome X/1A	1:25000	16	1/500 sec	50	Bridge coverage gaps from previous overflights
8/3/76	Point Storkersen	Side	CIR 2443/12	1:25000	17	1/500 sec	50	Film/Filter Test
8/8/76	Colville River Delta	Side	Ektachrome X/1A	1:12000	18-25	1/500 sec	50	Coverage of 31 Photo Plots

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35mm AERIAL PHOTOGRAPHY COVERAGE TABLES[1]

RF	Scale (ft/in)	Aircraft altitude above ground datum (ft.) — Camera focal length: 28mm	35mm	50mm	55mm	100mm	135mm	Photo Coverage/exposure — Length (ft)	Width (ft)	Gross Area (acres)
1/1,200	100	120	150	220	220	390	530	90	140	0.3
1/2,400	200	230	300	390	430	790	1,060	190	280	1.2
1/3,000	250	280	370	490	540	980	1,330	240	350	1.9
1/3,600	300	330	450	590	650	1,180	1,600	280	420	2.8
1/4,200	350	380	520	690	760	1,310	1,860	330	500	3.8
1/4,800	400	440	590	790	870	1,580	2,130	380	570	4.9
1/5,400	450	500	670	890	980	1,770	2,390	420	640	6.2
1/6,000	500	550	740	980	1,080	1,970	2,660	470	710	7.7
1/7,200	600	660	890	1,180	1,300	2,360	3,190	570	850	11.0
1/9,600	800	880	1,190	1,580	1,740	3,150	4,260	750	1,130	19.6
1/12,000	1,000	1,120	1,480	1,970	2,170	3,940	5,320	940	1,420	31.0
1/15,000	1,250	1,380	1,860	2,460	2,710	4,920	6,620	1,180	1,770	48.0
1/20,000	1,500	1,830	2,480	3,280	3,610	6,570	8,860	1,410	2,120	68.8
1/25,000	2,080	2,290	3,090	4,100	4,510	8,210	11,080	1,960	2,950	133
1/36,000	3,000	3,300	4,460	5,910	6,500	11,820	15,960	2,830	4,250	276
1/48,000	4,000	4,420	5,940	7,880	8,670	15,760	—	3,770	5,670	490
1/50,000	5,000	5,500	7,420	9,850	10,840	—	—	4,710	7,090	767
1/72,000	6,000	6,600	8,910	11,820	13,000	—	—	5,660	8,400	1104
1/90,000	7,500	8,250	11,140	14,800	16,250	—	—	7,070	10,630	1725
1/120,000	10,000	11,000	14,840	—	—	—	—	9,420	14,180	3070
1/144,000	12,000	13,200	—	—	—	—	—	11,320	16,800	4400

1/ for 24x36mm format

Figure 4. 35mm coverage tables (adapted from Jensen and Meyer, 1976).

[illegible] (SECS)

PSR	Ground speed (MPH): 70	80	90	100	110	120	130	140	150
600	.2	.2	.1	.1	.1	.1	10.0	9.2	8.5
720	.2	.2	.2	.2	.1	.1	.1	.1	.1
800	.2	.2	.2	.2	.2	.1	.1	.1	.1
900	.3	.2	.2	.2	.2	.2	.1	.1	.1
960	.3	.3	.2	.2	.2	.2	.2	.1	.1
1000	.3	.3	.2	.2	.2	.2	.2	.2	.1
1200	.4	.3	.3	.3	.2	.2	.2	.2	.2
1500	.5	.4	.4	.3	.3	.3	.2	.2	.2
1584	.5	.4	.4	.3	.3	.3	.3	.2	.2
2000	.6	.5	.5	.4	.4	.4	.3	.3	.3
2400	.7	.6	.6	.5	.5	.4	.4	.4	.3
3000	.9	.8	.7	.6	.6	.5	.5	.5	.4
3168	1.0	.9	.8	.7	.6	.6	.5	.5	.5
4000	1.2	1.1	1.0	[illegible]	.8	.7	.7	.6	.6
4800	1.3	1.3	1.1	1.0	.9	.9	.8	.7	.7
5000	1.5	1.3	1.2	1.1	1.0	.9	.8	.8	.7
6000	1.8	1.6	1.4	1.3	1.2	1.1	1.0	.9	.9
6336	1.9	1.7	1.5	1.4	1.2	1.1	1.0	1.0	.9
7000	2.1	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0
7200	2.2	1.9	1.7	1.5	1.4	1.3	1.2	1.1	1.0
7920	2.4	2.1	1.9	1.7	1.5	1.4	1.3	1.2	1.1
8000	2.5	2.1	1.9	1.7	1.6	1.4	1.3	1.2	1.1
9000	2.8	2.4	2.2	1.9	1.8	1.6	1.5	1.4	1.3
10000	3.1	2.7	2.4	2.1	2.0	1.8	1.7	1.5	1.5
12000	3.7	3.2	2.9	2.6	2.3	2.1	2.0	1.8	1.7
15000	4.6	4.0	3.6	3.2	2.9	2.7	2.5	2.3	2.1
15840	4.9	4.3	3.8	3.4	3.1	2.8	2.6	2.4	2.3
20000	6.2	5.4	4.8	4.3	3.9	3.6	3.3	3.1	2.9
24000	7.4	6.4	5.7	5.2	4.7	4.3	4.0	3.7	3.4
30000	9.2	8.1	7.2	6.4	5.9	5.4	5.0	4.6	4.3
31680	9.7	8.5	7.6	6.8	6.2	5.7	5.3	4.9	4.5
40000	12.3	10.7	9.5	8.6	7.8	7.2	6.6	6.1	5.7
45000	13.8	12.1	10.7	9.7	8.8	8.1	7.6	6.9	6.4
50000	15.3	13.4	11.9	10.7	9.8	8.9	8.3	7.7	7.2
55000	16.9	14.8	13.1	11.8	10.7	9.8	9.1	8.4	7.9
60000	18.4	16.1	14.3	12.9	11.7	10.7	9.9	9.2	8.6
63360	19.4	17.0	15.1	13.6	12.4	11.3	10.5	9.7	9.1
75000	23.0	20.1	17.9	16.1	14.6	13.4	12.4	11.5	10.7
90000	27.6	24.2	21.5	19.3	17.6	16.1	14.9	13.8	12.9
100000	30.7	26.8	23.9	21.5	19.5	17.9	16.5	15.3	14.3
125000	38.3	33.4	29.8	26.8	24.4	22.4	20.6	19.2	17.9
125720	38.9	34.0	30.2	27.2	24.7	22.7	20.9	19.4	18.1
150000	46.0	40.3	35.8	32.2	29.3	26.8	24.8	23.0	21.5
200000	61.4	53.7	47.7	42.9	39.0	35.8	33.0	30.7	28.6
250000	76.7	67.1	59.7	53.7	48.8	44.7	41.3	38.3	35.8
300000	92.0	80.5	71.6	64.4	58.5	53.7	49.6	46.0	42.9
350000	107.4	94.0	83.5	75.2	68.3	62.6	57.8	53.7	50.1
400000	122.7	107.4	95.4	85.9	78.1	71.6	66.1	61.4	57.3
450000	138.0	120.8	107.4	96.6	87.8	80.5	74.3	69.0	64.4
500000	153.4	134.2	119.3	107.4	97.6	89.5	82.6	76.7	71.5
1000000	306.8	268.4	238.6	214.7	195.2	179.0	165.2	153.4	143.2

[illegible]

Figure 5. 35mm coverage and exposure interval table (adapted from Jensen and Meyer, 1976).

a 35mm log card developed at the RSL. Each exposed roll of film was labeled with a number on the cassette canister and recorded on the 35mm flight log.

Film Processing and Cataloguing

All exposed film was taken to Anchorage at the end of the field season for local (E-4) processing, but the Kodacolor film had to be sent to the Kodak Processing Laboratory in California. The reversal film was processed in strip form and stored in transparent sleeves. The 35mm flight logs were then taped onto the sleeves, labeled with the film roll number, and, together with corresponding flight plan map, collected into a three-ring, hard-cover binder. Transparencies selected for mapping were placed in ventilated glass slides and labeled with the date, film, filter, scale, roll number and slide number. Slides were also stored in transparent sleeves and placed in the 3-ring binder.

Mapping and Interpretation

Mapping of the vegetation at Phalarope Lake and the Big Lake Pond Area was accomplished by means of a locally purchased, 14x14-inch easel-type rear projection screen and a 35mm Kodak carousel projector. The system was "plumbed" by adjusting the screen and/or projector until the X and Y directions of a projected grid slide were equal. Sequential 1:3000, CIR and color transparencies were then projected to an approximate scale of 1:300, and detail delineated on acetate (transparent film) overlays attached to the screen. A base map was then drafted from the overlays either by direct transfer of detail, or, in the case of excessive scale variation, by means of the Bureau of Land Management overhead reflecting projector.

The photo mosaic of Point Storkersen was prepared from 1:9000 (approximate) scale Kodacolor print enlargements of the original 1:25000 scale negatives. The 60% overlap on sequential photographs resulted in two complete sets of photographs - one for mosaic construction and one for stereo analysis or field checking. Briefly, the mosaic was constructed by (1) trimming adjacent prints to include an area slightly greater than one half the overlap, (2) registering the detail between adjacent prints, and (3) gluing the prints to a hard surface. Section corners were then annotated on the completed mosaic.

Other specific problems encountered during the 1976 field season included the following: (1) organization and application of the 35mm system, (2) aircraft scheduling, (3) weather conditions, (4) use of camera mounts, (5) turnaround and field checking, and (6) contracting for BLM photography.

Organization and Application of the 35mm Aerial Photography System

The original approach to monitoring vegetation changes on the Colville River Delta was to photograph and map a series of randomly located, 160 acre, vegetation plots. A scale of 1:25000 was originally planned but 1:12000 was ultimately used because of heavy overcast conditions. These plots could be reflown at some future time to assess vegetation changes occurring over the interim between coverages.

After analysis of the Colville River photography, it was decided that this system might not provide enough intensive and/or extensive information on vegetation or other surface features.

An alternative approach that would permit both extensive (broad area) and intensive (local) monitoring of resource features would be a multi-stage remote sensing system. Multi-stage remote sensing implies the use of a variety of sensors, photography, scales, and interpretation techniques, and has been proven to be a logical, efficient, and organized method for the application of 35mm aerial photography to field level resource problems (4) (5)

The basics of a two-stage system were established at Point Storkersen during the 1976 field season and appear to be ideal for monitoring vegetation in PET 4. Briefly, the two-stage system would include: (1) a "high stage" of either small scale (circa 1:25000-1:50000 or smaller) 35mm color photography in mosaic form or conventional, medium scale (1:20000-1:40000) 9x9-inch format aerial photography and (2) a "low stage" (circa 1:3000 to 1:6000) of 35mm photography.

The high stage photography would include complete study area coverage and provide the "big picture" (overview) for assessment of broad vegetation types, drainage patterns, determination of lake size and configuration, and assessment of oil development (e.g., well sites, winter roads). In addition, the high stage photography would be useful for (1) flight planning and flight line layout and (2) exact location of 35mm vegetation photo plots for field checking and possible future reflight. These latter applications are particularly significant in view of the paucity of detailed, up-to-date maps or aerial photography of the North Slope. For example, the 1:63360 (1" = 1 mile) USGS quadrangles of the Colville River Delta simply showed most of the area as either big lakes or marsh, making accurate location of the 1:12000 photography virtually impossible. Moreover, the quadrangles were of 1950 vintage, and since that time, many of the finer identifiable surface features (e.g., ponds, streams, frost polygons) have either disappeared or been altered to the point of being unrecognizable.

The low stage 35mm photography would be applied to intensive monitoring (mapping) of randomly selected vegetation plots and/or key vegetation areas.

Aircraft Scheduling

During the 1976 field season, it became obvious that the existing policy of aircraft procurement for North Slope aerial photography operations - that is, relying solely on one local contractor - needs to be reevaluated. Some of the problems encountered included (1) the questionable ability of some pilots to fly straight flight lines, (2) the uncooperative attitude of certain pilots, (3) the low priority of USFWS projects for aircraft scheduling, (4) atrocious contracting rates (e.g., $262/hour originally for a Cessna 206 - later reduced to $185/hour), and (5) the continual rotating of pilots just when they were beginning to get the "feel" for flying aerial photography. Alternative sources of aircraft for the 1977 field season should be evaluated in light of the type and cost of operations desired (e.g., side mount, floor mount, high stage 35mm versus 9x9-inch coverage), photo experience of pilots, and availability of aircraft during the crucial peak of vegetation development.

Weather

Clouds and ground fog were continual problems on the North Slope and only a few clear days, on the average, may be available each month for aerial photography operations. For example, during the last two weeks of the 1976 field season (near peak of vegetation development), only two half days and one full day of clear weather were available for aerial photography overflights.

Camera Mounts

There was some confusion this past summer over the relative merits of side mount and floor mount operations. The side mount was designed and built by the RSL for use on any unmodified high-wing aircraft provided struts or pontoons do not interfere with the camera field of view. It is ideal for local field situations where aircraft equipped with a camera port (belly hole) or cargo hatch are (usually) not available. Its main disadvantages include (1) lack of correction for crab, (2) inability to use lens with focal lengths shorter than 50mm, (3) inability to fly long or parallel lines of coverage and (4) the need to have one's head and arms out of the aircraft window. This latter feature was particularly important in view of the relatively cold (35-45°) summer time temperatures on the Beaufort Sea Coast. Side mount operations are oriented to coverage of specific objects (e.g., a pond, a vegetation bed), short line coverage (3-4 photos), or small area coverage (usually no more than 5-10 acres for vegetation analysis to the specific level).

The floor (belly) mount has the advantages of (1) ability to fly longer contiguous line coverage, (2) capability for correction of crab, tip, and tilt, (3) comfortable in-plane working conditions, and (4) ability to use wide angle (28mm) lens. However, in contrast to side mount operations, flight line alignment and navigation during floor mount operations is almost solely the responsibility of the pilot - not an easy task considering he already has responsibility for aircraft operation, maintaining proper air speed and proper altitude.

Turnaround and Field Checking

One of the usual advantages of the 35mm system is a fast film turnaround - obtaining processed film 2-3 days after it is taken - for nearly real-time monitoring of resource features. However, on the North Slope, it became apparent that a minimum of 2 weeks would be required to obtain processed transparencies and even longer for obtaining prints. As a result, field checking may require a good deal of documentation (field notes) and sketch mapping at the time of photography to correlate vegetation types with photographic signatures. It may also be a good idea to extend the field season until the processed imagery can be obtained and employed in field checking.

Both slide transparencies and prints can be used for field checking, but print enlargements appear to be more adaptable for field work because detail can be directly annotated on acetate overlays attached to the print (6). The use of slide transparencies requires some type of viewer. Simple ones have been constructed from wood and glass, where detail is documented by means of a special grid slide superimposed on the original transparency (3).

Contracting for BLM Aerial Photography

The pending transfer of management responsibility of PET 4 from the Department of the Navy to the Bureau of Land Management (BLM) has resulted in a significant expansion of the BLM aerial photography program on the North Slope. Consequently, the contracting for BLM aerial photography must be considered a valid alternative high stage system to 35mm photography.

The BLM employs a sophisticated 9x9-inch format, metric mapping camera (RC-8) in aerial photography operations and the precision, quality and larger format of this photography make it a vastly superior product to 35mm photography. Moreover, it appears that the BLM contracting rates can be justified if two or more USFWS departments can contract for the same flight. For example, in 1976, the Office of Special Studies purchased from the BLM 1:40,000 9x9-inch format color photography of a large tract of near-virgin tundra on the West Shore of Teshekpuk Lake. The cost to the Office of Special Studies for one set of prints was only $750 -- the rest of the cost being borne by another USFWS department. Significantly, at original contracting rates, we could not even fly our side mount aircraft from Point Storkersen to Teshekpuk Lake for $750.

Contracting, however, does have some inherent problems, some of which include (1) questionable availability of BLM aircraft for USFWS projects, (2) slow turnaround and high probability of not receiving the photography until after the field season, and (3) high contracting costs per project compared to the cost of 35mm coverage. In addition, contracting for aerial photography requires a written contract to protect the purchaser from receiving poor quality photography (e.g., excessive crab, drift, scale variation) or undesirable products (e.g., laminated or unlaminated color prints). If contracting is deemed feasible, it would be well to consult a good contracting manual such as Contracting For Forest Aerial Photography in the United States by Avery and Meyer (7).

V. RECOMMENDATIONS

A. Two Stage Remote Sensing System

1. Select concrete study areas with defined boundaries (e.g., Point Storkersen) at both Teshekpuk Lake and Colville River Delta. Areas should probably be no larger than 100 square miles.
2. Obtain complete small scale coverage of these areas either with 35mm photography compiled into a mosaic or with conventional

9x9-inch color aerial photography contracted from the Bureau of Land Management. The scale selected will depend on the size of the area selected and the capabilities of the pilot, but scales of 1:25000-1:70000 for 35mm coverage and 1:20000-1:40000 for 9x9-inch coverage should be adequate.

3. Within the study area establish a low stage system of small (5 acre) vegetation plots. These may either be established statistically as a random sample similar to that used on the Colville River Delta or preselected in key vegetation areas. Vegetation plots should be flown with 35mm photography at a scale of 1:6000 or larger.

B. Films/Filters

1. Kodacolor II is designed for inexpensive development of color prints and therefore should be employed for 35mm high stage coverage and the subsequent mosaic construction.
2. Vegetation plots should be flown with color infrared film (either Type 2236 or Type 2443) because of the capability of the CIR to differentiate both *Arctophila fulva* from *Carex aquatilis* and *Arctophila fulva* from open water.
3. The 1A (haze) filter for color photography and the Wratten 12 (yellow) filter for CIR photography should continue to be used. But tests should be run using a Wratten 15 (orange) filter as a substitute for the Wratten 12.

C. Methods

Continue to follow procedures established for flight planning, photography cataloguing and storage, and mapping. Consult the *Montana 35mm Aerial Photography System Operating Manual* by Meyer, 1973, for actual in-flight procedures.

D. Time of Photography

Overflights for mosaic compilation may be conducted throughout the field season, but overflights for vegetation analysis should be conducted during the first two weeks of August.

E. Aircraft Procurement

1. It is recommended that an aircraft be contracted on a priority basis during the first two weeks of August. This will enable personnel to take advantage of every clear day during the peak of vegetation development.

2. Side mount operations employing local aircraft should be adequate for photographing vegetation plots. For example, Helmerick's aircraft could be used on the Colville River Delta.

3. If 35mm contiguous line coverage of study areas is to be undertaken, an experienced photo pilot and aircraft equipped with a camera port should be obtained. As a possible source, the Naval Artic Research Laboratory at Barrow maintains a Cessna 180 equipped with a camera port, a sophisticated vertical camera mount, and experienced photo pilot. The contracting rates are reasonable ($85/hour).

F. Field Checking

Because vegetation plot area flights will necessarily be conducted near the end of the field season, photography will not be available for field checking during most of the field season. It is, therefore, recommended that a good deal of documentation by field notes and sketch mapping be completed in as many of the vegetation plots as is feasible. Once the 35mm photography is taken, processed, and returned, it should be analyzed and compared with field notes. Selected vegetation plots exhibiting confusing color-signature correlations or representative vegetation types should then be field checked using the 35mm photography. It is recommended that (3x5-inch) print enlargements be obtained of each vegetation plot if possible.

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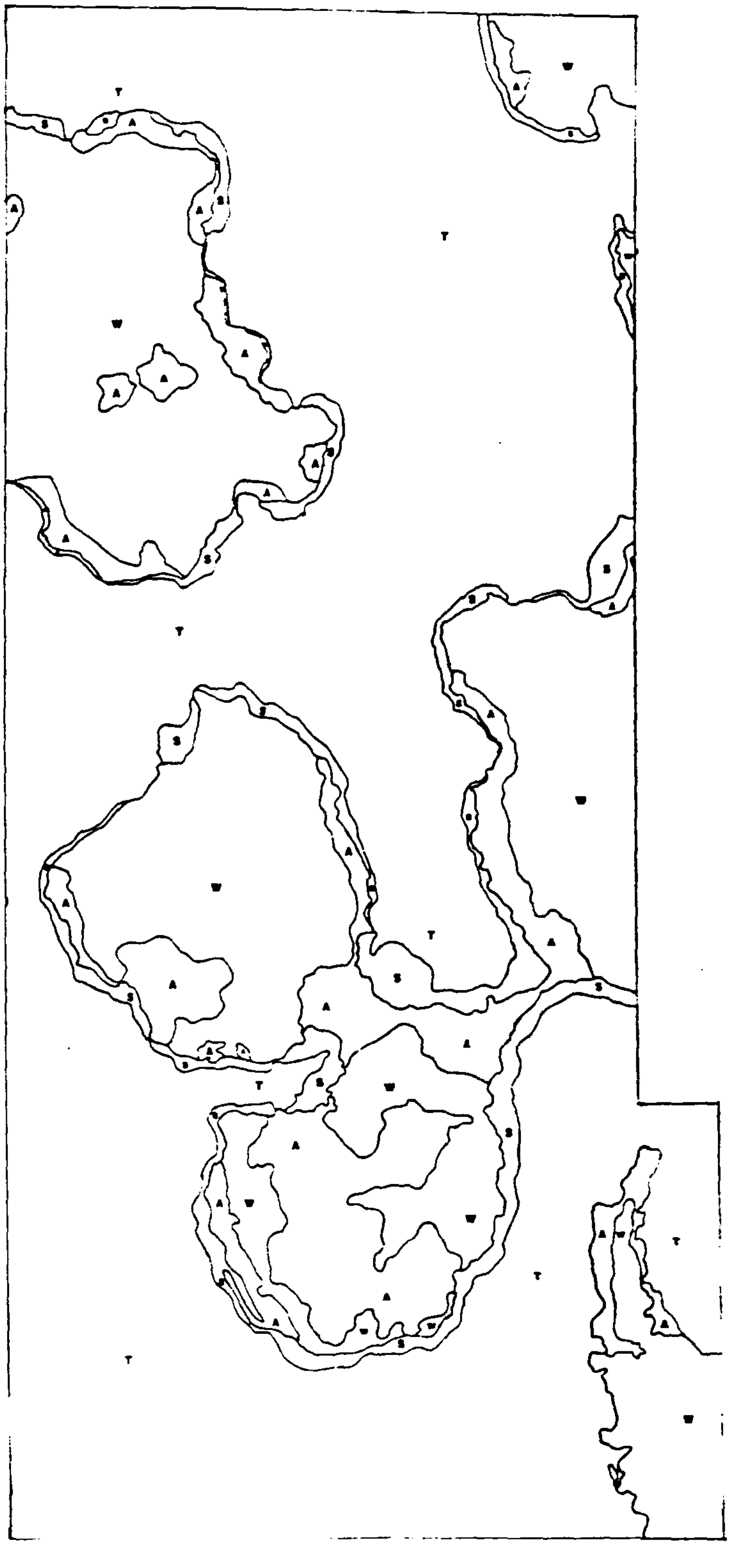
The actual overflight operations were conducted with the assistance of Dr. Dirk V. Derksen, Head, U.S. Fish and Wildlife Service, Alaska Area Office of Special Studies and Project Field Supervisor, Biological Technician (USFWS), Mike Jacobson, and Temporary Biological Technicians, Thomas Rothe and Chris Franson.

Coverage for the photo mosaic of Point Storkersen was almost solely the result of the timely arrival of James King, USFWS Flyway Biologist, with a Beaver equipped with a cargo hatch. He was one of the better photo pilots we had during the 1976 field season and generously remained at Point Storkersen long enough to squeeze in an overflight.

Special thanks go to Doreen M. Gerwing for typing of this report and Robert W. Scheierl, Loyola M. Caron and Phillip D. Grumstrup for proofing.

APPENDIX



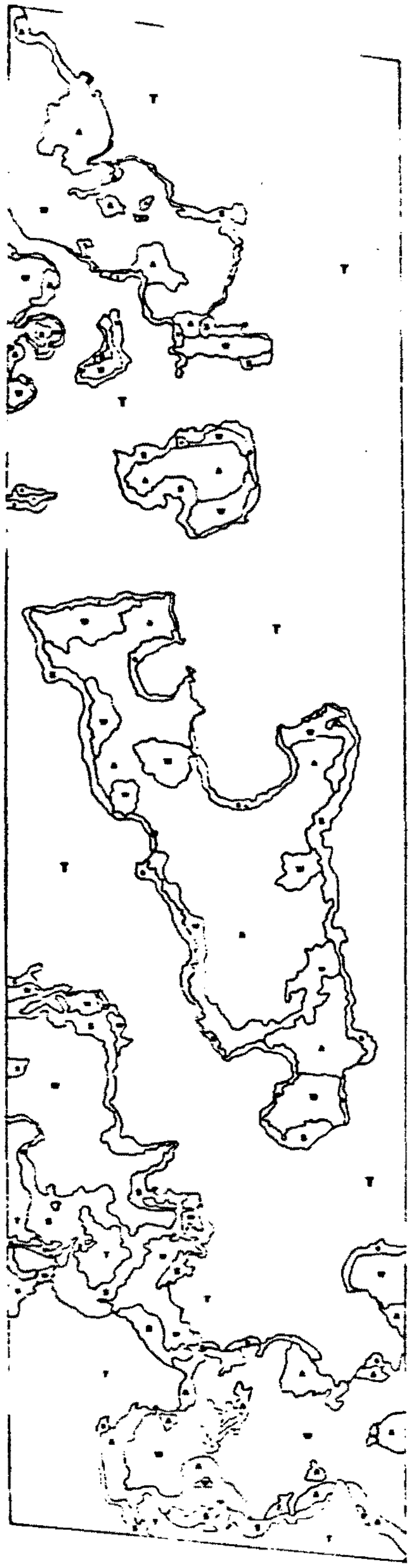
Vegetation Type Map of [illegible] Area
East of Big Lake

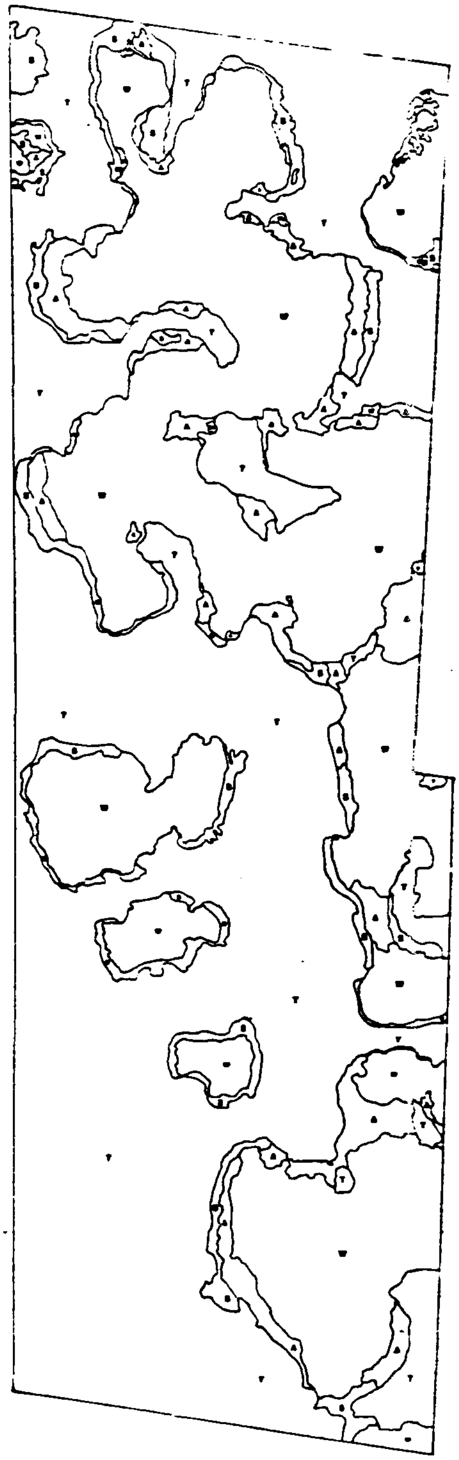
Location: Pt. Storkersen study area - Arctic North Slope

Photo numbers: #6-Roll 6 - #1-Roll 6

Map scale: Approximately 1:[illegible]

Key: A - *Arctophila fulva*
S - *Carex aquatilis*
W - Open water
T - Tundra (wet and dry)





III. RESULTS AND ANALYSIS

Film-Filter/Scale Tests

Films

There appears to be little difference in the capability of CIR and color films to detect and separate *Arctophila fulva* and *Carex aquatilis* at this particular vegetation stage (Figure 7). However, CIR was superior to color film for differentiating *Arctophila fulva* from open water - a particularly significant problem on color film on Phalarope Lake and the Pond Area. CIR film was also superior to color film for differentiating areas of standing water and wet tundra from dry tundra. There was no observed difference between CIR Type 2236 and Type 2443. However, past RSL experience suggests that in many cases, Type 2443 highlights subtle color differences among features more so than Type 2236.

Filters

The use of the 1A (haze) and Wratten 12 (yellow) filters for color and CIR photography, respectively, was adequate for detection of emergents and other vegetation. The CIR photography tended to develop to a uniform bluish cast as a result of the large amount of flooded tundra and the tendency of tundra vegetation to remain in a seemingly perpetual cured state. The use of a Wratten 15 filter (orange) could possibly be used to "warm" the scene - that is to say, increase the red rendition thereby highlighting color differences among resource features.

Scales

The major purpose for the testing of scales was to determine the smallest possible scale (largest area coverage per photograph) that could be used to adequately detect and separate *Arctophila fulva* and *Carex aquatilis* beds. Comparative analysis of the four scales (1:3000, 1:6000, 1:12000, 1:25000) suggests that extensive and homogeneous *Arctophila* and *Carex* beds can be identified on scales as small as 1:25000. However, for accurate detection and delineation of small or marginal emergent beds characteristic of the small pond regime, an original scale of 1:6000 or larger will be required. A comparison of scales is presented in Figure 8.

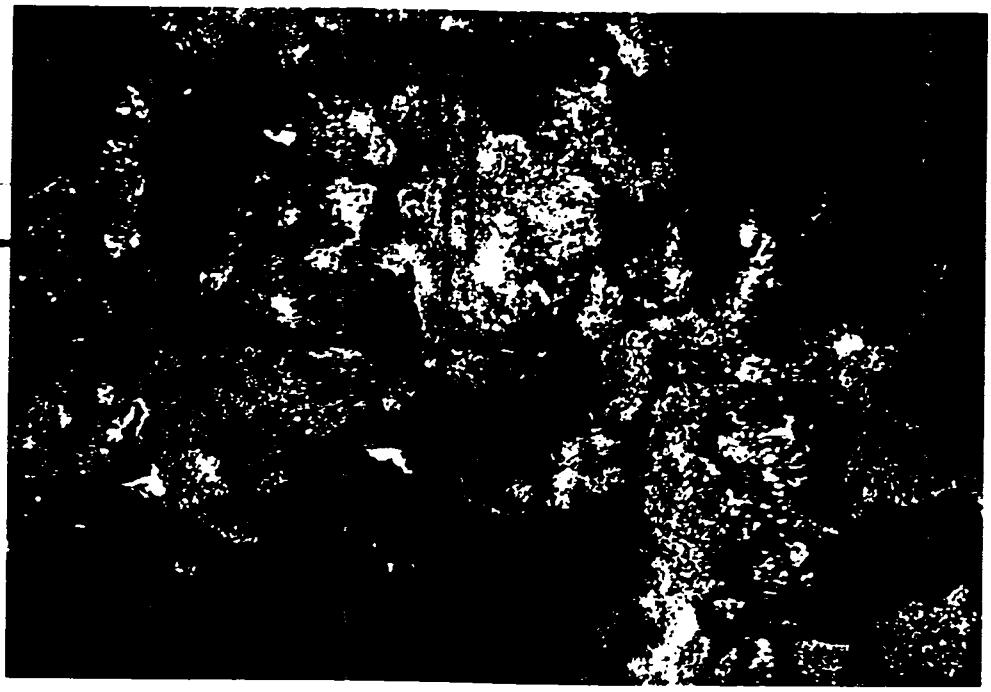


Figure 6. CIR Type 2236 print enlargement of an original 1:3000 transparency of a portion of Phalarope Lake. Carex aquatilis beds appear bluish to light pink and Arctophila fulva beds appear greenish.

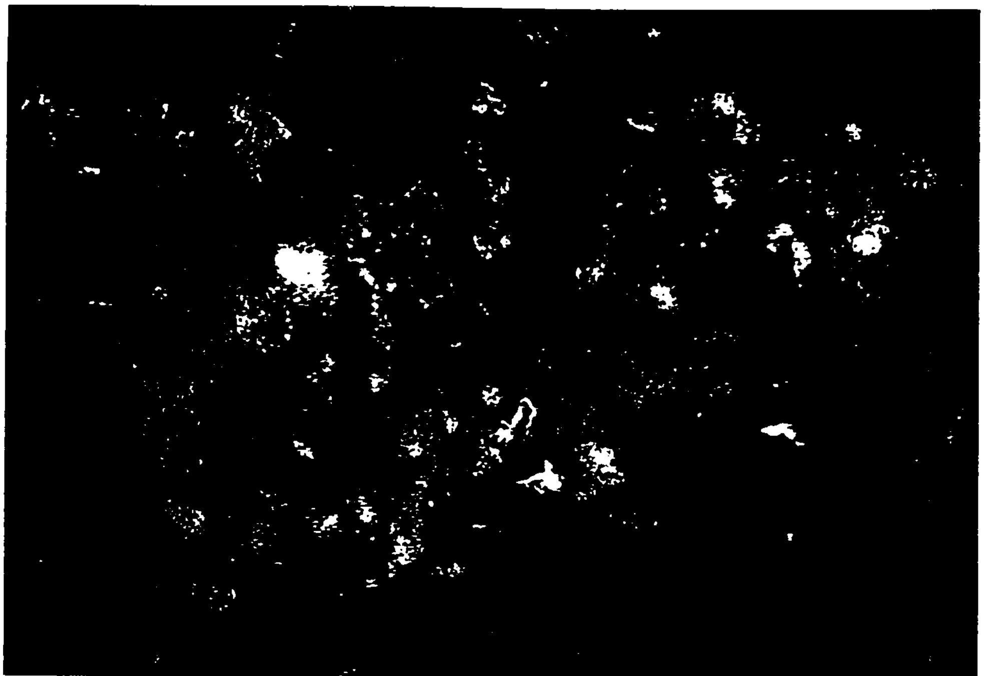


Figure 7. Ektachrome X print enlargement of nearly the same area exhibited in Figure 6. Carex aquatilis appears green and Arctophila fulva appears reddish brown. Original scale: 1:3000.

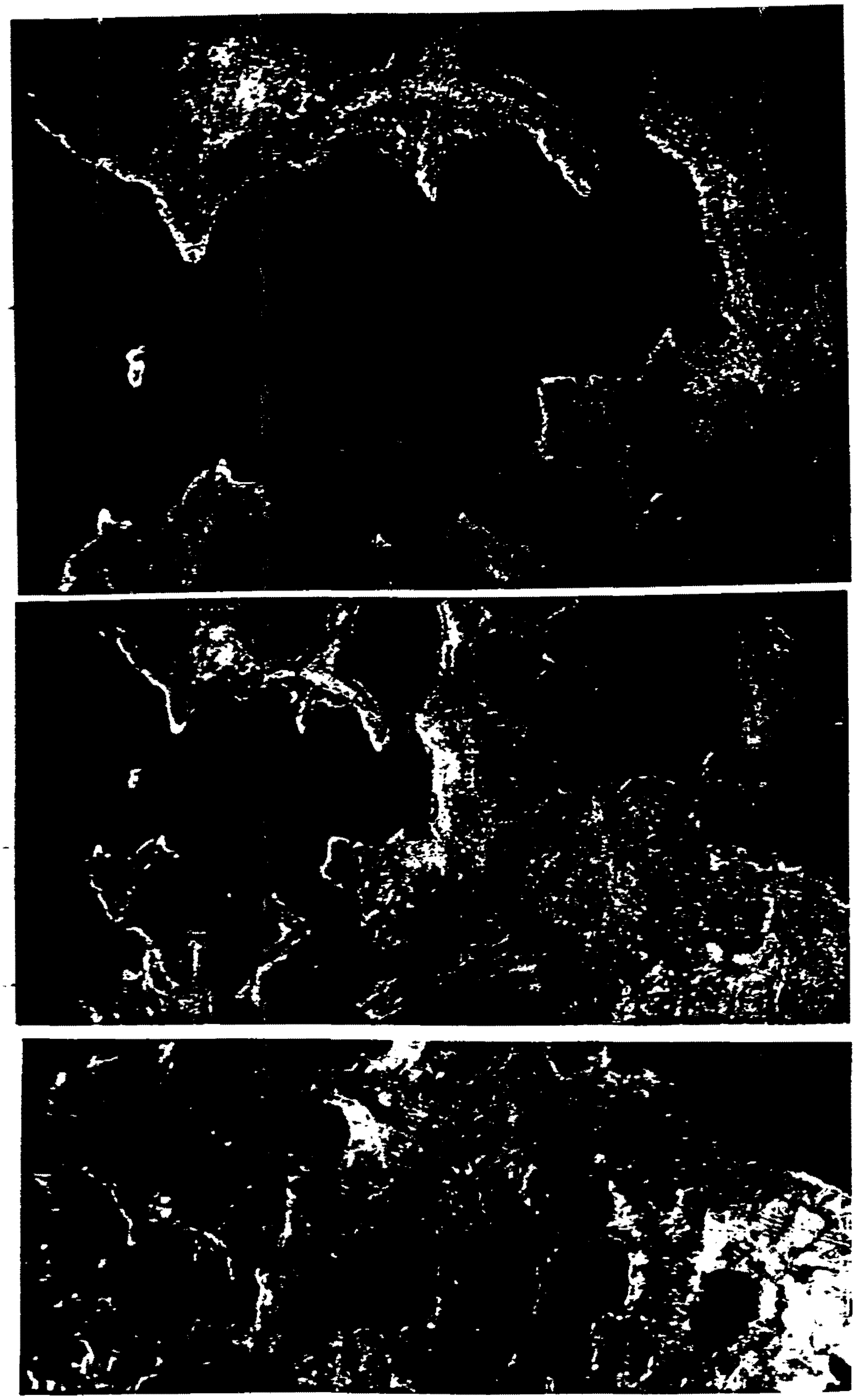


Figure 3. Comparison of scales in the Pond Area east of Big Lake. Original scales from top to bottom: 1:3000, 1:6000 and 1:12000. Notice the rolligon tracks on the 1:12000 photograph.

The effect of oil development (e.g., well sites, winter roads, bulldozer operations) can easily be detected on both CIR and color film at scales as small as 1:25000. However, detection of oil exploration effects (e.g., rolligon tracks) usually requires scales of 1:12000 or larger (Figure 8 and 9).

Season-Signature Effects

The optimum time for detection of Arctophila and Carex on the North Slope appears to be the first or second week of August. At this time, both species are at or near peak of vegetation development with Carex visually appearing as a bright green and Arctophila as a reddish-green. Analysis of the early August photographs suggest that the Arctophila was just beginning to tassel, thereby highlighting differences between the Arctophila and Carex. Should the field season be extended to the middle of August to take advantage of this phenological difference, better discrimination of emergents at smaller scales may be possible.

Mosaic Analysis

The photo mosaic of Point Storkersen (Figure 10) provided a pictorial overview of the area's land and water resources that was previously unavailable. Specifically, the mosaic was useful for (1) assessing the general drainage patterns (e.g., Fawn Creek), (2) assessing tundra damage and oil development (e.g., Big Pingo caterpillar scars, Storkersen well pond, winter road), (3) determining lake size and configuration, and (4) general location of vegetation beds. A particularly interesting feature evident on the mosaic was the apparent color dichotomy of ponds. That is, a few ponds appeared dark brown to black in contrast to the majority of which photographed light brown to orange. Investigation revealed that the darker ponds contained a much higher concentration of Arctophila and greater water depth. This color difference may be a useful technique for broad "first level" pond analysis over large areas.

The mosaic was also useful in establishing the exact location of the larger scale 35mm vegetation photo plots - an important procedure if these plots are to be reflown at some future time.

Mapping

Point Storkersen

Large scale (1:300) vegetation maps were prepared of the Big Lake

Figure 9. Illustration of rolligon tracks near Big Lake.
Photograph: Ektachrome X at original scale of 1:3000.

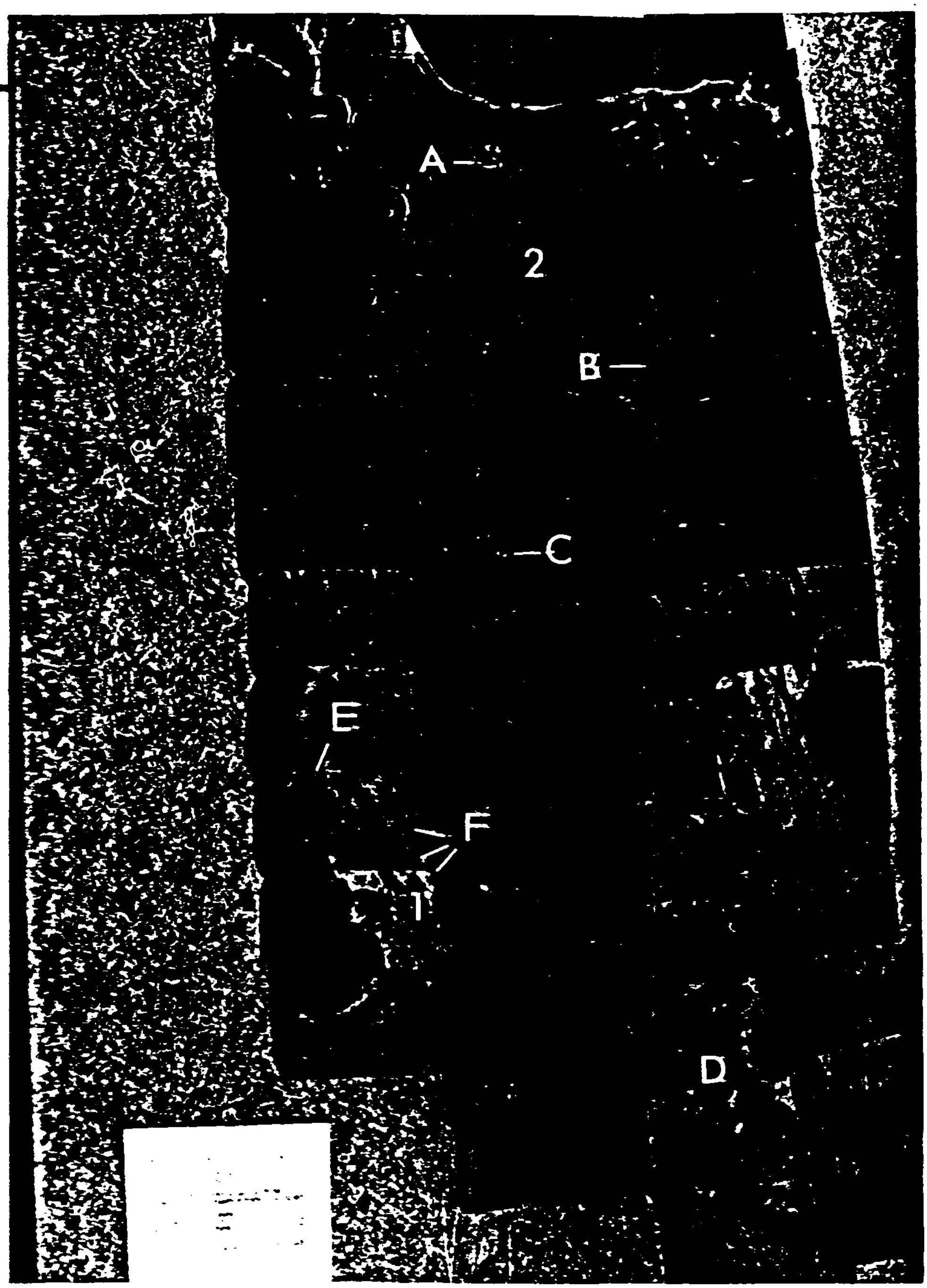


Figure 10. Photo mosaic of Point Storkersen study area. The mosaic was constructed from print enlargements of 1:25000 Kodacolor II photography. Illustrated A - Storkersen well, B - winter road, C - Big Pingo Caterpillar scars, D - lake basin wetlands complex, E - large, homogeneous Arctophila fulva bed, F - color dichotomy of small ponds and location of Pond Area (1) and Pharlarope Lake (2) vegetation plots.

Pond Area and a portion of Phalarope Lake. The classification scheme basically included Arctophila fulva, Carex aquatilis, open water and tundra. Adequate ground truth was not available (or desired at this time) to break down the tundra vegetation into finer classes. The type map of Phalarope Lake is presented in Figure 11 and maps of the Pond Area are presented in the Appendix. Although the maps were compiled from 1:3000 (original scale) transparencies enlarged to 1:300, it is apparent that original scales of 1:6000 should be adequate for vegetation mapping.

Colville River Delta

No mapping was attempted on the Colville River Delta because (1) the 1:12000 scale was too small to adequately detect emergent vegetation, (2) there were no detailed maps or aerial photography for exact location of the 35mm photography and (3) there was little available ground truth for the area.

IV. DISCUSSION

General

The original objectives of the 1976 35mm photography project were to establish baseline emergent vegetation data on two selected (virgin) PET 4 wetlands areas - the Colville River Delta and in the big lake wetlands regime in proximity to Teshekpuk Lake. The vegetation data would be used to document vegetation changes resulting from the (pending) construction of oil facilities. However, equipment malfunction (motordrive), inaccessibility of aircraft, bad weather, short field season, cost of flight operations and lack of a specific 35mm applications program combined to limit 1976 overflight operations primarily to the Point Storkersen study area established by Bergman, et al., 1976. As it turned out, this was fortunate. Administrative delays and logistical problems limited 1976 PET 4 field operations to general reconnaissance activities. Consequently, adequate ground truth for correlation with overflights was not available. In addition, the effective implementation of a 35mm aerial photography system in a new area (ecosystem) requires a certain amount of preliminary organization, equipment tests, and film/filter/scale tests for resource feature detection - all of which requires a fair amount of time. The 1976 aerial photography objectives were, therefore, primarily directed toward organization and testing.

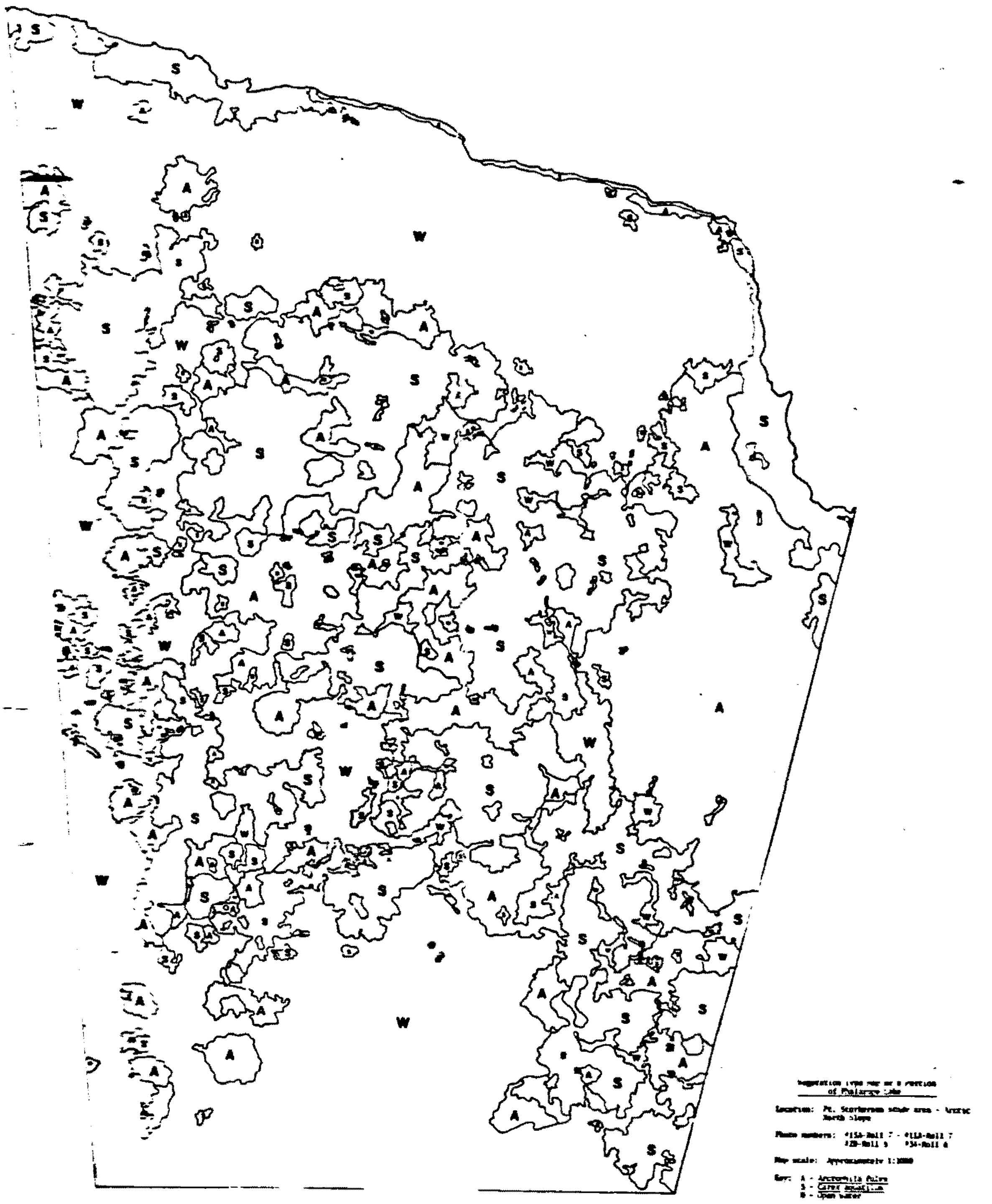


Figure 11. Emergent vegetation type map of a portion of Phalarope Lake. The classification scheme includes Arctophila fulva (A), Carex aquatilis (S) and open water (W). Unlettered types refer to areas appearing white on both color and CIR photographs and that were unidentifiable.