BIRD USE OF ABANDONED GRAVEL PADS IN ARCTIC ALASKA

1990 FINAL REPORT

BY

LGL ALASKA RESEARCH ASSOCIATES, INC.
4175 TUDOR CENTRE DR. SUITE 101
ANCHORAGE, ALASKA 99508

FOR

BP EXPLORATION (ALASKA) INC.
900 E. BENSON BLVD.
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Executive Summary

In 1989, BP Exploration (Alaska) Inc. and LGL Alaska Research Associates, Inc., initiated a series of studies of wildlife use of disturbed habitats in Arctic Alaska. A major goal of these studies was to assess the impacts of gravel fill on the wildlife community in and around the Prudhoe Bay oil field and to collect information useful for rehabilitating habitats affected by gravel fill. The findings of the 1989 work (Pollard et al. 1990) indicated that abandoned gravel pads were used by wildlife to a surprising extent. Levels and types of uses varied by species and habitat type, but gravel pads almost always attracted more individuals per time period than did undisturbed tundra plots.

Findings of the 1989 research, and agency interest in the research results, suggested that the use by birds of gravel fill sites warranted more detailed analysis. Studies were modified in 1990 to this end. One experiment (the "nesting study") was designed to explore the effects of abandoned gravel pads on the nesting density, success, and diversity of tundra-nesting bird species. Another experiment (the "post-breeding observational study") was designed to compare several different microhabitat types present on and adjacent to abandoned gravel pads in terms of their post-breeding use by bird species.

For the nesting study, thirteen study sites were used for most comparisons; at each site a biologist laid out a 10-hectare plot surrounding an abandoned gravel pad and another one on adjacent undisturbed tundra. On average, gravel covered approximately 25 percent of the area of the disturbed plots. Data on bird nesting densities, nesting success, and species diversity within plots were collected, and comparisons were made between disturbed and undisturbed plots. Results of the nesting study indicated that:

- Overall, more nests were initiated on undisturbed plots (153) than on disturbed plots (128), but the difference between the two in mean nest densities was not statistically significant.

- Most of the undisturbed plots had more nests than did corresponding disturbed plots, although at four sites the disturbed plots had more nests.

- There were 105 successful nests in the disturbed plots and 111 in the undisturbed plots. Thus, overall nest success was higher in disturbed plots (82 percent) than in undisturbed plots (73 percent), but this difference was not statistically significant.

- More species nested in the disturbed plots (16) than in the undisturbed plots (13). There was no significant difference between disturbed and undisturbed plots in a commonly-used index of diversity (Shannon) that incorporated both numbers and relative abundances of species.

- More nests of moderately abundant species were found in undisturbed plots, but more nests of uncommon species (species with fewer than 3 nests total) were found in disturbed plots.

- The density of nests (all species and plots combined) on the undisturbed portions of disturbed plots was about the same as nest density on the undisturbed plots. This suggests that, at least during a year with relatively high nest densities such as 1990, the value of tundra near abandoned gravel pads as nesting habitat is not diminished by the presence of those pads.

For the post-breeding observational study, elevated blinds were installed at four gravel pad sites for approximately a one-month period following nesting. At each site, bird use was observed on study plots established on various kinds of disturbed microhabitats and on undisturbed tundra. Systematic observations of bird use were made during 2.5-hour sessions in the mornings and afternoons. Data collected included numbers of each species observed, their behavior, and the microhabitat used.

Results of the observational study indicated that:

- Levels of bird use (observations per time period) were usually, but not always, higher on gravel plots than on natural tundra. The most common species using gravel plots was Lapland Longspur.

- The levels of bird use on gravel plots appeared to be related to presence or absence of vegetation and to vegetation type. Levels of use (all species combined) were higher on plots with natural plant colonization than on plots with seeded cultivars. Gravel plots with no vegetation attracted few birds.

- Low levels of use on tundra plots may have been related to the geobotanical type of the particular tundra patch. One tundra plot, composed primarily of high-centered polygons, may have more closely represented optimal longspur habitat than did other tundra

plots, and it had a level of use equal to that of the adjacent gravel plots. Other tundra plots were composed of strangmoor and non-patterned ground.

- Aquatic plots (i.e., reserve pits, an impoundment, and a pond) generally had relatively high levels of use and high species diversity compared with gravel and tundra plots. Species diversity (but not level of use) was always lower on plots without water.

- The most commonly observed behavior on most gravel plots was feeding. Bird behavior was difficult to observe on tundra plots because of concealing vegetation, but it is probable that feeding was the most common behavior on tundra plots also.

- On gravel plots, it appeared that birds were feeding primarily on seeds of forb species which had colonized those sites.

In summary, findings of the 1990 studies are encouraging. During the nesting season, there were no statistically significant differences in nest density, nest success, or species diversity of nesting birds between disturbed plots that contained abandoned gravel pads and undisturbed plots that did not, even though few birds nested on gravel. The association of some nests with natural vegetation and thermokarst on abandoned gravel fill suggests that habitat manipulation may improve the value of abandoned sites as nesting habitat for some birds. During the post-breeding season, Lapland Longspurs were observed more often on abandoned gravel fill, where their most commonly observed behavior was feeding, than on tundra. Levels and types of post-breeding uses of abandoned pads depended on the character of the microhabitats available on the pads, especially the vegetational characteristics and water regime.

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Acknowledgments

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Introduction

In Arctic Alaska, activities related to petroleum development can potentially result in disturbances to wildlife habitats. One of the principal kinds of disturbance is the placement of gravel fill (Walker et al. 1986; 1987a,b,c). Gravel fill is used to support facilities and transportation associated with the production phase of development, and is required to prevent thawing of the underlying permafrost. In past years, gravel fill was also used in the construction of exploratory well pads which since have been abandoned. This practice was discontinued in 1986 when technological advances led to the use of temporary ice pads for exploratory drilling in winter.

The oil industry and regulatory agencies are interested in learning how the placement of gravel fill affects wildlife habitat and wildlife populations. Information concerning impacts of gravel fill upon wildlife will be useful in establishing guidelines for the eventual rehabilitation of abandoned gravel pads and in minimizing potential future impacts should additional petroleum development occur in the Arctic.

Several studies have been conducted to gain insight into the effects of various aspects of oil-related development on wildlife and habitats in the Prudhoe Bay oil field. Troy and Burgess (1983), Troy et al. (1983), Meehan (1986), and Troy (1986, 1988, 1990) have investigated the effects of roads, road dust, habitat fragmentation, and abandoned peat roads on bird nest densities and bird use of tundra habitats. Troy and Carpenter (1990) studied bird displacement before and after construction of oil field facilities. Jorgenson (1988, 1989) and Jorgenson et al. (1990) studied revegetation of disturbed sites.

In 1989, BP Exploration (Alaska) Inc. (BPX) and LGL Alaska Research Associates, Inc., initiated a pilot study (Pollard et al. 1990) to investigate further the effects of development-related habitat disturbance on wildlife. During this pilot study, observations were made of wildlife uses of disturbed habitats (e.g., abandoned gravel pads and impoundments) and of "natural" habitats that resembled disturbed habitats (e.g., flood-plain alluvium and ponds). These observations set the stage for developing firm hypotheses about the relationship between disturbed habitats and wildlife populations which could be more rigorously tested in future years.

The results of the 1989 studies showed that both birds and mammals used disturbed habitats and that the extent of use differed among different groups of

animals. During these studies, observations of nesting birds in the vicinities of abandoned gravel pads suggested that the pads may not have had an adverse effect on birds nesting on nearby tundra. Other observations indicated that certain microhabitat features on and near pads may have attracted some nesting birds. Observations of birds feeding and resting on these pads suggested that specific microhabitat features may have attracted birds. The studies in 1990 focused on abandoned gravel pad sites and were designed to examine these ideas further.

This report describes and discusses the 1990 studies and is organized in two parts. Part One addresses the first of our 1990 studies: Bird Nesting and Abandoned Gravel Pads (the "nesting study"). Part Two addresses the second of our studies: Post-breeding Use of Abandoned Gravel Pads (the "observational study").

Study Area

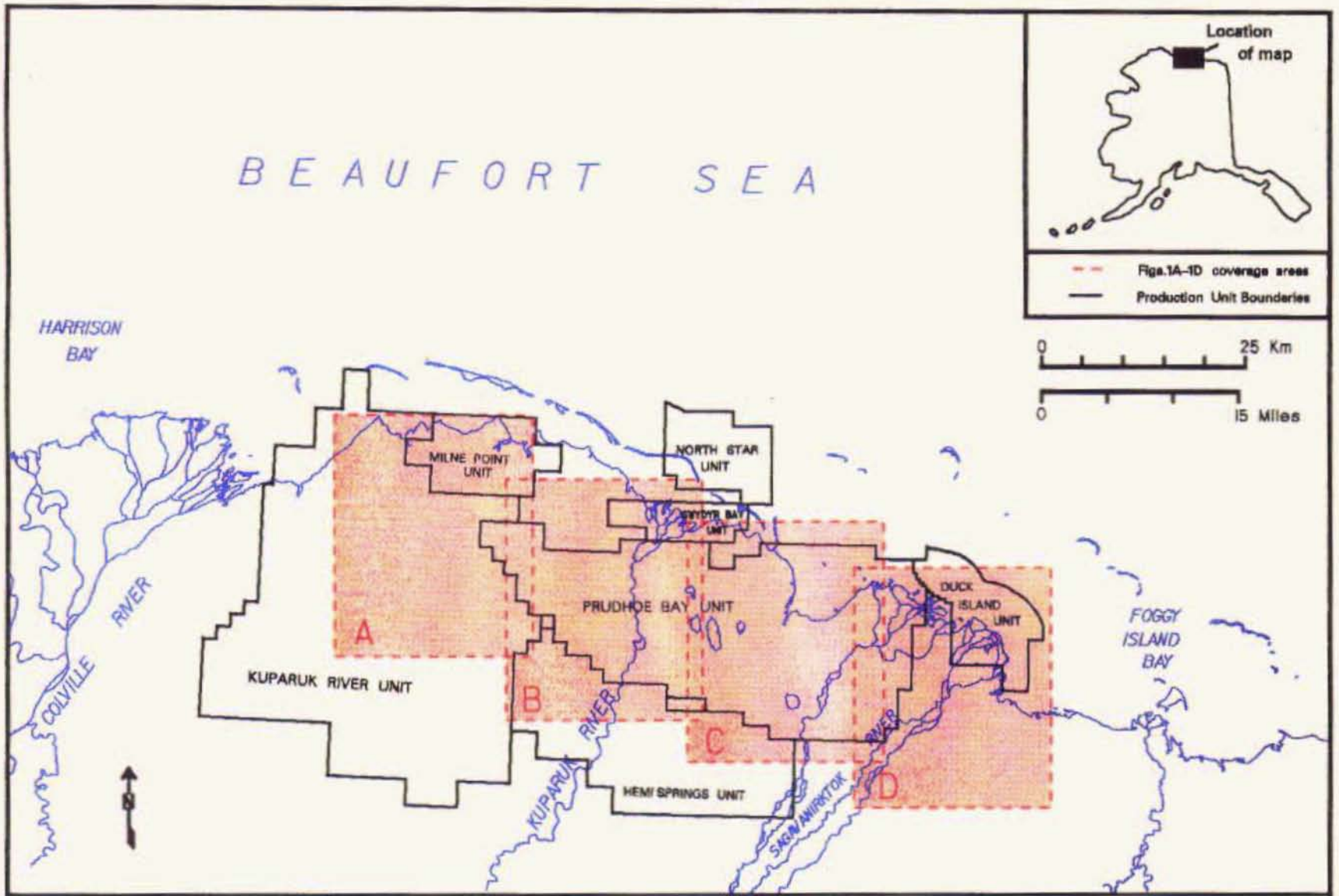
Study sites (Table 1) were located on the Arctic Coastal Plain of Alaska in or near the Kuparuk and Prudhoe Bay oil fields (Fig. 1 and 1A-D). Physiography of the landscape in the region is typical of that of the coastal plain in general. Soils are moist to wet and the vegetation is dominated by graminoids. The topography is generally flat but has a high degree of microrelief caused primarily by the formation of frost polygons, by the formation and drainage of thaw lakes, and by thermokarst. Many lakes and ponds of various sizes and depths are present. Two major river drainages, the Kuparuk and the Sagavanirktok, pass through the study area.

Part One: Bird Nesting and Abandoned Gravel Pads

Objective

The 1990 nesting study had one major objective:

- To test the null hypotheses that there is no difference in bird nest density, nest success, or species composition of nesting birds between plots containing abandoned gravel pads and undisturbed plots



DATUM: NAD27
PROJECTION: UTM ZONE 6
SPHEROID: CLARKE 1866

Figure 1

General location of study area in relation to oil production units on the Arctic Coastal Plain, Alaska. Figures 1A–1D depict specific locations of all study sites. Names and descriptions of all study sites can be found in Appendices (A and B).

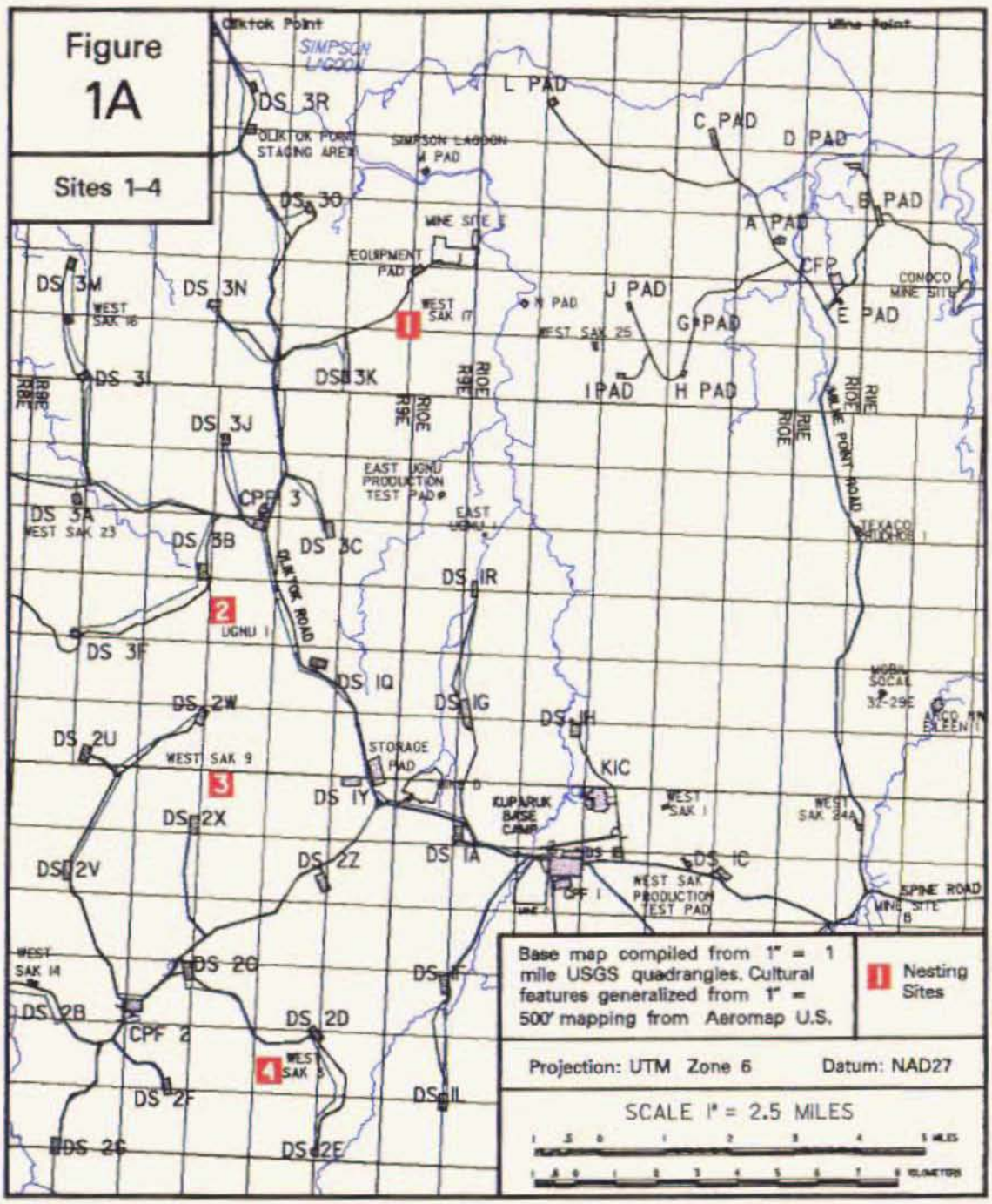
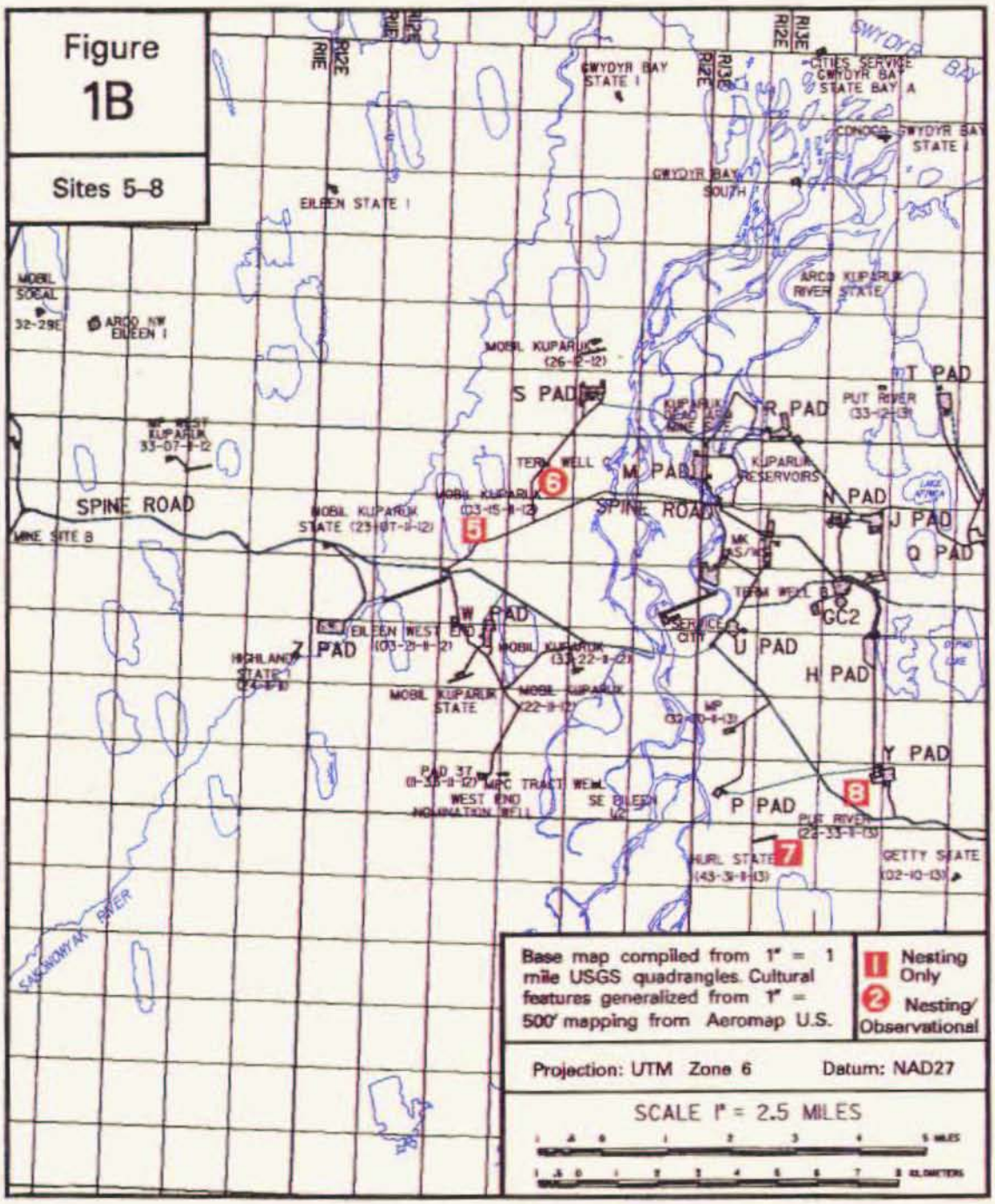
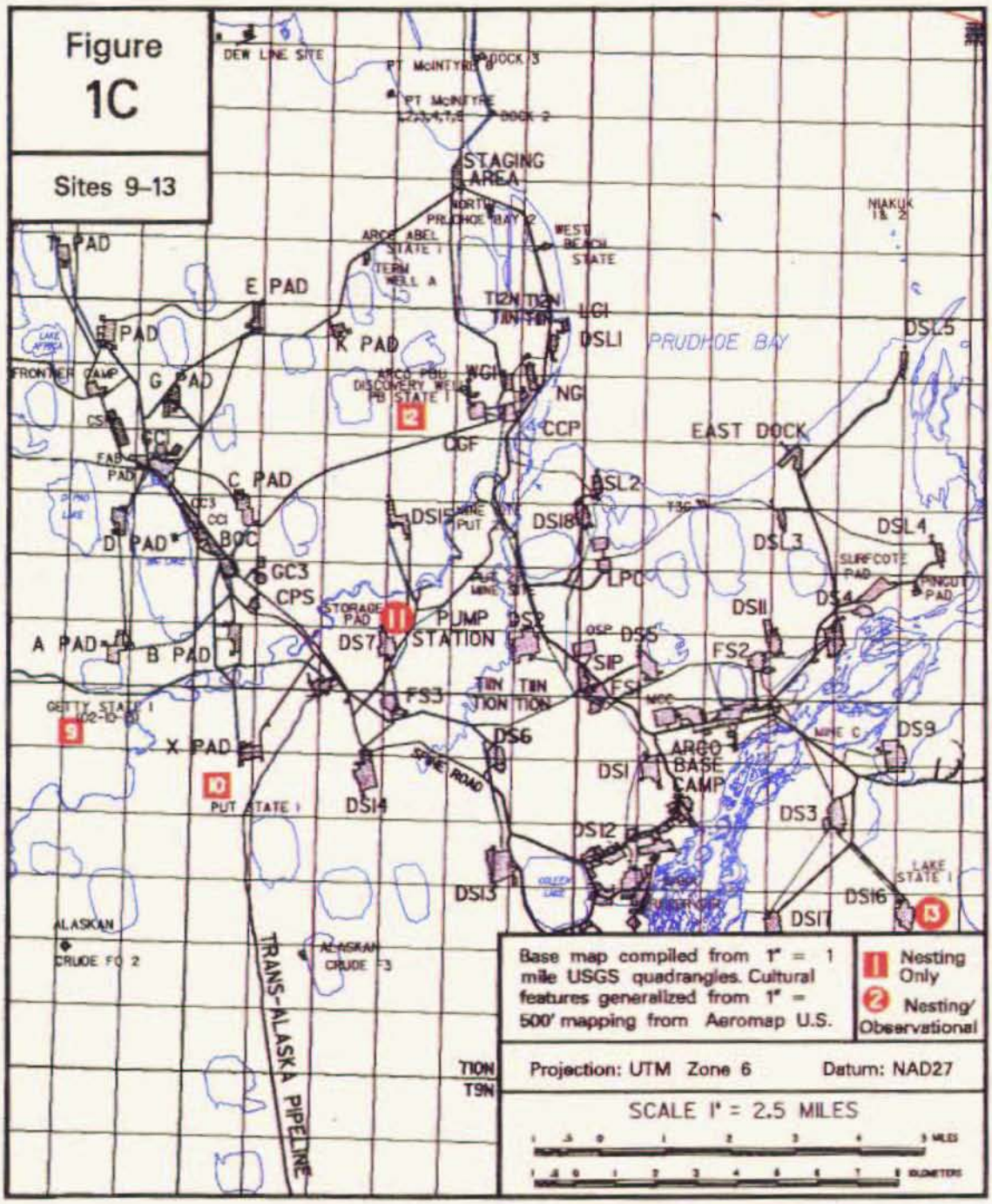


Figure
1A
Sites 1-4
Oliktok Point
SIMPSON LAGOON
DS 3R
OLIKTOK POINT STAGING AREA
SIMPSON LAGOON 4 PAD
DS 3O
MINE SITE E
EQUIPMENT PAD
L PAD
C PAD
D PAD
B PAD
A PAD
CPF 4
CONOCO MINE SITE
DS 3M
WEST SAK 16
DS 3N
WEST SAK 17
N PAD
WEST SAK 25
J PAD
G PAD
E PAD
DS 3I
DS 3K
I PAD
H PAD
DS 3J
EAST LISBURNE PRODUCTION TEST PAD
CPF 3
DS 3A
WEST SAK 23
DS 3B
DS 3C
EAST LISBURNE 1
DS 1R
OLIKTOK ROAD
LISBURNE 1
DS 3F
DS 1Q
DS 1G
DS 1H
DS 2W
DS 2U
WEST SAK 9
STORAGE PAD
KIC
DS 1Y
DS 2X
KUPARUK BASE CAMP
WEST SAK 1
WEST SAK 24A
DS 2V
DS 2Z
DS 1A
DS 1C
CPF 1
WEST SAK PRODUCTION TEST PAD
SPINE ROAD
MINE SITE B
WEST SAK 14
DS 2C
DS 2B
CPF 2
DS 2D
WEST SAK 3
DS 2F
DS 1L
DS 2G
DS 2E
PRUDHOE BAY
MINE POINT ROAD
R9E
R10E
Base map compiled from 1" = 1 mile USGS quadrangles. Cultural features generalized from 1" = 500' mapping from Aeromap U.S.
Nesting Sites
Projection: UTM Zone 6
Datum: NAD27
SCALE 1" = 2.5 MILES

Figure
1B

Sites 5–8

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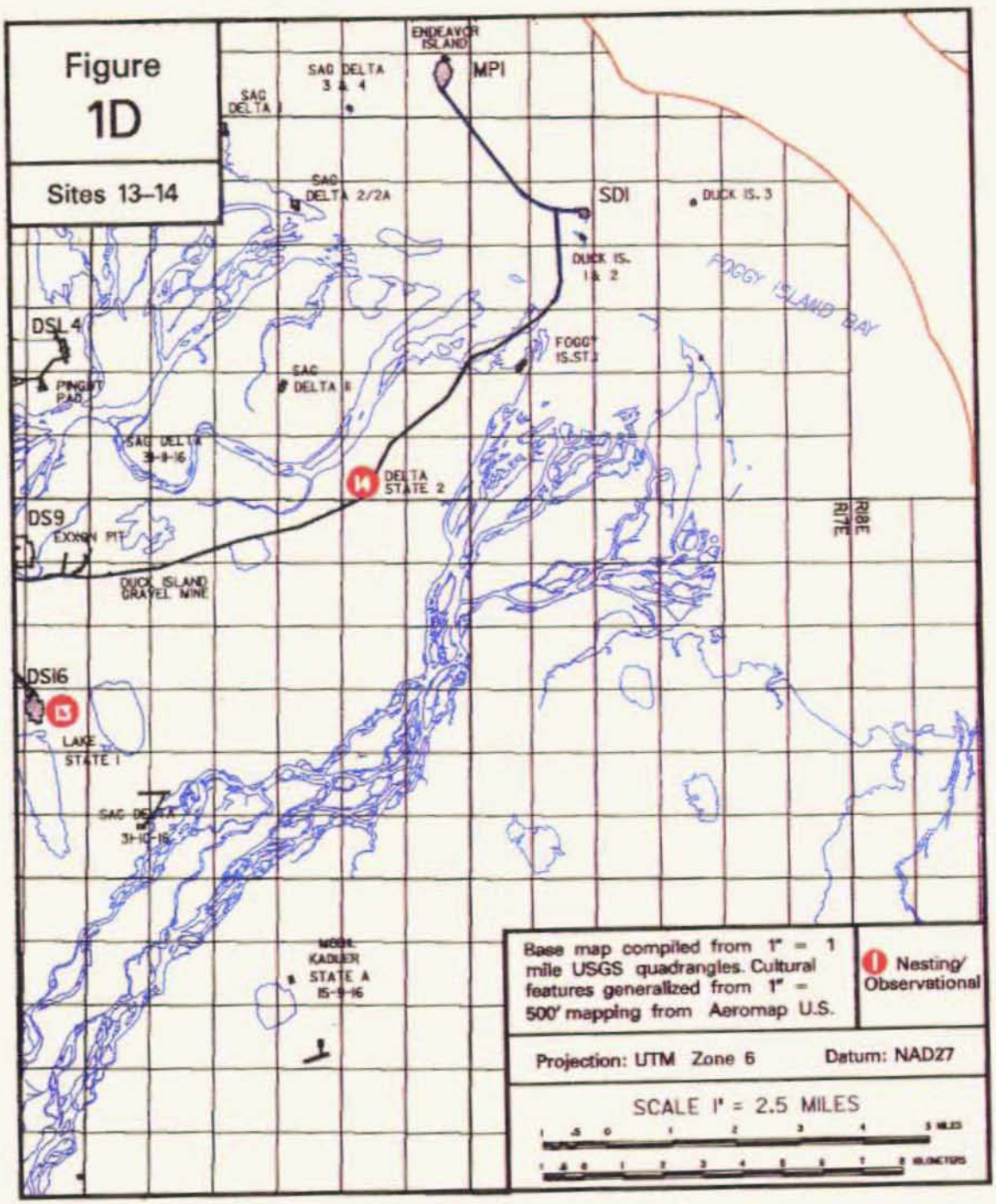
DOCK 3
DOCK 2
STAGING AREA
NORTH PRUDHOE BAY
WEST BEACH STATE
NIAKUK 1 & 2
ARCO ABEL STATE 1
TERM WELL A
T1 PAD
E PAD
K PAD
G PAD
PRUDHOE BAY
DSL5
EAST DOCK
FRONTIER CAMP
ARCO POW DISCOVERY WELL PB STATE 1
CCP
CGF
C PAD
D PAD
BOC
GC3
CPS
DSL2
DSL3
DSL4
SURFCOTE PAD
PINGUT PAD
DSI5
DSI8
LPC
DS2
PUMP STATION
STORAGE PAD
DS7
A PAD
B PAD
DS5
DSP
SIP
FS2
DSI1
DS4
FS3
FS1
MOC
DS9
ARCO BASE CAMP
DSI
DS3
X PAD
GETTY STATE 1
PUT STATE 1
DS6
DSI4
SPINE ROAD
DSI2
DSI3
DSI6
DSI7
LAKE STATE 1
ALASKAN CRUDE PS 2
ALASKAN CRUDE PS 3
TRANS-ALASKA PIPELINE
T10N
T9N
Base map compiled from 1" = 1 mile USGS quadrangles. Cultural features generalized from 1" = 500' mapping from Aeromap U.S.
1 Nesting Only
2 Nesting/ Observational
Projection: UTM Zone 6
Datum: NAD27
SCALE 1" = 2.5 MILES
MILES
KILOMETERS



Figure
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MPI
SAG DELTA 3 & 4
SAG DELTA 1
SAG DELTA 2/2A
SDI
DUCK IS. 3
DUCK IS. 1 & 2
FOGGY ISLAND BAY
DSL 4
FOGG IS. ST. 1
SAG DELTA 4
PINGUT PAD
SAG DELTA 31-9-16
DELTA STATE 2
DS9
EXXON PIT
DUCK ISLAND GRAVEL MINE
R8E
R7E
DS16
LAKE STATE 1
SAG DELTA 31-10-16
KADLUK STATE A 15-9-16
Base map compiled from 1" = 1 mile USGS quadrangles. Cultural features generalized from 1" = 500' mapping from Aeromap U.S.
Nesting/ Observational
Projection: UTM Zone 6
Datum: NAD27
SCALE 1" = 2.5 MILES

Table 1. Name, number, and location of sites of nesting and post-breeding observational studies of birds at Prudhoe Bay, Alaska, 1990. Sites are located on Figures 1A-D.

Site No.	Site Name	Location (Figure)
1	West Sak 17	1A
2	Ugnu 1	1A
3	West Sak 9	1A
4	West Sak 3	1A
5	Mobil Kuparuk 3-15-11-12	1B
6	Term Well C	1B
7	Hurl State	1B
8	Put River 22-33-11-13	1B
9	Getty State	1C
10	Put State 1	1C
11	Storage Pad	1C
12	Prudhoe Bay State 1	1C
13	Lake State 1	1C and 1D
14	Delta State 2	1D

Methods

Site Selection and Plot Set-up

We selected fourteen sites for the nesting study (Figs. 1A-1D). Eight of these had been study sites during 1989 (see Pollard et al. 1990). Thirteen sites contained an abandoned gravel pad from an exploratory well. One site, Put River 22-33-11-13 ("BP Pad"), originally contained an abandoned pad but since 1989 has been the focus of a major rehabilitation project by BPX, and gravel was essentially absent in 1990. (For detailed descriptions of sites, see Appendix A.)

At each site, we established a pair of study plots (disturbed and undisturbed) of 10 hectares each. One of the pair, designated as the "disturbed" plot, contained an abandoned gravel pad and surrounding tundra. Many additionally contained other disturbances such as reserve and/or flare pits, old vehicle tracks, and other areas of barren ground; one site, Put State 1, contained an old peat road. An "undisturbed" tundra plot was established near

(usually one meter from but as far as 300 meters from) the disturbed plot at each site. Three undisturbed plots (Ugnu 1, West Sak 3, and Put State 1) contained minor disturbances (surface disruptions) which were vegetated and usually difficult to observe on the ground, but which could be seen on aerial photographs. At Put State 1, the peat road in the disturbed plot also passes through the undisturbed plot.

Plot boundaries at each site were set such that the two plots contained similar habitat types, excluding the affected area of the disturbed plot. To obtain the best possible habitat match, we examined color infrared (CIR) aerial photographs (scale 1"= 500') taken in 1989 by Aeromap U.S. and sketched boundaries on the photographs prior to entering the field. The ten-hectare plots were either square (316.2 m x 316.2 m) or rectangular (200 m x 500 m, or 250 m x 400 m).

In the field, we used the CIR photographs, a hand-held compass, and a surveyor's chain to set up the plots. A grid system marked at intersections with 3-ft-tall stakes was established in each plot. Grid cells were 52.7 m x 52.7 m in square plots and 50 m x 50 m in rectangular plots. Each stake was marked with a letter and number so that nests could be relocated at a later date.

To facilitate the display of nest distributions, we mapped study sites from 1"= 500' CIR aerial photographs (see Appendix A). Gravel pads, gravel spray, reserve and flare pits, obvious non-gravel disturbances, and geobotanical types in both disturbed and undisturbed plots were delineated on maps. Geobotanical types (see Appendix D for classification system) were based on Walker et al. (1983). In some cases geobotanical types were lumped when more than one type of vegetation or landform was present. We used a planimeter to measure areas of gravel and gravel-related disturbances on maps. Spatially limited disturbances (such as thermokarsting and vegetative changes around the perimeters of pads) that were too small to map at the scale we used, were not depicted on maps but can be seen on aerial photos.

Data Collection

Nest Searching. Methods for nest searches were adapted from those described by LGL (1983), Martin (1983), and Troy and Wickliffe (1990). Two census techniques—"searches" and "rope drags"—were used at each study plot. During the searches, a biologist slowly walked a zig-zag pattern to make four passes through each grid of each plot in an attempt to locate bird nests either by flushing individuals from the nest or by waiting for birds suspected of

having a nest in the area to return. The rope drags involved two biologists walking abreast along the grid lines dragging a nylon rope between them in an attempt to flush tight-sitting birds from their nests. During this procedure, birds seen that had not been flushed, but that exhibited behavior indicating that they might be nesting in the area, were also observed to see if they would return to the nest. Two searches and two rope drags were used at each site during the course of the season (Table 2). The second search period overlapped the first rope drag.

Table 2. Schedule of activities for nesting study at disturbed gravel sites, Prudhoe Bay, Alaska, 1990.

Activity	Dates
Plot set-up	May 29-June 6
First Search	June 7-11
First Rope-drag	June 12-24
Second Search	June 12-20
Second Rope-drag	June 25-July 7
Nest Monitoring	June 20-July 25

When a nest was located, it was marked using methods described by LGL (1983) with a plain wooden tongue depressor on which we wrote a unique number and the species name. The tongue depressor was placed approximately one meter from the nest toward the gridline having the lower letter of the alphabet. A florescent orange tongue depressor with a direction arrow and the number of paces to the nest indicated on it was then placed on that gridline. All nests could thus be relocated. Information including species name, nest number, date, habitat type, number of eggs or young, and number of paces to the nearest grid markers was recorded in a field notebook.

Nest Monitoring. After completing the second search (Table 2), we began to monitor nests to determine hatching success. Nests were checked every three to five days. A single biologist walked through the plots and checked the status of each nest by looking for eggs, chicks, or signs of hatching or predation. Success or failure of a nest was determined using the criteria of

Troy and Wickliffe (1990). New nests found during monitoring were marked similarly to those discovered during plot set-up and nest searches.

Data Analysis

Nesting data from disturbed and undisturbed plots were analyzed and compared on the basis of nests per unit area (e.g., nests/km^2), nest success, and species diversity of nesting birds. In all cases, null hypotheses were rejected when $P \leq 0.05$. Data gathered at the rehabilitation site, Put River 22-33-11-13, were not included in statistical comparisons because gravel had been removed from this site.

Nest density data (total nests per 10-hectare plot) were paired for co-located disturbed and undisturbed plots. The null hypothesis of no difference in mean nest densities between disturbed and undisturbed plots was tested by using a Wilcoxon signed ranks test in the computer package SYSTAT® (Wilkinson 1989).

All known nests on both plot types were classified as successful or unsuccessful. The null hypothesis of no difference in nest success between disturbed and undisturbed plots was tested by using the chi-square test for differences in probabilities.

Species diversity of nesting birds was compared between disturbed and undisturbed plots in two ways. Species richness (the total number of species present) was used because of its simplicity. Shannon's diversity index (Begon et al. 1986:595), which takes into account the relative abundance of species in addition to the total number of species present, also was used because it is a commonly applied diversity measure that gives managers a wildlife-oriented option for establishing mitigation goals. The value of the index increases with the presence of more species and decreases if the distribution of relative abundance (nests, in this case) among species is uneven. Table 3 illustrates the behavior of Shannon's index for a hypothetical set of study plots.

Index data were paired for co-located plots, and the null hypothesis of no difference in mean diversity indices between disturbed and undisturbed plots was tested by a paired-sample t test in the computer package SYSTAT® (Wilkinson 1989). Green (1979) and Zar (1984) have noted the tendency of Shannon's index to underestimate the diversity of a sampled population, but our relative comparison of mean indices between disturbed and undisturbed plots should remain valid (assuming proportional underestimation of true

Table 3. Examples of Shannon's diversity index (H) for a set of hypothetical communities. Shannon's diversity index* varies positively with species richness (S) and the evenness with which individuals are distributed among species. For each community, total abundance (individuals) is denoted by T. (Table is adapted from Begon et al. 1986.)

Community 1		Community 2		Community 3		Community 4	
Species	Abundance	Species	Abundance	Species	Abundance	Species	Abundance
A	10	A	2	A	10	A	2
B	5	B	2	B	5	B	2
C	3	C	2	C	1	C	2
D	1	D	2	D	1	D	2
E	1	E	2	E	1	E	2
				F	1	F	2
				G	1	G	2
	S=5		S=5		S=7		S=7
	T=20		T=10		T=20		T=14
	H=1.28		H=1.61		H=1.44		H=1.95

*Shannon's diversity index (H) = $\sum P_i \ln P_i$ where P_i is the proportion of total individuals in the i^{th} species.

diversity in both habitat types). Green (1979) further advises that a high diversity index does not necessarily mean high environmental quality.

Results

Disturbed plots are compared with undisturbed plots on the basis of nest density, nest success, and species composition. Because gravel had been removed from Put River 22-33-11-13, results from that site are presented separately (Appendix A, Site 8).

Nest Density

Although more nests were initiated in the undisturbed plots (153 nests total, or 117.7 nests per km^2) than in the disturbed plots (128 nests total, or 98.5 nests per km^2) (Tables 4 and 7), we were unable to reject the null hypothesis of no difference in mean nest densities between plot types ($z=-1.37$, $P=0.17$). Higher nesting densities generally occurred in the undisturbed plot of each pair, although in four cases (Ugnu 1, Term Well C, Prudhoe Bay State 1, and Storage Pad) the disturbed plot had higher densities. The highest nesting density occurred at the disturbed plot at Ugnu 1, where 21 nests were found.

The nest density on the portions of disturbed plots unaffected by gravel was about the same as the nest density on undisturbed plots. Gravel pads and gravel spray cover, on average, approximately 25 percent of the surface area of the disturbed plots (Table 5). A total of 122 nests (125.1 nests/km^2) was found on unaffected portions of disturbed plots compared to 153 nests (117.7 nests/km^2) on undisturbed plots.

Nest Success

Nest success was higher in the disturbed plots (82 percent) than in the undisturbed plots (73 percent)(Table 4); as a consequence, there were nearly as many successful nests in the disturbed plots (105) as in undisturbed plots (111). Nevertheless, we were unable to reject the null hypothesis of no difference in nest success between plot types (chi-square=3.53, df=1, $0.05<P>0.10$). The site that showed the greatest difference in nest success between plots was Hurl State where only 7 of 18 nests (39 percent) were successful in the undisturbed plot, but 6 of 6 (100 percent) were successful in the disturbed plot. Term Well C also had very low nest success in the undisturbed plot (29 percent), but fewer total nests (7) were involved.

Table 4. Comparison of bird nesting and success by site on disturbed and undisturbed study plots, Prudhoe Bay, Alaska, 1990. N is the total number of successful nests. Sites are ranked by the total number of nests located in disturbed plots.

Site No.	Site	Number of Species		Total Nests		Percent Success and Successful Nests (N)			
		Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed		Disturbed	
2	Ugnu 1	3	6	11	21	82	(9)	81	(17)
P	West Sak 9	5	5	15	12	80	(12)	75	(9)
6	Term Well C	6	4	7	12	29	(2)	83	(10)
12	Prudhoe Bay State 1	5	5	11	12	91	(10)	83	(10)
13	Lake State	5	5	18	12	78	(14)	75	(6)
1	West Sak 17	7	5	13	11	69	(9)	82	(9)
9	Getty State	7	5	16	10	88	(14)	80	(8)
4	West Sak 3	3	5	13	8	77	(10)	100	(8)
11	Storage Pad	4	4	7	8	71	(5)	75	(6)
10	Put State 1	7	3	11	7	100	(11)	86	(6)
7	Hurl State	7	5	18	6	39	(7)	100	(6)
5	Mobil Kuparuk 13-15-11-12	5	5	9	5	44	(4)	60	(3)
14	Delta State 2	2	2	4	4	100	(4)	100	(4)
	Overall	13	16	153	128	73	(111)	82	(105)

Table 5. Percentage of area covered by gravel and tundra disturbances on disturbed study plots, Prudhoe Bay, Alaska, 1990. Sites are ranked by the percent gravel disturbance.

Site No.	Site	Percent Gravel Disturbance*	Percent Tundra Disturbance**	Percent Total Disturbance
3	West Sak 9	39		39
14	Delta State 2	39		39
12	Prudhoe Bay State 1	33	40	73
4	West Sak 3	28		28
7	Hurl State	28	5	33
1	West Sak 17	26		26
5	Mobil Kuparuk 13-15-11-12	25		25
6	Term Well C	21		21
2	Ugnu 1	20		20
10	Put State 1	18	8	26
9	Getty State	17		17
11	Storage Pad	17		17
13	Lake State 1	13		13
	Mean	25	4	29

* Includes gravel pad, gravel spray, and associated reserve pits and overburden.

** Includes obvious non-gravel disturbances to tundra such as vehicle tracks and barren ground.

Species Composition

Overall, the number of species (richness) that nested on disturbed plots (16) was higher than that on undisturbed plots (13) (Table 4). Taking into account the abundance of each nesting species, however, we were unable to reject the null hypothesis of no difference in mean Shannon's diversity indices (Table 6) between disturbed and undisturbed plots ($t = 0.81$, d.f. = 12, $P = 0.43$).

Semipalmated Sandpiper, Pectoral Sandpiper, and Lapland Longspur were by far the most common (>23 total nests each) species nesting in both disturbed and undisturbed plots (Table 7). There was no significant difference in the mean numbers of nests of Semipalmated Sandpiper ($z=0.62$, $P=0.53$) and Lapland Longspur ($z=-0.50$, $P=0.62$) between disturbed and undisturbed plots. There were more Pectoral Sandpiper nests in undisturbed plots than in disturbed plots, and the difference was statistically significant ($z=-2.46$, $P=0.01$). When only successful nests are considered, the total number of nests of these three species combined was almost the same in disturbed and undisturbed plots (82 and 84 respectively).

Moderately abundant species (those with 7 to 23 total nests) generally nested more commonly in undisturbed plots than in disturbed plots. One exception to this was Red-necked Phalarope, which was more common in disturbed plots. This may have been caused by this species' apparent preference for thermokarst sites, which occurred on tundra around the perimeter of some gravel pads. They seemed to select thermokarst sites around Ugnu 1, Term Well C, Getty State, and Prudhoe Bay State 1. Three species—Dunlin, Stilt Sandpiper, and Buff-breasted Sandpiper—had only one nest each in disturbed plots, but had 6 or 7 nests each in undisturbed plots. These numbers are small and whether or not these species are responding to differences in habitats within the study plots is unclear.

More species that were uncommon (<3 total nests) nested in disturbed than in undisturbed plots, and the overall higher species richness in disturbed plots resulted mainly from differences in this category. Among species with fewer than 3 nests total, three (Canada Goose, King Eider, and Rock Ptarmigan) nested only in undisturbed plots, but six (Greater White-fronted Goose, Northern Shoveler, Willow Ptarmigan, Ruddy Turnstone, Baird's Sandpiper, and Snow Bunting) nested only in disturbed plots (Table 7).

Table 6. Number of nesting species (irrespective of success) and Shannon's diversity indices for disturbed and undisturbed plots, Prudhoe Bay, Alaska, 1990. Sites are ranked by diversity-index values calculated for disturbed plots.

Site No.	Site	Number of Species		Shannon Diversity Index	
		Undisturbed	Disturbed	Undisturbed	Disturbed
5	Mobil Kuparuk 13-15-11-12	5	5	1.52	1.61
7	Hurl State	7	5	1.85	1.56
13	Lake State 1	5	5	1.49	1.55
1	West Sak 17	7	5	1.80	1.50
2	Ugnu 1	3	6	1.04	1.50
9	Getty State	7	5	1.72	1.50
4	West Sak 3	3	5	0.91	1.49
12	Prudhoe Bay State 1	5	5	1.59	1.47
3	West Sak 9	5	5	1.40	1.36
6	Term Well C	6	4	1.75	1.33
11	Storage Pad	4	4	1.28	1.26
10	Put River 1	7	3	1.85	1.00
14	Delta State 2	2	2	0.56	0.56
	Mean	5.1	4.5	1.44	1.36
	Overall (all sites combined)	13	16	1.94	1.84

Table 7. Comparison of nesting density and success of bird species on disturbed and undisturbed study plots, Prudhoe Bay, Alaska, 1990. Species are ranked by the total number of nests found on both plot types combined.

Species	Density in nests/square km (total number of nests)				Percent Success (number of successful nests)			
	Undisturbed		Disturbed		Undisturbed		Disturbed	
Lapland Longspur	30.8	(40)	27.7	(36)	78	(31)	75	(27)
Semipalmated Sandpiper	26.2	(34)	28.5	(37)	76	(26)	95	(35)
Pectoral Sandpiper	29.2	(38)	17.7	(23)	71	(27)	87	(20)
Red-necked Phalarope	5.4	(7)	12.3	(16)	86	(6)	81	(13)
Dunlin	5.4	(7)	.8	(1)	71	(5)	100	(1)
Buff-breasted Sandpiper	5.4	(7)	.8	(1)	86	(6)	100	(1)
Red Phalarope	3.8	(5)	2.3	(3)	60	(3)	100	(3)
Lesser Golden Plover	3.8	(5)	1.5	(2)	60	(3)	0	
Stilt Sandpiper	4.6	(6)	.8	(1)	50	(3)	100	(1)
Oldsquaw	.8	(1)	.8	(1)	0		0	
Ruddy Turnstone			1.5	(2)			50	(1)
Gr. White-fronted Goose			.8	(1)			100	(1)
Canada Goose	.8	(1)			100	(1)		
Northern Shoveler			.8	(1)			0	
King Eider	.8	(1)			0			
Willow Ptarmigan			.8	(1)			100	(1)
Rock Ptarmigan	.8	(1)			0			
Baird's Sandpiper			.8	(1)			0	
Snow Bunting			.8	(1)			100	(1)
Total or Mean	117.7	(153)	98.5	(128)	73	(111)	82	(105)

Discussion

In this section, we discuss nest density and nest success patterns, and compare them with the findings of other researchers. On this basis we present some ideas about how gravel placement may affect the quality of adjacent nesting habitats.

Nest Density

The average nest densities for both disturbed plots (98.5 nests/km^2) and undisturbed plots (117.7 nests/km^2) (Table 7) were relatively high compared to most other previously reported nest densities for the Arctic Coastal Plain. In the Prudhoe Bay oil field, densities ranged from 42 to 89.2 nests/km^2 on various types of disturbed and undisturbed plots over almost 10 years of studies (Troy 1982; Troy and Burgess 1983; Troy et al. 1983; Troy 1986, 1988; Troy and Carpenter 1990; Troy and Wickliffe 1990). However, Norton et al. (1975) reported higher densities (93.4 to 99.9 nests/km^2) than Troy and his colleagues during two years of studies in the Prudhoe Bay oil field in the early 1970's. On an inland plot south of Deadhorse, nest densities averaged 120 nests/km^2 (Hohenberger et al. 1980, 1981). On study plots at Barrow, nest densities ranged from 42.4 to 154.5 (average = 93.6) nests/km^2 (Myers and Pitelka 1975a, b; Myers et al. 1977a, b; 1978a, b; 1979a, b, c; 1980a, b, c; 1981a, b, c). Nest densities on study plots in ANWR were generally low (Spindler and Miller 1983, Oates et al. 1987), although Martin and Moitoret (1981) had densities up to 136.5 nests/km^2 on a plot in the Canning River Delta.

The three most common species in this study (Semipalmated and Pectoral sandpipers and Lapland Longspur) often have been some of the most common species in the studies cited above for the Arctic Coastal Plain. Semipalmated Sandpipers, and probably to a lesser extent Lapland Longspurs, generally exhibit less variation in numbers from year to year than do Pectoral Sandpipers, which often show strong year-to-year fluctuations and have clumped distributions (Pitelka et al. 1974, Custer and Pitelka 1977).

Of the common species, only Pectoral Sandpiper showed a significant difference in nest density between disturbed and undisturbed plots; nest density was higher in undisturbed plots. Nests of Pectoral Sandpipers were located on a number of our study plots near gravel pads, notably West Sak 9 and West Sak 3. At West Sak 9 (Site 3), 4 Pectoral Sandpiper nests were located on tundra near the north side of the gravel pad (Fig. A-3). At West Sak 3 (Site 4), a Pectoral Sandpiper nest was found on disturbed tundra inside a flare pit

southeast of the pad (Fig. A-4). During the previous season, a Pectoral Sandpiper nested at the breach in the gravel berm surrounding this same flare pit (pers. obs.). Pectoral Sandpiper nests also were located near gravel pads at West Sak 17 (Site 1), Term Well C (Site 6), Hurl State (Site 7), Getty State (Site 9), and Put State 1 (Site 10). Since some Pectoral Sandpipers do not seem to avoid nesting sites near abandoned gravel pads, the reasons for higher nest densities of this species in undisturbed plots may be related to factors other than the presence of these pads.

The high nest densities that we found during the 1990 field season were not confined to this study. C. Moitoret, U.S. Fish and Wildl. Serv. (pers. comm.), found densities of 89.9 and 94.2 nests/km^2 on two large plots in the Kuparuk oil field near some of our westernmost study sites. During the previous two seasons, densities in these same plots had ranged from 49 to 67 nests/km^2. Ongoing studies by D. Troy, Troy Ecol. Res. Assoc. (pers. comm.), also had higher densities in 1990 than in previous seasons.

Reasons for these relatively high nesting densities in 1990 may be related to weather conditions. Birds begin nesting on the tundra as it becomes clear of snow (Custer and Pitelka 1977, Seastedt and MacLean 1979, Holmes 1966), and a late snow melt can cause a delay in the arrival of some birds to the nesting grounds (Pitelka 1959) or a delay in nest initiation (Green et al. 1977). Troy (1988) reported lower levels of bird use of tundra habitats during years of cold and/or late snow melt at Prudhoe Bay. Holmes (1970) found that the effects of severe climatic conditions on the food supply of Dunlin at Barrow could affect their breeding density. On Bathurst Island in the Canadian High Arctic, cold weather and late snow-melt caused disastrous nesting conditions for tundra nesting birds in some years (Mayfield 1978). Catastrophic reductions in nesting caused some years to be classified as "nonbreeding years" by Mayfield (1983).

The 1990 nesting season may represent a year of optimal conditions for tundra-nesting bird species because snow cover had disappeared from the Prudhoe Bay region before May 28. In a removal experiment, Holmes (1966) felt that there was a critical time by which pairing and mating must take place. He found that, with one exception, Dunlin territories were reoccupied prior to June 15, but not thereafter. Thus, during years in which snow persists into mid-June, tundra habitats may not be clear in time for birds to reach maximum nesting densities.

Observer-related factors may also influence observed differences in nest densities among studies or years. Spindler and Miller (1983) point out the difficulties in duplicating search effort and pattern among different census crews and crew leaders, and in duplicating nest-finding skills among observers and years. Thus, sets of nest density data are most validly compared when gathered by the same people in the same year.

Habitat fragmentation has been identified as a possible factor negatively affecting bird use of tundra habitats (Meehan 1986), although Troy (1988) found that fragmentation of tundra by oil field facilities did not appear to influence bird use. Habitat fragmentation should not have had any effect on the comparisons made between disturbed and undisturbed study plots in our study. Each site was located in an area surrounded by roads, pipelines, and facilities so that each of the paired plots within a given site was contained within the same tundra "fragment."

Nest Success

When compared with others' results, nest success in the current study was high both in disturbed plots (82 percent) and in undisturbed plots (73 percent) (Table 4). Nest success at P-Pad in the Prudhoe Bay oil field declined from 54 percent to 36 percent over two years (Troy and Carpenter 1990), while nest success at the Pt. McIntyre reference area during the same years declined from 63 percent to 44 percent. Nest success for other studies at Prudhoe Bay has ranged from 39 percent to 76 percent for nests of known outcome (Troy et al. 1983, Troy 1986). Norton et al. (1975) found nest success of 38 percent and 86 percent over two years on study plots at Prudhoe Bay, although his method of measuring success differed slightly from the above studies. On an inland plot south of Deadhorse, the nest success doubled over a two-year period from 35 percent to 70 percent (Hohenberger et al. 1980, 1981). During five years of study at Barrow, nest success averaged approximately 66 percent (Myers and Pitelka 1975a, b; Myers et al. 1977a, b; 1978a, b; 1979a, b, c; 1980a, b, c; 1981a, b, c).

Nest predation by Arctic foxes probably was responsible for most of the losses during this study. Troy and Carpenter (1990) reported heavy nest losses due to Arctic foxes at P-Pad, and Norton et al. (1975) felt that removal of Arctic foxes may have increased the nest success on his study plots. Wiggins and Johnson (1991) hypothesized that the increased abundance of nesting

Common Eiders (*Somateria mollissima*) along the Endicott causeway may be related to the absence of Arctic foxes there after break-up.

A reduction in nest density has been postulated to reduce predation (Pitelka et al. 1974). Experiments by Page et al. (1983) showed a decrease in nesting success of Snowy Plovers in California with an increase in nest density. He felt that the maintenance of low nesting density was an important antipredator adaptation. Since nesting densities at Prudhoe Bay seemed to be higher than usual in 1990, we might have expected lower nest success than in other years due to effects of predation, assuming predator populations were at normal levels. However, for this study, overall nest success was relatively high. It is only when we look at the individual study plots (Table 4) that low nest success appears for some plots. The undisturbed plot at Hurl State, for instance, had a relatively high nest density and relatively low nest success. This may be an example of predation operating in a density-dependent fashion on a local level to regulate nest success.

Effects of Gravel Placement

According to Connors (1983), tundra covered with gravel is lost as bird nesting habitat. This is probably true immediately after gravel placement has occurred and while pads are being used during oil field operations. The abandoned gravel pads that were part of this study did not serve as nesting habitat for most species. However, some species (Greater White-fronted Goose, Red-necked Phalarope, Baird's Sandpiper, Lapland Longspur, and Snow Bunting) did have nests on gravel. Nests occurred on gravel at Ugnu 1 (4 nests), Storage Pad (1 nest), and Prudhoe Bay State 1 (1 nest). These sites have been abandoned for some time, and varying amounts of plant colonization and thermokarsting have altered the gravel substrate. Nests on pads usually were associated with vegetation, although a Baird's Sandpiper nested on barren gravel.

Abandoned gravel pads do not seem to adversely affect the suitability of adjacent tundra as nesting habitat. On average, gravel covered approximately 25 percent of the area of the disturbed study plots (Table 5). If we assume that this area is totally lost as nesting habitat, and that the remaining habitat in the disturbed plots is equal in value to equivalent amounts of habitat in the undisturbed plots, then we can calculate the number of nests we would expect to find on disturbed plots. Since 153 nests were found on undisturbed plots, we would expect to find 75 percent of that number, or 115 nests, on the undisturbed portions of disturbed plots. In actuality, 128 nests were found on disturbed

plots. Subtracting the 6 nests that were found on gravel leaves 122 nests on the undisturbed portions of disturbed plots. This would seem to indicate that any effect of abandoned gravel pads on nesting habitat does not go beyond the limits of the area covered by gravel.

To a certain degree, abandoned gravel pads may enhance the suitability of adjacent tundra as nesting habitat. Thermokarsting of tundra near the edges of gravel pads produces water-filled pits and other areas of microrelief. Red-necked Phalaropes seem to be attracted to these areas. This may have been responsible for the higher number of nests of this species (16 vs. 7) in disturbed plots (Table 7), although this difference was not statistically significant. Studies of abandoned peat roads in the Prudhoe Bay oil field by Troy (1991) suggest that thermokarsting and enhanced microrelief may increase bird use of an area for nesting. He reported that thermokarsting and vegetation changes associated with peat roads probably benefited birds. He suggested that in reclaiming abandoned sites one should strive for heterogeneity of habitat, and that a combination of ridges and ditches might increase bird use of an area. Other studies also have suggested that greater variability of microrelief may benefit tundra nesting birds (e.g., Norton et al. 1975, Martin and Moitoret 1981). Further studies on the effects to nesting habitats of thermokarsting and variability of microrelief may prove beneficial in developing plans for future rehabilitation of gravel facilities.

Conclusions

The findings of this study concerning bird nesting and abandoned gravel pads are encouraging in many ways. Although there was a tendency for more nests to be found on undisturbed tundra plots than on disturbed tundra plots containing abandoned gravel pads, the difference in mean nest densities between plot types was not significant statistically. Of the common species, only Pectoral Sandpiper showed a statistically significant difference in nest density between disturbed and undisturbed plots. It nested more commonly in undisturbed plots than in disturbed plots, but this difference may not have been related to the presence of the abandoned gravel pads. In some cases, disturbed study plots actually had higher nest densities than did nearby undisturbed plots, even though gravel covered an average of approximately 25 percent of the area in disturbed plots. Excluding the gravel-covered area in disturbed plots, we found that the density of nests on the two plot types was about the same.

Similarly, the presence of abandoned gravel pads did not seem to affect nest success or species diversity of nesting birds. There was a tendency (not statistically significant) for disturbed plots to have greater nest success than undisturbed plots, and there were almost as many successful nests on disturbed plots as on undisturbed plots overall. On a per-plot basis, there was a slight tendency for undisturbed plots to have more nesting species than nearby disturbed plots; but more species nested on all disturbed plots combined than on all undisturbed plots combined. There also was a tendency for undisturbed plots to have a higher Shannon's diversity index value than disturbed plots, but again the difference was not significant statistically.

Although gravel fill generally does not serve as nesting habitat for tundra-nesting bird species, some birds did nest on abandoned gravel pads during this study. These nests were all located on older pads that had some naturally occurring plant colonization and thermokarsting. In some cases, abandoned gravel pads may have enhanced the suitability of adjacent tundra as nesting habitat by creating water-filled pits and a greater degree of microrelief as the result of thermorkarsting near the pad.

Overall, these findings suggest that the nesting-habitat value of undisturbed tundra surrounding abandoned gravel pads is similar to that of undisturbed tundra elsewhere. Nest density, nest success, and species diversity of nesting birds all were similar on both disturbed and undisturbed plots. The association of some nests with natural vegetation and thermokarst on and near abandoned gravel fill indicates that manipulation short of restoration may improve the value of abandoned sites as nesting habitat for some birds.

Part Two: Post-breeding Use of Abandoned Gravel Pads

Objectives

- To compare levels and kinds of post-breeding bird use among several microhabitat types in disturbed and undisturbed terrain at and near abandoned gravel pads
- To describe microhabitats preferred by post-breeding tundra bird species at abandoned gravel pads and in undisturbed areas

Methods

Site Selection and Plot Set-up

Of the fourteen sites selected for the nesting study, we focused on a subset of four to conduct the post-breeding observational study on and near the gravel pads. Each of these sites had patches of distinct microhabitat types which could be compared on the basis of bird use. At each site, we established a plot within each of three to five distinguishable microhabitats. At least one gravel plot and one tundra plot were established at each site; other plots were set up in disturbed areas such as reserve pits, impoundments, or gravel berms. Some plots also included various types (e.g., seeded or naturally colonized) or degrees (e.g., sparse to dense) of vegetative cover. We tried to standardize plot size within each site, but size sometimes varied due to the limited availability of a particular microhabitat type. Each plot was established such that the microhabitat within the plot was as homogeneous as possible. We erected an elevated observation blind at each site to provide a clear view of all study plots at that site.

We also made maps of the observational sites using 1"= 150' CIR aerial photographs (see Appendix B). The purpose of these maps was to illustrate the spatial relationships among the various plots and microhabitats at each site.

Data Collection

Observations were made from 17 July to 13 August to coincide with the period when most nesting had been completed and fall staging was beginning. Observations were made at each site every other day from 17-31 July (Table 8).

Table 8. Dates of observations at disturbed study sites, Prudhoe Bay, Alaska, 1990.

Date	Term Well C	Storage Pad	Delta State	Lake State 1(A)	Lake State 1(B)
17-Jul	X	X			
18			X	X	
19	X	X			
20			X	X	
21	X	X			
22			X	X	
23	X	X			
24			X	X	
25	X	X			
26			X	X	
27	X	X			
28			X	X	
29	X	X			
30			X	X	
31	X	X			
1-Aug					
2					
3				X	X
4	X	X			
5				X	X
6					
7				X	X
8				X	X
9				X	X
10				X	X
11				X	X
12				X	X
13				X	X

After 31 July, Delta State 2 was dropped from the study because very few birds were using the site. At the same time, a second set of plots was set up at Lake State 1 because of the high level of use there. On 5 August, Term Well C and Storage Pad were also dropped from the study because few birds were present, and simultaneous observations were made daily by two observers at Lake State 1 only.

Observation periods were 2.5 hour (hr) each in the morning and afternoon. During each 2.5-hr period, the observer slowly scanned a study plot for three minutes (min) with binoculars and with the naked eye. During a two-min period following each scan, data from the scan were recorded. Then the observer shifted to the next plot for three min, recorded data during the following two min, and so on. Because each site had at least three plots, it took 15 min (five min per plot) to complete one cycle of the plots. For all sites that had more than three plots, it was possible to scan two adjacent plots at the same time such that the 15-min cycle was maintained. Thus, each plot at each site was scanned ten times during each 2.5-hr observation period (20 times per day).

We recorded the number of individuals of each species per scan, their behavior (feeding, resting/preening, interacting, hunting, or walking/swimming), and habitat features (e.g., vegetation type, landform, microhabitat) used by the observed individuals. For birds landing on the plot during a three-min scanning period, the behavior recorded was the behavior first observed after about ten seconds. Birds flying over the plot but not landing on it were not recorded.

Data Analysis

Observational data were compared only among plots within sites, and compared data were all gathered during the same 2.5-hr observation periods. This reduced the effects of variability induced by spatial and temporal differences among samples. Given the limited number of available abandoned gravel pads and the unique character of each of them, it was not feasible to observe replicates of each plot (microhabitat) configuration. In most cases, observations of bird use of plots within a given site constituted repeated measures of the same experimental units (the plots), and data (such as use levels) thus gathered were not appropriate for statistical analyses (see Hurlbert 1984).

Several criteria were used to compare bird use among plots within each of the disturbed study sites. Mean numbers of observations and species per 2.5-hour period were calculated to measure the levels of bird use. Since plots

sometimes varied in size (due to a limited amount of specific microhabitat available), an adjusted level of use was calculated which reduced numbers of observations per period to a standard plot size (the smallest plot at each site). Thus, the adjusted values for level of use represent the number of observations per unit area per unit time. We compared species richness among plots; species diversity among plots was compared on the basis of Shannon's diversity index. We also compared plots with respect to proportions of bird behavior observed on them for Lapland Longspur, because it was the most common species, and for all other species combined. Finally, we made comparisons by reporting how the total number of observations on each plot was distributed among the species that occurred there.

Results

In this section, we compare bird use among plots within each of the disturbed study sites. Levels of use and levels adjusted to a standard plot size (Table 9), species diversity, behavior (for Lapland Longspurs and for all other species combined), and species distribution among plots are compared. Physical characteristics of plots, such as gravel thickness, extent of thermokarsting, amount of vegetation, presence of water/mud, and type of tundra, are also compared among plots within a given site (Table 10 and Appendix B).

At most of the observational study sites, birds were less visible on tundra plots than on other plots because of concealing vegetation. However, searches of the tundra plots made routinely after each observational period suggested that invariably few birds escaped being seen despite the plant cover. Thus, relative comparisons of levels of bird use among plots are valid irrespective of differences in visibility. Behaviors of birds observed on tundra plots were more difficult to discern than was the presence of birds, and comparisons of behaviors among plots should be qualified accordingly.

Term Well C

The highest mean number of observations per 2.5-hr period occurred on the berm; the lowest number occurred on the tundra plot (Fig. 2a). The range in the total numbers of observations was from 14 on the tundra plot to 192 on the berm. The 2 plots containing water (i.e., the reserve pit and the pond) had slightly lower numbers of observations than the berm. Half of the observations on the gravel plot occurred during one 2.5-hr observation period; if these data

Table 9. Means and standard deviations of numbers of observations and species per 2.5-hr period on study plots at Prudhoe Bay, Alaska, 1990. Values for adjusted means are given in a separate column where plot sizes vary within a site.

Site	Plot	# Periods	Number of Observations			Number of Species	
			Mean	SD	Adjusted Mean	Mean	SD
Term Well C	Gravel	18	4.4	9.3	2.1	.7	.6
	Reserve Pit	18	8.4	15.4	4.0	1.5	1.3
	Berm	18	10.7	10.1	10.7	1.2	.7
	Tundra	18	.8	1.2	.4	.6	.8
	Pond	18	6.3	7.6	3.0	1.6	1.3
Storage Pad	"Wet" Thermokarsted Gravel	18	5.6	5.6		1.3	1.0
	"Dry" Thermokarsted Gravel	18	5.6	6.4		.9	.6
	Tundra	18	5.9	4.4		1.2	.7
Delta State 2	Gravel	14	.8	1.1		.5	.7
	Reserve Pit	14	7.1	7.7		1.8	1.2
	Tundra	14	1.4	1.8		.8	.7
Lake State 1(A)	Seeded Gravel	32	4.8	3.9	1.7	1.1	.7
	Unseeded Gravel	32	11.2	8.4	3.9	1.6	.6
	"Road"	32	12.3	14.9	12.3	1.2	.8
	Gravel Spray	32	22.4	12.4	10.5	2.9	1.3
	Tundra	32	.9	1.7	.3	.4	.6
Lake State 1(B)	Seeded Gravel	18	3.4	4.0	3.4	.9	.7
	Unseeded Gravel	18	19.1	20.6	19.1	1.7	.6
	Impoundment	18	13.2	14.3	3.5	3.1	1.6
	Tundra	18	1.0	2.4	.2	.4	.7

Table 10. Plot size and physical characteristics at disturbed gravel sites, Prudhoe Bay, Alaska, 1990. (See Appendix B for detailed plot descriptions.)

Site	Plot	Area (m)	Characteristics
Term Well C	Gravel	3000	Thick gravel, no vegetation
	Reserve Pit	3000	Water-filled, mud edge
	Berm	1440*	Mixed gravel and overburden, vegetated (graminoids)
	Tundra	3000	Moist graminoids, strangmoor
	Pond	3000*	Water-filled, partial mud edge
Storage Pad	"Wet" Thermokarsted Gravel	3900	Moderately thick gravel, wet troughs, "lush" plant colonization
	"Dry" Thermokarsted Gravel	3900	Moderately thick gravel, dry troughs, "sparse" plant colonization
	Tundra	3900	Moist graminoids, mixed high and low-centered polygons
Delta State 2	Gravel	5000	Moderately thick gravel, no vegetation
	Reserve Pit	5000	Water-filled, mud edge
	Tundra	5000	Moist and wet graminoids, non-patterned ground
Lake State 1 (A)	Seeded Gravel	1800	Moderately thick gravel, dense cultivars (fertilized)
	Unseeded Gravel	1800	Moderately thick gravel, sparse natural colonization (fertilized)
	"Road"	625*	Thin gravel, natural colonization, moderate cover
	Gravel Spray	1330*	Thin gravel, wet thermokarst troughs, natural colonization, dense cover
	Tundra	1800	Moist and wet graminoids, non-patterned ground
Lake State 1 (B)	Seeded Gravel	392	Thin gravel, dense cultivars (fertilized)
	Unseeded Gravel	392	Thin gravel, dense natural colonization (fertilized)
	Impoundment	1475*	Water and mud filled
	Tundra	1800	Moist and wet graminoids, non-patterned ground

* indicates areas approximated using a planimeter. (Others were measured in the field.)

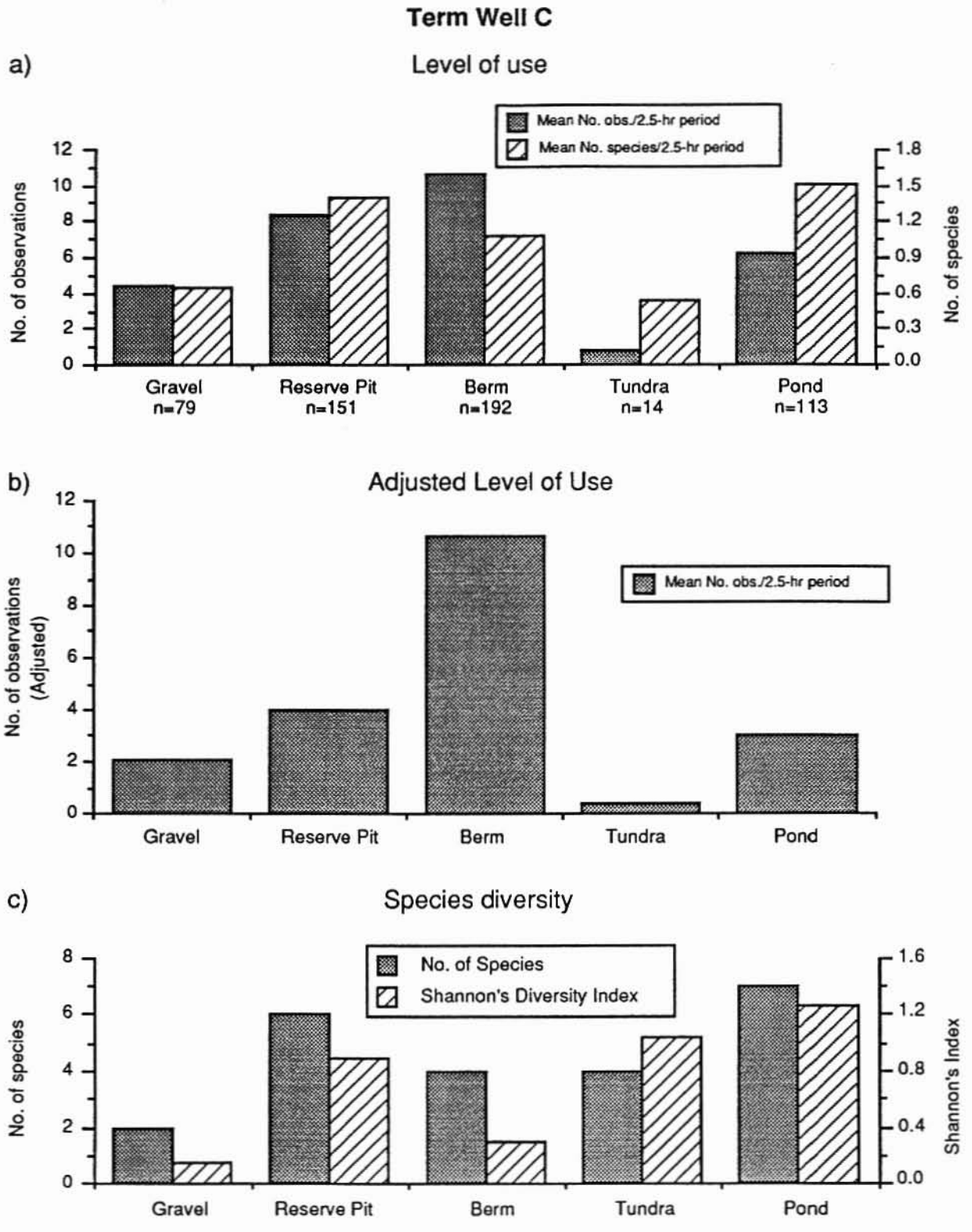


Fig. 2. Levels of bird use (a), levels of use adjusted to standard plot size (b), and species diversity (c) on study plots at Term Well C, Prudhoe Bay, Alaska, 1990. In (a), n is the total number of observations. The gravel, reserve pit, and berm plots represent disturbed habitats; the tundra and pond plots are undisturbed habitats.

are disregarded, the level of use on the gravel plot would approach the low level of use observed on the tundra plot. When the level of use is adjusted to the size of the smallest plot (berm, Table 10), the numbers of observations on all other plots are reduced by almost 50 percent (Fig. 2b).

The mean numbers of species observed per 2.5-hr observation period were highest on the reserve pit and pond plots. These plots attracted more shorebirds than did other plots; Semipalmated Sandpiper was the most commonly observed species on the reserve pit, and Red-necked Phalarope was the most commonly observed species on the pond (Table 11). In addition, 2 gull species were observed at the pond. The numbers of species per observation period were lowest on the gravel and tundra plots.

Table 11. Relative abundances of bird species (percent of total) on individual study plots and on all study plots combined at Term Well C, Prudhoe Bay, Alaska, 1990.

	Study Plot					
Species	Gravel	Reserve Pit	Berm	Tundra	Pond	All Plots
Lapland Longspur	97	15	93	64		52
Semipalmated Sandpiper		72	1		18	24
Red-necked Phalarope		8			58	14
Pectoral Sandpiper		2	4		11	4
Redpoll	3		3	14		2
Stilt Sandpiper		3			1	1
Glaucous Gull					5	1
Sabine's Gull					5	1
Willow Ptarmigan				14		<1
Black-bellied Plover					2	<1
Baird's Sandpiper		1				<1
Parasitic Jaeger				7		<1

The pond and the reserve pit also had the highest numbers of species during the entire study period (Fig. 2c), with 6 and 7, respectively. The berm and tundra plots each had 4 species, and 2 species were observed on the gravel plot.

Species diversity (Shannon's index) was greatest on the pond and slightly lower on the tundra and reserve pit (Fig. 2c). Although the number of species on the berm was equal to that on the tundra, the diversity index was lower on

the berm because of the disproportionate abundance of longspurs (Table 11). The diversity index was low on the gravel plot for the same reason.

Bird behaviors did not occur in the same proportions on each plot at Term Well C. Most of the observations of Lapland Longspurs around the edges of the reserve pit and on the berm were of birds feeding (Fig. 3a). On the gravel plot, longspurs tended to gather near the well head, and most observations there were of birds resting/preening. On the tundra plot, we were able to detect the presence of birds, but their behavior was often concealed by vegetation. This accounts for the high percentage of "other" behavior. No longspurs were observed at the pond plot. Longspurs represented 52 percent of the total number observations of all species on all plots combined (Table 11).

Feeding was the most frequently observed behavior on the reserve pit and pond plots of birds other than longspurs (Fig. 3b). These other species were predominantly Semipalmated Sandpipers and Red-necked Phalaropes (Table 11). Numbers of observations of non-longspurs were low on the gravel, berm, and tundra plots.

Storage Pad

At this site, the mean numbers of observations per 2.5-hr period were almost identical for all three plots (Fig. 4a). The mean number of species per 2.5-hr period was highest on the "wet" thermokarsted gravel plot and lowest on the "dry" thermokarsted gravel plot, but differences were small. (Because all plots were the same size, no adjustment to level of use was necessary.)

For the entire study period, species richness ranged from 6 in the "wet" thermokarst to 4 on the "dry" thermokarst; 5 species occurred on the tundra plot (Fig. 4b). The species diversity index was low on all plots due to the high percentage of longspurs (Table 12).

There was little difference in types of bird behaviors on the study plots at Storage Pad. For Lapland Longspurs, feeding was the most common behavior on all plots (Fig. 5a). Much of the "other" behavior in each plot was the result of birds whose presence was detected but whose behavior was concealed by thermokarst troughs or vegetation. Longspurs represented 92 percent of the total number of observations on all plots combined (Table 12).

For bird species other than longspurs, feeding was observed more often on the gravel pad plots than on the tundra plot (Fig. 5b). However, this apparent difference may not be meaningful because numbers of observations were low.

Term Well C

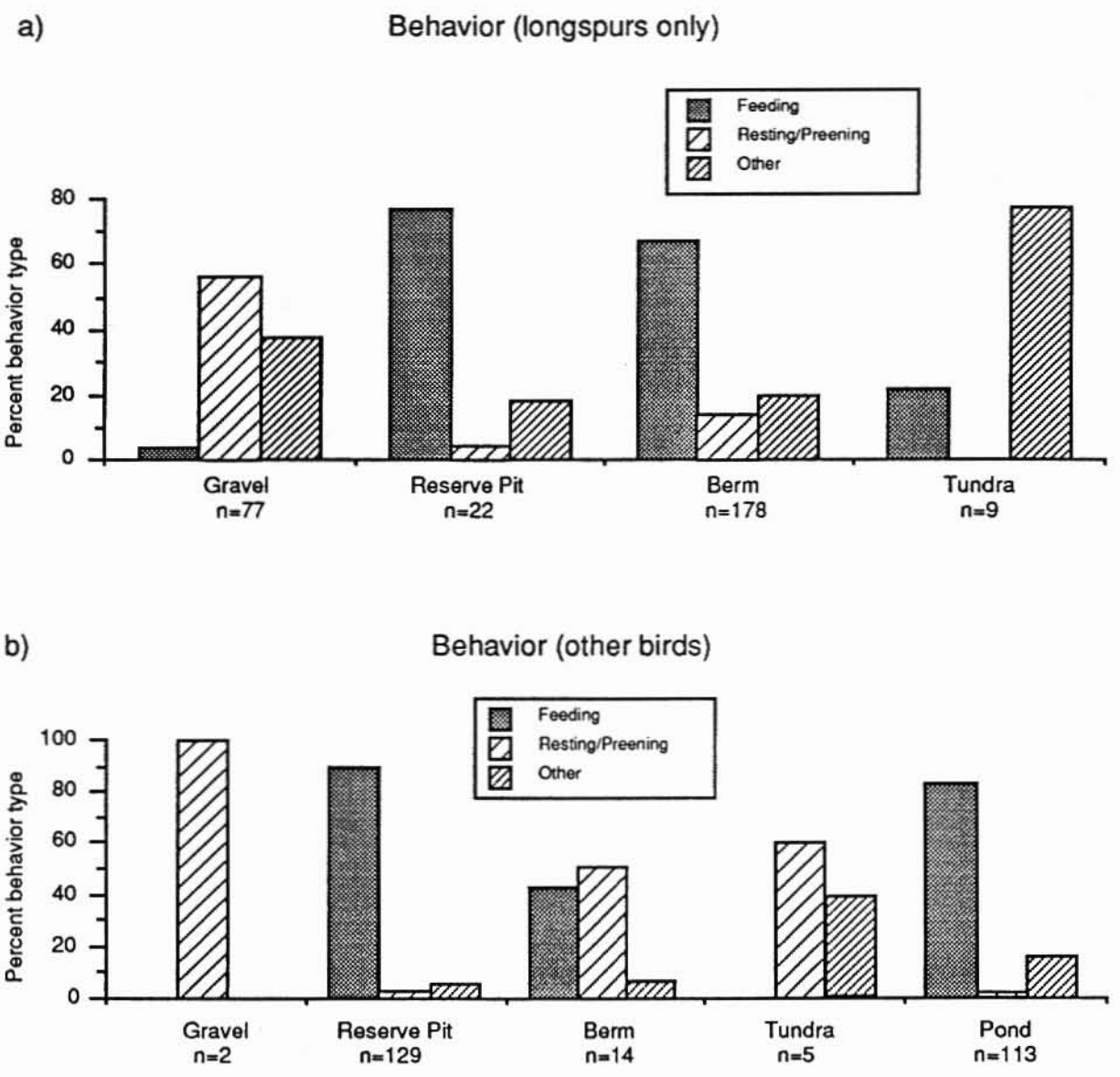


Fig. 3. Proportions of behavior for Lapland Longspurs (a), and for all other bird species (b) on study plots at Term Well C, Prudhoe Bay, Alaska, 1990. (n is the total number of observations.) The gravel, reserve pit, and berm plots represent disturbed habitats; the tundra and pond plots are undisturbed habitats.

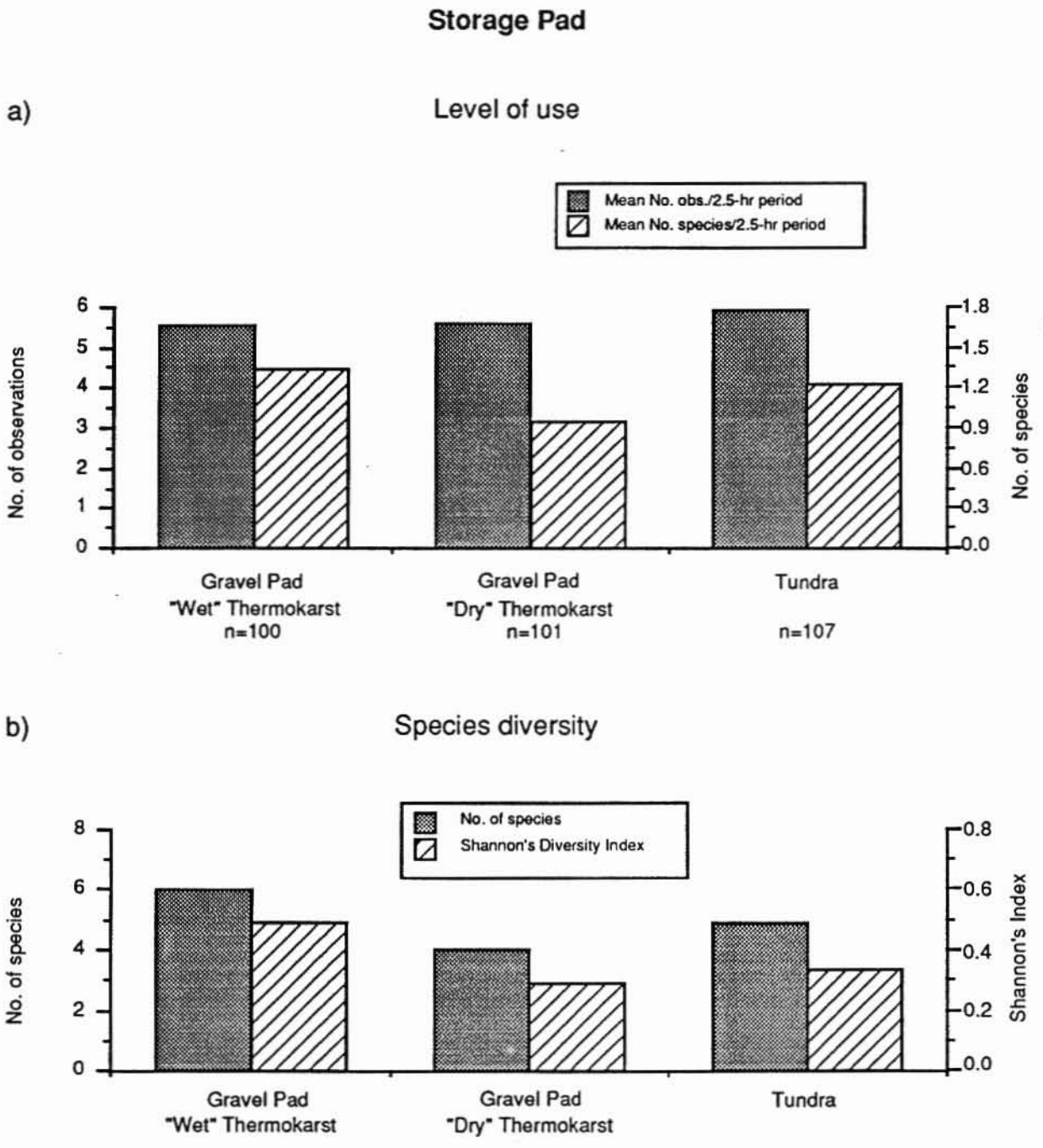


Fig. 4. Level of bird use (a), and species diversity (b) on study plots at Storage Pad, Prudhoe Bay, Alaska, 1990. "Wet" and "dry" thermokarst are gravel pad plots. In (a), n is the total number of observations.

Storage Pad

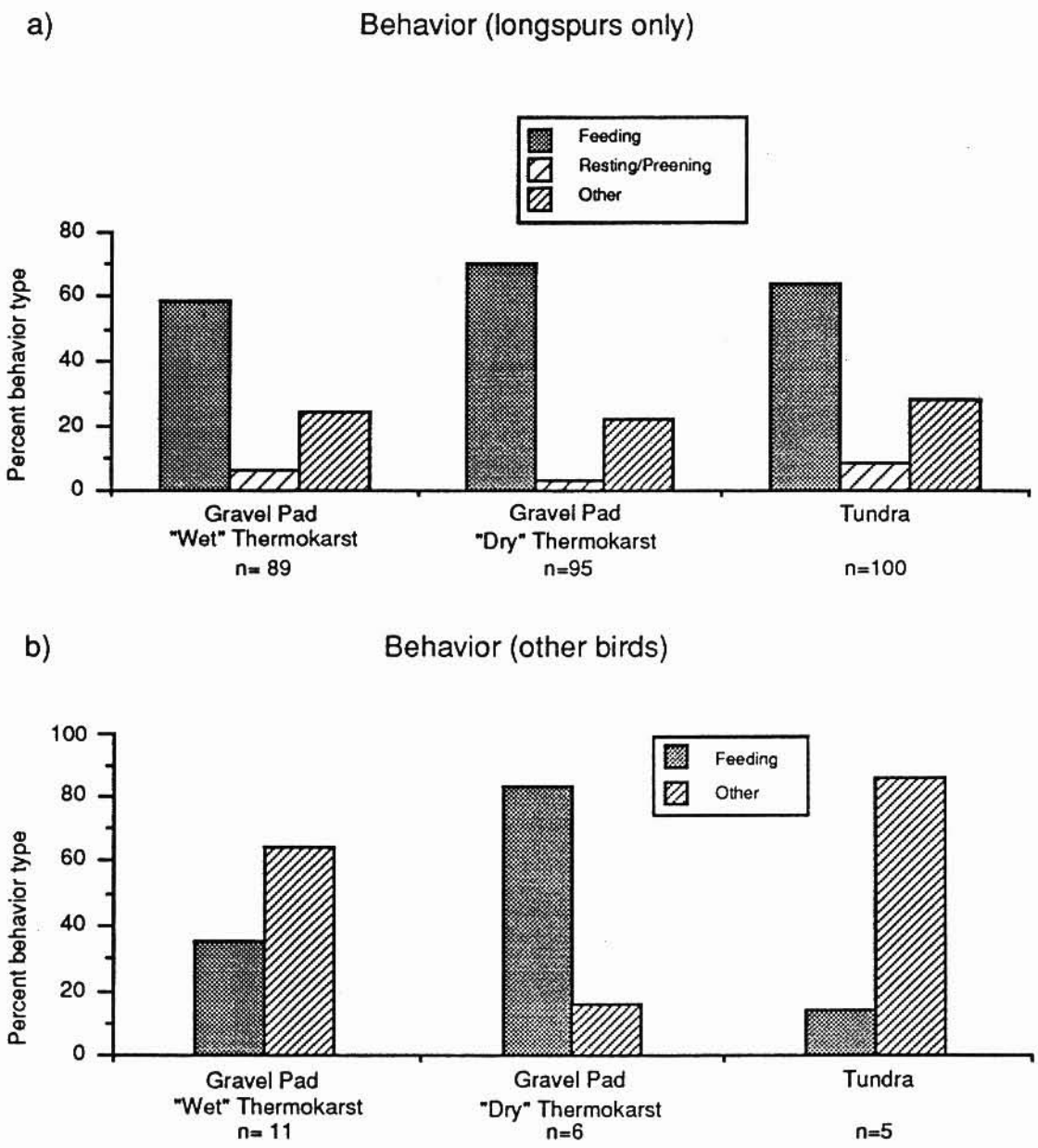


Fig. 5. Proportions of behavior for Lapland Longspurs (a), and for all other bird species (b) on study plots at Storage Pad, Prudhoe Bay, Alaska, 1990. (n is the total number of observations.)

Table 12. Relative abundances of bird species (percent of total) on individual study plots and on all study plots combined at Storage Pad, Prudhoe Bay, Alaska, 1990.

Species	Study Plot			
	"Wet" Thermokarst	"Dry" Thermokarst	Tundra	All Plots
Lapland Longspur	89	95	93	92
Snow Bunting	6	1		2
Common Raven	1	4		2
Semipalmated Sandpiper	2	1		1
Pectoral Sandpiper	1		3	1
Red-necked Phalarope	1		1	1
Parasitic Jaeger	1		2	1
Buff-breasted Sandpiper			1	<1

Delta State 2

The mean numbers of observations and species per 2.5-hr period were highest by far in the reserve pit (Fig. 6a). The tundra plot was slightly higher than the gravel plot with respect to both numbers of observations and species per period. (Because all plots were the same size, no adjustment to level of use was necessary.)

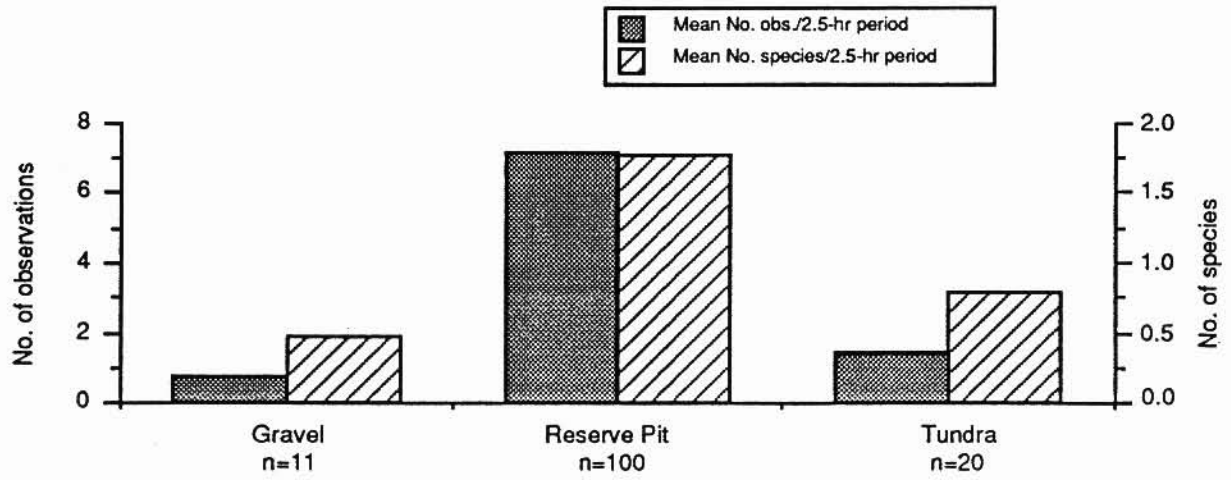
During the entire study period, we recorded 6 species at the reserve pit, 3 on tundra, and 2 on gravel (Fig. 6b). Individuals using the reserve pit were primarily shorebirds (mainly Semipalmated Sandpiper), but longspurs were also observed around the edges of the pit (Table 13). The species diversity index was also greatest in the reserve pit and lowest on the gravel plot.

For Lapland Longspurs, feeding was the most commonly observed behavior on the gravel plot (Fig. 7a). On the reserve pit, longspur behavior was varied; "other" behavior was primarily of birds walking on gravel near the edge of the water. On tundra, the high proportion of "other" behavior resulted when birds known to be present could not be observed well enough to determine behavior. Longspurs represented 34 percent of the total number of observations for all plots combined (Table 13).

For birds other than longspurs, most were observed on the reserve pit where the predominant behavior was feeding (Fig. 7b). Numbers of observations on the gravel and tundra plots were low.

Delta State 2

a) Level of use



b) Species diversity

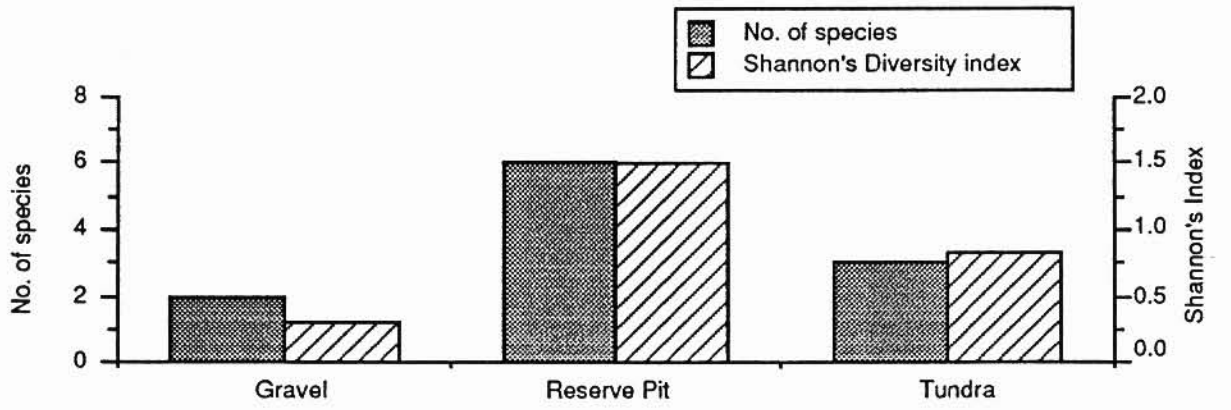


Fig. 6. Level of use (a), and species diversity (b) on study plots at Delta State 2, Prudhoe Bay, Alaska, 1990. (n is the total number of observations.)

Delta State 2

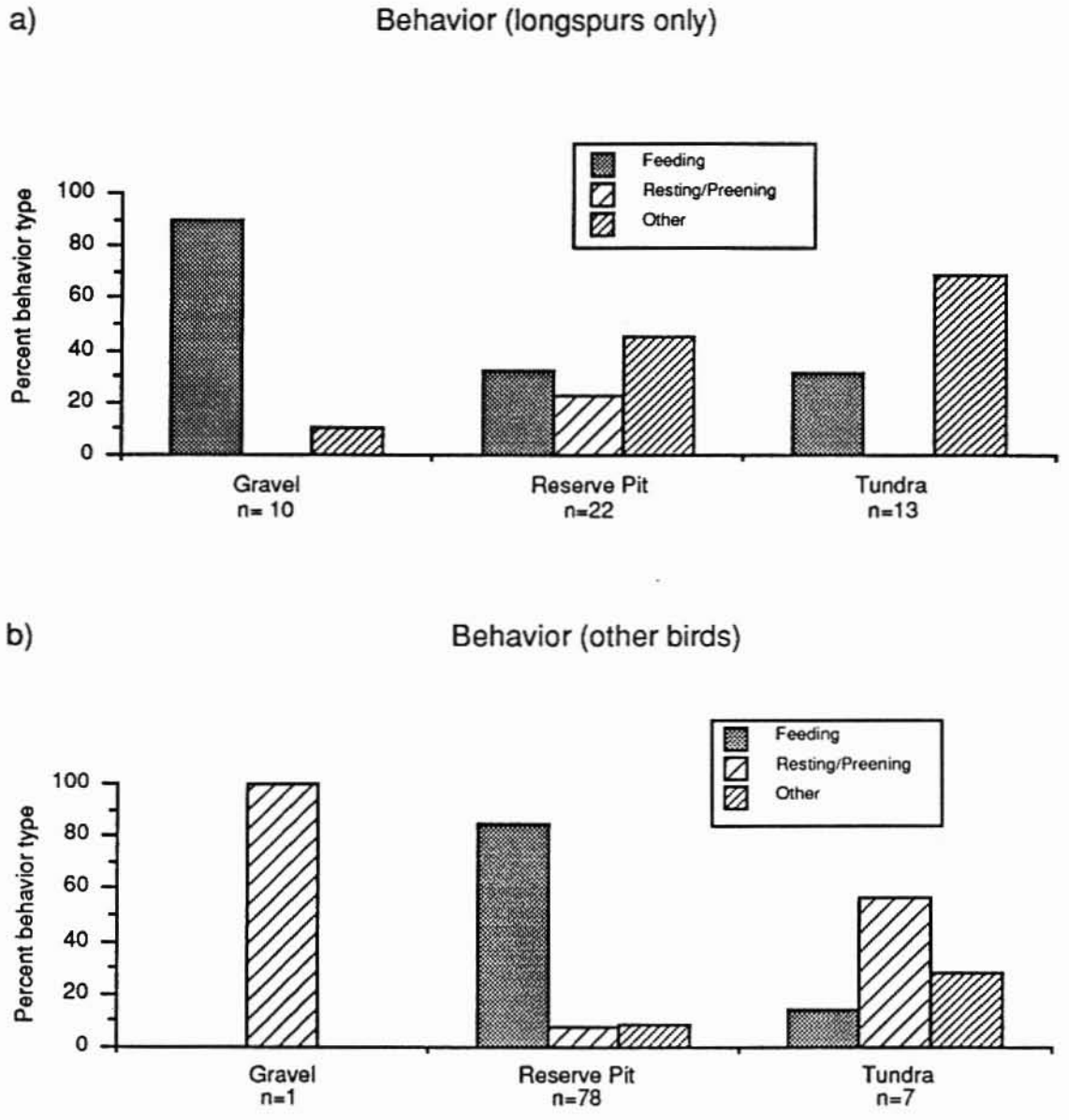


Fig. 7. Proportions of behavior types for Lapland Longspurs (a), and for all other bird species (b) on study plots at Delta State 2, Prudhoe Bay, Alaska, 1990. (n is the total number of observations.)

Table 13. Relative abundances of bird species (percent of total) on individual study plots and on all study plots combined at Delta State 2, Prudhoe Bay, Alaska, 1990.

Species	Study Plot			
	Gravel	Reserve Pit	Tundra	All Plots
Semipalmated Sandpiper		42		35
Lapland Longspur	91	22	65	29
Red-necked Phalarope		17		14
Baird's Sandpiper		11		9
Pectoral Sandpiper		5	25	8
Ruddy Turnstone		3		2
Parasitic Jaeger	9		10	2

Lake State 1 (A)

The mean number of observations per 2.5-hr period was highest on the gravel spray plot and lowest on the tundra plot (Fig. 8a). The unseeded gravel plot and the "road" plot each had fairly high use; the level of use at the seeded gravel plot was about half that of these plots. The mean numbers of species observed per period followed a similar trend—the gravel spray and the tundra had the highest and lowest counts, respectively.

When level of used was adjusted to the size of the smallest plot (the "road", Table 10), the "road" and gravel spray plots had the highest numbers of observations per period (Fig. 8b). The levels of use on the seeded, unseeded, and tundra plots each were reduced by about 65 percent.

Species richness was highest on the gravel spray (11 species) (Fig. 8c). A greater diversity of shorebirds was observed on this plot than on others (Table 14). Richness on other plots ranged from 3 to 5 species. The species diversity index was greatest on the gravel spray and lowest on the seeded and "road" plots. The low diversity index values for the seeded and "road" plots were due to the high proportion of longspurs (Table 14). Diversity on the tundra plot was slightly higher than on the seeded and "road" plots, but it too was quite low because of the disproportionate number of longspurs.

For Lapland Longspurs, feeding was the dominant behavior observed on all plots except tundra (Fig. 9a). The high percentage of "other" behavior on tundra reflects our inability to observe behaviors in dense vegetation. For birds other than longspurs, behavior followed a similar trend (Fig. 9b), although numbers of

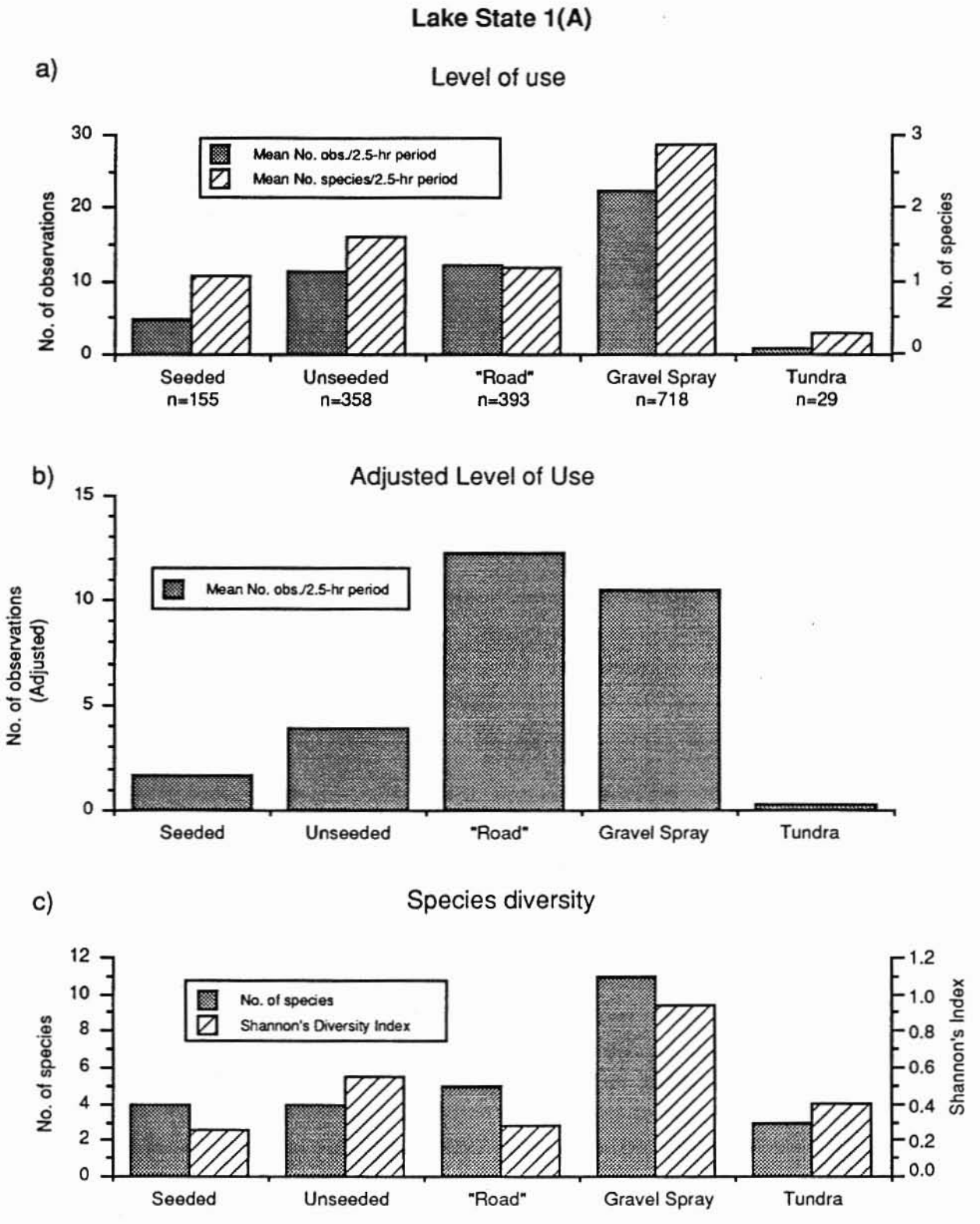


Fig. 8. Levels of bird use (a), levels of use adjusted to standard plot size (b), and species diversity (c) on study plots at Lake State 1(A), Prudhoe Bay Alaska, 1990. In (a), n is the total number of observations. The seeded, unseeded, "road", and gravel spray plots represent disturbed habitats; the tundra plot is undisturbed habitat.

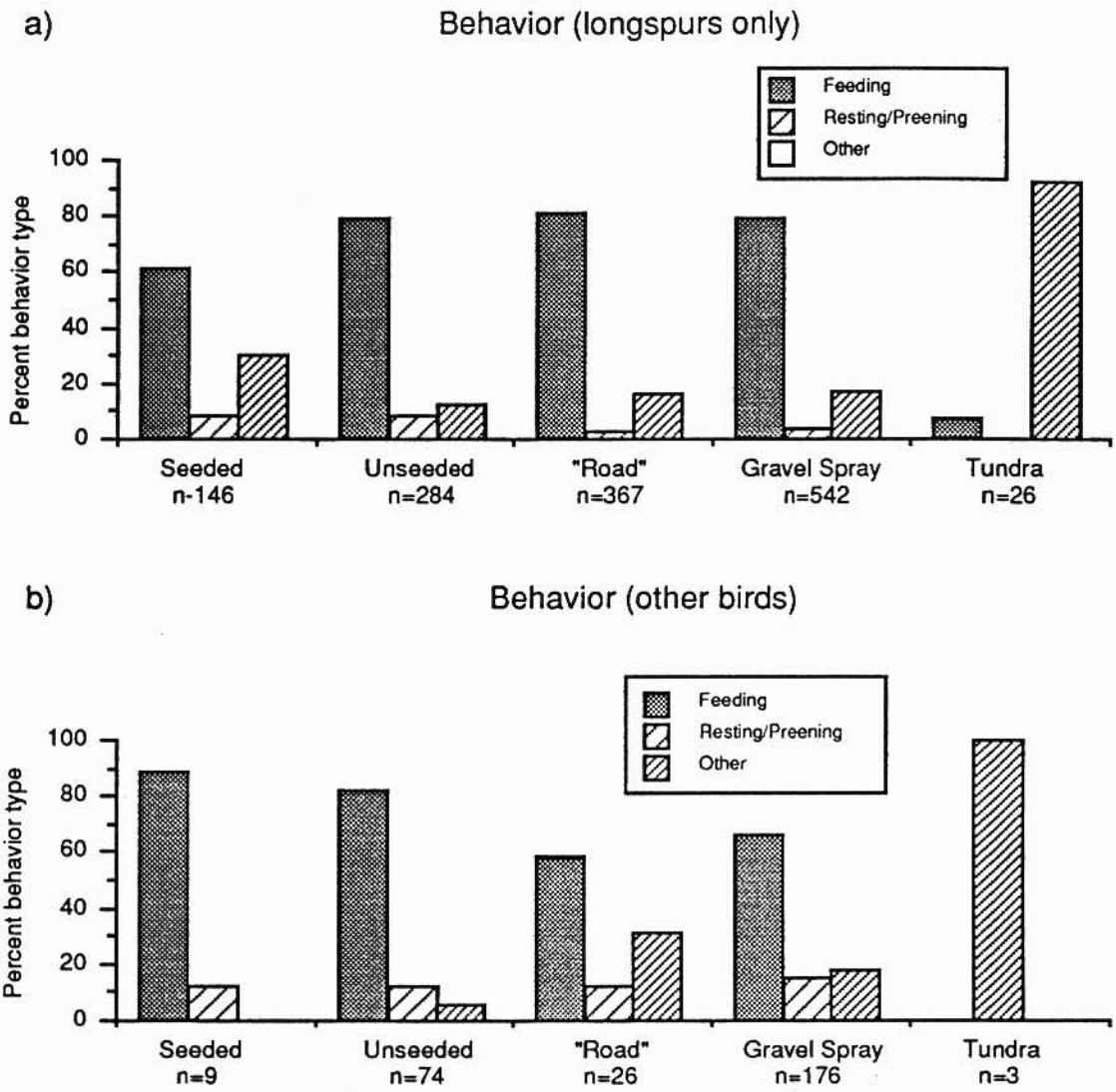


Fig. 9. Proportions of behavior types for Lapland Longspurs (a), and for all other bird species (b) on study plots at Lake State 1 (A), Prudhoe Bay, Alaska, 1990. (n is the total number of observations.) The seeded, unseeded, "road", and gravel spray plots represent disturbed habitats; the tundra plot is undisturbed habitat.

observations were particularly low on the tundra and seeded plots. Longspurs represented 83 percent of the total number of observations on all plots combined (Table 14).

Table 14. Relative abundances of bird species (percent of total) on individual study plots and on all study plots combined at Lake State 1(A), Prudhoe Bay, Alaska, 1990.

	Study Plot					
Species	Seeded	Unseeded	"Road"	Gravel Spray	Tundra	All Plots
Lapland Longspur	94	79	93	75	90	83
Snow Bunting	4	20	5	4		8
Semipalmated Sandpiper	1		<1	10		4
Pectoral Sandpiper		1	1	7	7	3
Red-necked Phalarope			<1	3		1
Greater White-fronted Goose	1					<1
Northern Pintail				<1		<1
White-rumped Sandpiper				<1		<1
Dunlin				<1		<1
Buff-breasted Sandpiper				<1		<1
Parasitic Jaeger		<1		<1	3	<1
Yellow Wagtail				<1		<1

Lake State 1 (B)

The mean numbers of observations per 2.5-hr period were much greater on the unseeded gravel and impoundment plots than on the seeded gravel and tundra plots (Fig. 10a). The mean number of species observed per period was greatest on the impoundment and lowest on the tundra. When the level of use was adjusted to size of the smallest plot (seeded and unseeded, Table 10), the numbers of observations per period on the impoundment and tundra plots dropped substantially (Fig. 10b).

Species richness was greatest at the impoundment (12 species) (Fig. 10c), mainly because shorebirds used that plot but not others (Table 15). Richness on the other plots ranged from 2 to 3 species. Likewise, the species diversity index was much greater at the impoundment and was much lower on the other plots.

For Lapland Longspurs, feeding was the primary behavior observed at all plots except tundra (Fig. 11a). The high percentage of "other" behavior on the tundra reflects our inability to discern behavior types in vegetation. For birds other than longspurs, behavior followed a similar trend (Fig. 11b), although

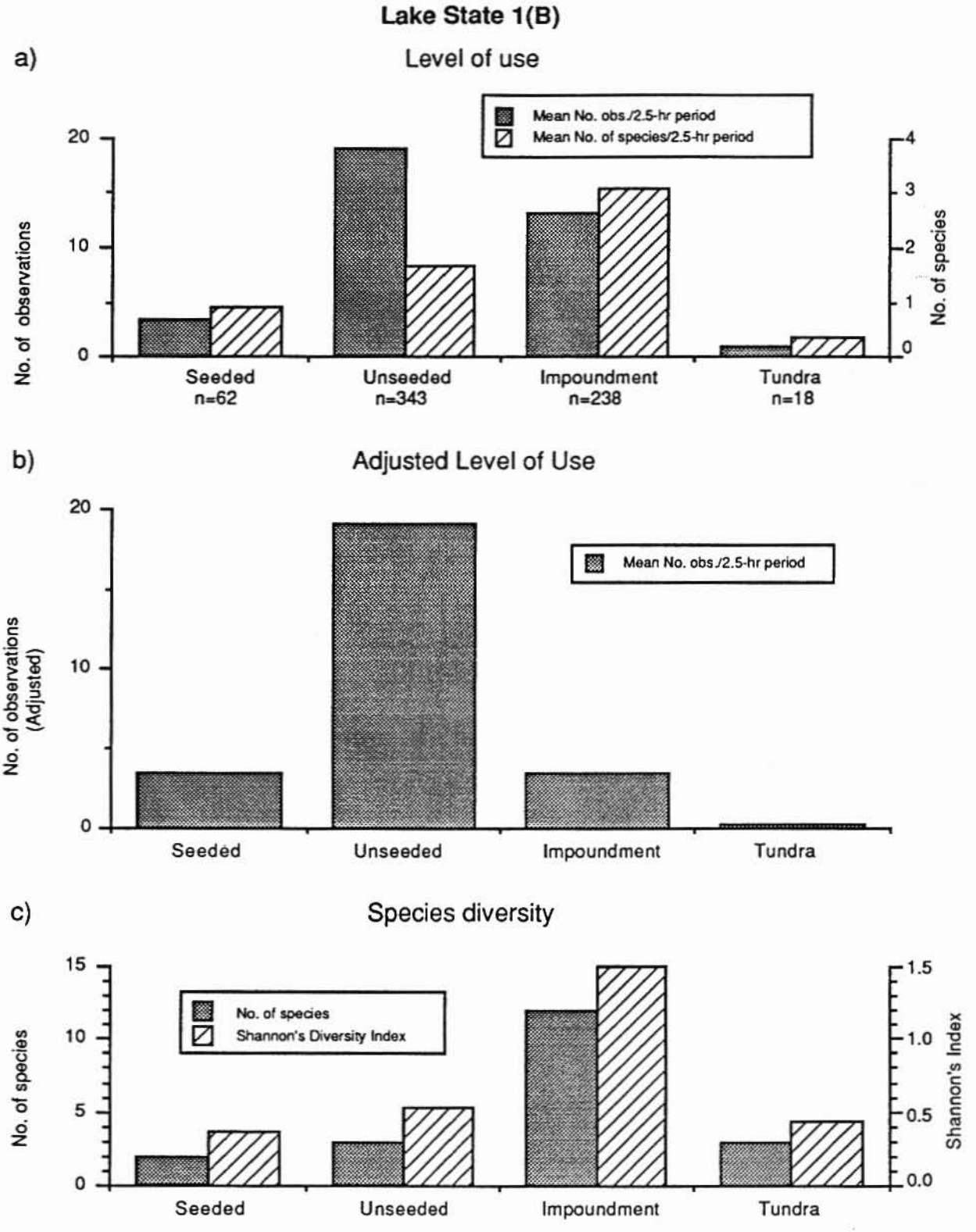


Fig.10. Levels of bird use (a), levels of use adjusted to standard plot size (b), and species diversity (c) on study plots at Lake State 1(B), Prudhoe Bay, Alaska, 1990. In (a), n is the total number of observations. The seeded, unseeded, and impoundment plots represent disturbed habitats; the tundra plot is undisturbed habitat.

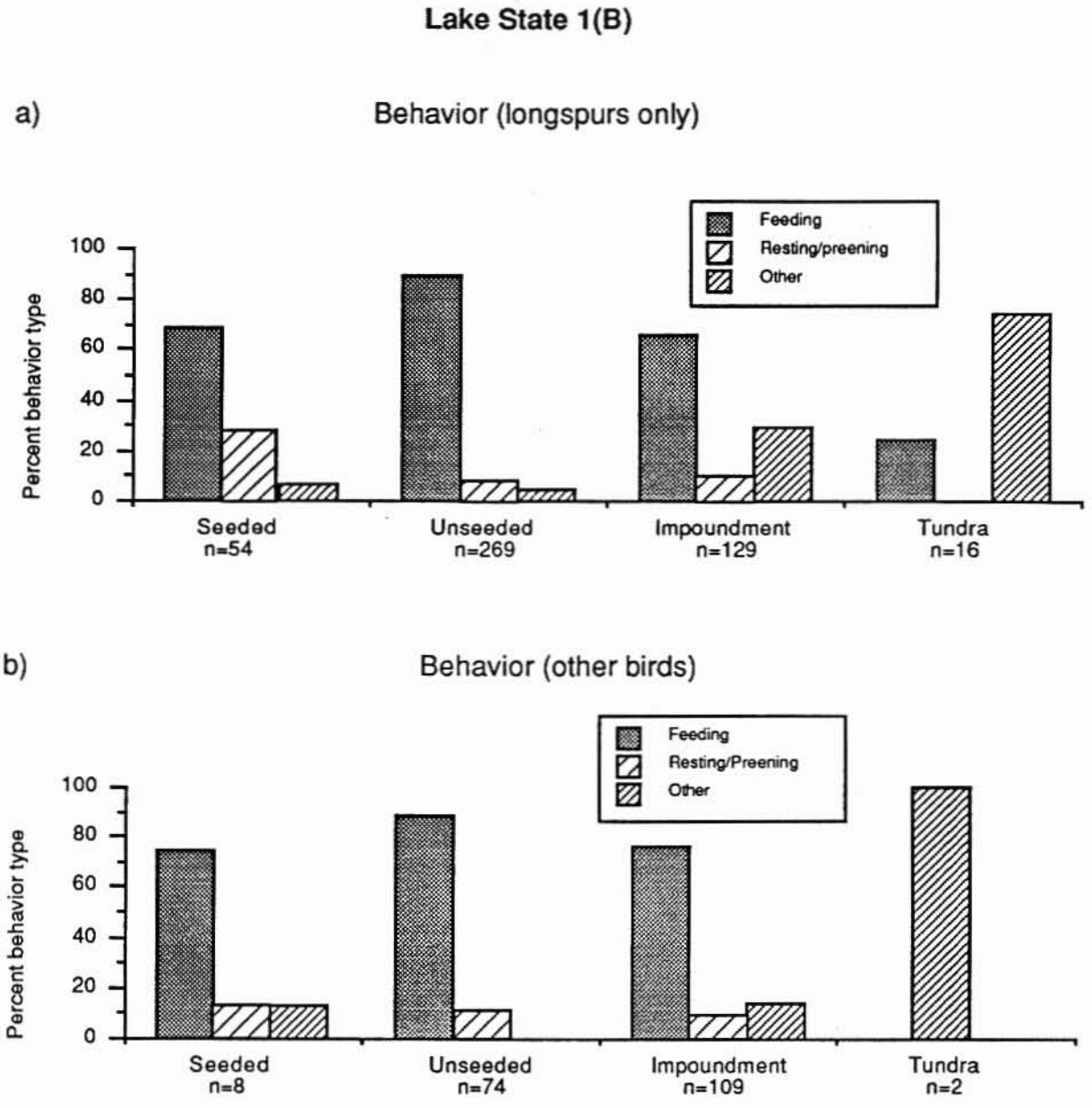


Fig. 11. Proportions of behavior types for Lapland Longspurs (a), and for all other bird species (b) on study plots at Lake State 1 (B), Prudhoe Bay, Alaska, 1990. (n is the total number of observations.) The seeded, unseeded, and impoundment plots represent disturbed habitats; the tundra plot is undisturbed habitat.

numbers of observations were low on the tundra and seeded plots. Longspurs represented 71 percent of the total number of observations on all plots combined (Table 15).

Table 15. Relative abundances of bird species (percent of total) on individual study plots and on all study plots combined at Lake State 1(B), Prudhoe Bay, Alaska, 1990.

Species	Study Plot				
	Seeded	Unseeded	Impoundment	Tundra	All Plots
Lapland Longspur	87	78	54	89	71
Snow Bunting	13	21	1	6	13
Pectoral Sandpiper			20	6	7
Semipalmated Sandpiper		1	8		3
Long-billed Dowitcher			8		3
Dunlin			3		1
Northern Pintail			1		<1
Lesser Golden Plover			1		<1
White-rumped Sandpiper			<1		<1
Red-necked Phalarope			1		<1
Parasitic Jaeger			<1		<1
Yellow Wagtail			1		<1

Discussion

Invariably, the microhabitat characteristics of the landscape on and near abandoned gravel pads affected the levels of use, species diversity, and behaviors we observed on them.

Level of Use

Among the plots that had no water, average levels of bird use (observations per time period) generally were higher on gravel than on natural tundra. This was the case for the berm at Term Well C, which was a mixture of gravel and overburden, and for all plots at Lake State 1 (A and B). Only at Delta State 2 did the gravel plot have a lower level of use than the tundra plot, though at Term Well C the large among-day variability lowered our confidence that the sample represented reality.

Pollard et al. (1990) observed larger numbers of Lapland Longspurs on vegetated gravel pads than on pads without appreciable vegetation, and differences in levels of use during the current study also appeared to be related partly to presence or absence of vegetation on gravel plots. Where vegetation was totally absent (as at Delta State 2 and the main gravel pad plot at Term Well C), level of use was low. Where vegetation was present (as on the berm at Term Well C and on all gravel plots at Lake State 1), level of use was higher.

The type of vegetation on a particular plot also appeared to affect the level of use. For instance, a variety of vegetation types was present on the plots at both Lake State 1 sites (A and B). Observations of birds were two to five times higher on plots that had natural plant colonization than on plots seeded with cultivars. This was true even in comparisons where colonizing plant species were very sparsely distributed [e.g., on the unseeded plot at Lake State 1(A)] and where cultivars formed a dense vegetative cover (e.g., the seeded plot). (See Jorgenson et al. 1990 for a quantitative description of the vegetated gravel at the Lake State 1 site.) The gravel spray plot at Lake State 1(A) and the unseeded plot at Lake State 1(B) both had abundant colonizers and higher levels of use than other plots. The reason for this apparent preference by birds (especially longspurs) for plots with colonizing vegetation rather than cultivars is unclear, but it may be related to relative differences in seed productivity, quality, or accessibility.

The Storage Pad site was unique in that the level of use of the tundra plot was as high as that of gravel plots. This high level of use may have been related to the geobotanical character of the tundra plot. The undisturbed plots at all other sites were composed of moist and wet graminoid tundra on non-patterned ground or strangmoor. The tundra plot at Storage Pad was an upland habitat type composed primarily of high-centered polygons. Custer and Pitelka (1977) found that an extensive complex of high-centered polygons represented optimal habitat for longspurs at Barrow. Over 90 percent of the birds observed at Storage Pad plots were longspurs. Thus, if the tundra plot represented optimal tundra habitat type for longspurs, a higher level of use would have been expected there.

Plots with some water present usually had relatively high levels of use. At Term Well C, only the berm had more use than the reserve pit and the pond, and the impoundment at Lake State 1(B) was surpassed in level of use only by the unseeded gravel plot. At Delta State 2, the reserve pit had the highest level of use. Although water was not a predominant feature of the gravel spray plot at

Lake State 1(A), the presence of small thermokarst pools on the plot seemed to attract birds, and this plot had a higher level of use than other plots at this site.

Adjusted Level of Use

When levels of use were adjusted to account for differences in plot sizes, overall trends were similar but between-plot differences were often accentuated. For example, the berm at Term Well C had a high observed level of use and a small size, thus the adjusted level of use exacerbated the difference between it and the other plots there. The same was true for the "road" plot at Lake State 1(A). At Lake State 1(B) the adjusted level of use of the impoundment relative to the other plots dropped dramatically because of the high level of use and small size of the unseeded plot.

We suspect that differences in levels of use among various plots were related partly to the relative sizes of the microhabitat "patches" on which the plots were located. That is, one would expect birds to concentrate themselves more in cases where a habitat that offered unique resources was relatively small. This concept is discussed further in the following section on behavior.

Species Diversity

Species diversity (Shannon's index) and species richness were always highest on plots with water. The reserve pit and the pond at Term Well C each had higher species diversity than did the gravel and the berm. Diversity indices at the reserve pit at Delta State 2 and at the impoundment at Lake State 1(B) were both higher than at other plots at those sites. At the gravel spray plot at Lake State 1(A), the general habitat type was not aquatic, but small thermokarst pools were present and species diversity was high. Where water was present, use of study plots by shorebirds, gulls, and waterfowl caused higher species diversity indices and species richness; where water was not present, Lapland Longspur was always the most common species and often accounted for more than 90% of the observations.

Behavior

Because we did not begin the observational study until after most nesting had been completed, we did not expect to find breeding-related behaviors such as displaying or incubating. Of the few nests that were still active, none were located on our observational plots. Most young birds had fledged by this time, and activities of adults and young were oriented toward preparation for

migration. Feeding was the most consistently observed behavior on the majority of study plots at all sites.

Plots where feeding was not the most consistently observed behavior were the gravel plot at Term Well C, and all of the tundra plots except at Storage Pad. It is probable that the predominant behavior of birds on tundra also was feeding, but our ability to discern bird behavior was hampered by the vegetation. On the tundra plot at Storage Pad, we were able to detect behavior, and most of the behavior observed there was feeding. The predominant behavior of the birds on the gravel plot at Term Well C was resting/preening; most of this occurred in the area around the well head where elevated perches were available.

Most of the observations we classified as feeding were of birds pecking at the surface of the gravel, and an alternative interpretation of these observations might be that birds were simply picking up grit. However, if high levels of use on gravel plots solely were the result of birds picking up grit, vegetated and unvegetated gravel plots should have had relatively equal use levels—during the current study, they did not. Thus if birds did use gravel pads as a source of grit, that use was probably secondary to feeding.

Most of the birds observed at gravel sites were Lapland Longspurs. If their predominant behavior was feeding, the question arises: what were they eating? Custer and Pitelka (1978), analyzed longspur stomach samples and found that diets at Barrow consisted primarily of insects, but that seeds composed up to 70 percent of their diet early in the season (late May), and 24 to 30 percent late in the season (August). These birds were collected within 10 km of the Naval Arctic Research Laboratory at Barrow and presumably were feeding on tundra habitats, although this is not clear. Seastedt (1980) found that adult longspurs fed nestlings various combinations of adult and larval insects at Barrow and at the Yukon-Kuskokwim Delta. He was not able to study diet after birds were capable of flight.

Because no birds were collected during this study, we have no stomach sample data with which to determine the exact diet composition for longspurs feeding at gravel sites. As mentioned earlier, most of our feeding observations were of birds pecking at the surface of the gravel; it was usually impossible to determine what they were eating or how successful they were. However, on occasion longspurs were observed eating seeds of plant species such as *Eriophorum* spp., *Sagina intermedia, Minuartia rubella, Saxifraga hirculus*, and *Dryas integrifolia.* Pollard et al. (1990) also observed longspurs feeding

on seeds of plant species growing on gravel pads, notably *Draba* spp., *Braya purpurascens*, and *Cochlearia officinalis*.

Although insects formed the bulk of the diet of longspurs in the studies by Custer and Pitelka (1978) and Seastedt (1980), it seems unlikely that longspurs were feeding on insects at gravel sites in our study. Densities of insects generally are much higher on tundra habitats than on gravel pads (pers. obs.), and it is more likely that the many forb species, which are prolific seed producers and common colonizers of gravel sites (Robus et al. 1986; Jorgenson 1988, 1989; Pollard et al. 1990), attracted longspurs to gravel because of the abundance of seeds at some of these sites.

Arctic tundra is composed of patches of different habitat types (Holmes 1970, Pitelka et al. 1974). Bird populations, including longspurs, are widely dispersed over these patches which provide them with their normal food and cover requirements. In this context, the gravel pads in this study can be considered to be patches of disturbed habitat surrounded by a mosiac of tundra habitat patches.

It has been proposed that habitat selection (or patch choice, in this case) falls within the realm of optimal foraging theory (Rosenzweig 1985). According to this theory, natural selection should favor a forager which behaves "optimally" by making dietary or patch choices that minimize the individual's cost:benefit ratio in terms of time and/or energy (Emlen 1966, MacArthur and Pianka 1966, Pyke 1984).

Some abandoned gravel pads may provide longspurs with habitat patches which are optimal for feeding, at least after the breeding season when seeds become more important in longspur diet. Seastedt and MacLean (1979), while studying longspurs on breeding territories at Barrow, felt that food density, rather than total quantity of food, was more important to the birds. Thus, longspurs may be attracted to those abandoned gravel pads where concentrations of seed-producing forbs enable them to obtain food at the least cost. Preferred forage also may be more visible on gravel than on tundra, and thus more accessible.

Conclusions

Data from the post-breeding observational study have increased our understanding of how and why birds use abandoned gravel fill. Some bird species (especially Lapland Longspur) are attracted to abandoned gravel pads during the post-breeding season. During the post-breeding period, these birds often are concentrated at abandoned gravel sites in higher densities than on nearby undisturbed tundra habitats.

Most of the birds attracted to abandoned gravel pads during this study were Lapland Longspurs, and one reason for the high level of use by longspurs of some pads probably is related to the vegetation found there. Where native forb species have naturally colonized abandoned gravel sites, levels of bird use often were high; this was true even where colonizing plants were distributed sparsely. Where pads were unvegetated or seeded with cultivated grass species, we observed little bird use. The most consistently observed behavior of longspurs on vegetated gravel sites was feeding. We suspect that they were feeding on the seeds of colonizing forb species, many of which are prolific seed producers.

Levels and types of bird use of abandoned gravel pads also are related to the presence or absence of standing water on pads. Where impounded water such as reserve pits or thermokarst pools were present at gravel sites, shorebirds (and sometimes waterfowl) were attracted, and their behavior primarily was feeding. Consequently, microhabitats with water had relatively high levels of use and always had higher species richness and species diversity than did dry gravel microhabitats.

These findings will be useful to managers beginning to consider wildlife-oriented goals for abandoned-site rehabilitation. Vegetating abandoned gravel pads (or portions of them) with native forb species probably would encourage high levels of use by bird species such as Lapland Longspur that use seeds as part of their diet. Creating ponds and pools with mud shorelines on or near abandoned gravel pads probably would increase the utility of rehabilitated sites to shorebirds and waterfowl and would result in greater species diversity than would occur in the absence of water.

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Appendix A

Nesting Study Site Descriptions

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Introduction

In this section we provide detailed descriptions of all sites which were part of the nesting study. Each site includes a disturbed and an undisturbed study plot. Included are verbal descriptions of the biophysical features of the plots (including areas of disturbance) and a summary of nesting results. Also included in these descriptions are site maps which show gravel distribution and other disturbances. Vegetation and landform types are depicted on the site maps as sets of numbers; the top number refers to the vegetation type, and the bottom number to the surface form. In addition, each nest found during the study is located on the site maps, and its outcome (successful or not successful) is indicated.

A list of bird and mammal species recorded during the two parts of this study (nesting and post-breeding use) can be found in Appendix C.

Vegetation type and landform descriptions (Appendix D) use terminology after Walker et al. (1983). Other potentially unfamiliar terms used in these descriptions include the following:

- Thermokarst - surface subsidence caused by increased depth of subsurface thaw
- Pad - the usually-raised gravel substrate from which drilling operations took place
- Reserve Pit - the sump where drilling muds and fluids were discharged during drilling. Berms surrounding these and the flare pits (below) are gravel and/or overburden
- Flare Pit - the sump within which any natural gas that escaped to the surface during drilling was burned off
- Forb - broad-leaved, herbaceous plant
- Overburden - soil, often highly organic, removed from the tundra surface and heaped into mounds or berms during construction of pads and reserve pits
- Graminoids - grasslike plants, including grasses and sedges
- Gravel Spray - thin surface sheets or traces of gravel, usually occurring near margins of fill

Site 1: West Sak 17

Location and Access

West Sak 17 (Fig. A-1) is located in the Kuparuk Unit in Sec. 26, T13N, R9E approximately 1.6 km northeast of Drill Site 3K. There is no road access to the pad, but it can be seen from the gravel road to Mine Site E at a point about 1.6 km beyond the access road to Drill Site 3K. From there it is a short walk southeastward across tundra to the gravel pad.

Description: Disturbed Plot

The well was spudded on January 24, 1981, and suspended on March 4, 1981. The pad dimensions are approximately 115 m x 80 m, and the gravel thickness varies from about 1 to 2 m. A gravel ramp at the southwest corner of the pad tapers to the tundra level. No thermokarsting is evident on the pad except on the gravel ramp. A small area of disturbance including some gravel spray is located off the north edge of the pad. The well head is located on the east-central portion of the pad. A large-diameter section of culvert (the well collar) is buried vertically in the gravel surrounding the well head.

A reserve pit attached to the east side of the pad was filled with water and mud. A flare pit south of the pad also contained water and mud, as well as disturbed tundra and dense vegetation, some of which was emergent. Both pits are enclosed by gravel berms. The gravel, gravel spray, and the two pits cover approximately 26 percent of the disturbed plot.

The tundra surrounding the pad is composed primarily of moist and wet graminoids, with tussock tundra east of the pad. The landform generally shows little relief and is a mixture of low-relief high-centered polygons, many of which are poorly defined, and mixed high- and low-centered polygons. Strangmoor is present north of the pad. Tundra thermokarsting around the edges of the pad is also evident in some areas, particularly near the gravel ramp and around the pits. In addition to the water in the pits, a portion of a natural pond is present on the south side of the plot.

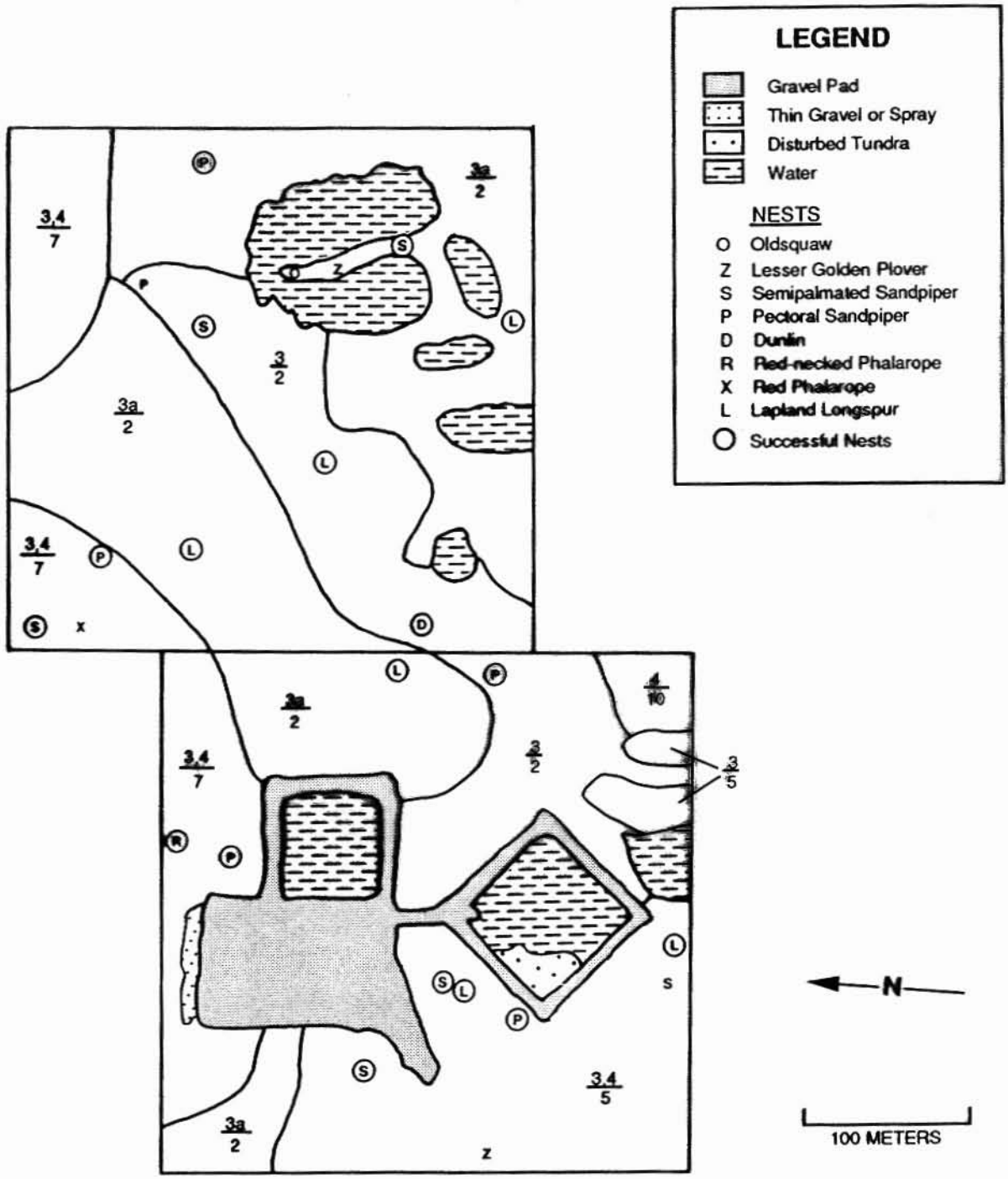


Fig. A-1. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, WS-17, Prudhoe Bay, Alaska, 1990.

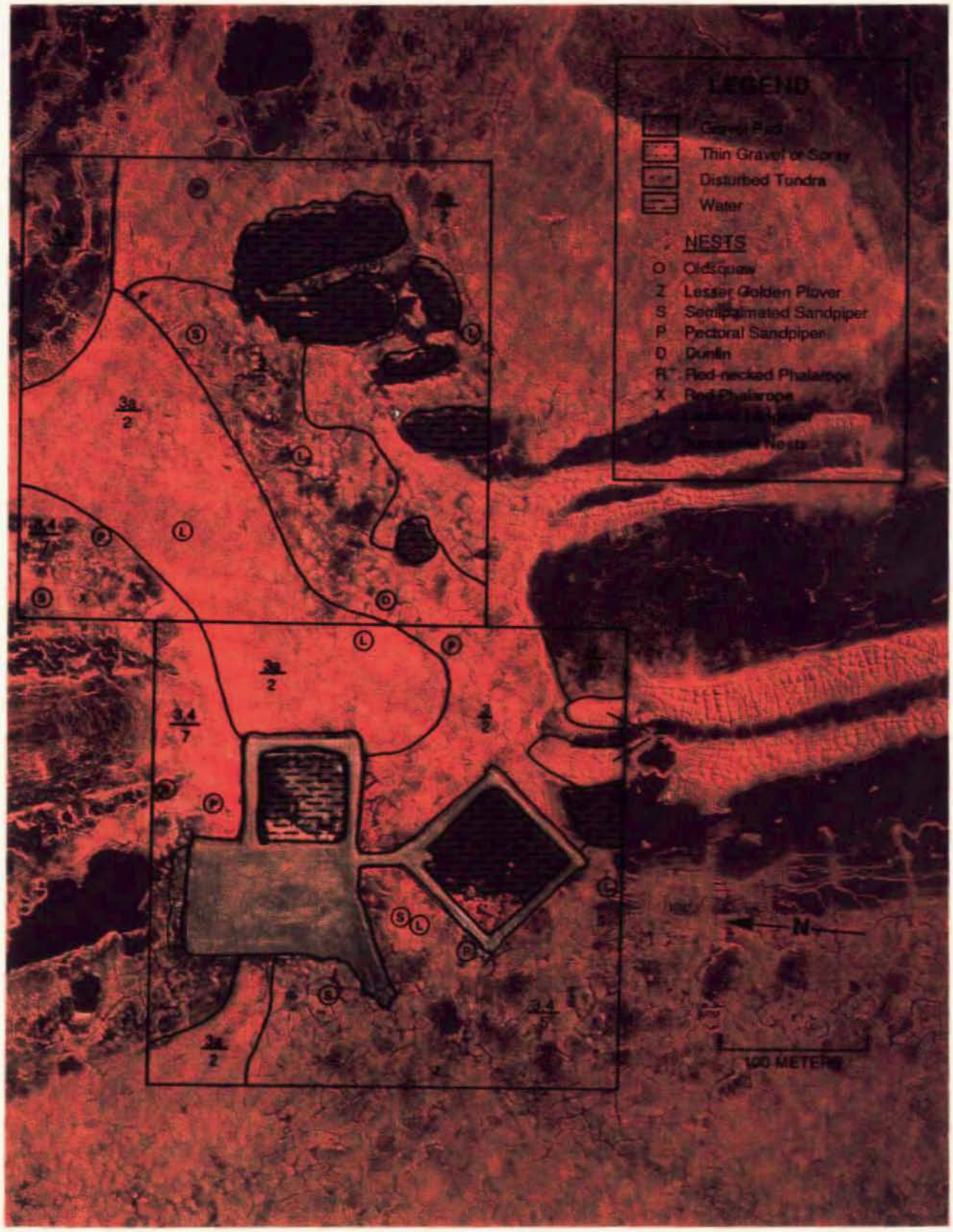


Fig. A-1. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, WS-17, Prudhoe Bay, Alaska, 1990.

Description: Undisturbed Plot

The undisturbed plot, located immediately northeast of the disturbed plot, is composed of moist and wet graminoids and moist tussock tundra. The landform is generally low-relief high-centered polygons, some of which are poorly defined. Moist and wet strangmoor is present on the north side of the plot. Ponds are located on the south and southeast portion of the plot.

Nesting

Seven species had 13 nests on the undisturbed plot, while 5 species had 11 nests on the disturbed plot (Table A-1). The percentage of successful nests was higher on the disturbed plot; both plots had 9 successful nests. Four species were successful in each plot. Primarily shorebirds and longspurs nested in both of the plots, although one Oldsquaw nested unsuccessfully in the undisturbed plot.

Seven of the 11 nests in the disturbed plot were located on tundra near the perimeter of the gravel pad (Fig. A-1.). Most nests seemed to be generally associated with areas where microrelief was most pronounced. This also appeared to be the case in the undisturbed plot.

Table A-1. Number of nests and nest success for bird species on disturbed and undisturbed study plots, WS-17, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Oldsquaw	0	1	1	0
Lesser Golden Plover	0	1	1	0
Semipalmated Sandpiper	3	0	3	100
Pectoral Sandpiper	2	1	3	67
Dunlin	1	0	1	100
Red Phalarope	0	1	1	0
Lapland Longspur	3	0	3	100
Total/Mean	9	4	13	69

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Lesser Golden Plover	0	1	1	0
Semipalmated Sandpiper	2	1	3	67
Pectoral Sandpiper	3	0	3	100
Red-necked Phalarope	1	0	1	100
Lapland Longspur	3	0	3	100
Total/Mean	9	2	11	82

Site 2: Ugnu 1

Location and Access

Ugnu 1 (Fig. A-2) is located in the Kuparuk Unit in Sec. 22, T12N, R9E, about 2.4 km south of CPF-3. There is no road access to the site. The best access is from the gravel road at a point about 1.6 km south of CPF-3. From there the site can be reached in about 20 min on foot.

Description: Disturbed Plot

The well was spudded on approximately February 1, 1969, and suspended on June 1, 1969. There was occasional drilling activity at the site until at least March 1978. A plug-and-abandon date of March 14, 1986 is on record.

Ugnu 1 is one of the most interesting of the nesting study sites in terms of microrelief and structural variety. The boundaries of this pad are not well defined because of the gradual gradation of pad edges into adjacent tundra. The dimensions of the main portion of the pad are approximately 90 m x 100 m. Small areas of thin gravel extend beyond this area on the north, south, and west sides of the pad. Nowhere is the gravel very thick; it is approximately 0.5 m in the thickest areas. This gravel site generally has smaller particle sizes and a higher percentage of sand and silt than do other sites in this study. Thermokarsting is well developed over the entire pad, forming deep troughs in some areas. The well head is located in the southeast portion of the pad and consists of a pipe embedded into the gravel. Debris in the area includes scattered pieces of wood and metal, small sections of pipe, electrical cord, and cement. Wood pilings about 0.5 m high are located on the eastern portion of the pad.

The site has been colonized extensively by many plant species; the vegetative cover is approximately 60 percent. *Carex aquatilis* and *Eriophorum* spp. are the primary colonizers in the wet areas around thermokarst troughs. Many grass and forb species are present on the drier areas. A detailed description of the vegetation is contained in Robus et al. (1986).

A large reserve pit to the east of the pad is filled with water. A mound of overburden east of the reserve pit is bisected by the plot boundary. The gravel disturbance, reserve pit, and overburden cover approximately 20 percent of the disturbed plot.

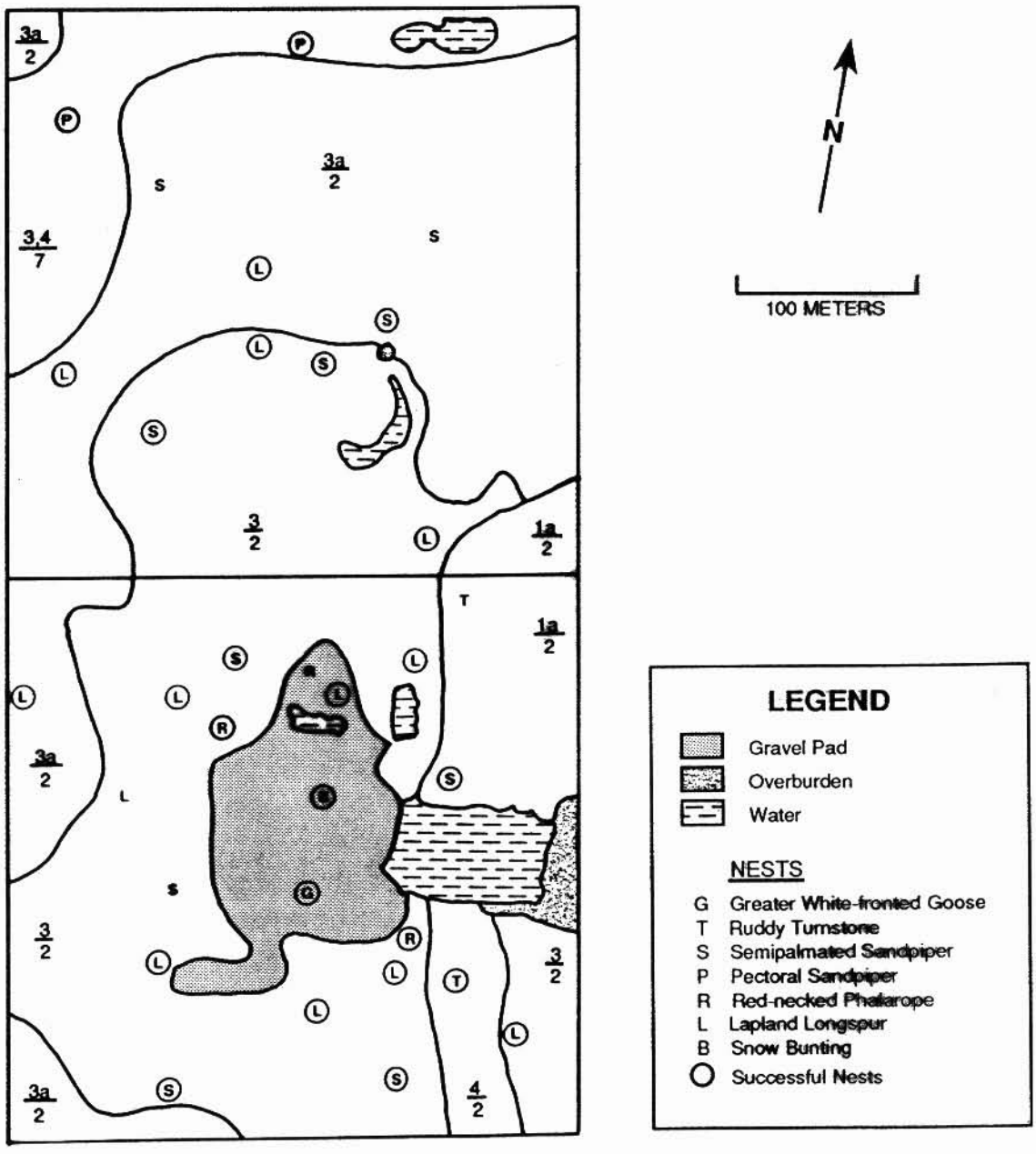
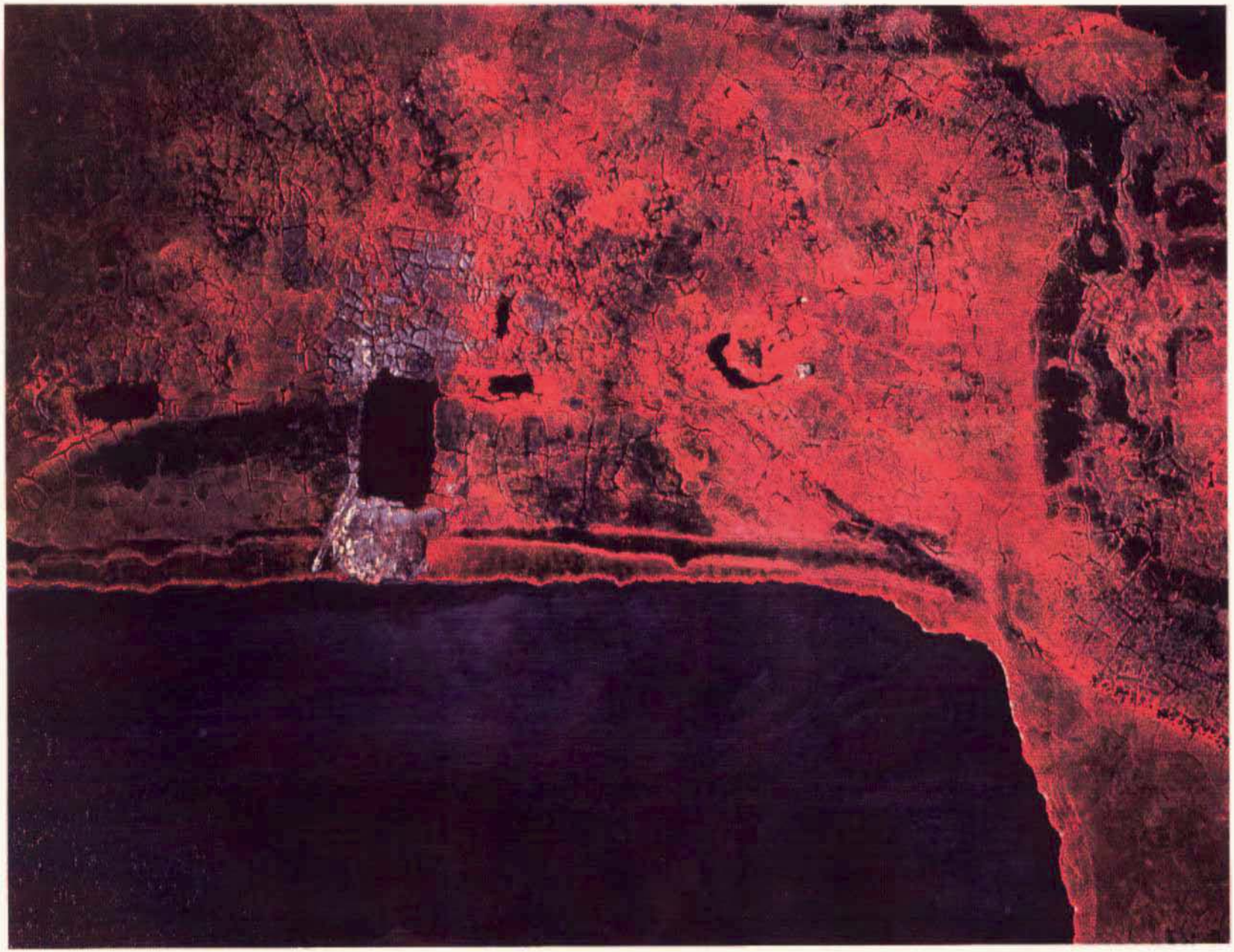


Fig. A-2. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Ugnu-1, Prudhoe Bay, Alaska, 1990.



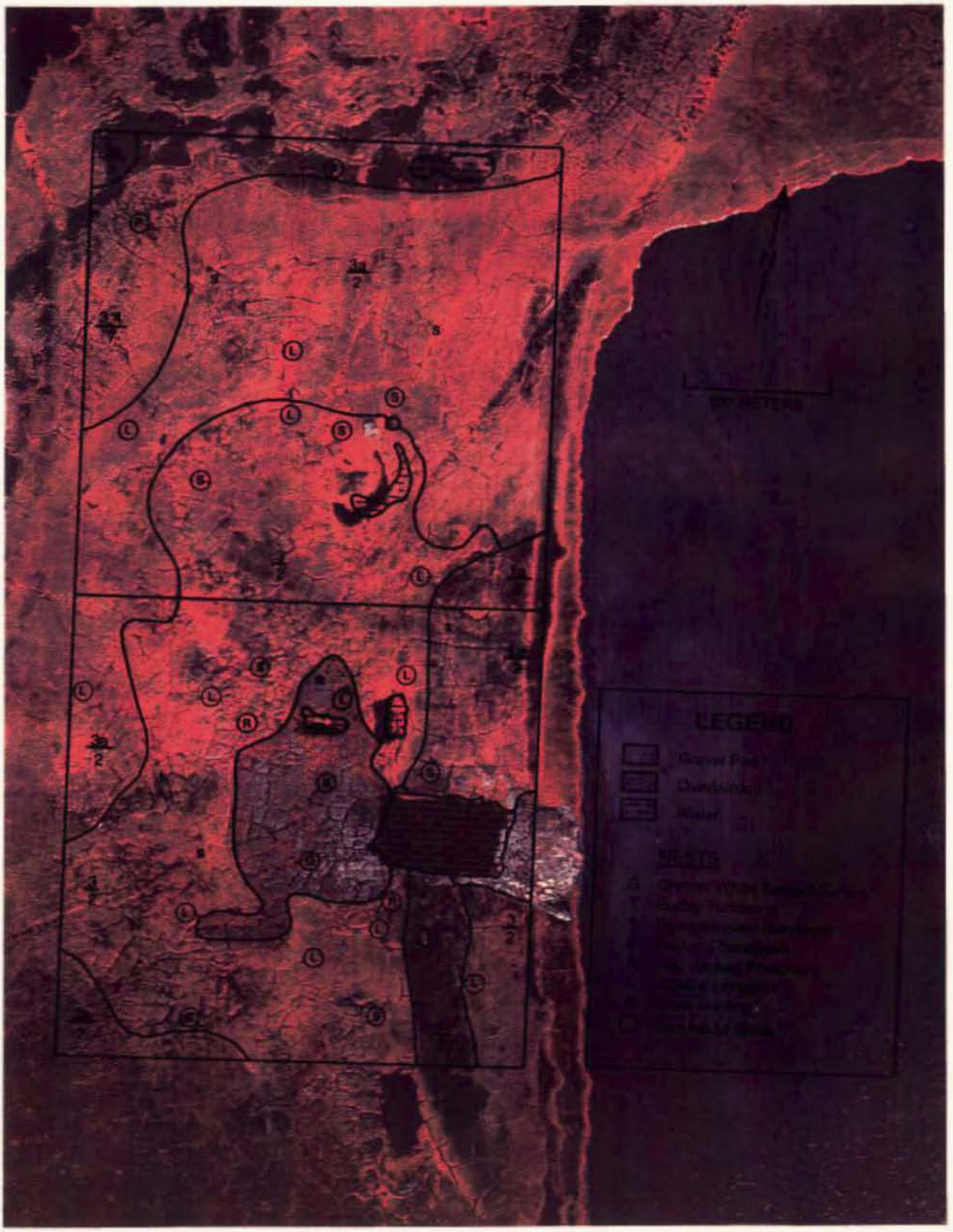


Fig. A-2. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Ugnu-1, Prudhoe Bay, Alaska, 1990.

Much of the tundra in the disturbed plot surrounding the gravel pad also shows a high degree of thermokarst disturbance. The vegetation is composed of moist graminoids; the landform is high-centered polygons of low to high relief. This vegetation and landform may have been caused by surface disruptions associated with the drilling activities. The remaining area is composed primarily of moist tussock tundra; this landform is low-relief, high-centered polygons. A sparsely vegetated area in the northeast portion of the plot was classified as prostrate shrub tundra. Besides the water-filled reserve pit, two small ponds are present, one of them within the gravel.

Description: Undisturbed Plot

The undisturbed study plot, located immediately north of the disturbed plot, shows some evidence of disturbance. A small pond in the southcentral portion of the plot has a mound of overburden on the north side and was surely man-made. In addition, the remnants of several small roads which pass through the plot can be seen from aerial photos. These roads are well vegetated and can also be seen from the ground, though with greater difficulty. Most of the plot is composed of moist tussock tundra; the landform is low-relief high-centered polygons. An area of graminoid tundra extending north from the disturbed plot to the southcentral portion of the undisturbed plot shows some possible thermokarsting disturbance. An area of moist and wet strangmoor is present on the north and northwest portions of the plot.

Nesting

The disturbed plot, with 21 nests, had the highest nest density of all plots in this study. Robus et al. (1986) found only 5 nests on a 10.5-ha plot at this site which also included the gravel pad. Six species nested on the plot. The undisturbed plot had 3 species and 11 nests. The percentages of successful nests were essentially identical in both plots; 17 and 9 nests were successful in the disturbed plot and the undisturbed plot, respectively (Table A-2.).

Four nests were located on the gravel pad (Fig. A-2). One of these, of a Snow Bunting, was in a 55-gal fuel drum which is buried in the gravel with the bunghole exposed. The other nests were more or less associated with vegetation on the pad and included a White-fronted Goose which successfully hatched a 2-egg clutch.

Sixteen nests were located in the graminoid tundra surrounding the pad and extending into the undisturbed plot. This area had a fairly high degree of microrelief and appeared to be a preferred nesting habitat. Two Red-necked

Phalaropes nested adjacent to water-filled thermokarst troughs. Three longspurs nested on the sides of thermokarst troughs in clumps of vegetation; 5 nests were located on the tops of high-centered polygons.

The only Ruddy Turnstones found nesting during this study were located on the disturbed plot at this site; one was on a sparsely vegetated area of low-relief high-centered polygons northeast of the pad, the other in a wet, sparsely vegetated area southeast of the pad.

Five of the remaining nests were located on moist tussock tundra in the undisturbed plot. These were nests of Semipalmated Sandpipers and Lapland Longspurs. Two Pectoral Sandpiper nests were located in strangmoor in the undisturbed plot; no Pectoral Sandpiper nests were found in the disturbed plot.

Table A-2. Number of nests and nest success for bird species on disturbed and undisturbed study plots, Ugnu-1, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semipalmated Sandpiper	3	2	5	60
Pectoral Sandpiper	2	0	2	100
Lapland Longspur	4	0	4	100
Total/Mean	9	2	11	82

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Greater White-fronted Goose	1	0	1	100
Ruddy Turnstone	1	1	2	50
Semipalmated Sandpiper	4	1	5	80
Red-necked Phalarope	2	1	3	67
Lapland Longspur	8	1	9	89
Snow Bunting	1	0	1	100
Total/Mean	17	4	21	81

Site 3: West Sak 9

Location and Access

West Sak 9 (Fig. A-3) is located in the Kuparuk Unit in Sec. 3, T11N, R9E, about half-way between Drill Site 2X and Drill Site 2W. From Drill Site 2X, it is readily visible to the north and can be reached in about 20 min on foot.

Description: Disturbed Area

The well was spudded on March 2, 1978, and suspended on April 9, 1978. During the winter of 1989-90, the well was plugged and abandoned.

The pad dimensions are about 130 m x 100 m, and gravel thickness varies from approximately 1 to 1.5 m. A small gravel ramp tapers from the pad to the tundra on the north part of the pad. Thermokarsting on the southwest quadrant of the pad is extensive. Other areas of the pad exhibit little or no thermokarst activity. The well head is located on the east-central part of the pad.

There are several plant species but low vegetative cover on the pad surface. Total vegetative cover on the pad is about 1 percent (Pollard et al. 1990). Colonization is more pronounced in thermokarsted areas.

A reserve pit east of the pad is filled with water and is similar in size to the pad. A flare pit south of the reserve pit is slightly smaller than the reserve pit and is also filled with water. Both pits are surrounded by gravel berms. There is virtually no plant colonization in the vicinity these pits. Large mounds of overburden 6 to 7 m high are present to the east of each pit. The gravel pad, reserve and flare pits, and overburden cover approximately 39 percent of the disturbed plot.

The tundra surrounding the gravel pad is geobotanically varied. It consists primarily of moist and wet graminoid tundra; landforms include frost-boil tundra, strangmoor, low-relief high-centered polygons, low-centered polygons, and non-patterned ground. Some of the tundra surrounding the pad appears to be partially disturbed. Thermokarsting on the west side of the pad continues onto the tundra to the west forming high-centered polygons. Other areas around the north and south sides of the pad also show signs of disturbance. Besides the water in reserve and flare pits, ponds are also present on the east, north and southwest portions of the plot.

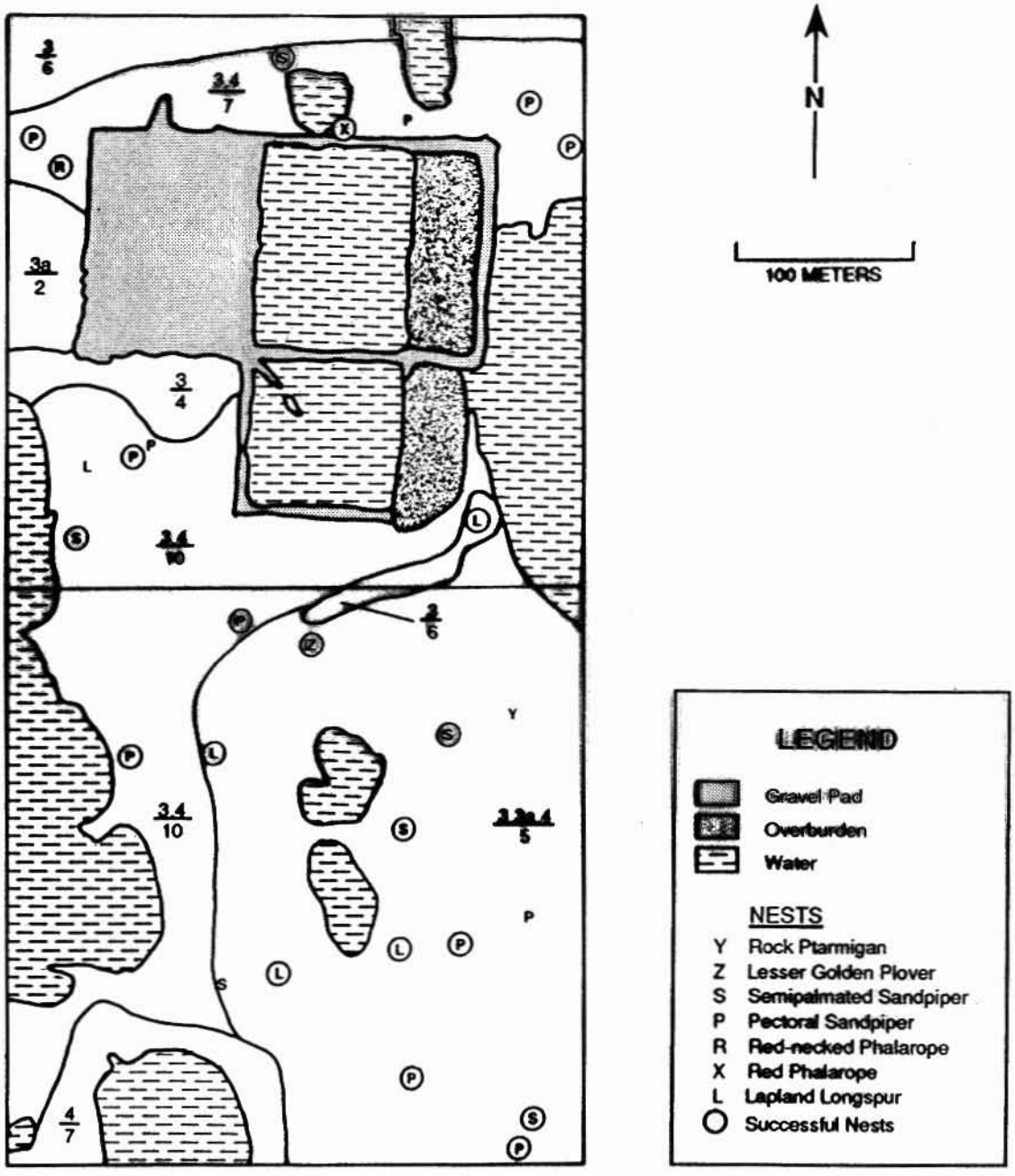
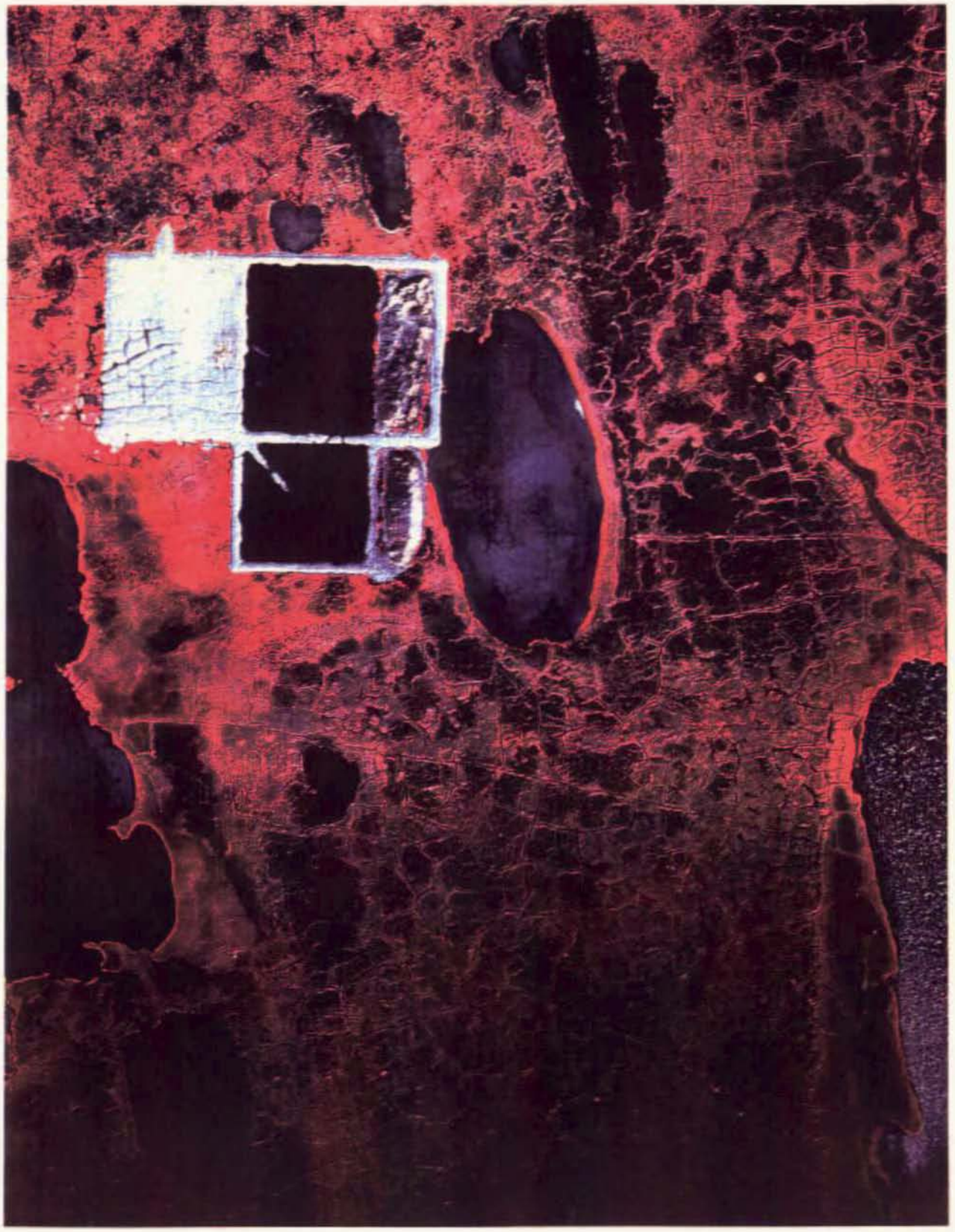


Fig. A-3. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, WS-9, Prudhoe Bay, Alaska, 1990.



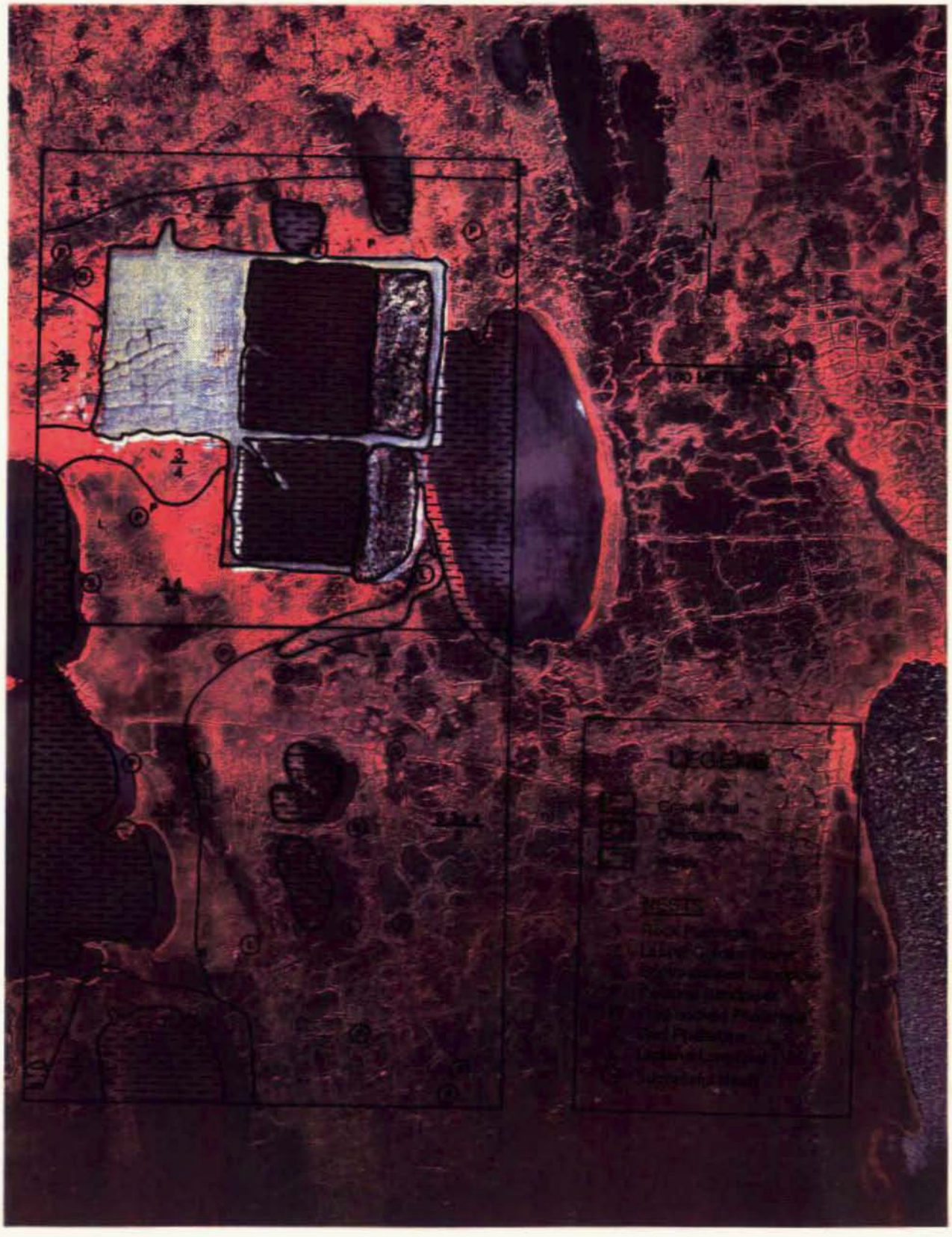


Fig. A-3. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, WS-9, Prudhoe Bay, Alaska, 1990.

Description: Undisturbed Plot

The undisturbed plot is located immediately south of the disturbed plot. The eastern portion is composed of a mixture of moist and wet graminoid tundra, and moist tussock tundra. The landform is primarily mixed high- and low-centered polygons. A small area of frost-boil tundra is present in the northcentral portion of the plot, and two ponds are centrally located in the plot.

The western portion of the plot is primarily non-patterned ground and water. A small area of wet strangmoor is present in the southwest corner.

Nesting

Fifteen nests were found in the undisturbed plot and 12 were found in the disturbed plot. Each plot had 5 nesting species which were primarily shorebirds and longspurs; a Rock Ptarmigan nested unsuccessfully in the undisturbed plot (Table A-3.). Twelve nests were successful in the undisturbed plot and 9 were successful in the disturbed plot.

In the disturbed plot, 7 nests were located in strangmoor adjacent to the north side of the pad (Fig. A-3). Parts of this area showed signs of disturbance. Four of these nests were of Pectoral Sandpiper. A Red Phalarope nested at the edge of a pond about 1 m from the edge of the gravel berm on the north side of the reserve pit. A Red-necked Phalarope nest was found northwest of the pad on thermokarsted tundra with water-filled troughs. Most of the remaining nests in the disturbed plot were on non-patterned ground on the southwest portion of the plot.

In the undisturbed plot, 13 of the 15 nests were located on the eastern portion, an area with a fairly high degree of microrelief. The remaining 2 nests were on non-patterned ground, although one was on a small ridge.

Table A-3. Number of nests and nest success for bird species on disturbed and undisturbed plots, WS-9, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Rock Ptarmigan	0	1	1	0
Lesser Golden Plover	1	0	1	100
Semipalmated Sandpiper	3	1	4	75
Pectoral Sandpiper	5	1	6	83
Lapland Longspur	3	0	3	100
Total/Mean	12	3	15	80

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semipalmated Sandpiper	2	0	2	100
Pectoral Sandpiper	4	2	6	67
Red-necked Phalarope	1	0	1	100
Red Phalarope	1	0	1	100
Lapland Longsur	1	1	2	50
Total/Mean	9	3	12	75

Site 4: West Sak 3

Location and Access

West Sak 3 (Fig. A-4) is located in the Kuparuk Unit in Sec. 26, T11N, R9E, about 1.3 km southwest of Drill Site 2D. There is no road access to the pad, but it can be seen from the gravel road west of Drill Site 2D and can be reached in 5 min on foot.

Description: Disturbed Area

The well was spudded on March 22, 1975, and suspended on April 26, 1975. The plugged-and-abandoned date on record is March 14, 1986.

The pad dimensions are approximately 70 m x 160 m. Gravel thickness on the eastern and southern portions is about 0.6 m. Two gravel ramps taper to the tundra surface; one is in the northeast corner and one is on the south side of the pad. A thicker raised area of gravel on the west side of the pad extends from the north side to the south about 80 percent the length of the pad. This gravel has a thickness of about 1.5 m. Moderate thermokarsting is evident on the thinner areas of the pad, but little thermokarsting occurs on the thicker areas. The well head consists of a pipe embedded vertically into a depression about 0.5 m deep in the gravel; it is located on the west central part of the pad. A number of wooden stakes delineate a revegetation study site on the raised portion of the gravel pad. This area was fertilized in 1986 (Jorgenson 1989).

Vegetative cover on the pad is less than 1 percent, including the fertilized area. Several grass and forb species are sparcely colonizing the thermokarst troughs.

There is a reserve pit on the west side of the pad and a flare pit to the north. A third pit, possibly another flare pit, is adjacent to the southeast edge of the pad. All pits are surrounded by gravel berms which have been breached to allow water to escape. The flare pit to the southeast contains a large mound of overburden in the center, approximately 1.7 m high. The mound is sparsely vegetated and is surrounded by water and partially-disturbed, vegetated tundra. A smaller mound of overburden in the center of the north flare pit was fertilized and seeded in 1986 as part of a revegetation study (Jorgenson 1989). This area is now heavily vegetated and is surrounded by water and partially-disturbed tundra. The reserve pit has a large mound of mud and cuttings which was seeded in 1986 (Jorgenson 1989). This area is sparsely vegetated and is

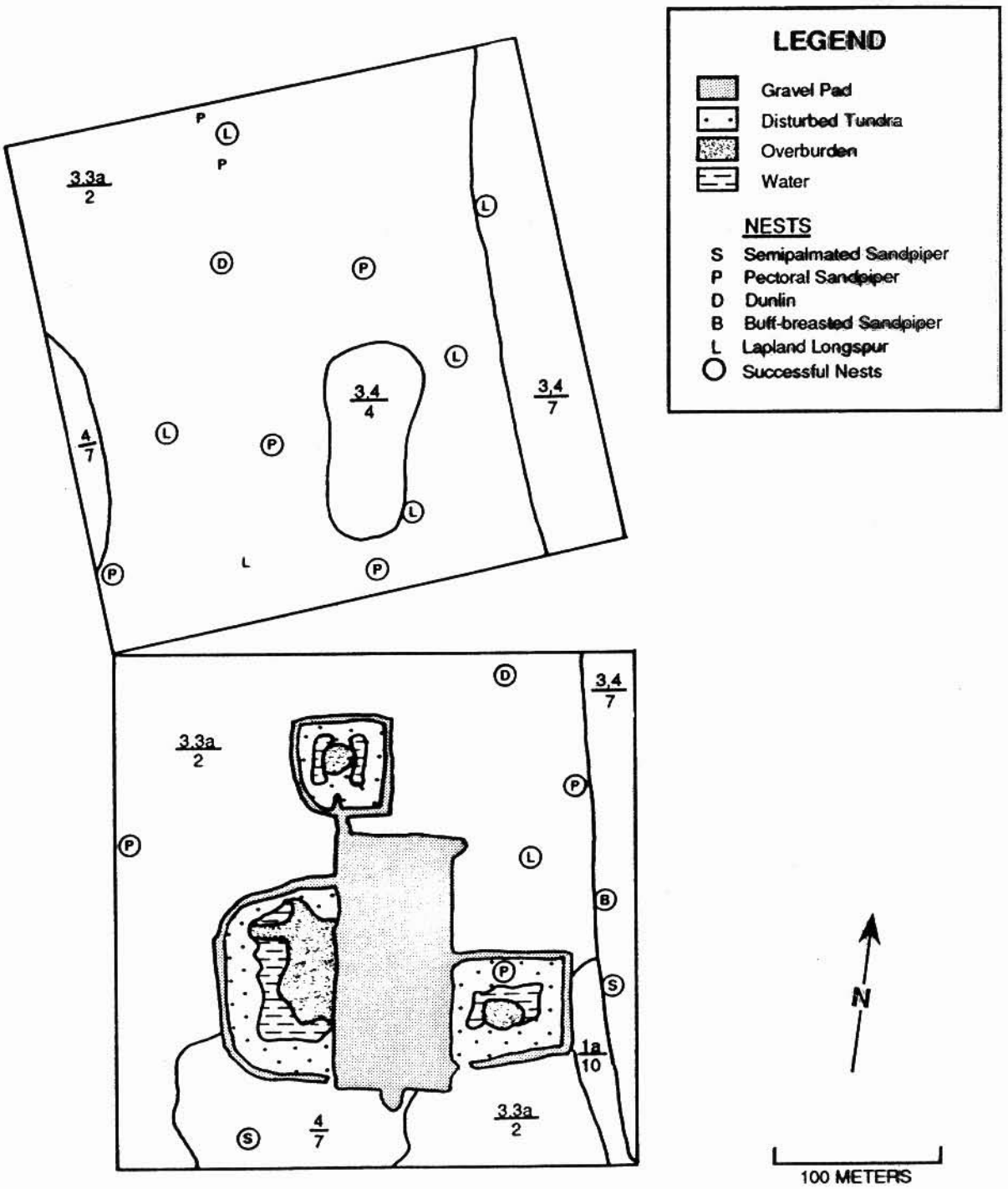


Fig. A-4. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, WS-3, Prudhoe Bay, Alaska, 1990.

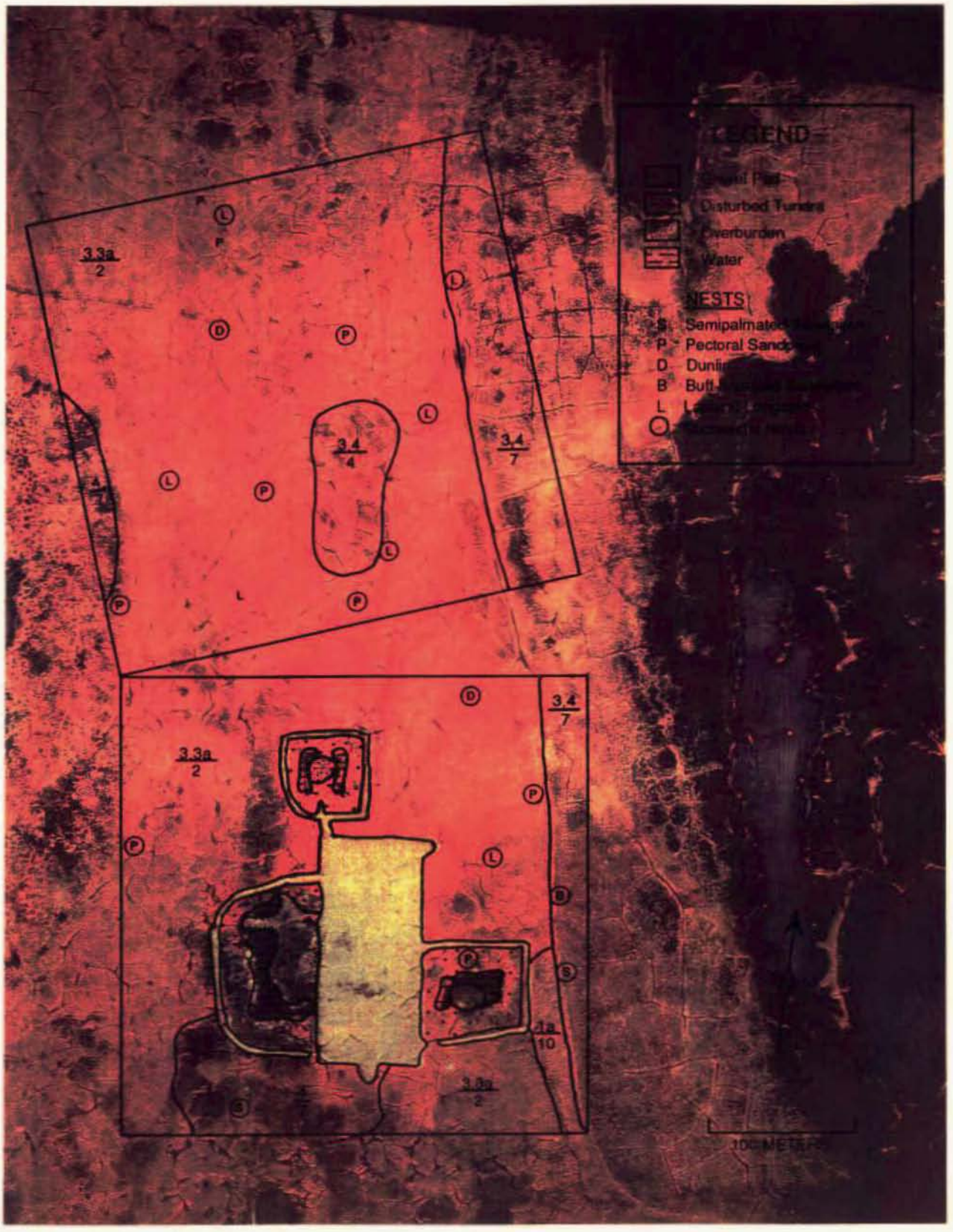


Fig. A-4. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, WS-3, Prudhoe Bay, Alaska, 1990.

surrounded by water and partially-disturbed tundra. The gravel pad and reserve and flare pits cover approximately 28 percent of the disturbed plot.

The tundra surrounding the pad is composed primarily of moist and wet graminoid tundra and moist tussock tundra. The landform is primarily low-relief high-centered polygons, many of which are poorly defined and often difficult to distinguish from the ground. Strangmoor is present on the eastern and southwestern portions of the plot. A small patch of prostrate shrub tundra is located near the southeastern flare pit.

Description: Undisturbed Plot

The undisturbed plot is located north of the disturbed plot. It was positioned at a slight angle to the disturbed plot in an attempt to match tundra habitats in the two plots. It is composed of moist and wet graminoid tundra and moist tussock tundra. The landform is primarily low-relief high-centered polygons which, as is the case in the disturbed plot, are often not well defined. Strangmoor is present on the eastern and western portions of the plot, and a patch of low-centered polygons is located southcentrally.

Nesting

Three species had 13 nests in the undisturbed plot, and 5 species had 8 nests in the disturbed plot (Table A-4). The proportion of successful nests was higher in the disturbed plot; all 8 nests were successful there. Ten nests were successful in the undisturbed plot. All nests in both plots were of either shorebirds or longspurs.

Nests appeared to be fairly evenly distributed throughout the undisturbed plot (Fig. A-4). In the disturbed plot, more nests were located on the eastern portion of the plot. One Pectoral Sandpiper nest was found on tundra inside the southeast flare pit.

It is interesting that no Semipalmated Sandpiper nests were found in the undisturbed plot. This was the only plot in the study in which no nests of this species were found.

Table A-4. Number of nests and nest success for bird species on disturbed and undisturbed study plots, WS-3, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Pectoral Sandpiper	4	2	6	67
Dunlin	1	0	1	100
Lapland Longspur	5	1	6	83
Total/Mean	10	3	13	77

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semipalmated Sandpiper	2	0	2	100
Pectoral Sandpiper	3	0	3	100
Dunlin	1	0	1	100
Buff-breasted Sandpiper	1	0	1	100
Lapland Longspur	1	0	1	100
Total/Mean	8	0	8	100

Site 5: Mobil Kuparuk 3-15-11-12

Location and Access

Mobil Kuparuk 3-15-11-12 (Fig. A-5) is located in the Prudhoe Bay Unit in Sec. 9, T11N, R12E. It is on the north side of the Spine Road approximately 1.6 km west of the access road to S Pad. A short spur road provides access to the pad from the Spine Road.

Description: Disturbed Site

Two wells were drilled on this pad. The first was spudded on April 21, 1975, the second on December 1, 1980. These wells were plugged and abandoned on May 22, 1977 and March 23, 1981, respectively.

The pad dimensions are approximately 220 m x 100 m. Gravel thickness is approximately 1.3 m over most of the pad, although it tapers to tundra level on the northern portion. Gravel spray and impounded water was present near the southern and northeastern edges of the pad. Little thermokarsting has taken place on the pad. A portion of the spur road connecting the pad with the Spine Road is also included in the plot. The gravel pad and gravel spray cover approximately 21 percent of the study plot.

Very few plants are growing on the main portions of the pad. Some *Carex* spp. and *Eriophorum* spp. are colonizing the spray on the south side of the pad. The spray northeast of the pad is much thinner and is well vegetated.

The tundra surrounding the pad is primarily wet graminoid tundra. The landform generally shows little relief and is composed primarily of non-patterned ground and strangmoor. A narrow ridge of high-centered polygons passes through the eastern portion of the plot. A large lake is located west of the plot.

Description: Undisturbed Plot

The undisturbed plot is also composed primarily of wet graminoid tundra on non-patterned ground and strangmoor. Several narrow ridges of strangmoor and high-centered polygons which pass through the plot are aligned more or less north to south. Several ponds are also present.

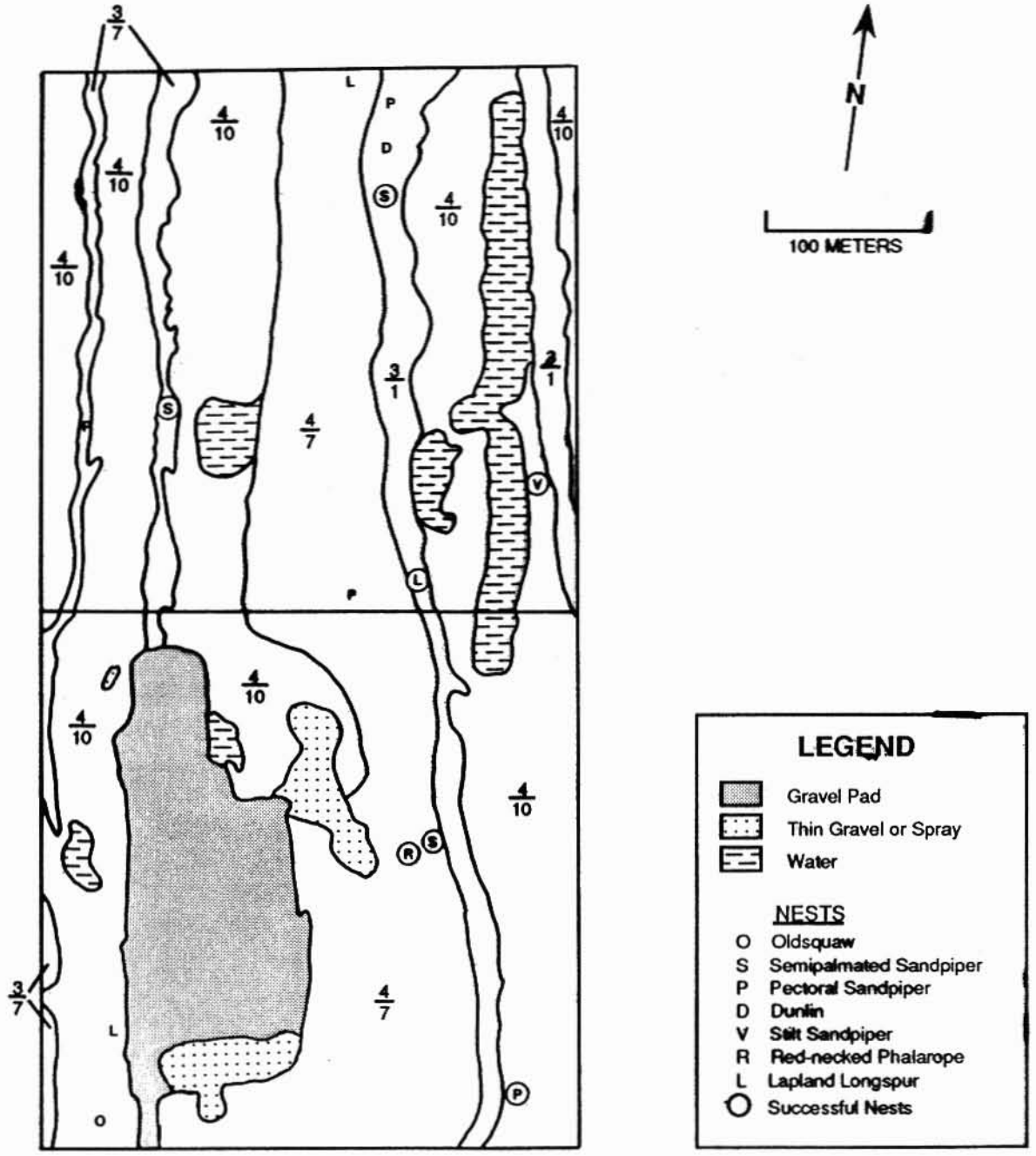
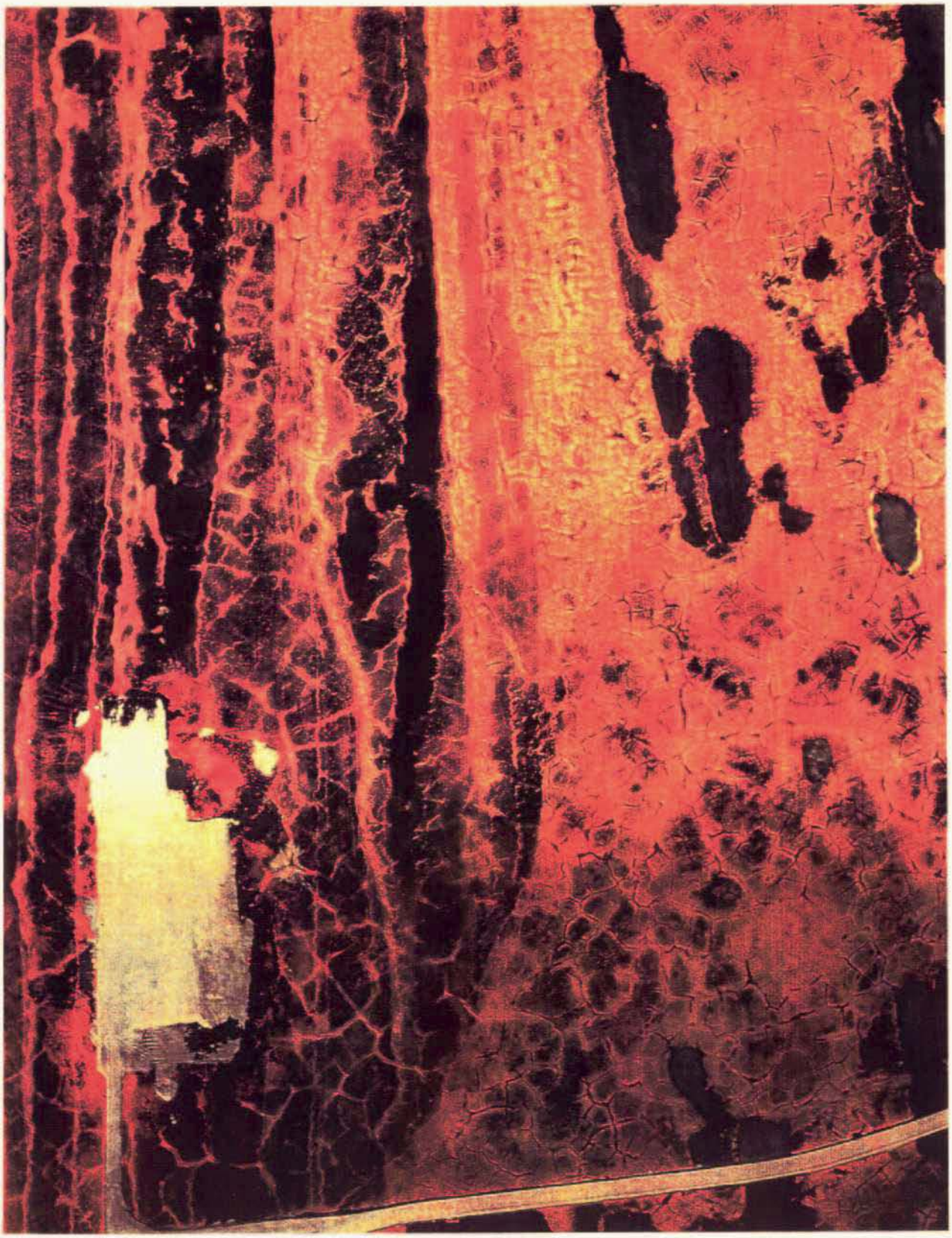


Fig. A-5. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Mobile Kuprauk 3-15-11-12, Prudhoe Bay, Alaska, 1990.



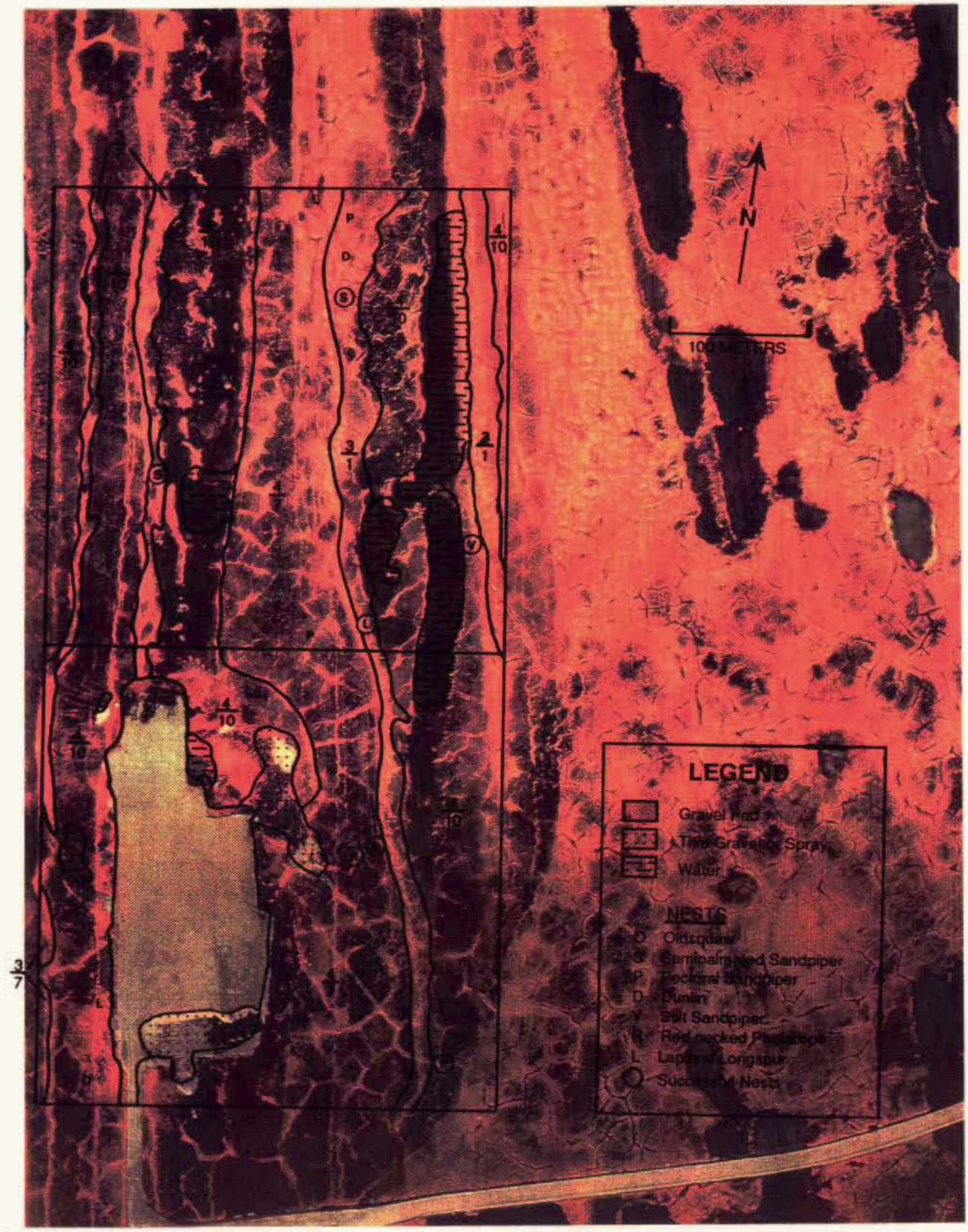


Fig. A-5. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Mobile Kuprauk 3-15-11-12, Prudhoe Bay, Alaska, 1990.

Nesting

Nesting densities were lower at this site than at most other sites in this study. Five species had 9 nests in the undisturbed plot, and 5 species had 5 nests in the disturbed plot (Table A-5). The proportion of successful nests was slightly higher in the disturbed plot; 4 nests were successful in the undisturbed plot compared to 3 in the disturbed plot. All nesting species were either shorebirds or longspurs with the exception of an Oldsquaw which nested unsuccessfully near the pad in the disturbed plot.

Some of the unsuccessful nests in both plots showed signs of fox predation. In the undisturbed plot, 6 of the 9 nests were located on the narrow ridges of strangmoor or high-centered polygons which pass through the plot. These ridges, because they were much drier than the surrounding habitat, may have been preferred routes of foxes passing through the area; nests located on them may have been more susceptible fox predation.

Table A-5. Number of nests and nest success for bird species on disturbed and undisturbed study plots, Mobil Kuparuk 13-15-11-12, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semipalmated Sandpiper	2	0	2	100
Pectoral Sandpiper	0	3	3	0
Dunlin	0	1	1	0
Stilt Sandpiper	1	0	1	100
Lapland Longspur	1	1	2	50
Total/Mean	4	5	9	44

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Oldsquaw	0	1	1	0
Semipalmated Sandpiper	1	0	1	100
Pectoral Sandpiper	1	0	1	100
Red-necked Phalarope	1	0	1	100
Lapland Longspur	0	1	1	0
Total/Mean	3	2	5	60

Site 6: Term Well C

Location and Access

Term Well C (Fig. A-6) is located in the Prudhoe Bay Unit in Sec. 3, T11N, R12E. An access road to the site leaves the Spine Road approximately 0.9 km east of the access road to S Pad. The pad is approximately 1 km north of the Spine Road.

Description: Disturbed Plot

The well was spudded on March 2, 1979, and suspended on April 25, 1979. A steel railing surrounds the well head.

The pad dimensions are approximately 150 m x 65 m. This is a thick pad with gravel depth over 2 m in some areas. An access road to the pad is on the west portion of the plot. A reserve pit south of the pad is surrounded by a berm composed of gravel and overburden. The pit is water-filled and has a mud bank. A small gravel pit between the reserve pit and the road is not attached to the pad. The gravel disturbance and reserve pit cover approximately 21 percent of the plot.

The tundra surrounding the pad is primarily moist and wet graminoid tundra. The landform is varied and includes poorly defined low-relief high-centered polygons, low-centered polygons and strangmoor, and a small area of well-defined high-centered polygons south of the pad. Much of the area between the road and the pad is heavily thermokarsted, non-patterned ground. Several ponds are present on the southern portion of the plot.

Description: Undisturbed Plot

The undisturbed plot is adjacent to the east side of the disturbed plot and slightly offset to the north. It is composed primarily of moist graminoid tundra. The landform is a combination of poorly defined low-relief high-centered polygons, and low-centered polygons and strangmoor. Patches of well-defined high-centered polygons are also present. Ponds are located on the southern portion of the plot.

Nesting

Six species had 7 nests in the undisturbed plot and 4 species had 12 nests in the disturbed plot (Table A-6). The undisturbed plot had the lowest nesting

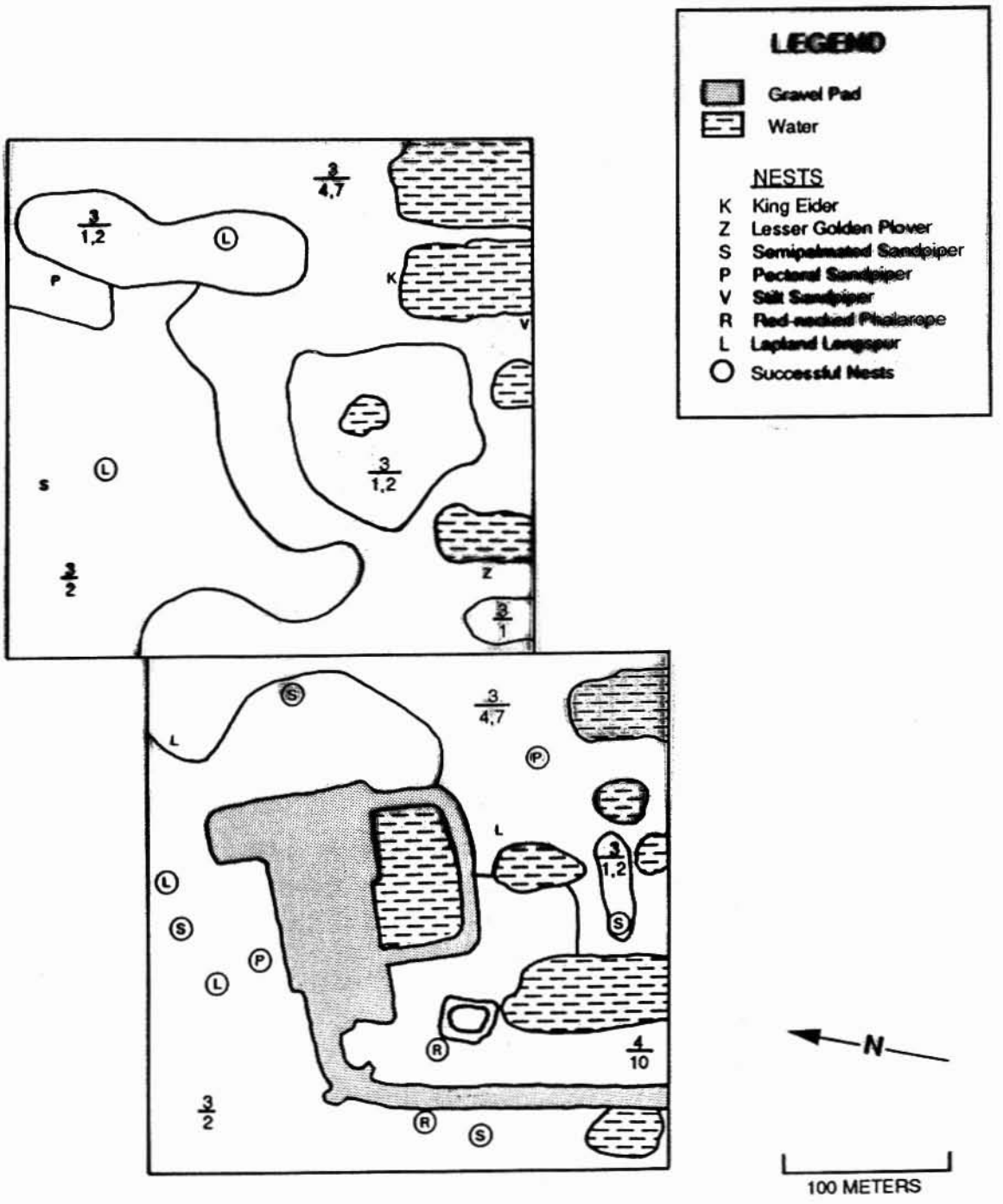


Fig. A-6. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Term Well C, Prudhoe Bay, Alaska, 1990.

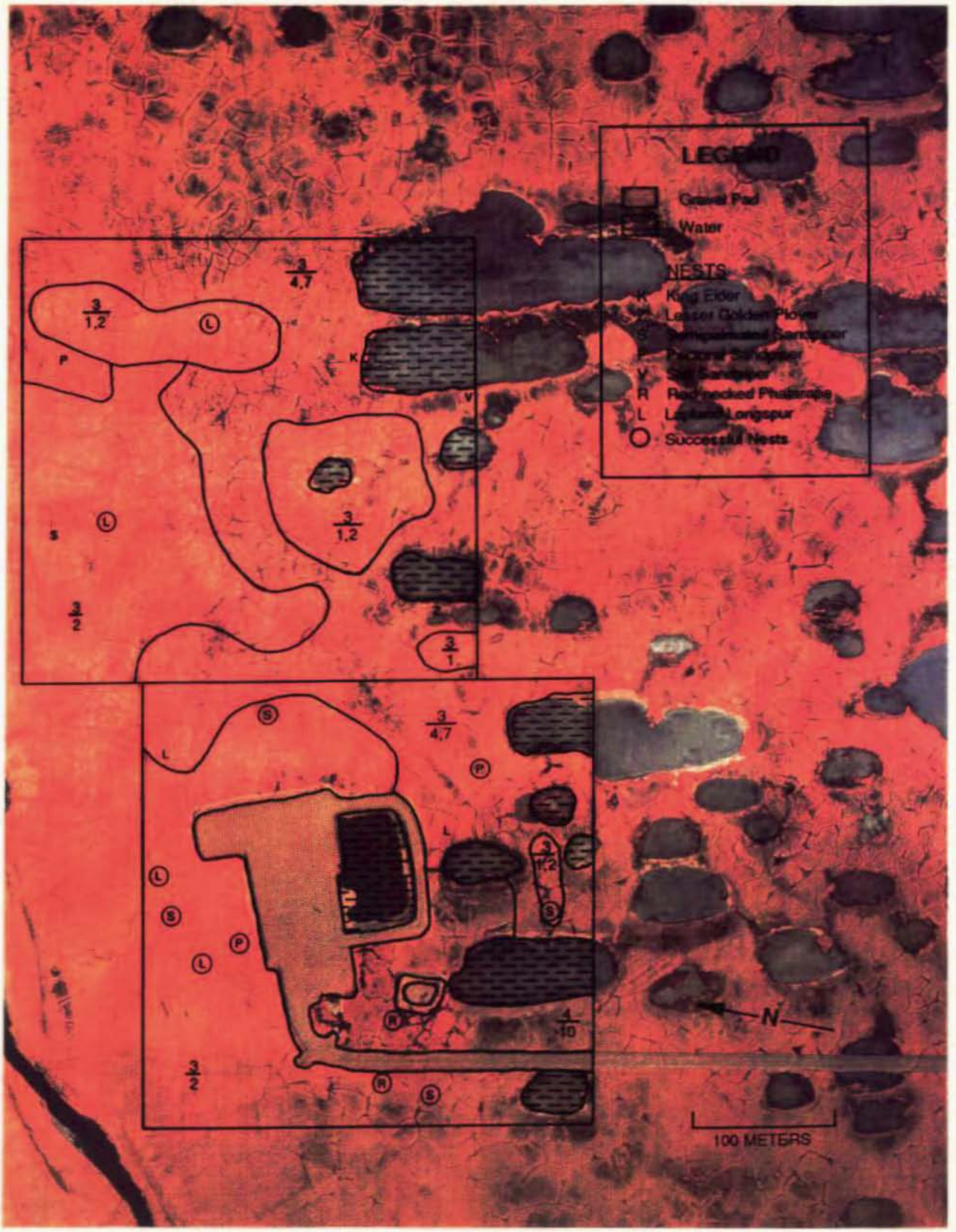


Fig. A-6. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Term Well C, Prudhoe Bay, Alaska, 1990.

success of all plots in this study; only 2 nests were successful. Nest success was higher in the disturbed plot; 10 nests were successful. All nesting species were either shorebirds or longspurs with the exception of a King Eider which nested unsuccessfully in the undisturbed plot.

On the disturbed plot, several nests were located near gravel disturbances. Red-necked Phalaropes nested on both sides of the access road in areas of thermokarsting near water-filled troughs. Four nests were clustered on tundra north of the pad, and a longspur nested unsuccessfully just south of the pad.

Table A-6. Number of nests and nest success for bird species on disturbed and undisturbed study plots, Term Well C, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
King Eider	0	1	1	0
Lesser Golden Plover	0	1	1	0
Semipalmated Sandpiper	0	1	1	0
Pectoral Sandpiper	0	1	1	0
Stilt Sandpiper	0	1	1	0
Lapland Longspur	2	0	2	100
Total/Mean	2	5	7	29

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semipalmated Sandpiper	4	0	4	100
Pectoral Sandpiper	2	0	2	100
Red-necked Phalarope	2	0	2	100
Lapland Longspur	2	2	4	50
Total/Mean	10	2	12	83

Site 7: Hurl State

Location and Access

Hurl State (Fig. A-7) is located in the Prudhoe Bay Unit in Sec. 5, T10N, R13E, approximately 2.1 km southeast of P Pad. There is no road access to the pad; it can be reached in about 30 min on foot from P Pad.

Description: Disturbed Area

Two wells have been drilled on this pad. The first was spudded on May 11, 1969, and has a plugged-and-abandoned date of April 4, 1980. The second well was spudded on January 6, 1981 and was suspended on February 18, 1981.

The pad dimensions are about 60 m x 180 m and gravel thickness averages approximately 1.6 m. A gravel road from an airstrip joins the pad on the north side. The pad surface is flat, and thermokarsting is evident only in a small area of spray at the west end where a water-filled trough was present. The well heads are located south and east of the pad center; one consists of a pipe embedded in the ground, and the other is a "christmas tree" with a railing around it. A shallow cement structure located east of the pad center is covered. A fairly extensive area of thin gravel and gravel spray surrounds much of the pad, particularly on the southern and northeastern sides. A large reserve pit adjacent to the southeast end of the pad was filled with mud and water. The gravel, gravel spray, and reserve pit cover approximately 28 percent of the plot. Including a barren area south of the reserve pit, approximately 33 percent of the plot is disturbed..

Very little vegetation was present on the gravel surface; total cover was less than 1 percent. Thick patches of *Eriophorum* spp. were colonizing some areas of gravel spray on the south side.

The area of barren ground south of the reserve pit appeared to be disturbed and is devoid of vegetation. The remaining area surrounding the pad is composed of moist and wet graminoid tundra. The predominant landform is non-patterned ground; some strangmoor, low-centered, and a small patch of high-centered polygons are also present. The remnants of an old road can be seen northeast of the gravel.

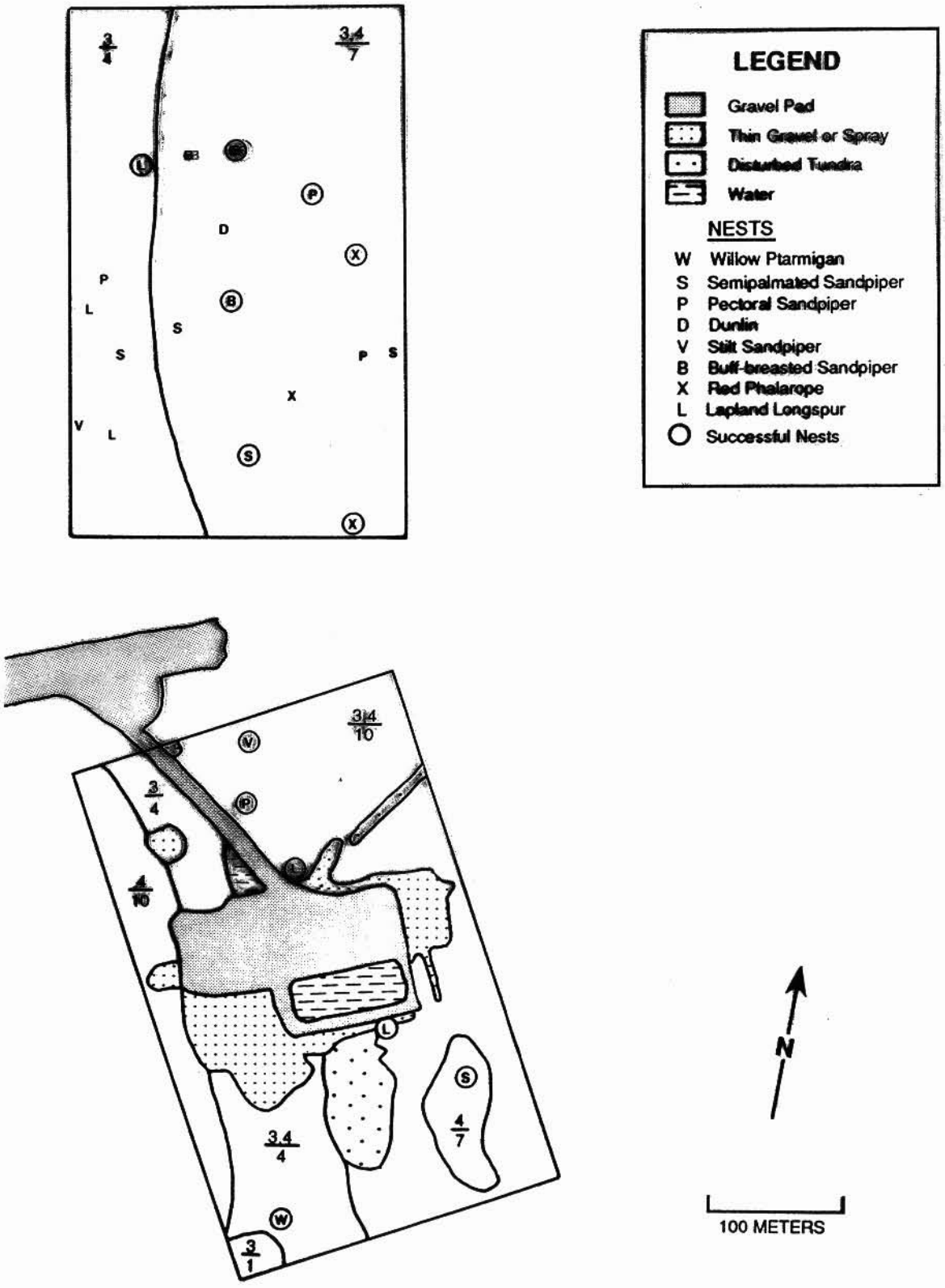


Fig. A-7. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Hurl State, Prudhoe Bay, Alaska, 1990.

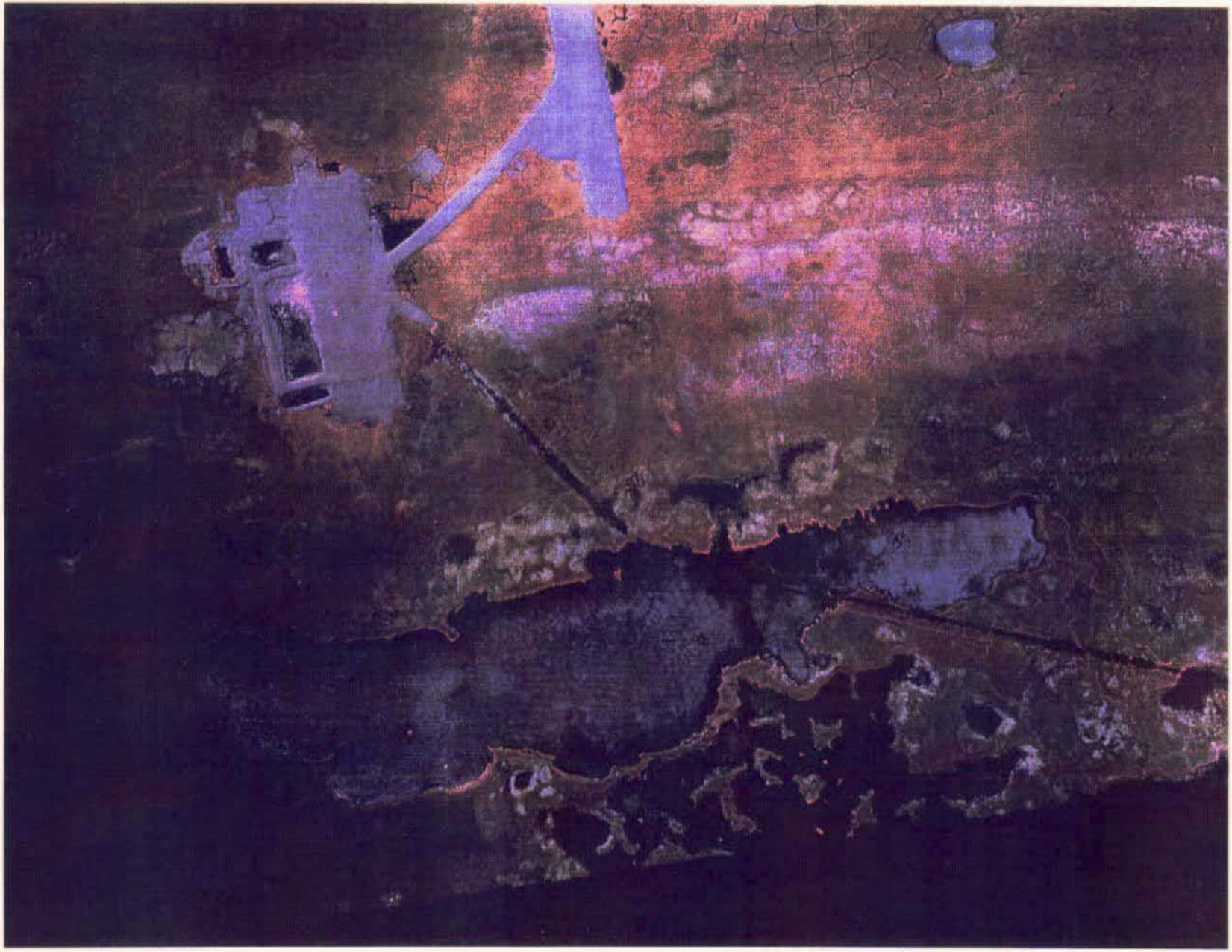


Fig. A-7. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Hurl State, Prudhoe Bay, Alaska, 1990.

Description: Undisturbed Plot

The undisturbed plot is located north of the disturbed plot on the opposite side of the airstrip. It is composed of moist and wet graminoid tundra. The predominant landform is strangmoor throughout most of the plot, but low-centered polygons are present on the western portion.

Nesting

Seven species had 18 nests on the undisturbed plot, and 5 species had 6 nests on the disturbed plot (Table A-7). All species were shorebirds or longspurs, with the exception of a Willow Ptarmigan which nested successfully in the disturbed plot.

The proportion successful nests was very different in the two plots. All 6 nests in the disturbed plot were successful and only 7 nests in the undisturbed plot survived. Much of the nest predation was directly attributable to fox. This was interesting because an arctic fox had a burrow located in gravel spray near the pad, yet the nest predation occurred in the undisturbed plot. Since nest densities were higher in the undisturbed plot, hunting conditions may have been better there. This may explain the lower success in the undisturbed plot. Page et al. (1983) showed a decrease in nest success when he experimentally increased nest density of Snowy Plovers. A density-dependent effect stemming from higher rates of nest predation at higher nesting densities has also been demonstrated for Field Sparrows (Fretwell 1972:115-117).

Table A-7. Number of nests and nest success for bird species on distubed and undisturbed study plots, Hurl State, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semipalmated Sandpiper	1	3	4	75
Pectoral Sandpiper	1	2	3	33
Dunlin	0	1	1	0
Stilt Sandpiper	0	1	1	0
Buff-breasted Sandpiper	2	1	3	67
Red Phalarope	2	1	3	67
Lapland Longspur	1	2	3	33
Total/Mean	7	11	18	39

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Willow Ptarmigan	1	0	1	100
Semipalmated Sandpiper	1	0	1	100
Pectoral Sandpiper	1	0	1	100
Stilt Sandpiper	1	0	1	100
Lapland Longspur	2	0	2	100
Total/Mean	6	0	6	100

Site 8: Put River 22-33-11-13

Location and Access

Put River 22-33-11-13 ("BP Pad") (Fig. A-8) is located in the Prudhoe Bay Unit in Sec. 33, T11N, R13E. It is approximately 0.5 km west of Y Pad. There is no road access to the site, but it can be reached in about 5 min by foot from Y Pad.

Description: Disturbed Plot

The well was spudded on January 24, 1969, and suspended on May 5, 1969. The well head has been removedfrom the site.

This site is the object of an experimental rehabilitation project being undertaken by BPX. Most of the gravel was removed from this site to within six inches of the origional grade in May 1989. Some additional gravel was removed in April 1990. Overburden was placed over the area of gravel removal. The area was fertilized and planted with *Poa glauca, Festuca rubra,* and *Arctagrostis latifolia* in May 1989. It was fertilized again after the first growing season in September 1989. A wooden snow fence was installed north of the gravel site just prior to gravel removal. The purpose of this fence is to attempt to accumulate drifting snow as a source of water for the cultivars. The cultivars were doing well during the 1990 field season. The cultivated area includes most of the area designated as "disturbed tundra" on the site map (Fig. A-8). The smaller portion of disturbed tundra showed signs of disturbance such as sparsely vegetated areas.

The area surrounding the disturbed portion of the plot is composed of moist and wet graminoid tundra. The landform is primarily strangmoor and non-patterned ground. Small patches of high-centered polygons and mixed high- and low-centered polygons extend into the undisturbed plot. Some of the ponds had dried up, and their mud bottoms were exposed. The disturbed area covers approximately 50 percent of the plot.

Description: Undisturbed Plot

The undisturbed plot is located south of the disturbed plot and is slightly offset from it. It is composed of moist and wet graminoid tundra. The landform is predominatly non-patterned ground and strangmoor, with patches of high-centered polygons and mixed high- and low-centered polygons. Several ponds are also present, some of which partially receded during the summer.

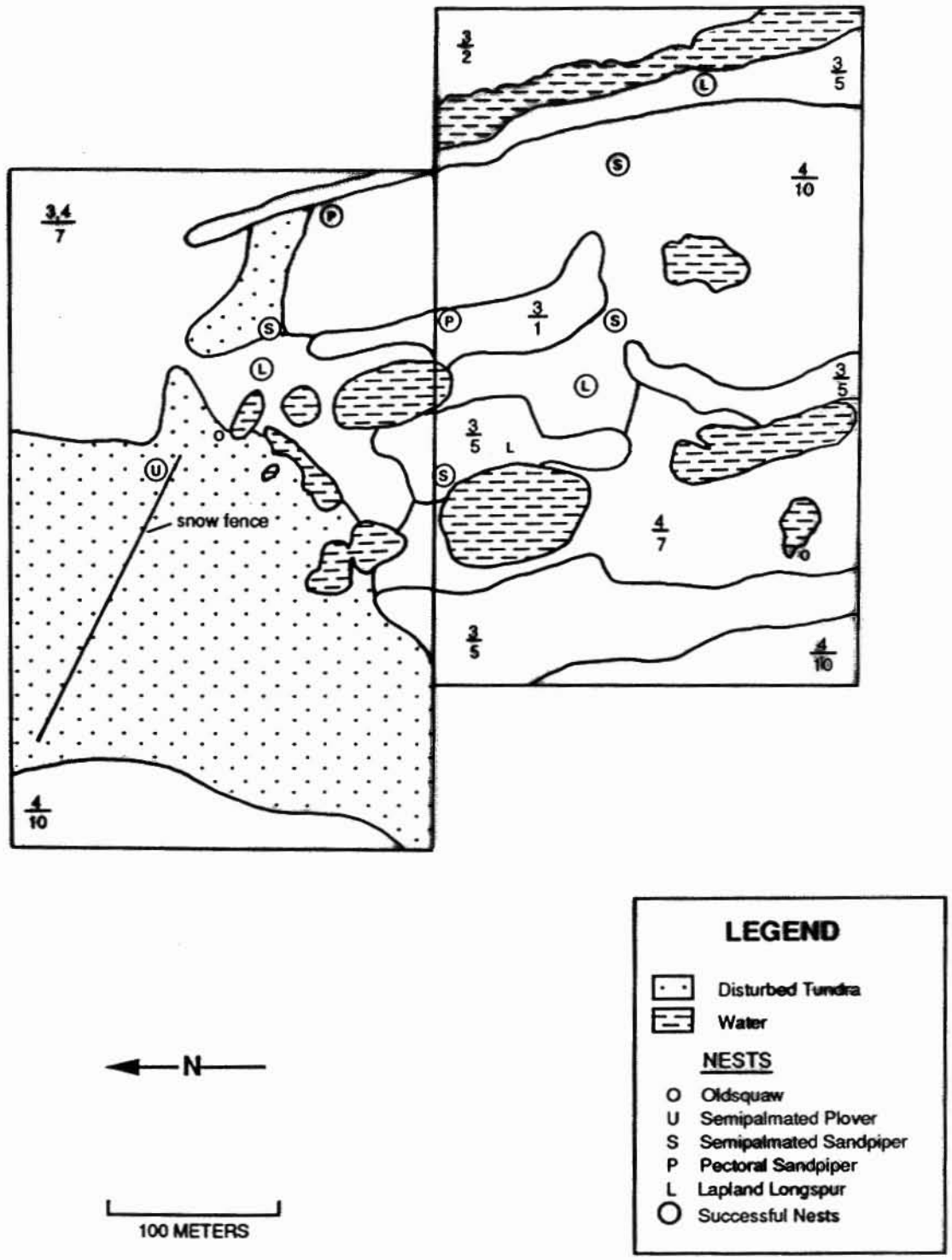
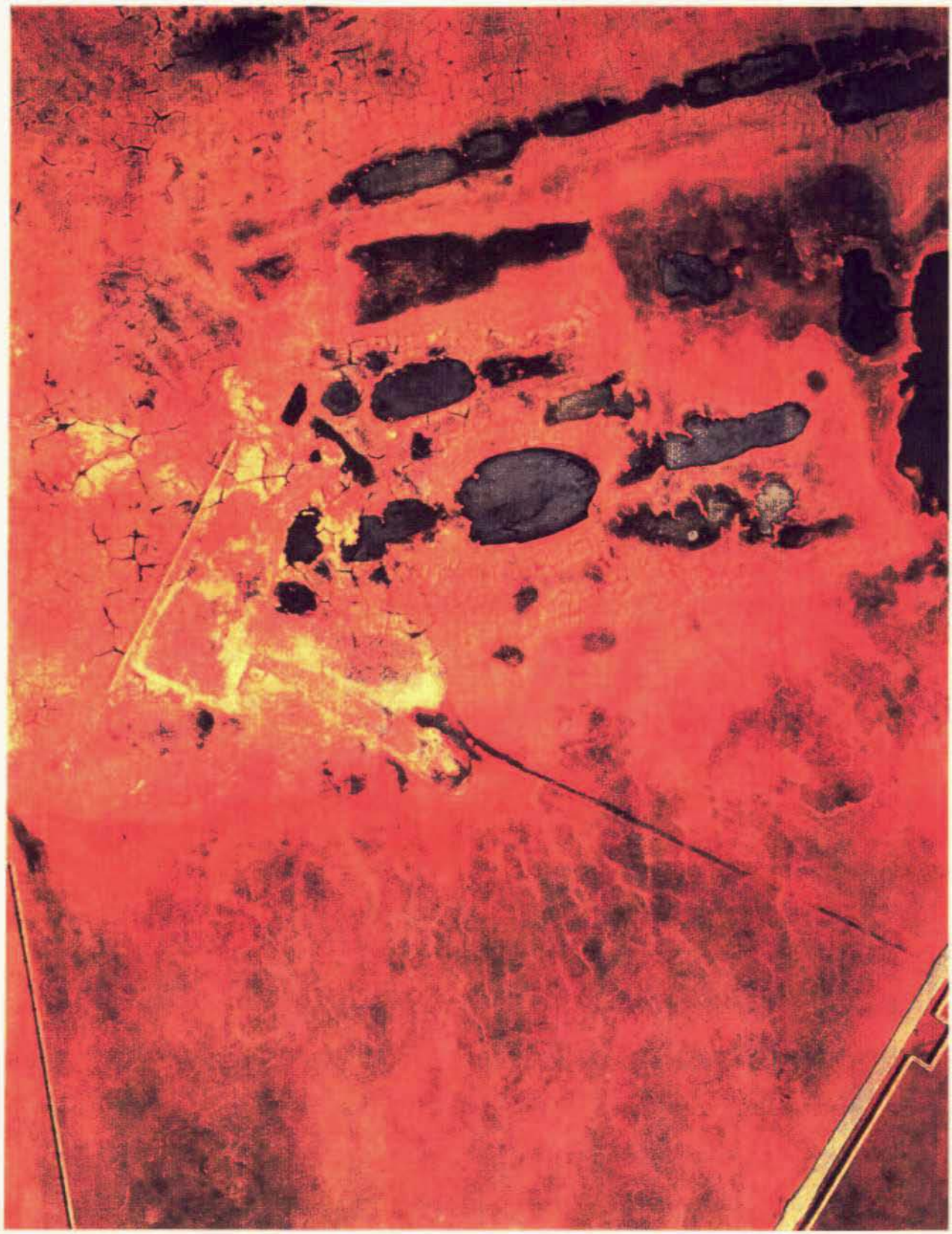


Fig. A-8. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Put River 22-33-11-13, Prudhoe Bay, Alaska, 1990.



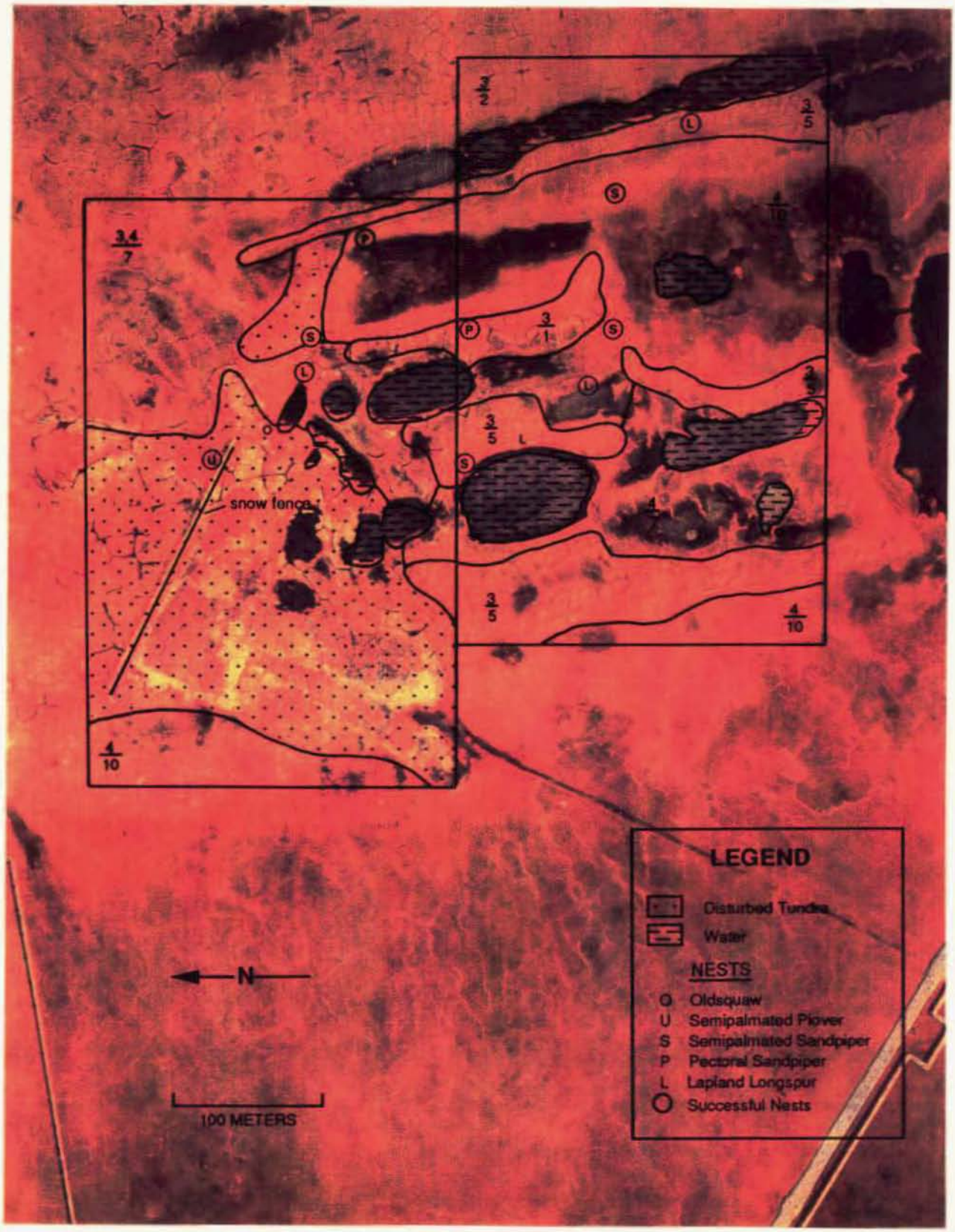


Fig. A-8. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Put River 22-33-11-13, Prudhoe Bay, Alaska, 1990.

Nesting

Four species had 8 nests in the undisturbed plot and 5 species had 5 nests in the disturbed plot (Table A-8). Six nests were successful in the undisturbed plot compared to 4 in the disturbed plot. Oldsquaws nested unsuccessfully in each plot. All other species were either shorebirds or longspurs.

The only Semipalmated Plover nest found during this study was located near the snow fence in the disturbed plot. This nest, with 3 eggs, was successful. This species was also known to have nested in this area during the previous year (pers. obs.).

The Oldsquaw nest in the disturbed plot was located among peat clumps on barren ground near the east end of the snow fence. This area became well vegetated with cultivars as the season progressed. The Oldsquaw nest in the undisturbed plot was located on tundra adjacent to a small pond.

Considering this single site, it is difficult to assess the effect of the gravel removal and revegetation program on nesting habitat. Only one bird, an Oldsquaw, nested on the area of gravel removal. The Semipalmated Plover nest was probably just outside the area of the former gravel pad.

Table A-8. Number of nests and nest success for bird species on disturbed and undisturbed study plots, BP 22-33-11-13, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Oldsquaw	0	1	1	0
Semipalmated Sandpiper	3	0	3	100
Pectoral Sandpiper	1	0	1	100
Lapland Longspur	2	1	3	67
Total/Mean	6	2	8	75

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Oldsquaw	0	1	1	0
Semipalmated Plover	1	0	1	100
Semipalmated Sandpiper	1	0	1	100
Pectoral Sandpiper	1	0	1	100
Lapland Longspur	1	0	1	100
Total/Mean	4	1	5	80

Site 9: Getty State

Location and Access

Getty State (Fig. A-9) is located in the Prudhoe Bay Unit in Sec. 2, T10N, R13E approximately 2 km southwest of A Pad. The closest access is from a gravel road south of A Pad from which Getty State can be seen. It lies approximately 1 km south of this road and can be reached in about 15 minutes on foot.

Description: Disturbed Plot

The well was spudded on December 13, 1975, and suspended on May 11, 1980. The well head consists of a "christmas tree" surrounded by a metal railing located southeast of the reserve pit.

The pad dimensions are approximately 180 m x 65 m. Gravel thickness over most of the pad is approximately 1.5 m. Little thermokarsting is evident other than on a small portion of the pad's western corner where gravel thickness was only about 0.6 m. Several small patches of gravel spray are present around the edges of the pad. A reserve pit attached to the north side of the pad was filled with water and is surrounded by a gravel berm. The gravel disturbance and reserve pit cover approximately 17 percent of the study plot.

The area surrounding the pad is composed of moist and wet graminoid tundra. The landform is primarily low-centered polygons and strangmoor with patches of high-centered polygons and non-patterned ground also present. Extensive thermokarsting has occurred on the tundra north and east of the pad producing deep water-filled troughs. Natural water bodies are present on the western portion of the plot.

Description:Undisturbed Plot

The undisturbed plot is adjacent to the west edge of the disturbed plot. The tundra is composed of moist and wet graminoids. The landform is primarily low-centered polygons and strangmoor with patches of mixed high- and low-centered polygons. A small patch of low-relief high-centered polygons overlaps the disturbed plot at the southern boundary of both plots. This southern boundary is paralleled by a peat road which is about 10 m off the plots. Several ponds are also present.

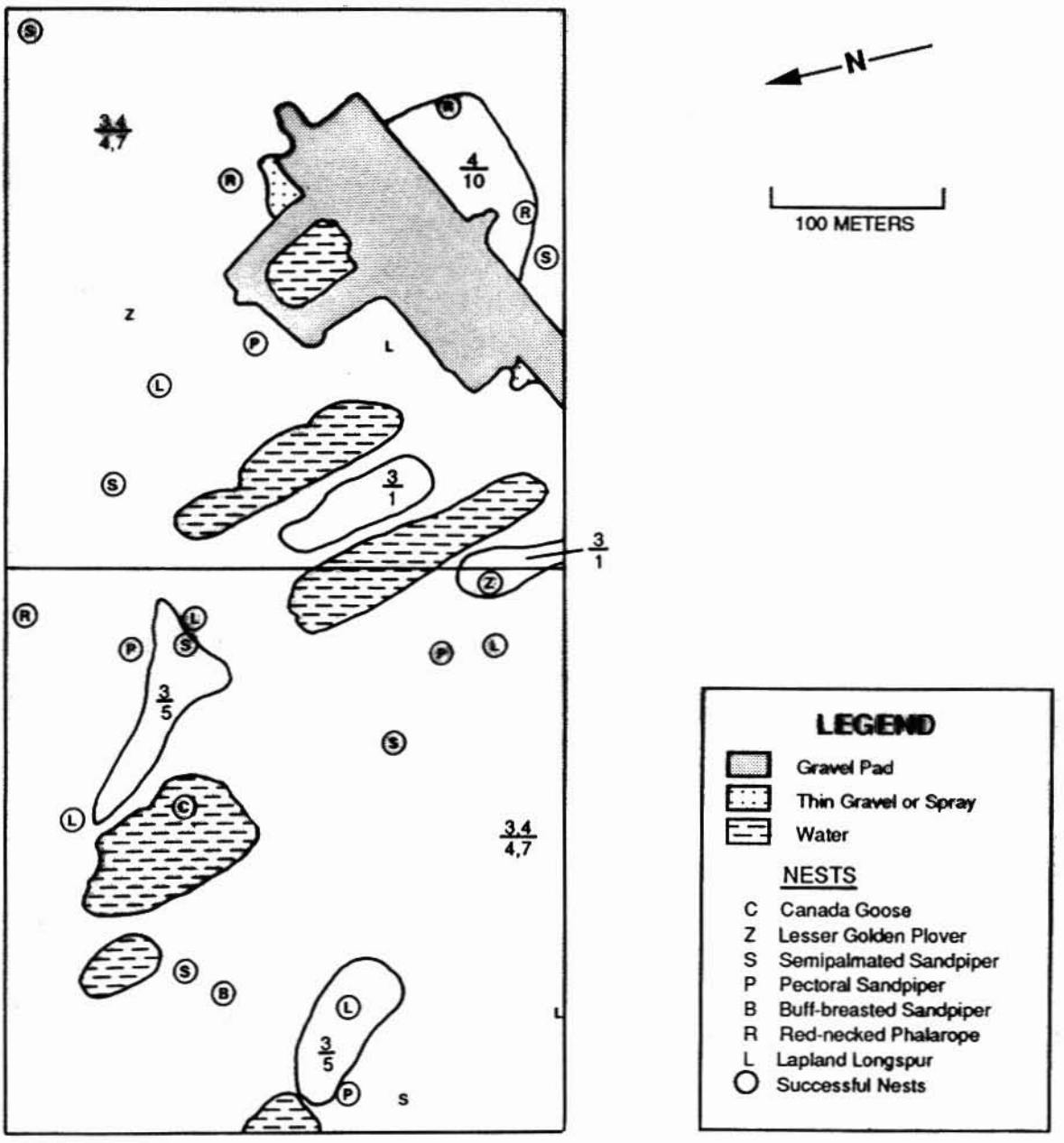


Fig. A-9. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Getty State, Prudhoe Bay, Alaska, 1990.

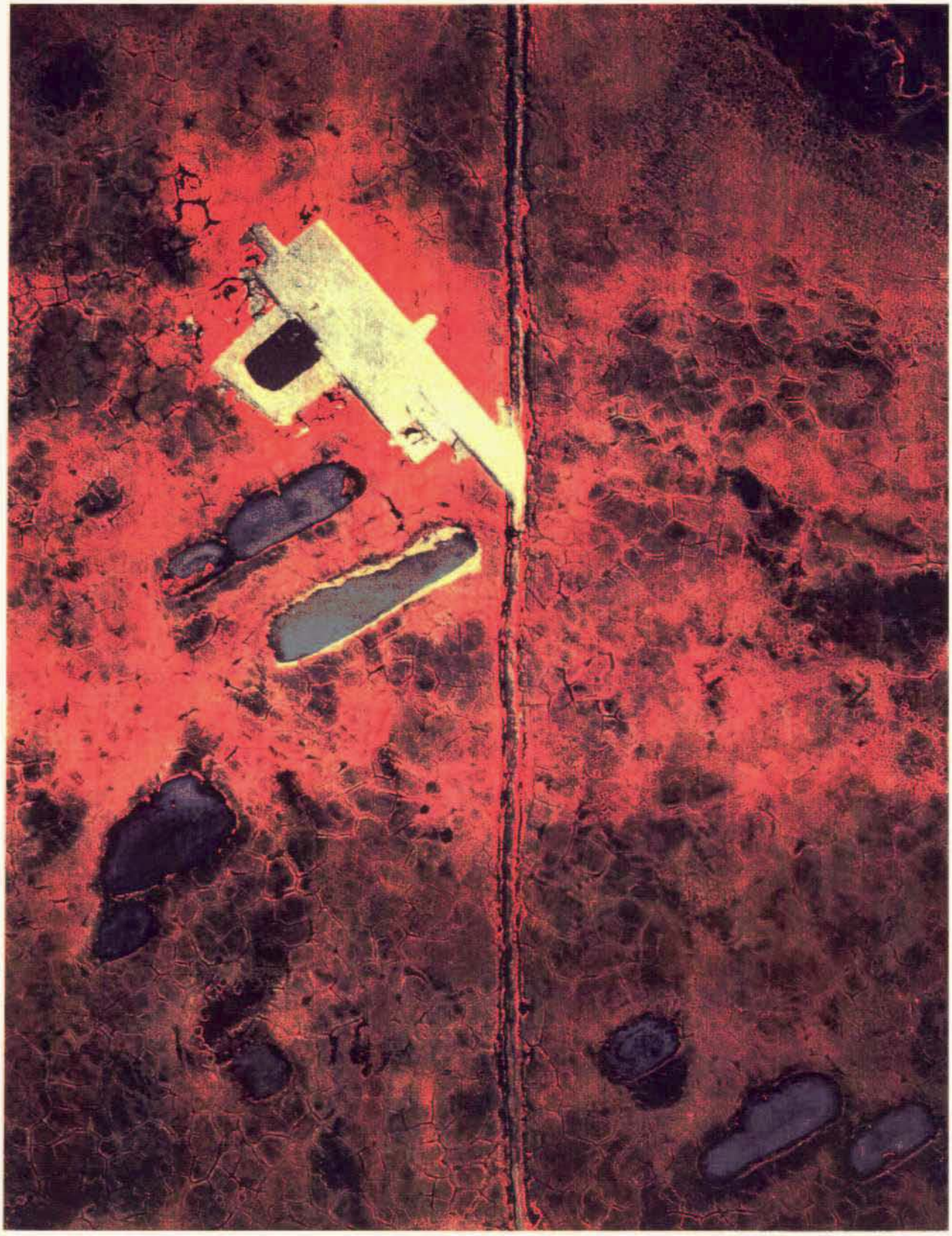


Fig. A-9. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Getty State, Prudhoe Bay, Alaska, 1990.

Nesting

Seven species had 16 nests in the undisturbed plot, and 5 species had 10 nests in the disturbed plot (Table A-9). Two nests failed in each plot. All species were either shorebirds or longspurs with the exception of a Canada Goose which nested successfully on an island in a pond in the undisturbed plot.

In the disturbed plot, 3 Red-necked Phalaropes nested on tundra near the pad in areas which had thermokarsted. Several other nests were also located near the gravel pad.

In the undisturbed plot, nests were scattered throughout and were located on all landforms. The Lesser Golden Plover which nested successfully in the southeast corner of the plot may have been a re-nest of the pair that failed in the disturbed plot.

Table A-9. Number of nests and nest success for bird species on disturbed and undisturbed study plots, Getty State, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Canada Goose	1	0	1	100
Lesser Golden Plover	1	0	1	100
Semipalmated Sandpiper	3	1	4	75
Pectoral Sandpiper	3	0	3	100
Buff-breasted Sandpiper	1	0	1	100
Red-necked Phalarope	1	0	1	100
Lapland Longspur	4	1	5	80
Total/Mean	14	2	16	88

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Lesser Golden Plover	0	1	1	0
Semipalmated Sandpiper	3	0	3	100
Pectoral Sandpiper	1	0	1	100
Red-necked Phalarope	3	0	3	100
Lapland Longspur	1	1	2	50
Total/Mean	8	2	10	80

Site 10: Put State 1

Location and Access

Put State 1 (Fig. A-10) is in the Prudhoe Bay Unit in Sec. 7, T10N, R14E, about 0.6 km southwest of X pad. There is no road access to the pad, but it can be seen from X pad, and reached in approximately 15 min on foot.

Description: Disturbed Area

The well was spudded on May 12, 1969, and suspended on July 1, 1979. Since then, the well has been plugged and abandoned.

The pad dimensions are approximately 70 m x 160 m. Gravel thickness averages about 1.3 m. Topography is fairly uniform, but some areas exhibit mild thermokarsting. No water was present in thermokarst troughs. The well head is located slightly north of the pad center and consists of a pipe imbedded in a gravel mound. A group of wood pilings is embedded in parts of the western portion of the pad. Some gravel spray is present near the east side of the pad. An old peat road passes through the study plot just north of the pad.

The gravel, gravel spray, reserve pits, and overburden (not including the peat road) cover approximately 18 percent of the disturbed plot. An area of disturbance north of the pad is sparsely vegetated and has scattered vehicle tracks and thermokarsting. Including this area, disturbance covers approximately 26 percent of the disturbed plot. The peat road is not included in this figure because it also passes through the undisturbed plot.

A wide variety of plant species is uniformly distributed over the pad surface; total vegetative cover is approximately 10 percent (Pollard et al. 1990). One *Festuca* sp. is well distributed over the entire pad surface. Mosses are colonizing the thermokarst troughs, and *Carex aquatilis* is growing on the thinner areas of gravel around the edges of the pad. *Salix* spp. and a number of forb species are also common.

A reserve pit bordering the north edge of the pad is filled with water and surrounded by overburden/peat. This pit is being colonized by *Eriophorum vaginatum, Carex aquatilis*, and *Arctophila fulva*. Another pit bordering the southwest part of the pad is also water-filled and surrounded by overburden; it is being colonized by *Carex* sp. and *Eriophorum* sp.

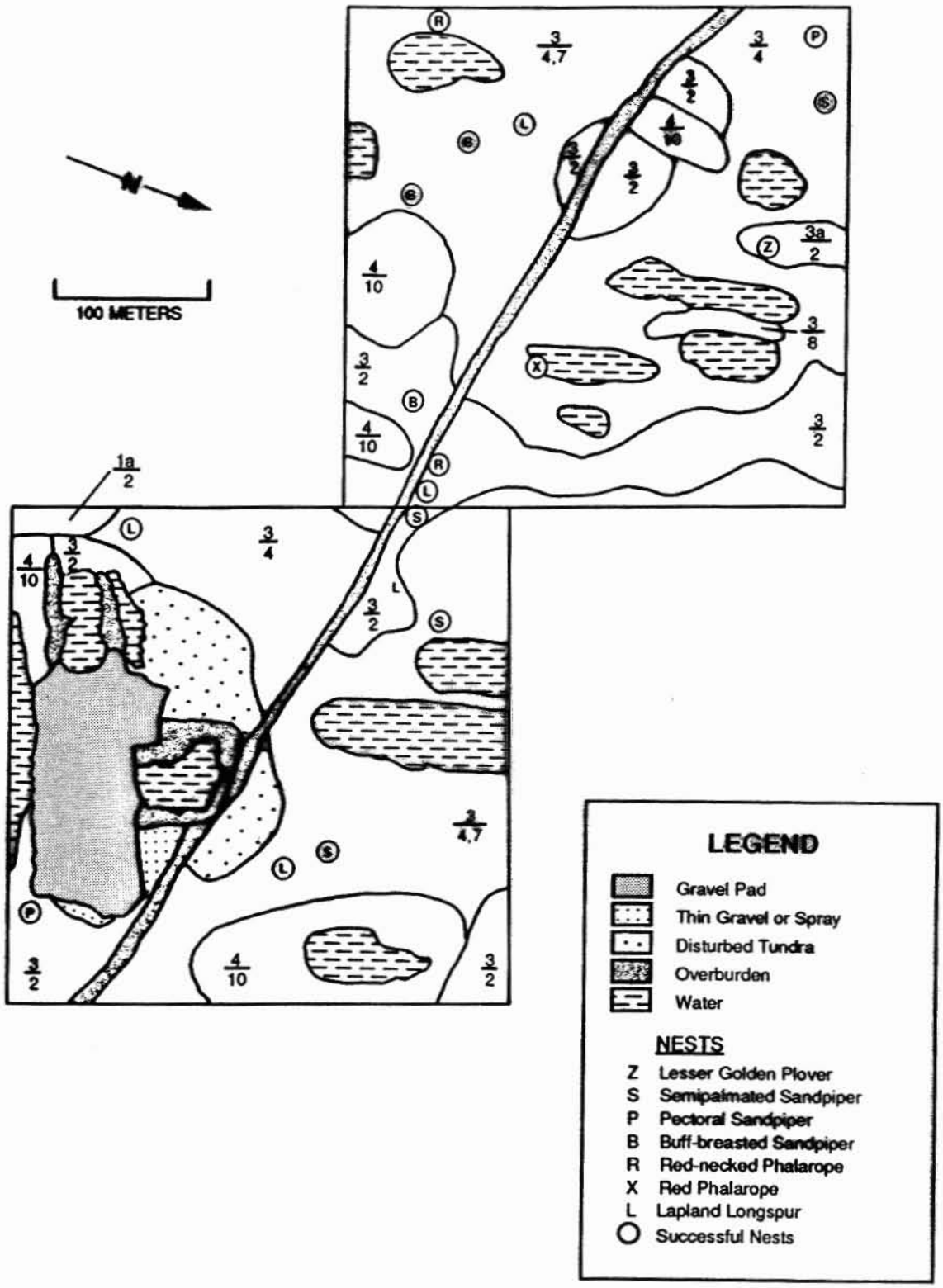
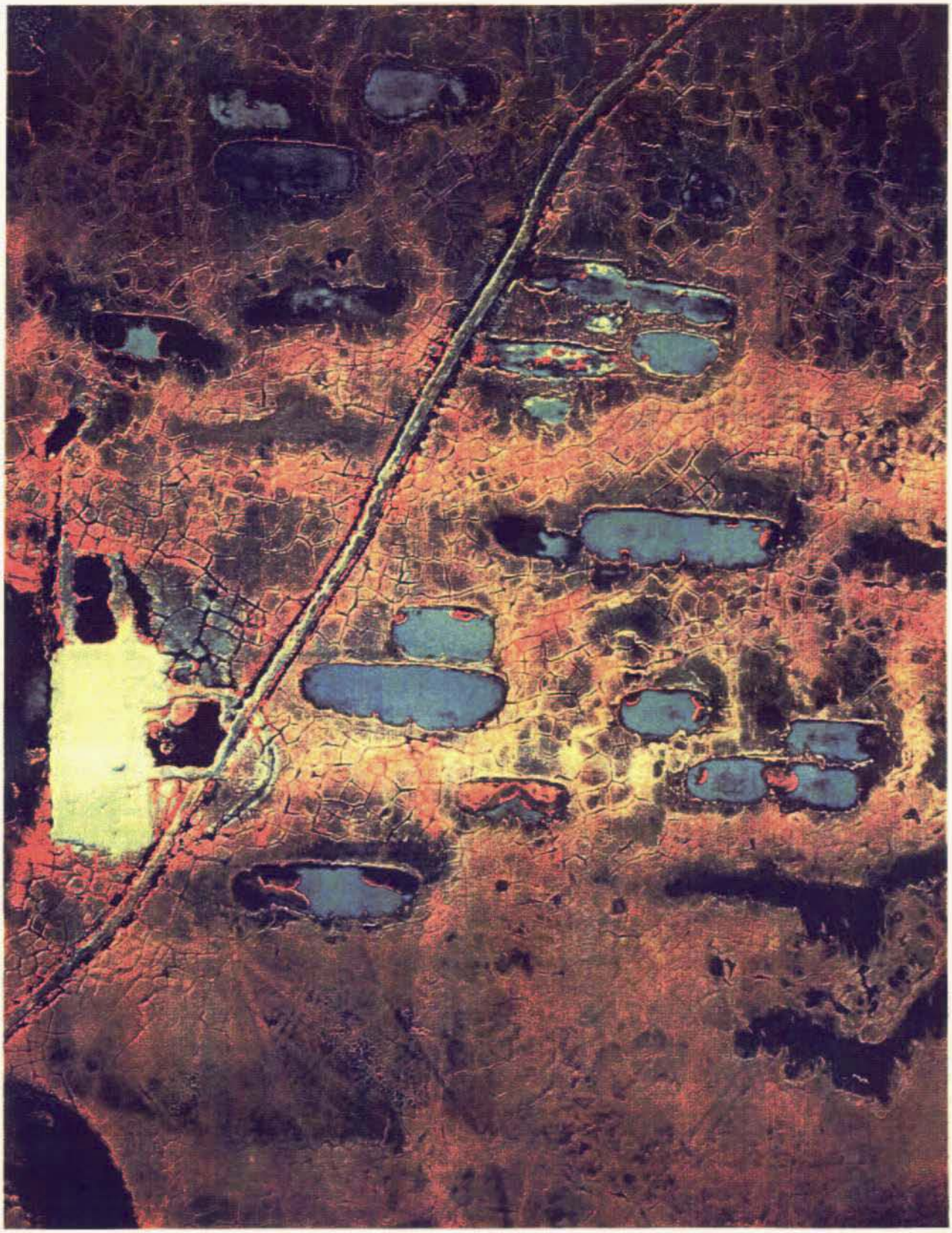


Fig. A-10. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Put State 1, Prudhoe Bay, Alaska, 1990.



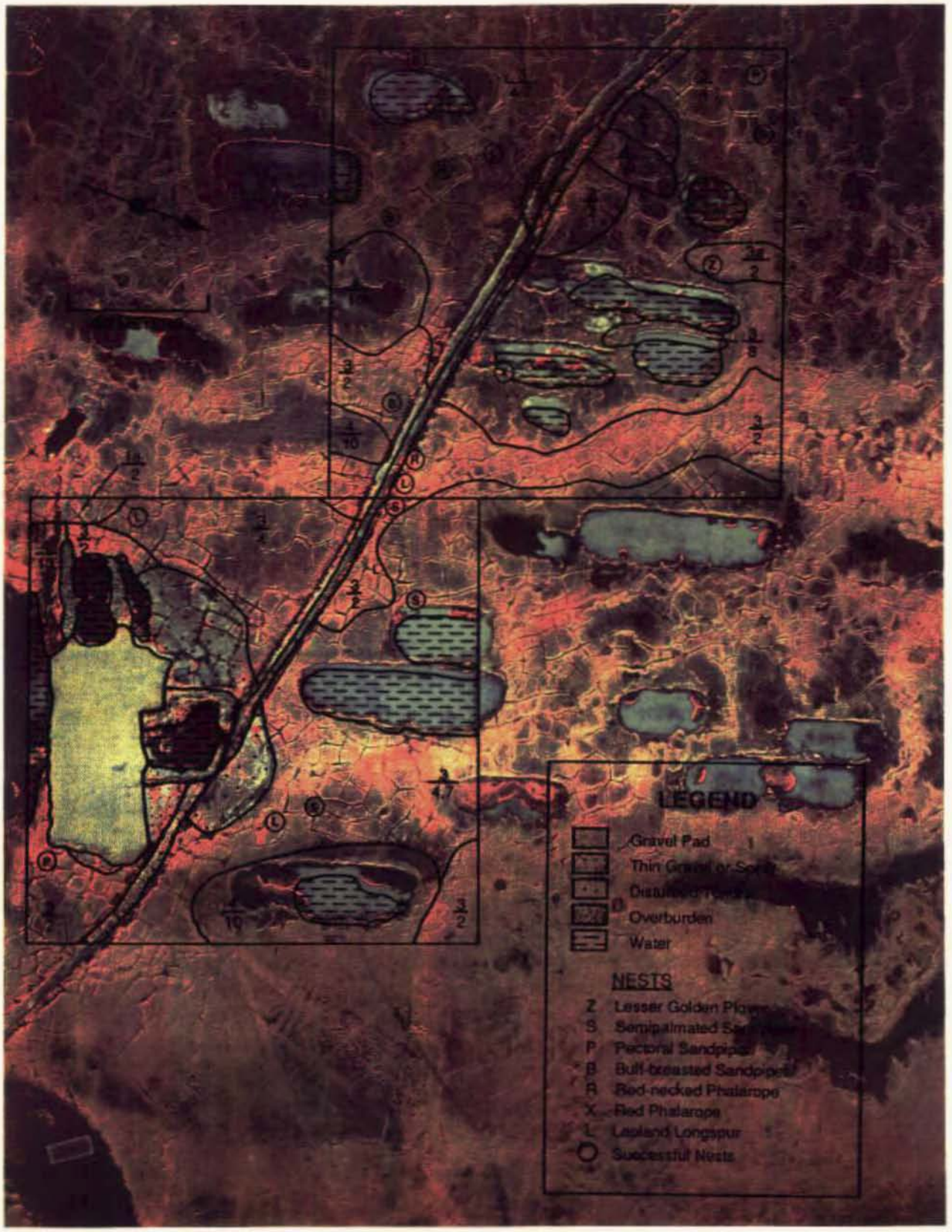


Fig. A-10. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Put State 1, Prudhoe Bay, Alaska, 1990.

The area surrounding the pad is primarily composed of moist and wet graminoid tundra; a small patch of prostrate shrub tundra is present in the southwest corner of the plot. The landform is a mixture of low-relief high-centered polygons, low-centered polygons, strangmoor, and non-patterned ground. Several ponds are located throughout the plot.

Description: Undisturbed Plot

The undisturbed plot is adjacent to the northwest corner of the disturbed plot. It was oriented such that the peat road which passes through the disturbed plot would similarly pass through the undisturbed plot, thus creating the same non-gravel disturbance in each.

The undisturbed plot is composed of moist and wet graminoid tundra. The landforms are similar to those of the disturbed plot with the addition of a small hummocky patch in the northcentral portion of the plot. Ponds are also scattered throughout this plot.

Nesting

Seven species had 11 nests on the undisturbed plot, and 3 species had 7 nests on the disturbed plot (Table A-10). All 11 nests in the undisturbed area were successful, and 6 of 7 were successful in the disturbed area. All species were either shorebirds or longspurs.

Two nests in the undisturbed plot seemed to be directly associated with the peat road. A Red-necked Phalarope nested in tundra at the edge of the water-filled peat road ditch, and a longspur nested in a crevice in the bank formed by the peat road ditch and adjacent tundra. These were both located in the southeastern corner of the plot (Fig. A-10). A Semipalmated Sandpiper which nested nearby in the disturbed plot also may have been attracted by the peat road, but its nest was slightly further away and the association was less evident. Peat roads have been shown to attract tundra-nesting birds (Troy 1990).

As was the case with the Red-necked Phalarope mentioned above, the 2 other phalarope nests found were also near water. Both were found in the undisturbed plot.

Three Buff-breasted Sandpipers successfully nested south of the peat road in the undisturbed plot. This was the largest number of nests of this species on any plots in this study.

Table A-10. Number of nests and nest sucess for bird species on disturbed and undisturbed study plots, Put State 1, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Lesser Golden Plover	1	0	1	100
Semipalmated Sandpiper	1	0	1	100
Pectoral Sandpiper	1	0	1	100
Buff-breasted Sandpiper	3	0	3	100
Red-necked Phalarope	2	0	2	100
Red Phalarope	1	0	1	100
Lapland Longspur	2	0	2	100
Total/Mean	11	0	11	100

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semipalmated Sandpiper	3	0	3	100
Pectoral Sandpiper	1	0	1	100
Lapland Longspur	2	1	3	67
Total/Mean	6	1	7	86

Site 11: Storage Pad

Location and Access

Storage Pad (Fig. A-11) is located in the Prudhoe Bay Unit in Sec. 27, T11N, R14E. It is about 0.3 km east of the north end of Drill Site 7. A gravel road from the pad intersects the southern end of the Drill Site 15 access road at an expansion loop in the pipeline next to the road. Storage Pad can be reached in about 2 min on foot from this point. This pad was not an exploratory well site.

Description: Disturbed Plot

The pad dimensions are approximately 185 m x 80 m. Gravel thickness is approximately 0.5 m over most of the pad. Thermokarsting is well developed and many troughs were filled with water, particularly on the southern portion. Plant colonization has occurred over the entire pad and is most pronounced on the southern portion. (For a list of plants identified at this site see Table B-1, Appendix B). Part of the gravel access road and a patch of gravel spray are also included in the disturbed plot. The gravel disturbance covers approximately 17 percent of the plot.

The area surrounding the pad is composed of moist and wet graminoid tundra. The landform is varied and includes well defined high-centered polygons, low-centered polygons, mixed high- and low-centered polygons, strangmoor, frost-boil tundra, and non-patterned ground. Ponds are well distributed throughout the the plot.

Description: Undisturbed Plot

The undisturbed plot is located approximately 0.3 km west of the disturbed plot. It lies about 100 m west of the north end of Drill Site7. It is composed of moist and wet graminoid tundra. The landform includes low-centered polygons, strangmoor, frost boil tundra, and non-patterned ground. A portion of an oxbow pond is located on the eastern portion of the plot.

Nesting

Five of 7 nests in the undisturbed plot were successful, and 6 of 8 nests were successful in the disturbed plot (Table A-11). Each plot had 4 species which were all either shorebirds or longspurs.

In the disturbed plot, a Baird's Sandpiper nested unsuccessfully on the southern portion of the gravel pad. The clutch had 3 eggs. At least 3 individual

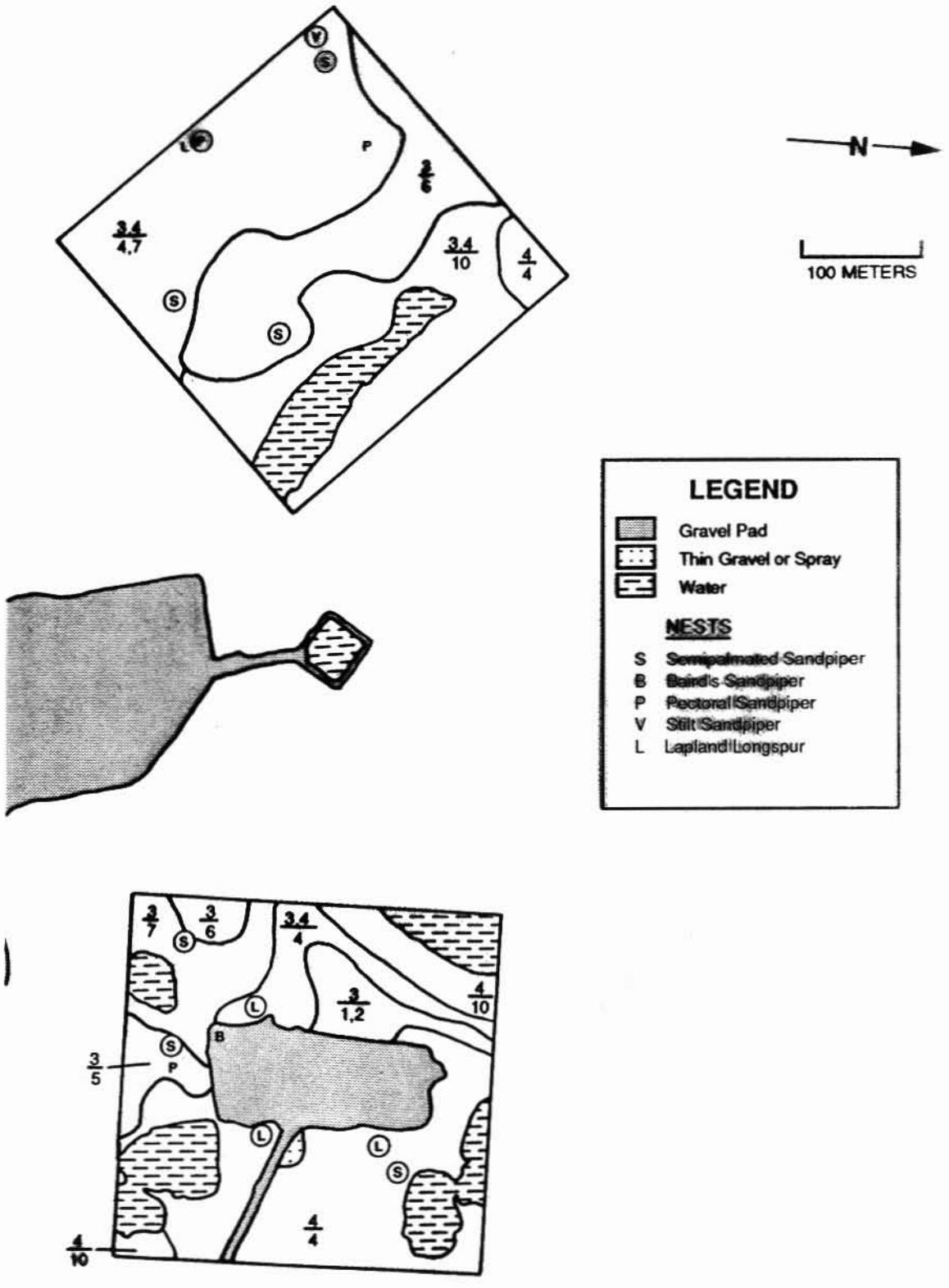


Fig. A-11. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Storage Pad, Prudhoe Bay, Alaska, 1990

Fig. A-11. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Storage Pad, Prudhoe Bay, Alaska, 1990.

adult birds were noted in the area. Although longspurs did not nest on the pad itself, 3 nests were located on tundra near the pad.

In the undisturbed plot, 6 of the 7 nests were located on low-centered polygons or strangmoor. The remaining nest occurred in an area of frost-boil tundra. No nests were found on non-patterned ground, although phalaropes often were observed around the oxbow pond. Some nests may have been missed in this area. During the course of the summer, dust was often noted on the tundra in both plots; this may have had an effect on bird nesting (Troy 1988).

Table A-11. Number of nests and nest success for bird species on disturbed and undisturbed study plots, Storage Pad, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semipalmated Sandpiper	3	0	3	100
Pectoral Sandpiper	1	1	2	50
Stilt Sandpiper	1	0	1	100
Lapland Longspur	0	1	1	0
Total/Mean	5	2	7	71

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semipalmated Sandpiper	3	0	3	100
Pectoral Sandpiper	0	1	1	50
Baird's Sandpiper	0	1	1	0
Lapland Longspur	3	0	3	100
Total/Mean	6	2	8	75

Site 12: Prudhoe Bay State 1

Location and Access

Prudhoe Bay State 1 (Fig. A-12) is located in the Prudhoe Bay Unit in Sec. 10, T11N, R14E. It is approximately 0.8 km west of the CGF facility. A peat road, which intersects the gravel road south of CGF, provides access to the pad. The site can be reached in about 10 min on foot.

Description: Disturbed Plot

The well was spudded on April 22, 1967 and plugged and abandoned on April 14, 1985. The well head is no longer evident on the pad.

The gravel pad is irregularly shaped and is roughly 150 m x 100 m. This is not a thick pad; gravel thickness is generally less than 1 m. A circular patch of gravel, which may have been a flare pad, is connected to the north edge of the pad by a gravel berm. Several other patches of gravel and extensive areas of gravel spray are scattered throughout the plot.

In addition to these gravel disturbances, much of the remaining portion of the plot shows signs of other disturbances, such as old vehicle tracks, sparsely vegetated areas, and thermokarsting caused by an old access road on the western portion of the plot. Troughs there and on other portions of the disturbed tundra were often water-filled. A small piece of the peat road is also present at the southern corner of the plot. The gravel and gravel spray cover approximately 33 percent of the study plot. Including all obvious surface disruptions, about 73 percent of this study plot is disturbed.

Little plant colonization has occurred over most of the pad, except on some areas of thin gravel. Areas of gravel spray are usually well vegetated. Wet thermokarst troughs have been colonized by *Eriophorum* spp. and *Arctophila fulva*.

The remaining portion of the disturbed plot is composed of moist and wet graminoid tundra. The landform is non-patterned ground. Portions of two ponds are also present.

Description: Undisturbed Plot

The undisturbed plot is located southwest of the disturbed plot and separated from it by about 100 m. It is composed of moist and wet graminoid tundra. The

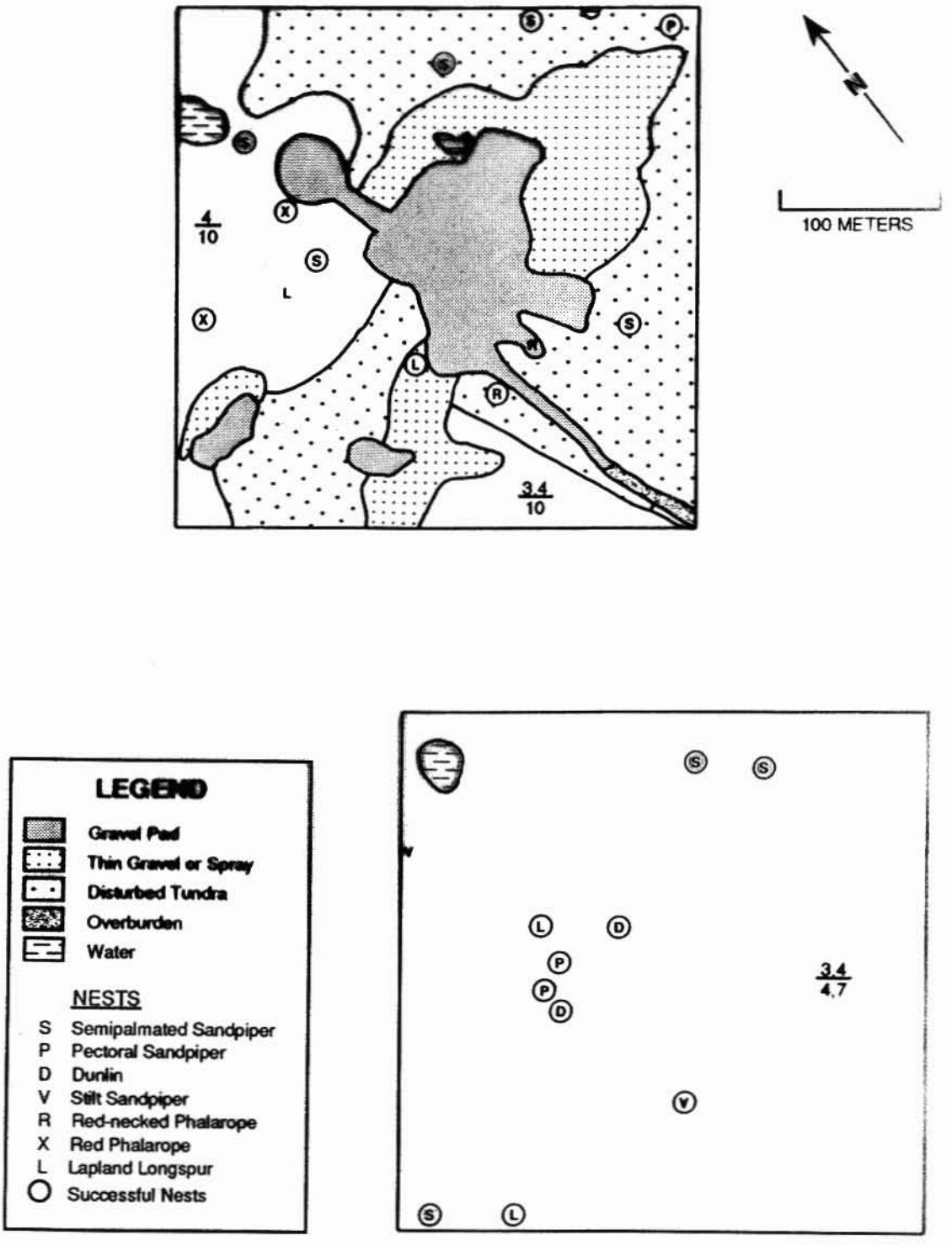


Fig. A-12. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Prudhoe Bay State 1, Prudhoe Bay Alaska 1990.

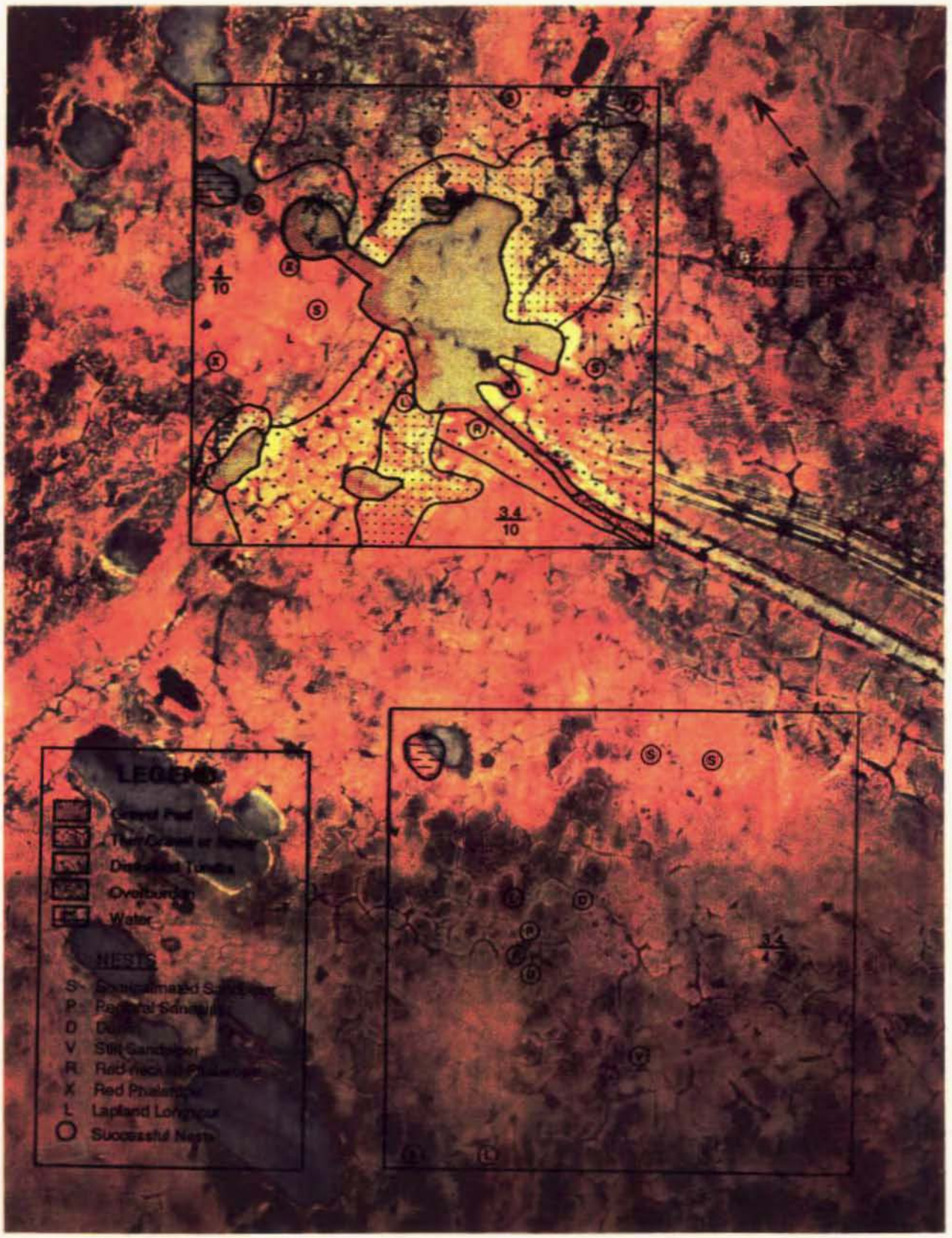


Fig. A-12. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Prudhoe Bay State 1, Prudhoe Bay, Alaska, 1990.

landform is a mixture of low-centered polygons and strangmoor. A small pond is present in the northern corner of the plot.

Nesting

Ten of 11 nests were successful in the undisturbed plot, and 10 of 12 nests were successful in the disturbed plot (Table A-12). Each plot had 5 species. All species were shorebirds or longspurs.

In the disturbed plot, 7 of the 12 nests were located in areas which showed some sign of disturbance. One Red-necked Phalarope nested unsuccessfully in a patch of grasses which had colonized the southern portion of the gravel pad. Five successful shorebird nests occurred on tundra which showed signs of heavy disturbance, and a longspur nested successfully in an area of vegetated gravel spray.

In the undisturbed plot, 5 nests were clustered slightly northwest of the plot center. Reasons for this clustering are unclear but may be related to the presence of microhabitat features such as microrelief and water. The remaining nests were scattered throughout the plot.

Table A-12. Number of nests and nest success for bird species on disturbed and undisturbed study plots, Prudhoe Bay State 1, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semipalmated Sandpiper	3	0	3	100
Pectoral Sandpiper	2	0	2	100
Dunlin	2	0	2	100
Stilt Sandpiper	1	1	2	0
Lapland Longspur	2	0	2	100
Total/Mean	10	1	11	91

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semipalmated Sandpiper	5	0	5	100
Pectoral Sandpiper	1	0	1	100
Red-necked Phalarope	1	1	2	50
Red Phalarope	2	0	2	100
Lapland Longspur	1	1	2	50
Total/Mean	10	2	12	83

Site 13: Lake State 1

Location and Access

Lake State 1 (Fig. A-13) is located in the Prudhoe Bay Unit in Sec. 24, T10N, R15E, approximately 0.3 km east of Drill Site 16. There is no road access to the pad. It can be seen from Drill Site 16 and reached in about 5 min on foot.

Description: Disturbed Area

The well was spudded on March 22, 1969, and was officially plugged and abandoned on January 25, 1981, although activity probably stopped well before that date.

Two gravel pads are present in the study plot. The dimensions of the main pad are approximately 105 m x 55 m. Gravel thickness is about 0.7 m. Areas of thin gravel and gravel spray are present beyond the northern and eastern edges of the pad. A small area of gravel, which may have been a flare pad, is connected to the northeast edge of this pad by a gravel berm. Thermokarsting is not evident. A number of areas of standing water are present in the thin gravel, and water has been impounded on the south side of the berm. The well head is located south of the pad center and consists of a pipe embedded in the gravel.

A smaller gravel pad to the southwest of the main pad is approximately 80 m x 35 m. Thin gravel, possibly the remnants of an old road, is scattered along the tundra west of the pad. The gravel disturbances cover approximately 13 percent of the plot.

This site is the object of an ARCO Alaska, Inc., revegetation study which was initiated in 1986 (Jorgenson 1988). The entire area was fertilized and specific plots were seeded with Tundra Blue Grass (*Poa glauca*) and Arctared Fescue (*Festuca rubra*). The pads are currently about 20 percent vegetated; seeded areas are more heavily vegetated than non-seeded areas. [See Table B-1 (Appendix B) for a list of plant species identified at this site. For a detailed description of the vegetation see Jorgensen (1988).]

The vegetation surrounding the pad is composed of moist and wet graminoids. Landforms are varied with well developed high-centered polygons, low-centered polygons, strangmoor, and a large area of non-patterned ground. Some areas are very wet and ponds are present on the south side of the plot.

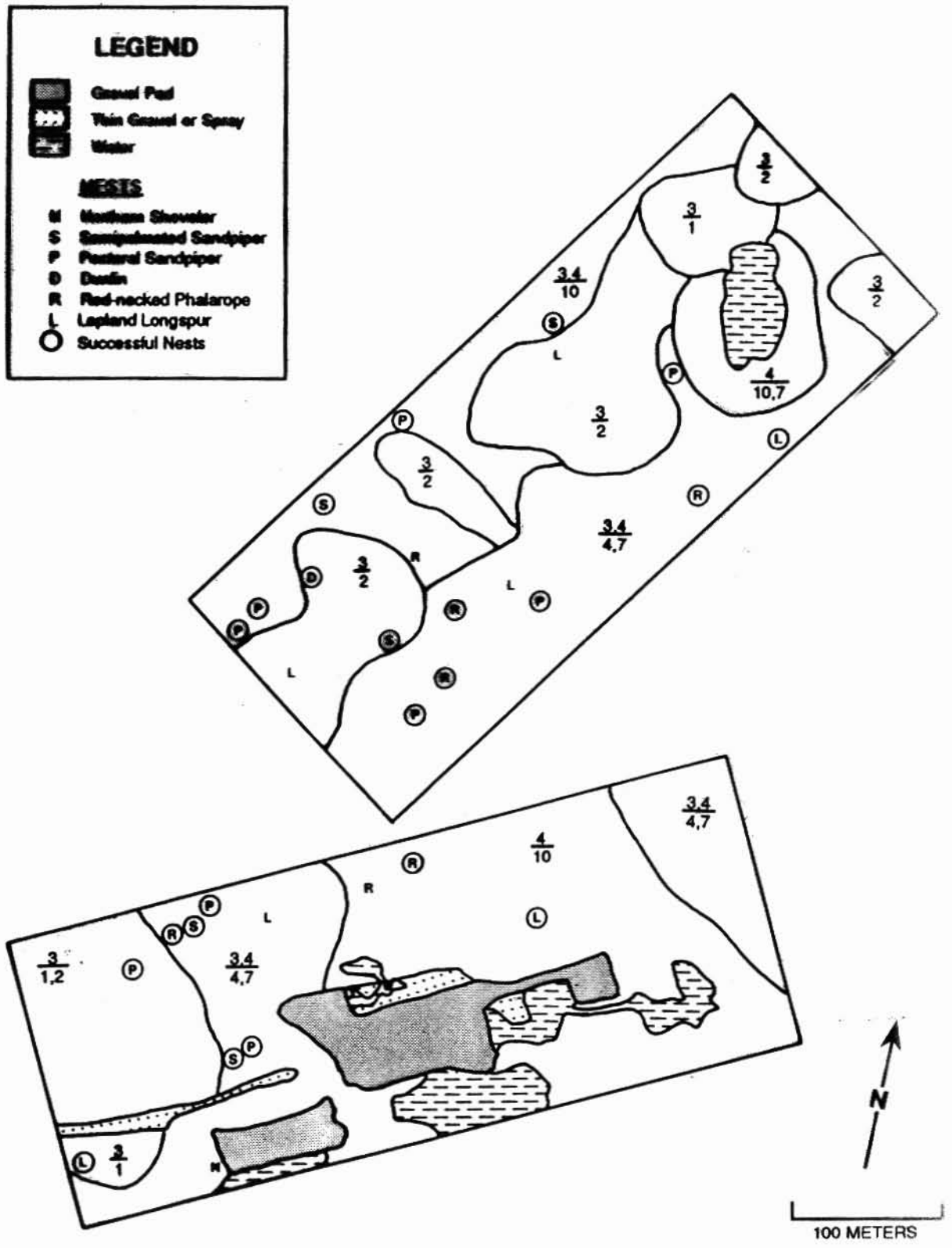


Fig. A-13. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Lake State 1, Prudhoe Bay, Alaska, 1990

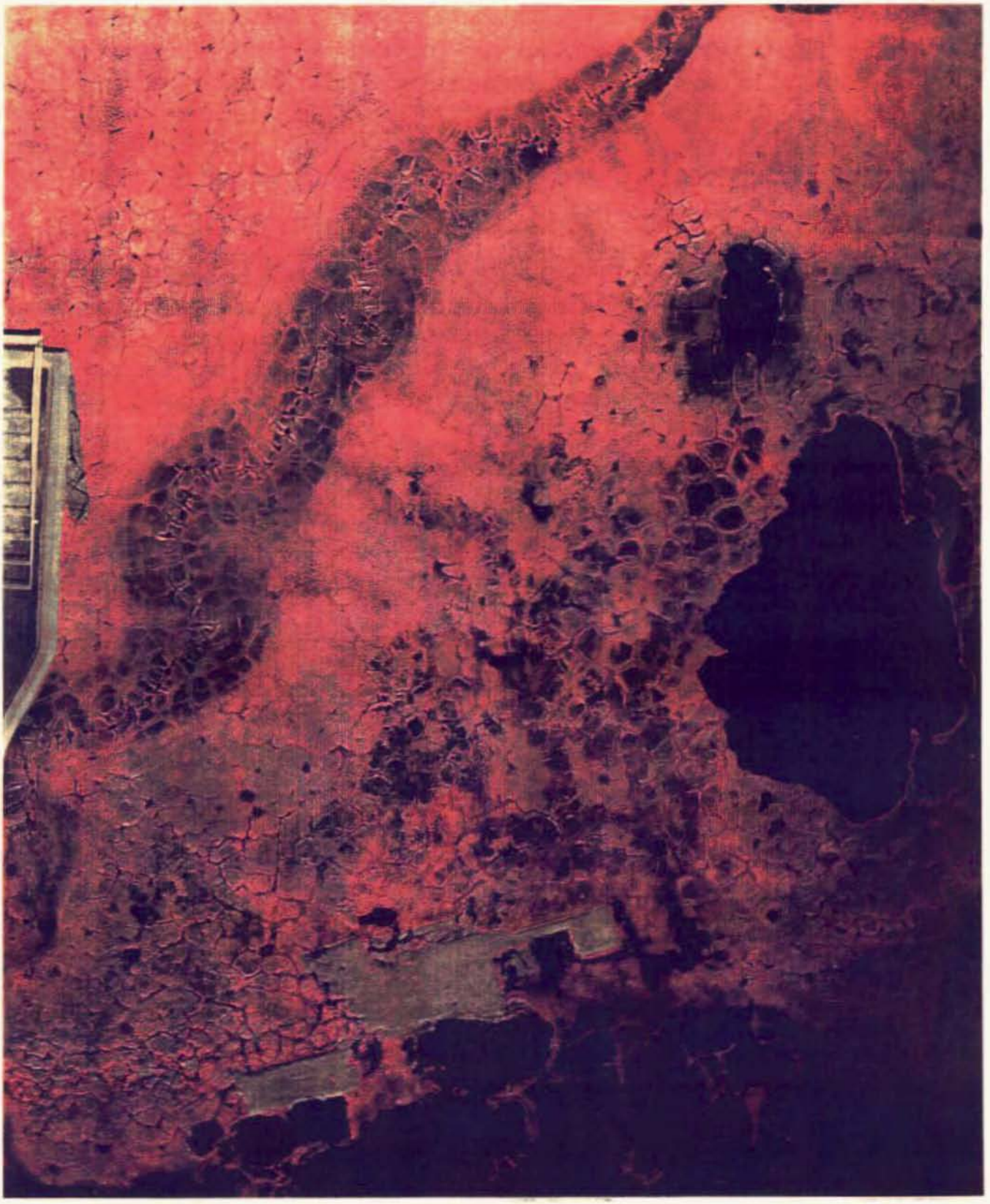


Fig. A-13. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Lake State 1, Prudhoe Bay, Alaska, 1990.

Description: Undisturbed Plot

The undisturbed plot is situated north of the disturbed plot and positioned at an angle to it. The vegetation type is composed of moist and wet graminoids. Landforms are variable with some well defined high-centered polygons, low-relief high-centered polygons that are not well defined, low-centered polygons, strangmoor, and non-patterned ground. A pond in the northeast portion of the plot was fairly well drained and consisted mostly of exposed mud.

Nesting

Eighteen nests were found in the undisturbed plot, and 12 were found in the disturbed plot (Table A-13.). Each plot had 5 species. All species were either shorebirds or longspurs with the exception of a Northern Shoveler which nested unsuccessfully in the disturbed plot near the smaller gravel pad. The proportion of successful was similar in each plot; 14 nests were successful in the undisturbed plot, and 9 were successful in the disturbed plot.

Several Red-necked Phalaropes nested at this site. We found 4 nests in the undisturbed plot and 3 in the disturbed plot. These plots seemed to be wetter than most of the other plots in this study, and that may have accounted for the large number of phalaropes nests.

Pectoral Sandpipers were also common with 6 nests in the undisturbed and 3 in the disturbed plots. Most of these nests were associated with low-centered polygons or small ridges on non-patterned ground. One nest was located on a high-centered polygon in the disturbed plot. All Pectoral Sandpiper nests were successful.

Table A-13. Number of nests and nest success for bird species on disturbed and undisturbed study plots, Lake State 1, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semipalmated Sandpiper	3	0	3	100
Pectoral Sandpiper	6	0	6	100
Dunlin	1	0	1	100
Red-necked Phalarope	3	1	4	75
Lapland Longspur	1	3	4	25
Total/Mean	14	4	18	78

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Northern Shoveler	0	1	1	0
Semipalmated Sandpiper	2	0	2	100
Pectoral Sandpiper	3	0	3	100
Red-necked Phalarope	2	1	3	67
Lapland Longspur	2	1	3	67
Total/Mean	9	3	12	75

Site 14: Delta State 2

Location and Access

Delta State 2 (Fig. A-14) is located just outside the east end of the Prudhoe Bay Unit in Sec. 35, T11N, R16E. It is visible from a point on the Endicott road about 8.0 km east of the Duck Island gravel pit. From that point, the site can be reached in 5 min on foot.

Description: Disturbed Area

There is only one well head on this pad. The well was spudded on March 5, 1975, and suspended on May 17, 1975.

The pad dimensions are approximately 75 m x 175 m. Much of the gravel appears to have been spread onto the adjoining area. The gravel is approximately 0.5 m thick. The reserve pit on the west side has been partially filled with gravel but primarily contains water and mud. Areas of gravel spray are present on both the east and west sides of the pad. No thermokarsting is evident, but shallow furrows caused by heavy equipment are present. The well head is located northwest of the pad's center. The gravel pad, gravel spray, and reserve pit cover approximately 39 percent of the plot.

The pad is sparsely vegetated; total plant cover is less than 1 percent. Most of the vegetation is around the edges of the pad. The gravel spray is characterized by heavily vegetated areas of disturbed tundra.

The vegetation type surrounding the gravel pad is primarily moist and wet graminoid tundra. A small area of prostrate shrub tundra is present on the north side of the plot. The land form is primarily non-patterned ground; some low-centered polygons and reticulate-patterned ground are also present.

Description: Undisturbed Plot

The vegetation of the undisturbed plot is also a combination of moist and wet graminoid tundra, and prostrate shrub tundra. Much of the plot is covered by non-patterned ground with some low-centered polygons in the southwest portion. The landform on a ridge that is centrally located in the plot is reticulate-patterned ground.

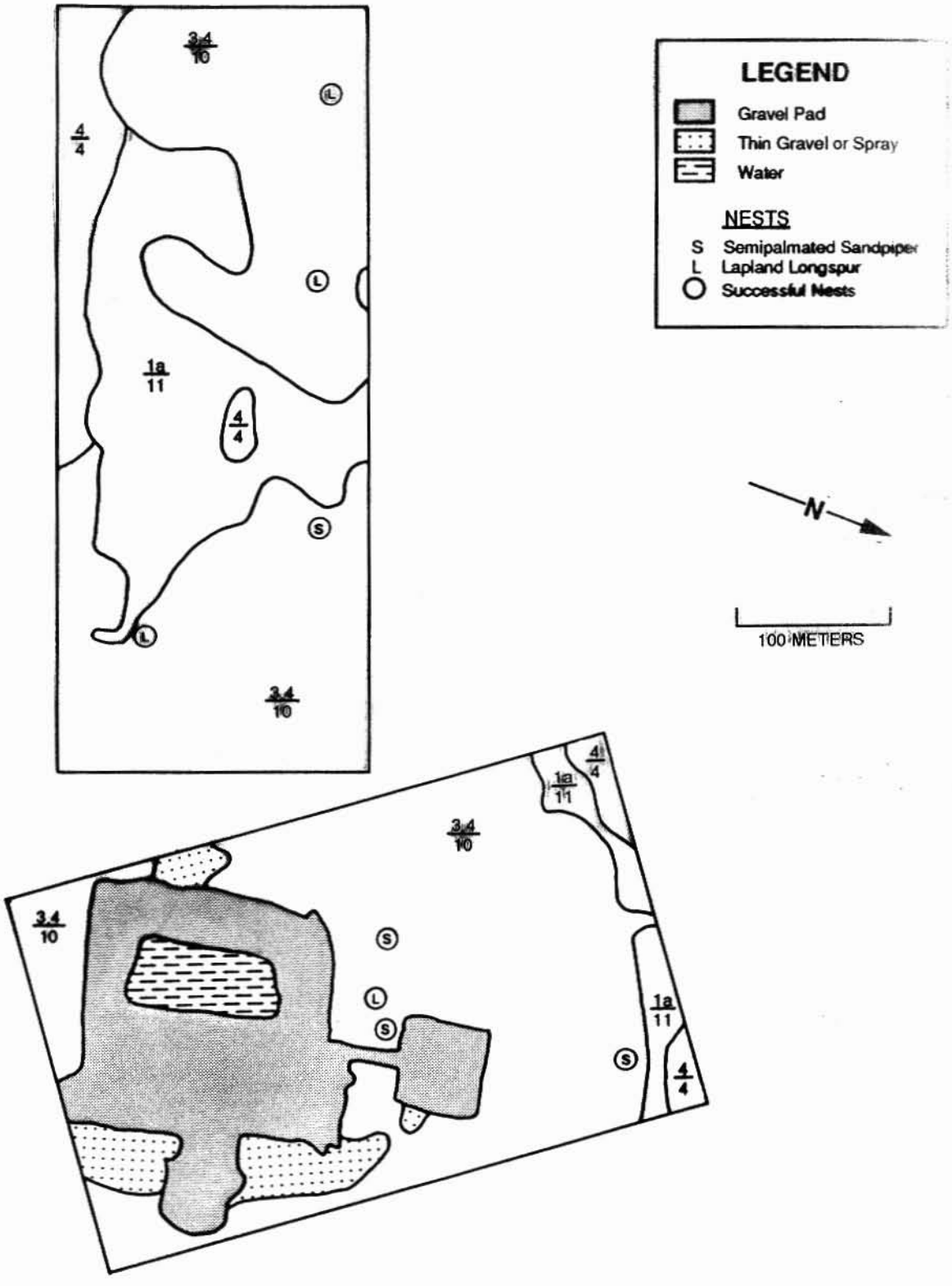


Fig. A-14. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Delta State 2, Prudhoe Bay, Alaska, 199

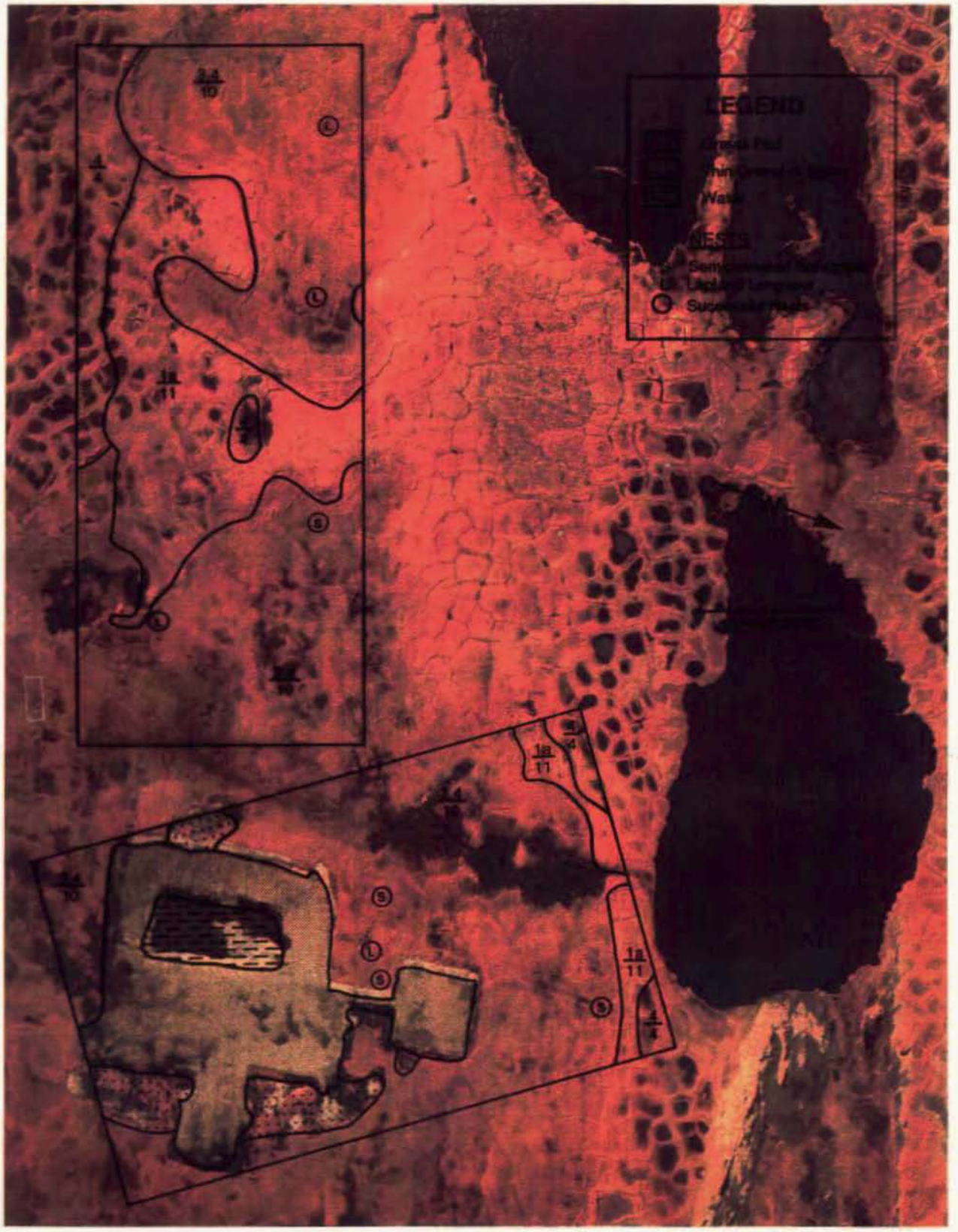


Fig. A-14. Gravel disturbance, nest locations, and geobotanical types of tundra patches on disturbed and undisturbed study plots, Delta State 2, Prudhoe Bay, Alaska, 1990.

Nesting

These plots, with only 4 nests each, had the lowest nest densities of any plots in the study. In the undisturbed plot, 1 Semipalmated Sandpiper and 3 longspurs nested; 3 Semipalmated Sandpipers and 1 longspur nested in the disturbed plot (Table A-14). All nests were successful.

Table A-14. Number of nests and nest success for bird species on disturbed and undisturbed study plots, Delta State 2, Prudhoe Bay, Alaska, 1990.

Undisturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semiplamated Sandpiper	1	0	1	100
Lapland Longspur	3	0	3	100
Total/Mean	4	0	4	100

Disturbed Study Plot

Species	Successful Nests	Failed Nests	Total Nests	Percent Success
Semipalmated Sandpiper	3	0	3	100
Lapland Longspur	1	0	1	100
Total/Mean	4	0	4	100

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Appendix B

Post-breeding Use Study Site Descriptions

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Introduction

In this section we provide descriptions of all sites which were part of the post-breeding observational study. Each site is made up of a combination of disturbed and undisturbed plots.

The disturbed plots include portions of the gravel pads, areas of thin gravel or gravel spray, and reserve pits. For disturbed plots, descriptions include plot size, gravel thickness, extent of thermokarsting, and presence or absence of vegetation and water. Where more than one gravel plot is present at a particular site, the extent and type of vegetative cover is compared among plots. Plant species were identified on plots with vegetation (Table B-1).

For undisturbed plots, the vegetation and landform are described (after Walker et al. 1983, see Appendix D).

Maps of the study sites are included in the site descriptions. These maps are provided to show the spatial relationships among plots.

Term Well C Observational Plots

Gravel Plot

The gravel pad at Term Well C is approximately 150 m x 65 m (Fig. B-1). This is a thick pad and gravel depth is over 2 m in most places. Virtually no vegetation is growing on the pad and no thermokarsting has occurred. We staked a 75 m x 40 m study plot with short pieces of wooden lath on the main portion of the pad immediately north of the reserve pit. This plot included the well head, which consists of a "christmas tree" surrounded by steel railing.

Reserve Pit Plot

The reserve pit plot has the same dimensions as the gravel plot. It includes the water in the pit and the mud bank below the base of the berm surrounding the pit. The reserve pit and the berm (see below) were scanned during the same three-min periods.

Table B-1. Checklist of vascular plant taxa found on study plots with vegetation at disturbed gravel sites, Prudhoe Bay, Alaska, 1990.

Species	Term Well C	Storage Pad		Lake State 1			Lake State 2
	Berm	"Wet" Thermokarsted	"Dry" Thermokarsted	Natural Spray	"Road"	Unseeded	Unseeded
Graminoids							
Agropyron spp.	x						
Alopecurus alpinus	x	x		x			
Arctogrostis latifolia	x	x	x	x	x		x
Carex aquatilis		x	x	x	x		
Carex Biglowii		x					
Carex capitata					x		
Deschampsia caespitosa	x	x	x	x	x		
Dupontia fischeri				x			
Eriophorum angustifolium	x	x	x	x	x		
Eriophorum russeolum				x			
Festuca baffinensis	x	x	x	x	x		x
Festuca vivipara		x	x	x	x		
Juncus arcticus		x	x	x	x		
Juncus castaneus				x	x		
Poa glauca	x						
Puccinellia borealis	x						
Tricetum spicatum	x			x	x		
Forbs							
Artemesia alaskana		x					
Artemesia glomerata		x	x				
Cerastrium Beeringianum	x	x	x	x	x		x
Chrysanthemum integrifolium			x				
Draba cinerea				x		x	
Draba lanceolata					x	x	
Draba spp.		x	x			x	x
Epilobium latifolium		x	x		x	x	x
Melandrium apelatum		x	x				
Minuartia rubella		x	x				x
Papaver lapponicum		x	x				x
Sagina intermedia				x	x	x	x
Saxifraga hirculus		x	x		x		
Saxifraga oppositifolia		x	x				
Shrubs							
Dryas integrifolia		x	x				
Salix arctica		x	x	x	x		
Salix spp.				x	x		x

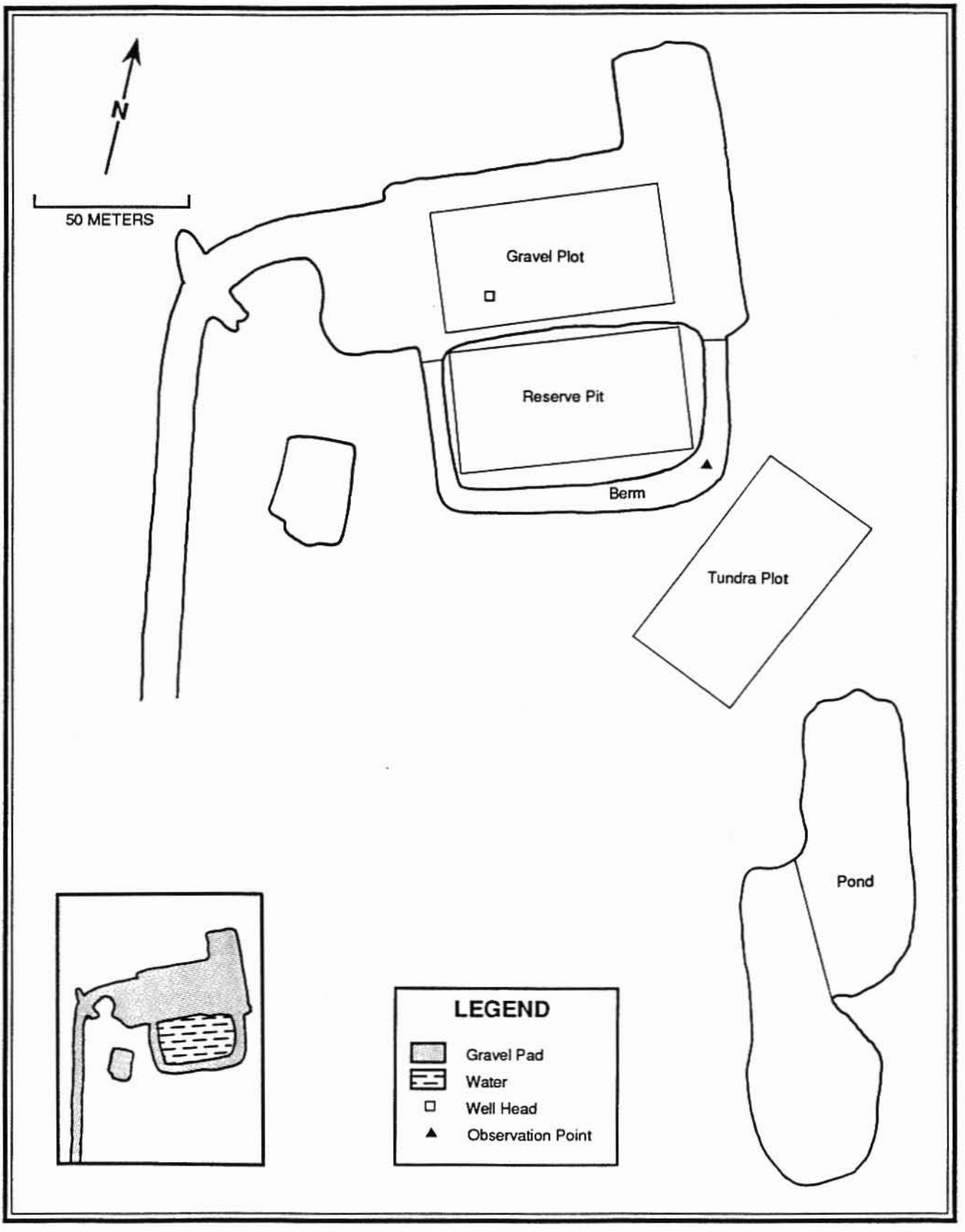

Fig. B-1. Location of disturbed and undisturbed study plots for observational study at Term Well C, Prudhoe Bay, Alaska, 1990. Inset shows types of gravel disturbances.

Berm

The berm is composed of a mixture of gravel and overburden, and it surrounds the reserve pit on the east, west, and south sides. The surface area is approximately 48 percent that of the other plots at this site. Portions of the berm are well vegetated, particularly the outside banks, which have less gravel; vegetation is also scattered on the top where gravel is mixed with overburden. Most of the vegetation is composed of graminoids (Table B-1).

Most of the berm (the top surface, the inside bank, and most of the outside bank) could be seen well from the blind. None of the outside bank on the west side could be observed, and observations were sometimes obscured by the vegetation on the southern bank.

Tundra Plot

The tundra plot is the same size as the gravel and reserve pit plots, and is located southeast of the reserve pit. The vegetation type is moist and wet graminoid tundra; the landform is primarily strangmoor. The tundra plot and the pond (see below) were scanned during the same three-min periods.

Pond Plot

The pond plot consists of a portion of a natural pond lying southeast of the tundra plot. It is similar in size to the gravel, reserve pit, and tundra plots. Water had receded, and a mud bank on the eastern pond edge was exposed. The entire pond could be seen well from the blind except for the water's edge in the northwest portion which was blocked by tundra vegetation.

Observer's Station

The blind was located on the berm above the southeast corner of the reserve pit.

Storage Pad Observational Plots

We set up two study plots on the gravel pad at this site (Fig. B-2). Gravel thickness over most of the pad is about 0.5 m. The pad exhibits a high degree of thermokarsting and is composed primarily of high-centered polygons. The primary differences between the two plots are the amount of standing water in thermokarst troughs and the extent of the vegetation.

"Wet" Thermokarsted Plot

A gravel study plot designated as "wet" thermokarsted was staked on the southern portion of the pad. Plot measurements are 60 m x 65 m. The plot is characterized by the presence of high-centered polygons formed by deep thermokarst troughs, many of which are water-filled. Plant species colonizing the pad are varied (Table B-1) and are similar to species on the "dry" thermokarsted plot (see below); however, vegetation is more robust on the "wet" plot, particularly near wet troughs.

"Dry" Thermokarsted Plot

A gravel study plot designated as "dry" thermokarsted was staked on the northern portion of the pad. Plot measurements were the same as the "wet" thermokarsted plot, 60 m x 65 m. This plot is also composed of high-centered polygons formed by deep troughs, however the troughs contain little water. Vegetation appears to be more sparsely distributed here than on the "wet" thermokarsted plot; however most of the plant species in the two plots are the same (Table B-1).

Tundra Plot

A tundra plot the same size as the gravel plots was staked adjacent to the west edge of the pad. The landform is primarily low-relief and high-relief high-centered polygons, although a small area of low-centered polygons is present on the southern portion of the plot. The vegetation is primarily moist graminoid tundra, although the tops of some high-centered approach dry prostrate shrub tundra. Most of the troughs do not contain water; a wet thermokarsted area was located in the northwestern portion of the plot.

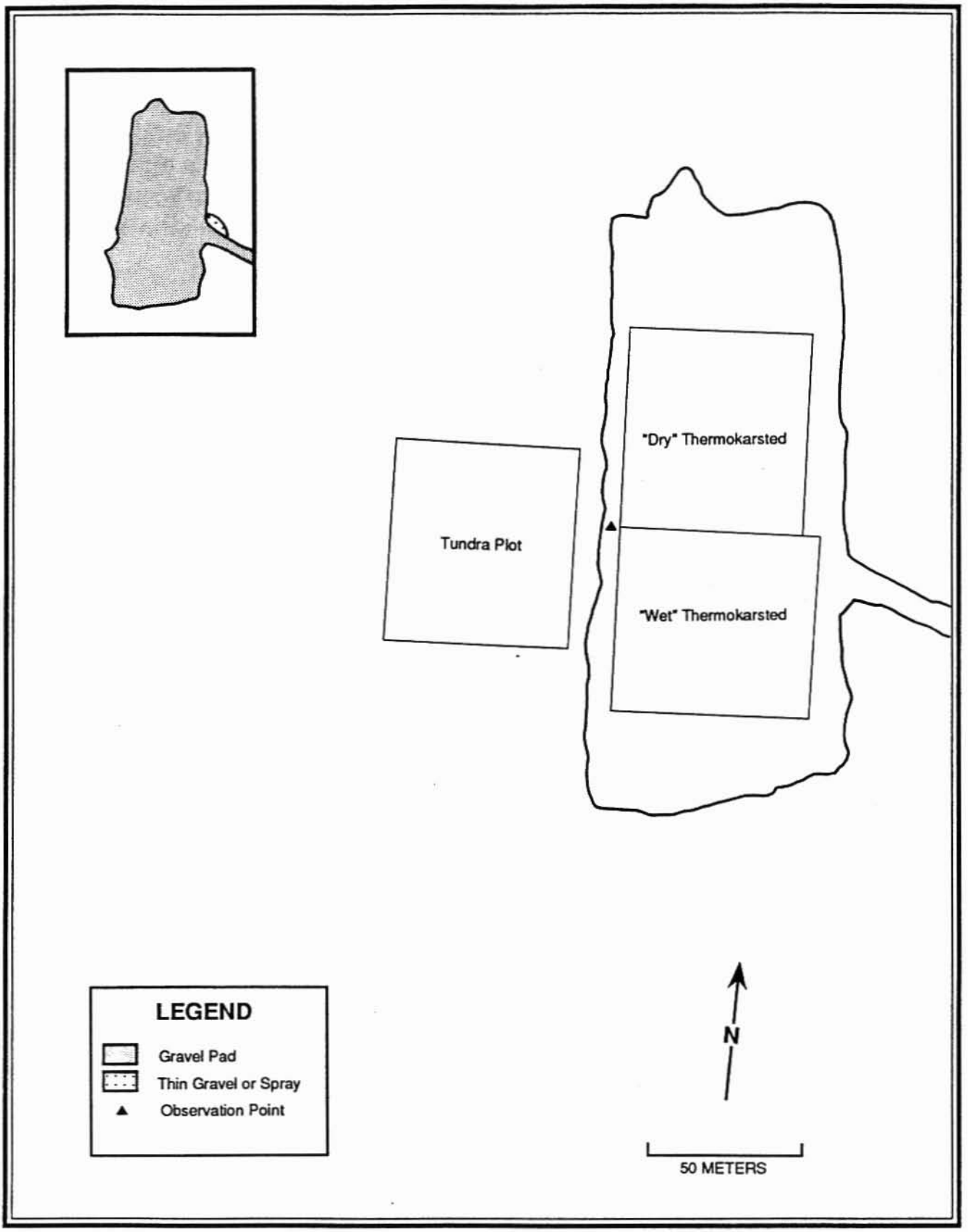

Fig. B-2. Location of disturbed and undisturbed study plots for observational study at Storage Pad, Prudhoe Bay, Alaska, 1990. Inset shows extent of gravel.

Observer Station

The blind was located on the western edge of the pad at the margin of the two gravel plots. The tundra plot was located west of the blind. Most of the area of the study plots could be seen well, except for the thermokarst troughs in all plots, which were sometimes obscured from view.

Delta State 2 Observational Plots

Gravel Plot

A gravel plot, 50 m x 100 m, was staked east of the reserve pit (Fig. B-3). The well head, consisting of a "christmas tree", is located on the plot near the northwest corner. Gravel thickness is approximately 0.5 m. No thermokarsting has occurred on the pad, but some vehicle tracks are present. Virtually no vegetation is present on the plot.

Reserve Pit Plot

The reserve pit plot has the same dimensions as the gravel plot. The plot includes the water in the pit, the mud around the water's edge, and the gravel bank extending down from the pad. Much of the mud in the pit is composed of cuttings from the drilling operation.

Tundra Plot

The tundra plot is located northeast of the reserve pit. The surface area is the same as that of the gravel and reserve pit plots; the dimensions are 71 m x 71 m. The vegetation is moist and wet graminoid tundra; the landform is non-patterned ground.

Observer Station

The blind was located on the gravel pad north of the reserve pit. The entire area of the gravel and reserve pit plots could be seen well, and probably no birds were missed. Observations on the tundra plot were obscured by the vegetation, however, we saw few birds during routine walks through the plot after the observation periods and probably few birds were missed.

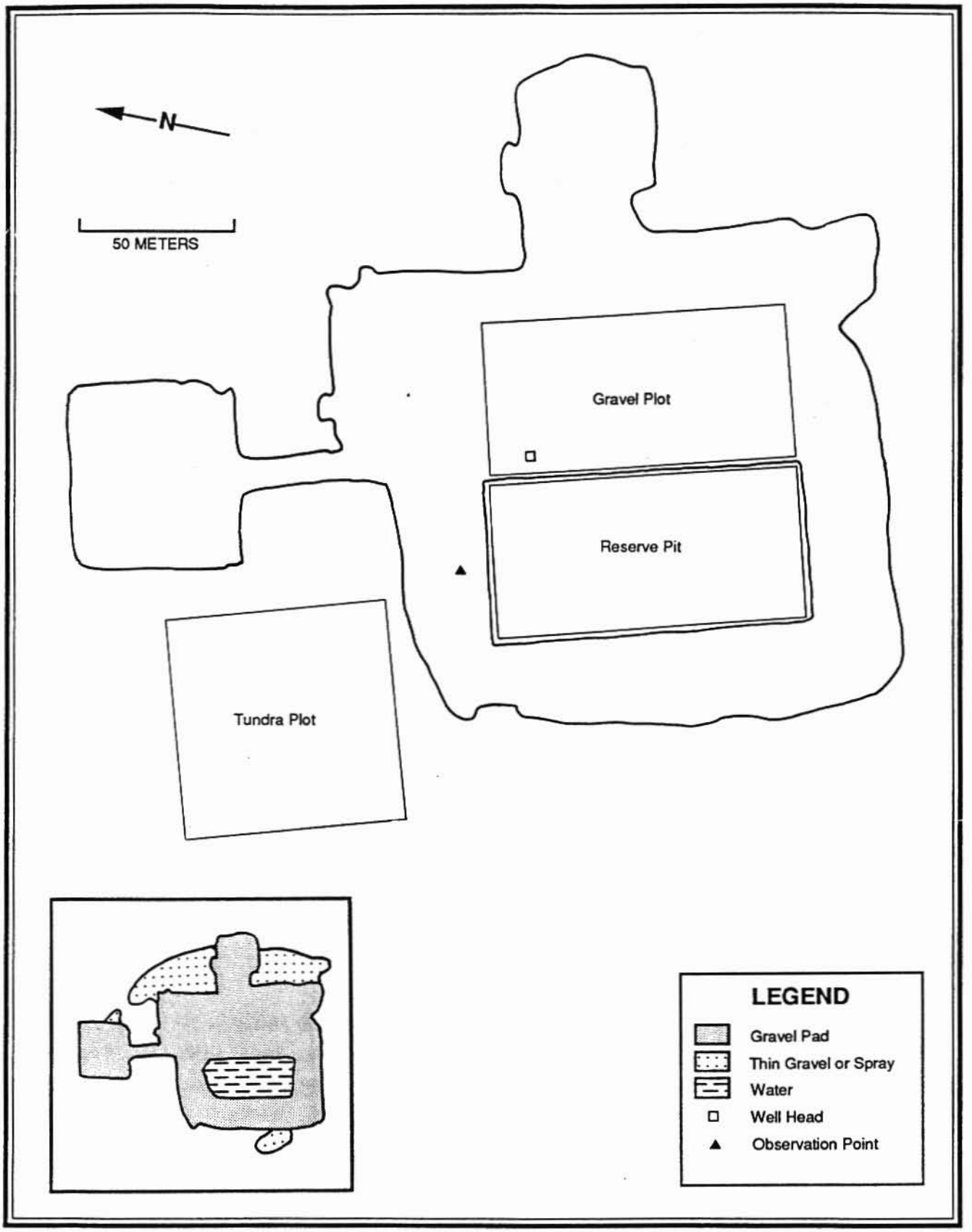

Fig. B-3. Location of disturbed and undisturbed study plots for observational study at Delta State 2, Prudhoe Bay, Alaska, 1990. Inset shows extent of gravel.

Lake State 1 Observational Plots

This site is the object of an ARCO Alaska, Inc., revegetation study which was initiated in 1986 (Jorgenson 1988). The gravel pads were fertilized and portions were seeded with Tundra Blue Grass (*Poa glauca*) and Arctared Fescue (*Festuca rubra*). Other portions were not seeded. No seed or fertilizer were distributed over gravel spray around the edges of pads or on the road connecting them. We made observations at the main drilling pad and a flare pad to the northeast, but not at a thick pad southwest of the main pad.

We established two sets of plots at this site (Fig. B-4). Initially, four gravel plots (seeded, unseeded, "road", and gravel spray) and one tundra plot were established at the main gravel pad to compare bird use among different types of gravel habitats. These plots are designated as Lake State 1(A). By August 3, a second set of plots was set up at the flare pad and was observed concurrently with the first set. The second set consists of seeded and unseeded gravel plots, an impoundment, and a tundra plot, and is designated as Lake State 1(B).

Lake State 1(A)

Seeded Plot

The dimensions of the seeded plot are 40 m x 45 m. Gravel thickness is approximately 0.7 m and no thermokarsting is evident. Cultivars were well established over the entire plot; they were green and robust on the southeastern portion, and brown and stunted on the northwestern portion. The well head (a pipe embedded into the gravel) is located in this area. Several small wire exclosures (associated with the revegetation study) are present on the plot.

Unseeded Plot

The unseeded plot is adjacent to the seeded plot and has the same dimensions. Gravel thickness is also approximately 0.7 m, and no thermokarsting is evident. Naturally colonizing forb species (Table B-1) are sparsely distributed on this fertilized plot, and there is little vegetative cover . The unseeded plot and the "road" plot were scanned during the same three-min periods.

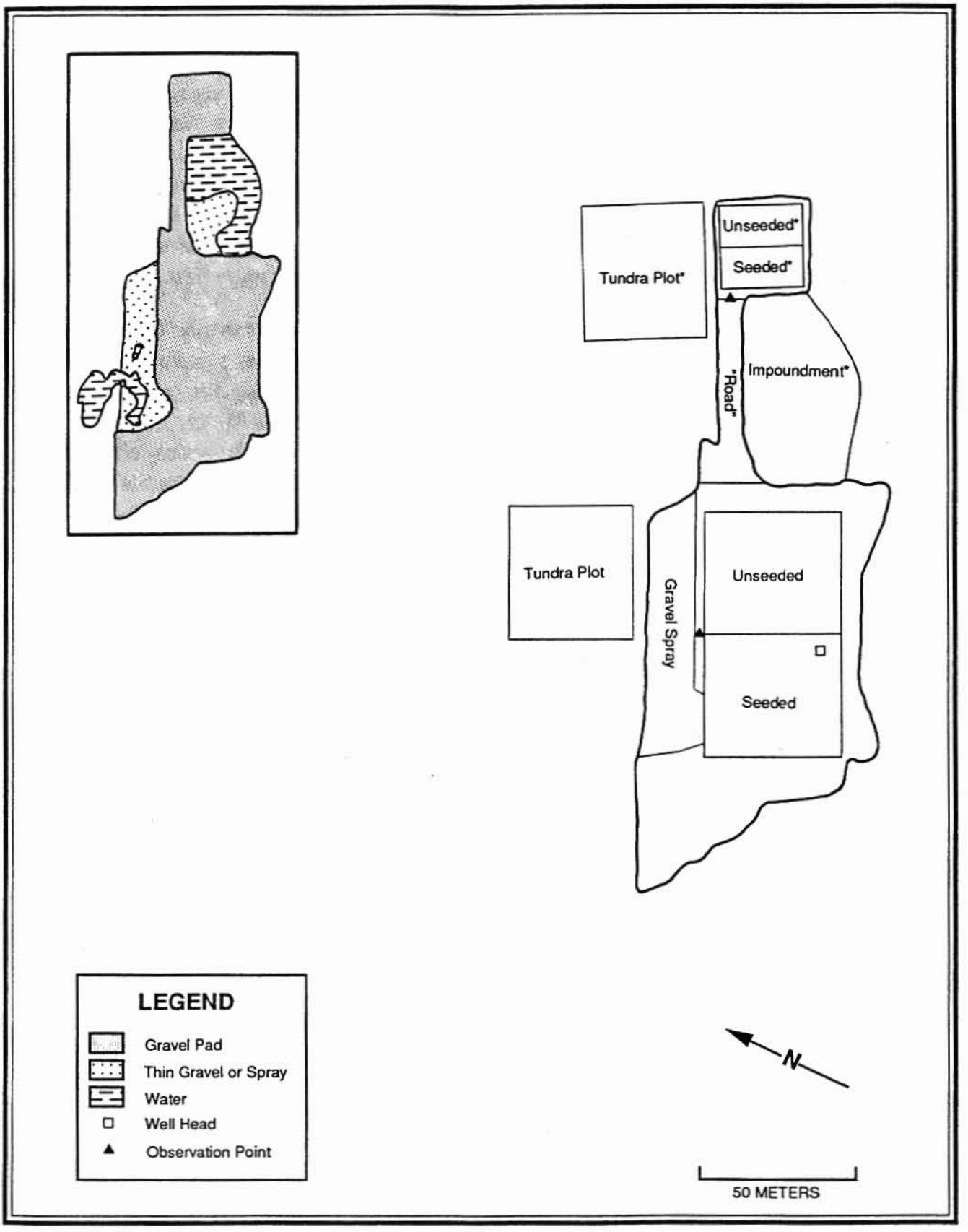

Fig. B-4. Location of disturbed and undisturbed study plots for observational study at Lake State 1 (A and B), Prudhoe Bay, Alaska, 1990. Inset shows extent of gravel. * indicates plots of Lake State 1(B).

"Road" Plot

A plot designated as the "road" plot was located on the gravel berm joining the main pad to the flare pad. The surface area of this plot is approximately 35 percent of the larger seeded and unseeded plots. A variety of graminoid, forb, and shrub vegetation has colonized the plot (Table B-1).

Gravel Spray Plot

The gravel spray plot is located north of the main pad and covers a surface area approximately 74 percent of the seeded and unseeded plots. Gravel is thinner here than on the pad, and the plot is well vegetated with graminoid, forb, and shrub species (Table B-1). Vegetative cover is higher than at the other unseeded plots. Several thermokarst troughs in this plot contained water and had exposed mud banks. Observations of bird use on the gravel spray plot and the tundra plot north of the main pad (see below) were made during the same three-min periods.

Tundra Plot

The tundra plot, located north of the gravel spray plot, has the same dimensions as the seeded and unseeded plots. The vegetation type is moist and wet graminoid tundra and the landform is non-patterned ground. The high level of use on the gravel spray plot (which was observed during the same 3-min scanning period), may have distracted our observations of the tundra plot, and some birds may have been missed. However, this number is probably relatively low as we saw very few birds on the tundra during routine walks after observation periods.

Observer's Station

The blind was located on the main pad between the gravel spray plot and the seeded and unseeded plots.

Lake State 1(B)

Seeded Plot

The dimensions of the seeded plot, located on the flare pad, are 14 m x 28 m. Gravel thickness is approximately 0.5 m and no thermokarsting is evident. This plot covers approximately 22 percent of the area of the tundra plot (see below). Cultivars are well established, and the vegetation was green and robust on the southeastern portion of this plot and brown and stunted on the northwestern portion. Small wire exclosures were also present. The seeded plot and the adjacent unseeded plot (see below) were scanned during the same three-min period.

Unseeded Plot

The unseeded plot is adjacent to the seeded plot and has the same dimensions. Gravel thickness is similar to that of the seeded plot. Natural plant colonization is occurring on this fertilized plot and includes graminoid, forb, and shrub species (Table B-1). Vegetative cover is greater than that on the unseeded plot at Lake State 1(A). *Sagina intermedia* was particularly abundant.

Impoundment Plot

The impoundment plot, located between the flare pad and the main pad, covers approximately 82 percent of the surface area of the tundra plot. Much of the water had receded, exposing areas of mud. A channel on the south side was water-filled. Graminoids were sparsely distributed over portions of the plot, particularly in drier areas. A peninsula of vegetated gravel spray extended into the impoundment from the main gravel pad.

Tundra Plot

The dimensions of the tundra plot are 45 m x 40 m. The vegetation is moist and wet graminoid tundra; the landform is primarily non-patterned ground.

Observer's Station

The blind was located near the western edge of the flare pad on the end of the gravel berm connecting it to the main pad. All plots could be seen well, and we probably missed few birds.

Literature Cited

Jorgenson, M. T. 1988. Revegetation of the Lake State 1 exploratory well site, Prudhoe Bay oilfield, Alaska, 1987. Report prepared for ARCO Alaska, Inc. and Kuparuk River Unit by Alaska Biological Research, Inc., Fairbanks, Alaska.

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Appendix C

List of Birds and Mammals

Table C-1. Wildlife species observed during nesting and observational studies, Prudhoe Bay, Alaska, 1990.

Birds	
Scientific Name	Common Name
Anser albifrons	Greater White-fronted Goose
Branta canadensis	Canada Goose
Branta bernicla	Brant
Anas acuta	Northern Pintail
Anas clypeata	Northern Shoveler
Somateria spectabilis	King Eider
Clangula hyemalis	Oldsquaw
Charadrius semipalmatus	Semipalmated Plover
Pluvialis squatarola	Black-bellied Plover
Pluvialis dominica	Lesser Golden-Plover
Phalaropus lobatus	Red-necked Phalarope
Phalaropus fulicaria	Red Phalarope
Limnodromus scolopaceus	Long-billed Dowitcher
Calidris himantopus	Stilt Sandpiper
Arenaria interpres	Ruddy Turnstone
Calidris alpina	Dunlin
Calidris pusilla	Semipalmated Sandpiper
Calidris fuscicollis	White-rumped Sandpiper
Calidris bairdii	Baird's Sandpiper
Calidris melanotos	Pectoral Sandpiper
Tryngites subruficollis	Buff-breasted Sandpiper
Stercorarius parasiticus	Parasitic Jaeger
Larus hyperboreus	Glaucous Gull
Xema sabini	Sabine's Gull
Lagopus mutus	Rock Ptarmigan
Lagopus lagopus	Willow Ptarmigan
Corvus corax	Common Raven
Motacilla flava	Yellow Wagtail
Calcarius lapponicus	Lapland Longspur
Plectrophenax nivalis	Snow Bunting
Carduelis flammea	Common Redpoll

Mammals	
Alopex lagopus	Arctic Fox

Appendix D

Vegetation and Landform Characteristics

Table D-1. Summary of the vegetation types and surface from units used in classifying tundra patches (after Walker et al. 1983). This information is displayed in fractional form on the maps, with the vegetation code in the numerator and the surface form code in the denominator.

VEGETATION	
Code	Dominant Vegetation
1	Riparian shrub tundra
1a	Riparian prostrate shrub, forb, grass tundra
2	Dry prostrate shrub, crustose lichen tundra
3	Moist sedge, prostrate shrub tundra
3a	Moist tussock sedge, prostrate shrub tundra
4	Wet sedge tundra

SURFACE FORM	
Code	Dominant Surface Form
1	High-centered polygons, center-relief > 0.5 m
2	High-centered polygons, center-relief ≤ 0.5 m
3	Low-centered polygons, center-relief > 0.5 m
4	Low-centered polygons, center-relief ≤ 0.5 m
5	Mixed high- and low-centered polygons
6	Frost-scar tundra
7	Strangmoor and/or discontinuous low-centered polygons rims
8	Hummocky terrain associated with steep slopes
10	Non-patterned ground or with pattern occupying < 20%
11	Reticulate pattern

Appendix E

Cartographic Notes

Cartographic Notes

The regional map (Figure 1) is a base map generalized from various sources, and projected to Universal Transverse Mercator, Zone 6, NAD27.

The specific area maps (Figures 1A to 1D) were produced from 1:63360 USGS quad maps. The coastline, rivers, and all facilities were taken from unit operator 1:6000 maps. The U.S. Public Land System (USPLS) grid was generated from a Bureau of Land Management (BLM) based protraction software package. All townships and sections are protracted. All features have been projected to Universal Transverse Mercator, Zone 6, NAD27.

Aerial Photography was obtained at a scale of 1"=500' with a cartographic camera using Kodak 2443 false color infra-red film. The date of each photograph and the original photograph label are given in Table E-1.

Table E-1. The following are dates and original labels of color infra-red aerial photographs used to produce overlays in Appendix A. The original scale of all photographs was 1"=500'. The photographs were enlarged and the scale is indicated on each overlay.

Figure	Date	Original Photo Label
A-1	8/22/89	Kup West Sak 17 #1
A-2	8/22/89	Kup Ugnu 1 #2
A-3	8/22/89	Kup West Sak 9 #2
A-4	8/22/89	Kup West Sak 3 #1
A-5	8/22/89	WPB MP 13-15-11-12 #2
A-6	8/22/89	WPB Term Well C #2
A-7	7/3/90	WPB Hurl State #2
A-8	8/22/89	WPB Put River 22-33-11-13 #1
A-9	8/22/89	WPB 37 #4
A-10	8/22/89	WPB 16 #16
A-11	8/22/89	EPB DS-7 #2
A-12	8/22/89	EPB 17 #6
A-13	8/22/89	EPB DS-16 #3
A-14	8/22/89	ENDCT 25 #10