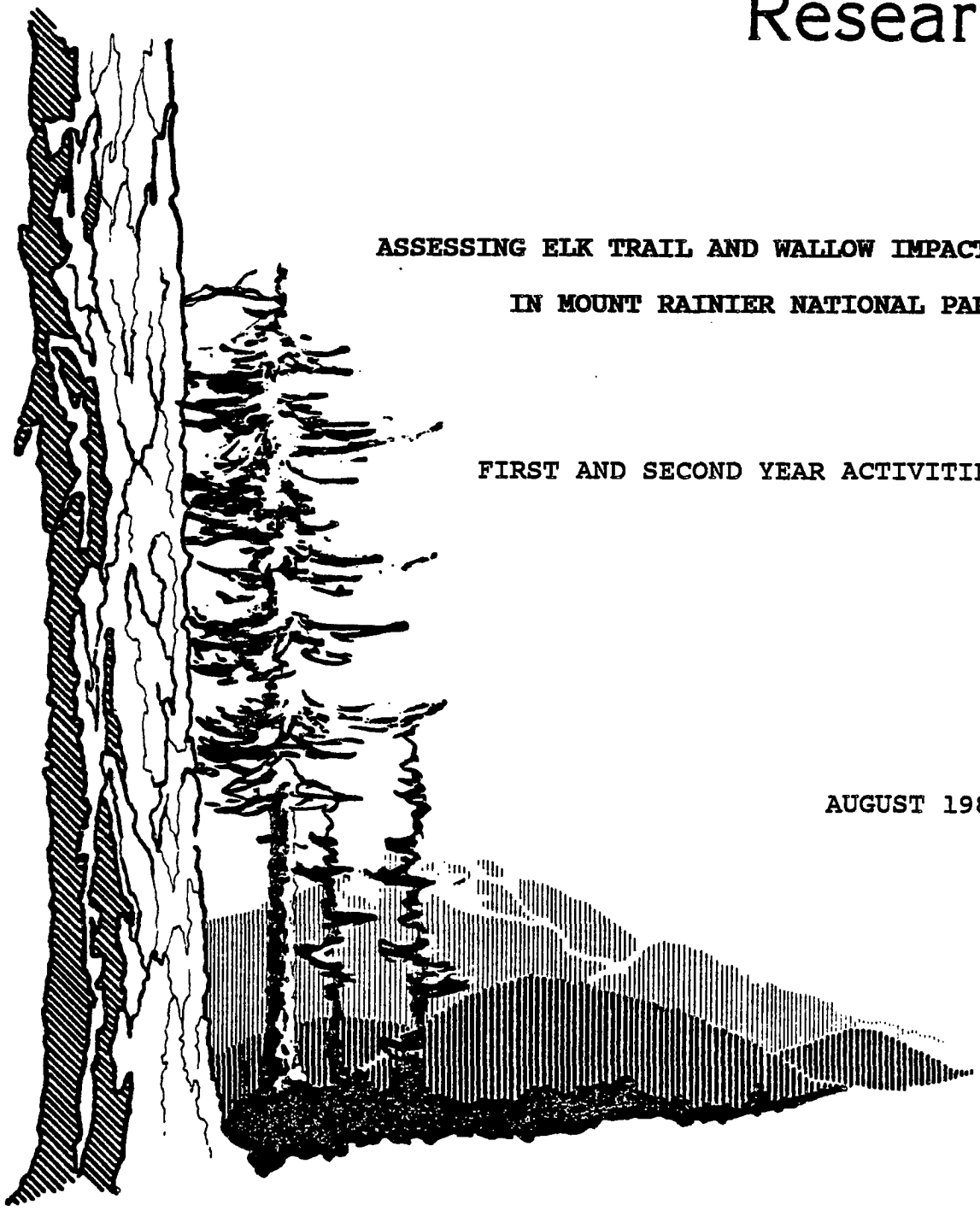
Remote Sensing Research



ASSESSING ELK TRAIL AND WALLOW IMPACTS IN MOUNT RAINIER NATIONAL PARK

FIRST AND SECOND YEAR ACTIVITIES

AUGUST 1987

Environmental Remote Sensing
Applications Laboratory - ERSAL
OREGON STATE UNIVERSITY

ASSESSING ELK TRAIL AND WALLOW IMPACTS IN MOUNT RAINIER NATIONAL PARK

FIRST AND SECOND YEAR ACTIVITIES

For the Period
August 1985 through July 1987

Submitted by

the

Environmental Remote Sensing
Applications Laboratory (ERSAL)
Oregon State University
Corvallis, Oregon

August 1987

TABLE OF CONTENTS

Preface ii

FIRST YEAR ACTIVITIES

Summary of Overall Progress 1

Field Enumeration and Mapping 1
Aerial Photographic Interpretation 4
Critical Area Inventory 5
Photo Sampling Sites 6

Conclusions. 10

Appendix A-I: Elk Trail Enumerations: Tabular and Photographic 11

Appendix A-II: 1985 Flight Map and Flight Specifications 20

Appendix A-III: Comparison and Accuracy Assessment of Photointerpretation with Ground Truth. . .23

SECOND YEAR ACTIVITIES

Summary of Overall Progress 29

Permanent Photo-Plots 29
Fremont Lookout North Ground Truth and Accuracy Assessment. 32
Transfer of Results to Rainier Park 33
Photo Index Maps. 33
Systematic Sampling for Elk Trails 33

Conclusions. 39

Appendix B-I: Photo-Plots Associated with Ten Sites for Monitoring Elk Trails. 40

Appendix B-II: Trail and Vegetation Widths for Fremont Lookout North Plot, 1986. 57

Appendix B-III: Project Correspondence 59

Appendix B-IV: Photo Index Maps for 1985 and 1986 Flights. .61

Appendix B-V: Presence and Absence of Elk Trails from Aerial Photography. 64

PREFACE

This report provides a description of the development of a remote sensing system to monitor elk trail and wallow impacts at Mount Rainier National Park. This document consists of two parts: the first section describing activities that took place between August 1985 and July 1986; the second section provides a description of the activities during the August 1986 through July 1987 timeframe.

The first year's activities involved 1) field enumeration and mapping of elk trails in forested areas, and 2) developing laboratory methods to map elk trails and wallows in non-forested areas from large scale aerial photography. The second year activities include: 1) establishing permanent photo-plots on both the 1985 and 1986 aerial photography, and 2) the systematic sampling of elk trails from the aerial photography. Accuracy assessments were conducted in both the first and the second years.

Acknowledgements are due to both Stan Schlegal and Bob Dunnagan of Mount Rainier National Park for providing on-site facilities and collaborating on all aspects of this project.

William J. Ripple, Principal Investigator
Barry J. Schrumpf, Co-Principal Investigator
Edward E. Starkey, Co-Principal Investigator

Oregon State University
Corvallis, Oregon
August 1987

ASSESSING ELK TRAIL AND WALLOW IMPACTS IN MOUNT RAINIER NATIONAL PARK

FIRST YEAR ACTIVITIES

For the Period

August 1985 through July 1986

ASSESSING ELK TRAIL AND WALLOW IMPACTS IN MOUNT RAINIER NATIONAL PARK

FIRST YEAR ACTIVITIES

SUMMARY OF OVERALL PROGRESS

There is concern that the apparent population growth of Mount Rainier's north elk herd may be subjecting several Park ecosystems to overuse, damage, and substantial alteration. The purpose of this project is to develop a system to inventory and monitor trails and wallows caused by elk in the northeastern part of Mount Rainier National Park. One objective of this project is to determine if trail and wallow impacts to vegetation and soils can be documented as elk impacts using remote sensing and other analytical techniques. The task of establishing an inventory and monitoring system was started in August 1985. Two approaches have been initiated: 1) complete enumeration of elk trails conducted in the field for forested areas with the aid of topographic maps and resource aerial photographs; and 2) mapping of trails and wallows in non-forested areas from large scale aerial photographs conducted in the laboratory. The following is a discussion of the first year activities beginning in August, 1985.

Field Enumeration and Mapping

Methods were developed to map and quantify elk trail impacts in areas covered partially by forest canopies. This elk trail enumeration and mapping is sensitive to both the number and

location of trails. This procedure identifies elk trails and provides statistics showing the areal extent of vegetation loss due to elk trails.

The methods involved enlarging Park resource aerial photography from a scale of 1:24,000 to a scale of 1:6,000. Topographic contour lines and stream locations were transferred from 7.5' topographic quadrangles to clear overlays on the enlarged photography. The mapping of elk trails was conducted in the field using the topographic overlays on the photographic enlargements. Sites selected for trail enumeration were completely canvassed by hiking each enumeration area. All elk trails that were discovered in enumeration areas were delineated on the photo enlargements. Oblique 35mm photographs were acquired from the end of each trail. Trail width measurements were taken at points five meters from the ends of each trail and at the point approximately midway between the two ends of each trail. The line intercept method was used to record the extent of any green vegetation that intercepted the tape measure as it was laid across each trail for the width measurements.

The enumeration areas were located in areas with significant elk impacts and in areas with little or no present impacts. Table 1 shows the average width of trails found in each of the five enumeration areas. The overall mean trail width was 0.43m with an average green vegetation width (intercept) of 0.04m. Table 2 illustrates the extent of elk trails and the amount of bare soil exposed in each of the enumeration areas. The extent of elk

TABLE 1. AVERAGE ELK TRAIL WIDTH AND AMOUNT OF BARE SOIL FOUND ON TRAILS IN FIVE ENUMERATION AREAS.

Enumeration Area	Average Trail Width (M)	Average Vegetation Width (M)	Average Bare Soil Width (M)
Upper Huckleberry Basin	--	--	--
Sunrise Lake	.41	.07	.34
Bear Park	.46	.05	.41
Clover Lake	.38	.04	.34
Lower Huckleberry Basin	.45	.03	.42
Overall Average	.43	.04	.38

TABLE 2. EXTENT OF ELK TRAILS AND AMOUNT OF BARE SOIL EXPOSED IN FIVE ENUMERATION AREAS.

Enumeration Area	Size of Area (Km^2)	Extent of Elk Trails (M/Km^2)	Amount of Bare Soil (M^2/Km^2)
Upper Huckleberry Basin	.068245	-0-	-0-
Sunrise Lake	.105548	1,568	508
Bear Park	.075807	6,575	2,687
Clover Lake	.166856	13,007	4,564
Lower Huckleberry Basin	.104175	14,502	6,329

trails (m/km^2) was determined by dividing the total length (m) of trails in an area by the size of the area (km^2). The lengths of trails were determined with the aid of an electronic digitizer tablet. The amount of bare soil (m^2/km^2) in each enumeration area was calculated by dividing the area of exposed bare soil (m^2) by the size of the enumeration area (km^2). Table 2 shows that the trail impacts were highest at the Lower Huckleberry Basin and Clover Lake areas and lowest at the Upper Huckleberry Basin and Sunrise Lake enumeration areas. Appendix A-I contains listings of all trail measurements and copies of the trail maps for each of the five areas.

Aerial Photographic Interpretation

185 natural color aerial photographs were obtained from flights on August 6 and August 12, 1985. The flight lines were located over a selected area in a region extending from Elysian Fields to Bear Park. The contact scale of the 9"x9" color negatives was approximately 1:6,000. Appendix A-II contains the flight map along with the flight plan specifications for the 1985 survey.

Standard aerial photographic interpretation methods were used to delineate elk trails for four non-forested areas selected for preliminary analysis. The photographic interpretation and mapping work was performed in the laboratory on enlarged prints at a scale of 1:2,400. Elk trails were delineated in four areas with four different slope aspects.

Field checking for elk trail mapping accuracy was accomplished in September of 1985. The preliminary interpretation overlays of delineated trails were removed from the enlargements before the field trip. The field checking consisted of a complete canvassing of each of the four areas. All trails were delineated on photographs in the field for each area using methods described in the elk trail enumeration and mapping section of this paper.

An accuracy assessment was conducted by comparing the results of the laboratory mapping to the results of the field mapping. Table 3 contains the results of the accuracy assessment. Overall, the results ranged from 61.0% of the trails interpreted correctly on Green Park Ridge to a high of 95.8% at the Bear Park East site. The ridge sites resulted in the lowest accuracies due to a lack of contrast between non-vegetated trails and slopes with drying vegetation cover. Since the 1985 season was very dry, the color of the herbaceous vegetation was brown instead of green on the aerial photography. This resulted in little contrast between the vegetation and the elk trails, causing mostly ommission errors on the ridges and other dry areas. The average trail width ranged from 40cm at the Bear Park East site to 59cm on Bear Park Ridge. Appendix A-III contains maps which can be used to compare the photo interpretation of the elk trails with the ground truth.

Critical Area Inventory

An inventory was conducted to identify critical areas for elk trampling and wallowing. A critical area was defined as a site in a wet meadow having bowl-shaped depressions or showing evidence of

trampling. Trampling activity was characterized by a loss of vegetation, while the bowl-shaped depressions were identified as features used by elk for wallowing.

Table 3. Remote Sensing Mapping Accuracy of Elk Trail Mapping at Four Sites in Mount Rainier National Park

Location	Aspect	Percent Correct	Average Trail Width
Bear Park North	North	92.4%	43cm
Bear Park East	East	95.8%	40cm
Bear Park Ridge	West	64.8%	59cm
Green Park Ridge	South	61.0%	52cm

All of the 185 aerial photographs were examined for critical areas; and twenty-three such areas were identified. A black arrow was placed adjacent to each critical area on the aerial photographs. These locations were transferred to 7.5' quadrangle maps to illustrate the location and the index number of each critical area (Figure 1). The description and location of each critical area can also be found in Table 4.

Photo Sampling Sites

Eleven primarily non-forested areas were selected as sample areas for elk trail monitoring. Enlargements corresponding to these areas were obtained from the August 1985 aerial photography. The scale of these enlargements is approximately 1:2,200. Table 5 shows the eleven locations and corresponding photo numbers representing these photo sampling sites.

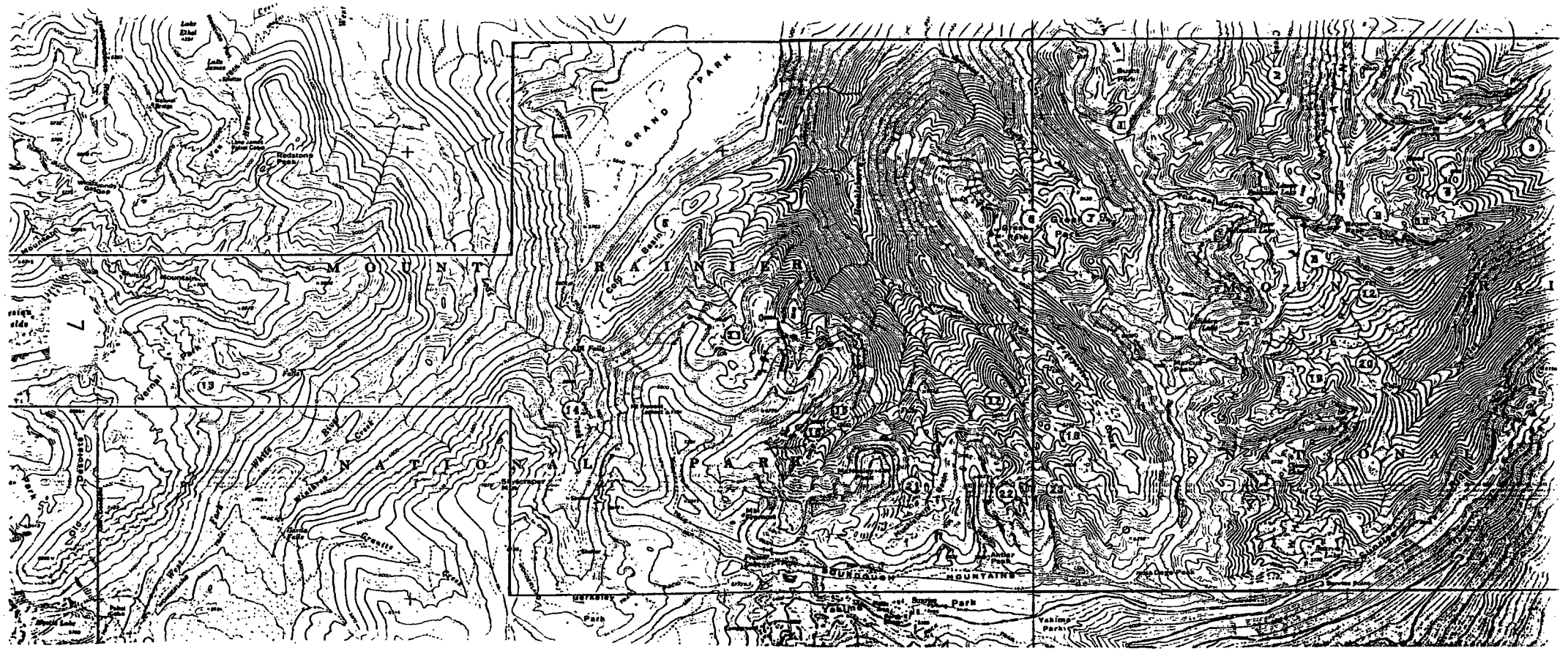


Figure 1. Location of twenty-three (23) critical areas for Elk trampling and wallowing.

Table 4.

Mount Rainier National Park
Critical Areas: Elk Trampling and Wallowing - 1985

Map Index Number	Photo Number	Ground Photo Number	Description
1	1-11	-	Bare soil areas adjacent to Lake
2	1-15	-	Bare soil areas along stream in small open area
3	1-19	-	Bare soil areas along with depressions in small open area
4	2-21	4a - 4g	Depressions in meadow near Lake
5	3-02	-	Depressions found throughout Cold Basin
6	3-11	-	Depressions in meadow opening
7	3-11	-	Depressions near Lake
8	3-16	8a	Large bare soil area and depressions near Brown Peak
9	3-20	9a - 9c	Depressions just west of Bear Lake
10	3-20	-	Wet bare soil area east of Bear Lake
11	4-16	-	Depressions in meadow near stream
12	4-29	-	Wet depressions in very small forest opening
13	5-07	-	Depressions scattered throughout Vernal Park
14	5-15	-	Brownish area near stream in meadow
15	5-22	-	Depressions in small opening just northeast of Lake
16	5-22	-	One depression on meadow edge southwest of Lake
17	5-24	-	Depression in very small forest opening
18	5-26	-	Small depression near stream southeast of Lake
19	5-32	-	Depressions and bare soil areas in meadow at photo center
20	5-32	-	Wet depression in small forest opening
21	6-08	21a - 21c	Two depressions and bare soil areas in Huckleberry Meadow
22	6-11	-	Two depressions along stream near small Lake
23	6-12	-	Two depressions along stream

TABLE 5. ELK TRAIL PHOTO SAMPLING SITES.

LOCATION	PHOTO NUMBER
BURNT PARK	1-11
BEAR PARK NORTH	2-19
BEAR PARK SOUTH	3-20
COLD BASIN	3-02
GREEN PARK	3-10
ELYSIAN FIELDS WEST	4-01
ELYSIAN FIELDS EAST	4-03
FREMONT LOOKOUT NORTH	4-16
FREMONT LOOKOUT	5-17
FREMONT LOOKOUT EAST	5-19
VERNAL PARK	5-07

CONCLUSIONS

Two methods were selected for identification of elk impacts to enable data collection in both forested and non-forested areas. The field enumeration and mapping was conducted in areas covered partially by forest canopies, while the aerial photographic interpretation method was used in non-forested areas.

Overall, the preliminary results look encouraging in that it should be possible to monitor elk trail and wallow impacts using the two types of techniques. It seems that a large aerial photographic scale of at least 1:2,400 is required for the monitoring of elk trails and wallows. Plans were made to continue during 1986 and 1987 with further development and testing of monitoring procedures. These objectives include:

1) The acquisition of new 1986 large-scale aerial photography.
2) Testing several aerial photography sampling techniques for monitoring elk trail impacts.
3) Establishing additional base-line data using one or more of the chosen sampling techniques.
4) Providing training to a staff member of Mount Rainier National Park in using the selected monitoring techniques along with providing written documentation on how to use these techniques.

APPENDIX A-I

Elk Trail Enumerations:

Tabular

and

Photographic

UPPER HUCKLEBERRY BASIN

TRAIL ENUMERATION - 1985
Scale = 1:2,500 Area = .068245 Km^2

Trail ARC #	Trail Width (M)	Vegetation Width (M)	Bare Soil Width (M)	Trail Length (M)	Area of Bare Soil (M^2)	Photo Number

NO ELK TRAILS WERE FOUND IN THIS ENUMERATION AREA.

SUNRISE LAKE

TRAIL ENUMERATION - 1985
Scale = 1:2,500 Area = .105548 Km^2

Trail ARC #	Trail Width (M)	Vegetation Width (M)	Bare Soil Width (M)	Trail Length (M)	Area of Bare Soil (M^2)	Photo Number
1	.47	.05	.42	25.7	10.8	1
2	.48	.08	.40	19.9	8.0	2
3	.32	.09	.23	24.2	5.6	3
4	.39	.07	.32	23.2	7.4	4
5	.42	.04	.38	20.0	7.6	5
6	.35	.08	.27	52.5	14.2	6
	$\bar{x}$ .41	$\bar{x}$ .07	$\bar{x}$ .34	Σ165.5M	Σ53.6M^2	

The trail and vegetation widths displayed are an average of three (3) observations per arc.

BEAR PARK

TRAIL ENUMERATION - 1985
Scale = 1:2,500 Area = .075807 Km^2

Trail ARC #	Trail Width (M)	Vegetation Width (M)	Bare Soil Width (M)	Trail Length (M)	Area of Bare Soil (M^2)	Photo Number
1	.44	.08	.36	91.1	32.8	2
2	.49	.03	.46	90.6	41.7	3
3	.44	.02	.42	67.0	28.1	4
4	.42	.08	.34	10.7	3.6	5
5	.60	.04	.56	8.8	4.9	6
6	.61	.02	.59	13.4	7.9	7
7	.41	.02	.39	29.7	11.6	8
8	.38	.07	.31	23.0	7.1	9
12	.44	.01	.43	24.6	10.6	13
13	.38	.01	.37	9.4	3.5	14
14	.48	.08	.40	38.3	15.3	15
15	.53	.11	.42	63.3	26.6	16
16	.40	.05	.35	28.5	10.0	17
	$\bar{x}$ .46	$\bar{x}$ .05	$\bar{x}$ .42	Σ498.4	Σ203.7	

The trail and vegetation widths displayed are an average of three (3) observations per arc.

CLOVER LAKE

TRAIL ENUMERATION - 1985

Scale = 1:2,500 Area = .166856 Km^2

Trail ARC #	Trail Width (M)	Vegetation Width (M)	Bare Soil Width (M)	Trail Length (M)	Area of Bare Soil (M^2)	Photo Number
2	.41	.13	.28	89.0	24.9	8
4	.33	.03	.30	55.3	16.6	9
5	.39	.03	.36	89.8	32.3	10
6	.43	.06	.37	31.7	11.7	11
7	.42	.04	.38	106.8	40.6	12
8	.32	.02	.30	16.1	4.8	13
10	.43	.03	.40	74.6	29.8	14
11	.30	.03	.27	27.8	7.5	15
12	.35	.03	.32	64.0	20.5	16
13	.33	.02	.31	20.6	6.4	17
14	.34	.07	.27	81.9	22.1	18
15	.39	.08	.31	85.3	26.4	19
16	.30	.03	.27	56.9	15.4	20
17	.35	.02	.33	312.4	103.1	21
18	.32	.06	.26	20.0	5.2	6
19	.33	.03	.30	31.5	9.4	(Roll 2) 3
20	.39	.01	.38	31.3	11.9	7
21	.34	.02	.32	60.9	19.5	9
22	.46	.00	.46	40.2	18.5	11
23	.44	.08	.36	20.9	7.5	12
24	.54	.04	.50	99.3	49.7	10
25	.41	.00	.41	76.2	31.2	13
26	.35	.02	.33	82.4	27.2	14
27	.26	.01	.25	21.7	5.4	15
28	.30	.03	.27	20.2	5.4	16
29	.48	.04	.44	44.5	19.6	17
30	.36	.06	.30	45.1	13.5	18
31	.37	.06	.31	13.7	4.2	20
32	.36	.09	.27	23.0	6.2	24
33	.62	.02	.60	12.2	7.3	19
34	.37	.02	.35	12.3	4.3	21
35	.37	.02	.35	17.7	6.2	22
36	.45	.01	.44	13.9	6.1	23
37	.32	.01	.31	40.2	12.5	25
38	.38	.01	.37	27.3	10.1	26
39	.44	.01	.43	31.7	13.6	27,28
41	.45	.00	.45	115.5	52.0	29
42	.34	.08	.26	39.1	10.2	30
43	.44	.02	.42	42.0	17.6	31
44	.47	.01	.46	37.3	17.2	32
45	.30	.09	.21	38.0	8.0	33
	$\bar{x}$ .38	$\bar{x}$ .04	$\bar{x}$ .35	Σ2,170.3	Σ761.6	

The trail and vegetation widths displayed are an average of three (3) observations per arc.

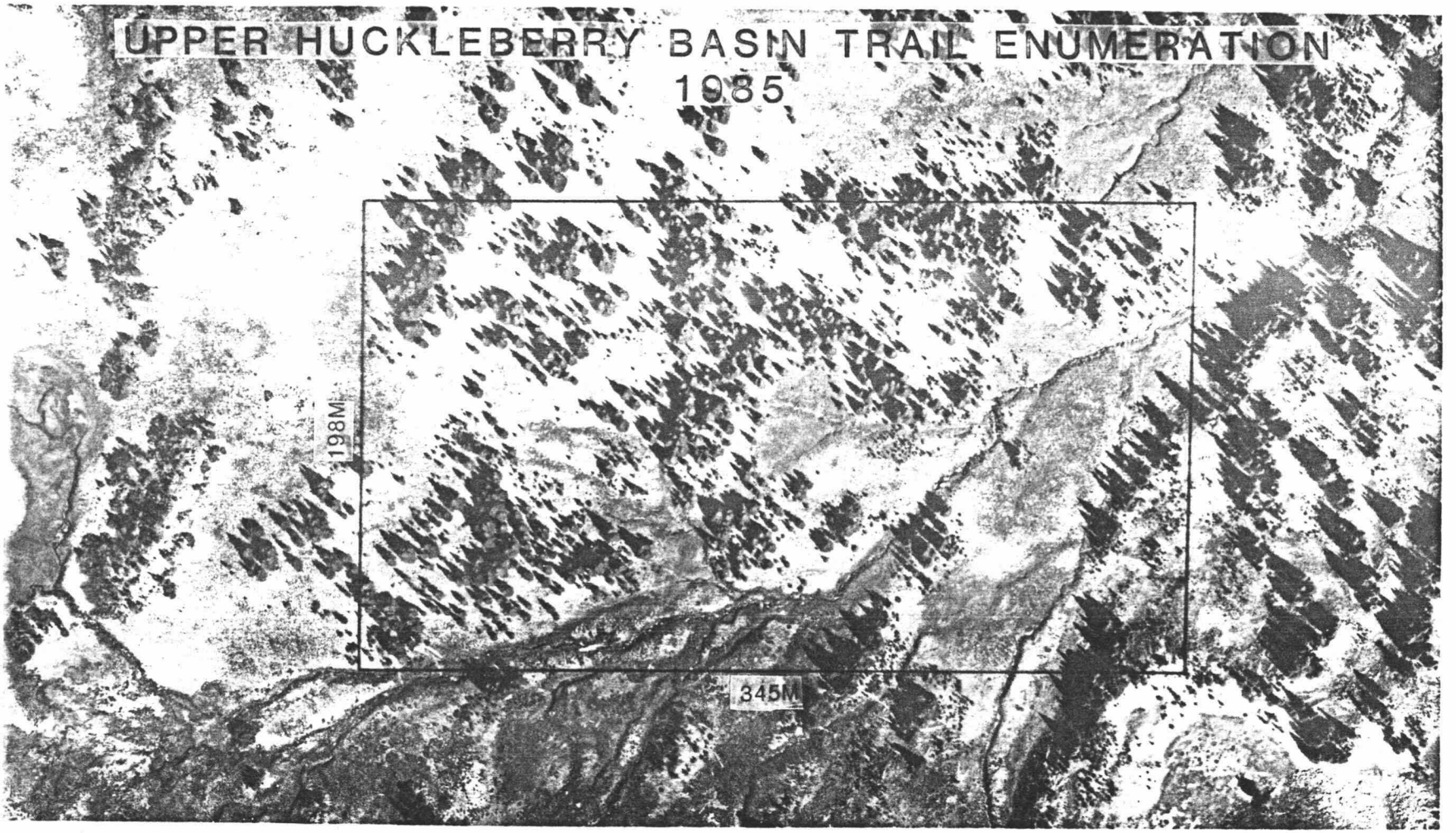
LOWER HUCKLEBERRY BASIN

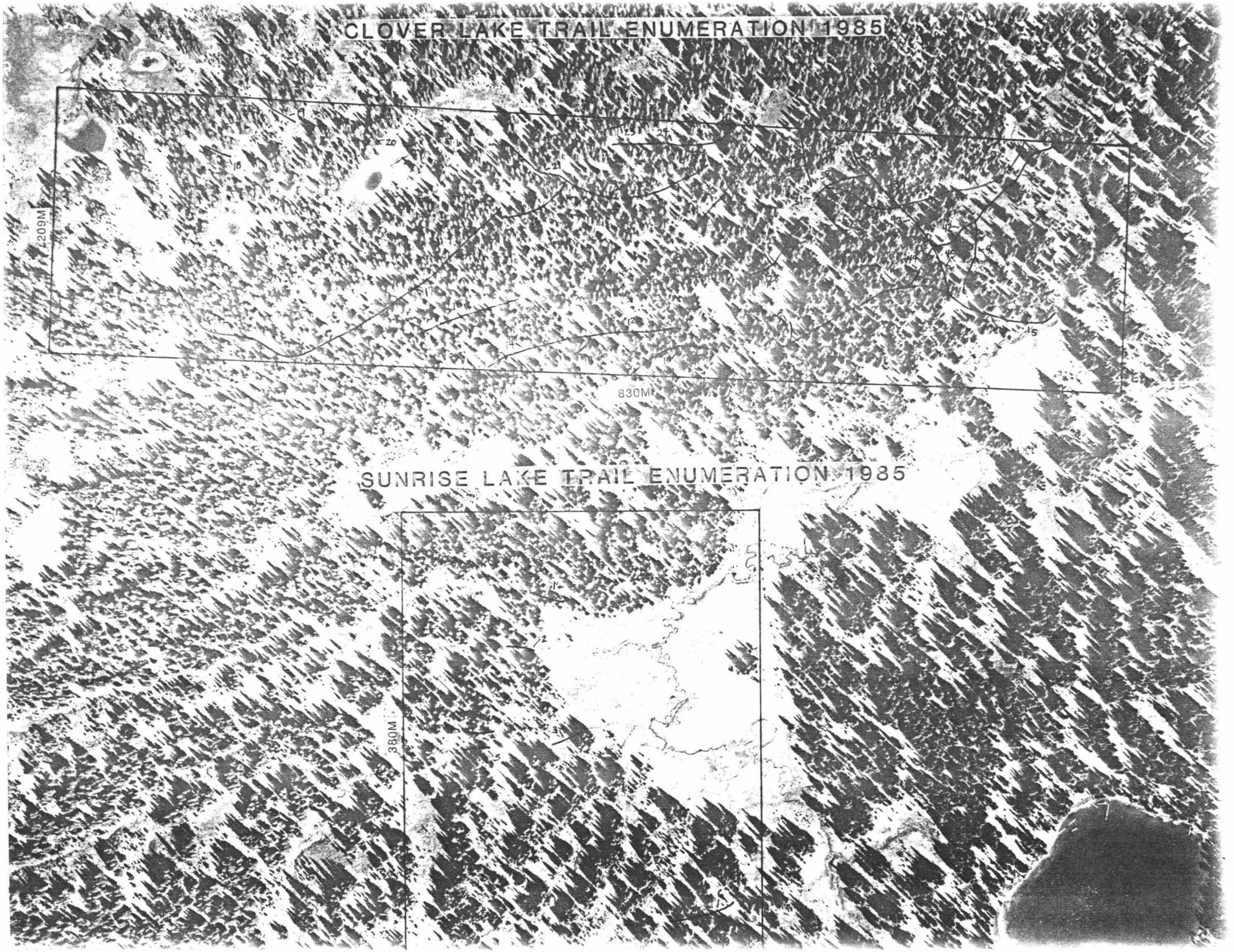
TRAIL ENUMERATION - 1985

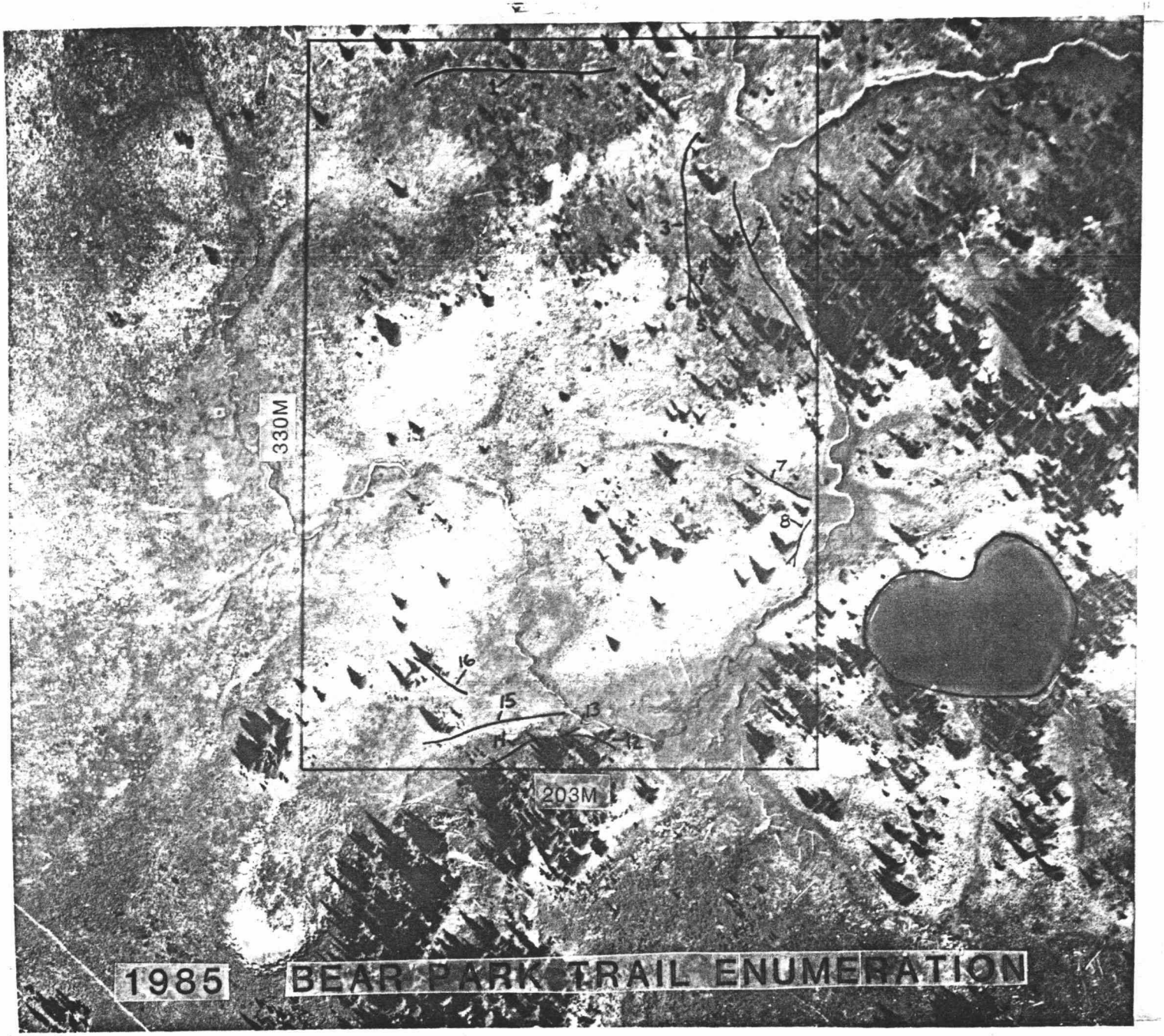
Scale = 1:2,500 Area = .104175 Km^2

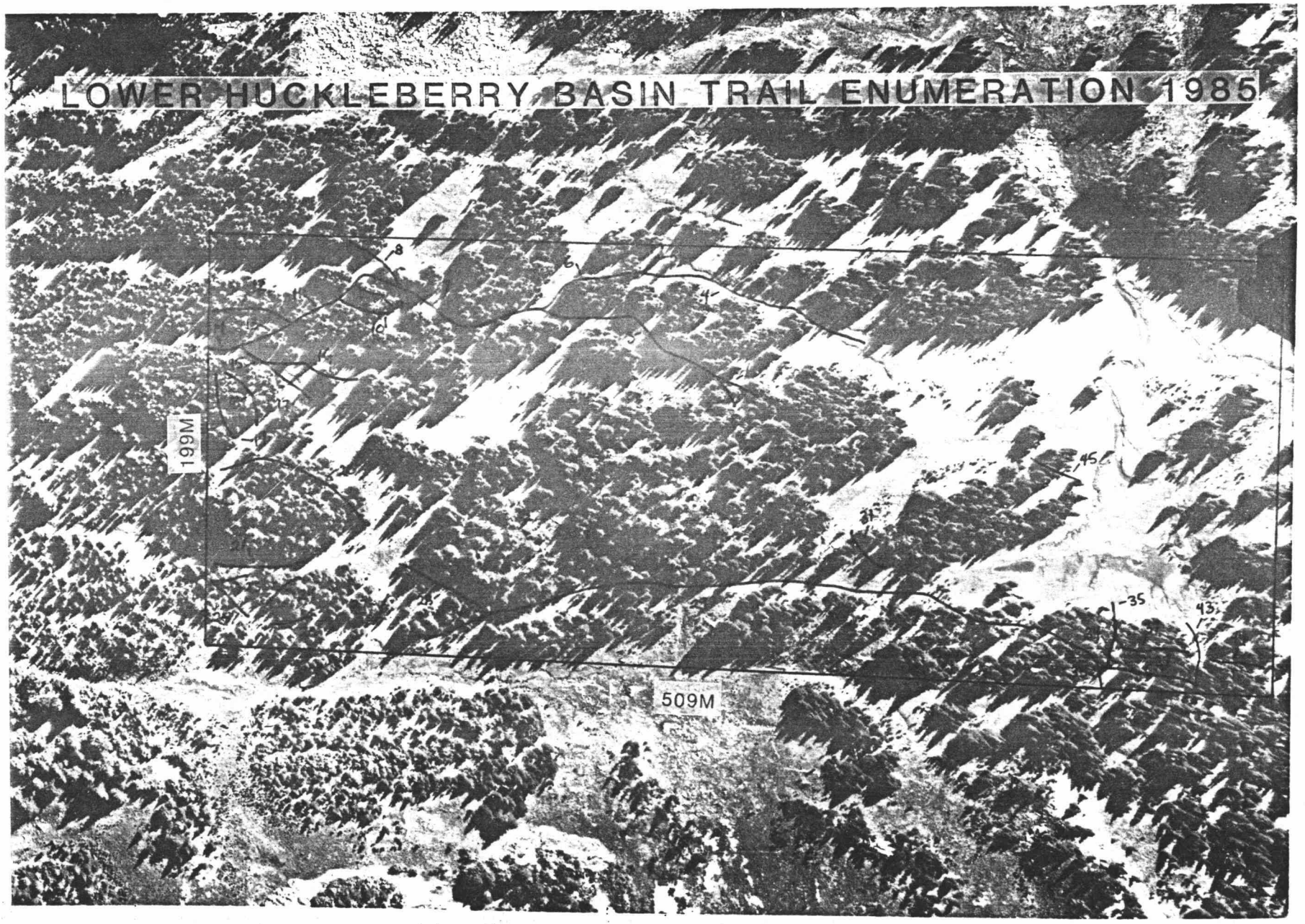
Trail ARC #	Trail Width (M)	Vegetation Width (M)	Bare Soil Width (M)	Trail Length (M)	Area of Bare Soil (M^2)	Photo Number
1	.49	.00	.49	22.3	10.9	5
2	.42	.02	.40	16.0	6.4	5
3	.50	.00	.50	92.7	46.4	8
4	.43	.07	.36	111.8	40.2	4
5	.27	.09	.18	15.6	2.8	6
6	.42	.00	.42	53.6	22.5	7
7	.51	.01	.50	75.6	37.8	9
8	.45	.02	.43	36.2	15.6	10
9	.42	.03	.39	15.0	5.9	11
10	.42	.04	.38	25.0	9.5	12
11	.55	.01	.54	24.9	13.4	13
12	.50	.01	.49	38.8	19.0	14
13	.64	.00	.64	26.4	16.9	15
14	.60	.00	.60	16.5	9.9	16
15	.50	.00	.50	13.2	6.6	15
16	.40	.02	.38	42.7	16.2	17
17	.42	.02	.40	26.0	10.4	17
18	.49	.02	.47	31.0	14.6	18
19	.60	.04	.56	30.4	17.0	19
20	.40	.04	.36	77.2	27.8	20
21	.39	.02	.37	42.9	15.9	21
23	.45	.07	.38	16.4	6.2	22
24	.43	.00	.43	20.1	8.6	24
25	.41	.05	.36	24.5	8.8	22
26	.31	.03	.28	16.4	4.6	23
27	.41	.05	.36	15.8	5.7	25
28	.37	.07	.30	43.6	13.1	26
29	.51	.01	.50	334.5	167.2	27
31	.37	.04	.33	24.5	8.1	28
33	.42	.03	.39	9.3	3.6	30
34	.48	.04	.44	13.3	5.9	31
35	.50	.00	.50	16.9	8.4	33
37	.36	.03	.33	37.2	12.3	35
39	.38	.02	.36	46.2	16.6	31
43	.45	.01	.44	31.6	13.9	36
44	.42	.02	.40	26.6	10.6	37
	$\bar{x}$ .45	$\bar{x}$ .03	$\bar{x}$ .42	Σ1510.7	Σ659.3	

The trail and vegetation widths displayed are an average of three (3) observations per arc.


UPPER HUCKLEBERRY BASIN TRAIL ENUMERATION
1985
198M
345M


CLOVER LAKE TRAIL ENUMERATION 1985
209M
830M
SUNRISE LAKE TRAIL ENUMERATION 1985
380M


330M
203M
1985 BEAR PARK TRAIL ENUMERATION


LOWER HUCKLEBERRY BASIN TRAIL ENUMERATION 1985
199M
509M
45
35
43

APPENDIX A-II

1985 Flight Map

and

Flight Specifications

Flight map showing the location of the seven (7) flight lines for the 1985 aerial survey.

FLIGHT PLAN SPECIFICATIONS

LOCATION: Northeast part of Mount Rainier National Park, Washington

FILM TYPE: Natural Color negatives/prints

CAMERA FOCAL LENGTH: 12" (304.8mm)

NEGATIVE FORMAT: 9" x 9" (228.6mm x 228.6mm)

DESIRED NEGATIVE SCALE: 1:5,000

ENDLAP: 60%

SIDELAP: 30%

SCALE OF BASEMAP: 1:50,000

AVERAGE TERRAIN ELEVATION: 5,850' above sea level

FLYING HEIGHT ABOVE TERRAIN: 5,000'

FLYING HEIGHT ABOVE SEA LEVEL: 10,850'

SIDE TO SIDE COVERAGE PER PHOTO: 1,143m x 1,143m on ground
22.86mm x 22.86mm on map

DISTANCE BETWEEN FLIGHT LINES: 800.1m on ground
16.00mm on map

NUMBER OF FLIGHT LINES: Seven lines (Two long, Five short)

WIDTH OF STUDY AREA (North/South): 4,800.6m on ground
96.012mm on map

DISTANCE BETWEEN PHOTO CENTERS: 457.2m on ground
9.144mm on map

NUMBER OF PHOTOS ON TWO LONG LINES: 35 Photos

NUMBER OF PHOTOS ON FIVE SHORT LINES: 21 Photos

LENGTH OF TWO LONG LINES: 15,544.8m on ground
310.90mm on map

LENGTH OF FIVE SHORT LINES: 9,144.0m on ground
182.88mm on map

ESTIMATE OF TOTAL NUMBER OF PHOTOS: 175 Photos

DESIRED FLIGHT DATE(S): Mid-August, 1985

APPENDIX A-III

Comparison and Accuracy Assessment

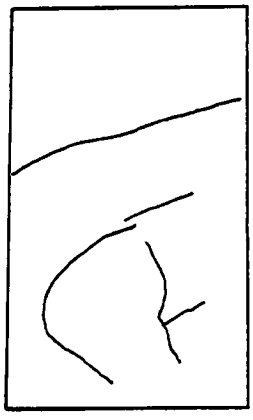
of

Photointerpretation

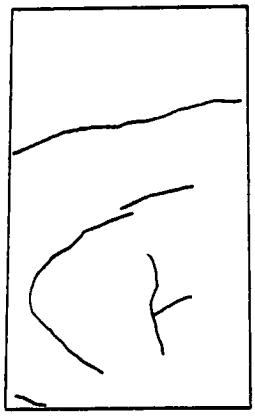
with Ground Truth

BEAR PARK NORTH SITE

PHOTO INTERPRETATION



GROUND TRUTH



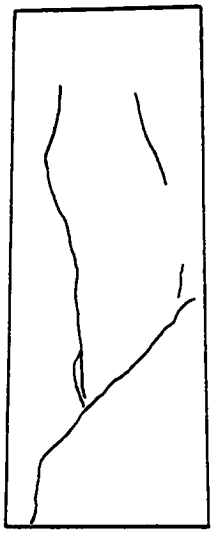
Scale **1:2112**

	Photo Interpretation	Ground Truth
Total Trail Length	**191.1 m**	**193.7 m**
Average Trail Width		**0.43 m**

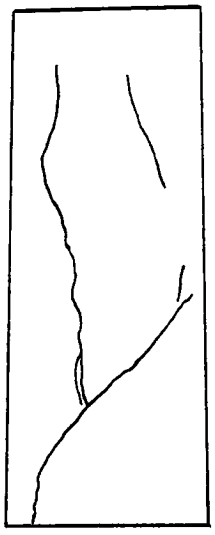
Accuracy **92.4%**

BEAR PARK EAST SITE

PHOTO INTERPRETATION



GROUND TRUTH



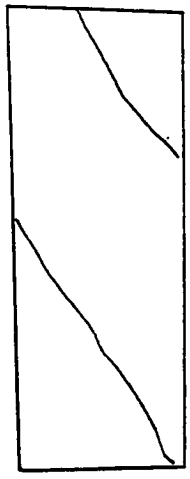
Scale **1:2251**

	Photo Interpretation	Ground Truth
Total Trail Length	**245.8 m**	**256.1 m**
Average Trail Width		**0.40 m**

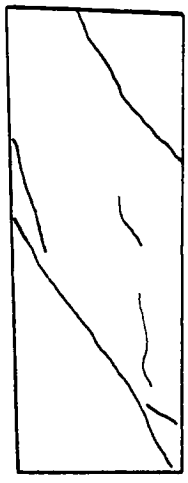
Accuracy **95.8%**

BEAR PARK RIDGE

PHOTO INTERPRETATION



GROUND TRUTH



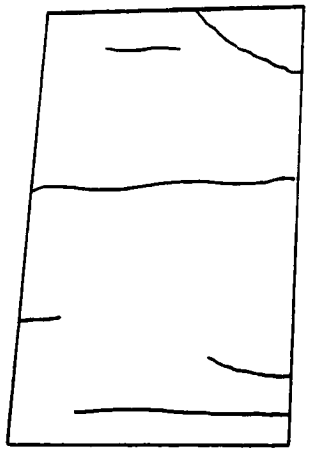
Scale **1:2112**

	Photo Interpretation	Ground Truth
Total Trail Length	**128.8 m**	**198.7 m**
Average Trail Width		**0.59 m**

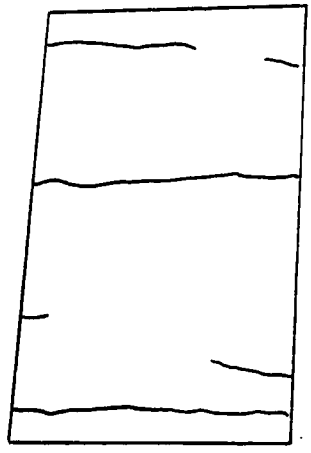
Accuracy **64.8%**

GREEN PARK RIDGE

PHOTO INTERPRETATION



GROUND TRUTH



Scale **1:2130**

	Photo Interpretation	Ground Truth
Total Trail Length	**220.2 m**	**251.4 m**
Average Trail Width		**0.52 m**

Accuracy **61.0%**

ASSESSING ELK TRAIL AND WALLOW IMPACTS IN MOUNT RAINIER NATIONAL PARK

Second Year Activities

For the Period

August 1986 through July 1987

ASSESSING ELK TRAIL AND WALLOW IMPACTS IN MOUNT RAINIER NATIONAL PARK

SECOND YEAR ACTIVITIES

SUMMARY OF OVERALL PROGRESS

Work continued on a remote sensing system to monitor trails caused by elk in Mount Rainier National Park. The following is a summary of progress from August 1, 1986 through July 31, 1987. The activity in this year involved: 1) the establishment of baseline data on elk trails in permanent photo-plots on 1985 and 1986 aerial photography, 2) accuracy assessment for the Fremont Lookout North photo-plot site, and 3) systematic sampling for elk trails from the aerial photography.

Permanent Photo Plots

Additional baseline data on elk trails were established for ten photo-plots on the 1986 aerial photography and six corresponding photo-plots on the 1985 aerial photography. These square photo-plots were selected by Mount Rainier National Park staff to serve as permanent sites for the elk trail monitoring system. Table 1 shows the 1986 and 1985 photography frame numbers associated with these selected sites; six of which have coverage from both years. Only sites that appeared to have favorable elk habitat and were relatively free from large areas of closed forest canopy were chosen. Sites near the edges of photographs were avoided because of radial displacement problems associated with photographic edges.

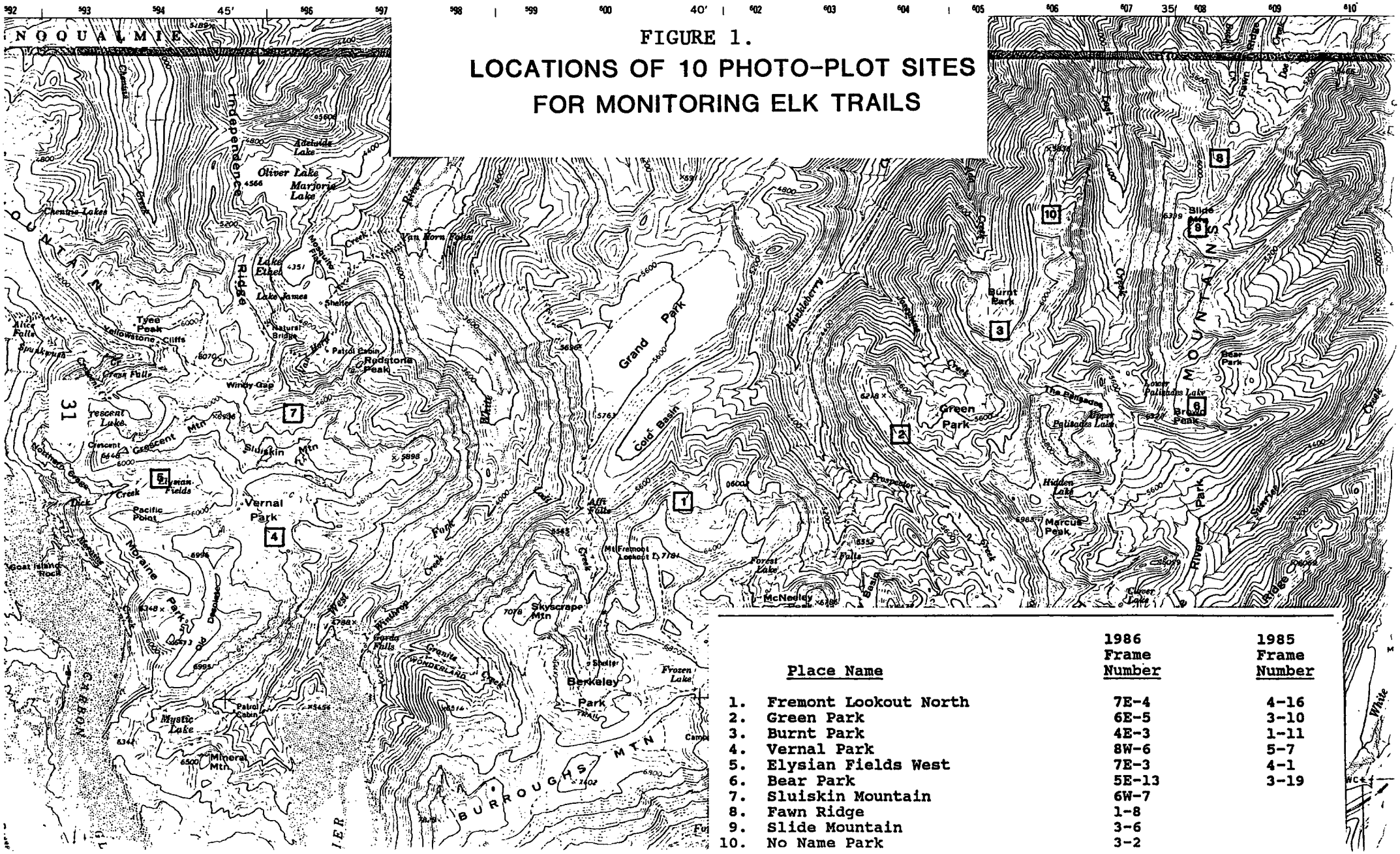
	Place Name	1986 Frame Number	1985 Frame Number
1.	Fremont Lookout North	7E-4	4-16
2.	Green Park	6E-5	3-10
3.	Burnt Park	4E-3	1-11
4.	Vernal Park	8W-6	5-7
5.	Elysian Fields West	7E-3	4-1
6.	Bear Park	5E-13	3-19
7.	Sluiskin Mountain	6W-7	
8.	Fawn Ridge	1-8	
9.	Slide Mountain	3-6	
10.	No Name Park	3-2	

Table 1. Locations and frame numbers associated with the photo-plot sampling sites selected by Mount Rainier National Park Staff.

Figure 1 shows the locations of the ten permanent photo-plots, and Appendix B-1 contains figures showing the trails delineated for each photo-plot. From August 1985 to August 1986 there appeared to be no detectable increase in elk trails in the Bear Park plot. The Elysian Fields West plot also had no detectable increase and appeared to be free from trails during both years. The interpretation results for Green, Burnt, and Vernal Park plots show slight increases in the extent of elk trails from 1985 to 1986. There appeared to be a significant one year increase in elk trails for the Fremont Lookout North plot. It should be noted that a portion of the trail differences on these sets of aerial photographs could be the result of differences in photo quality, distance from the photo centers, and plant phenological stages.

MT. RAINIER NATIONAL PARK

FIGURE 1.
LOCATIONS OF 10 PHOTO-PLOT SITES FOR MONITORING ELK TRAILS



	Place Name	1986 Frame Number	1985 Frame Number
1.	Fremont Lookout North	7E-4	4-16
2.	Green Park	6E-5	3-10
3.	Burnt Park	4E-3	1-11
4.	Vernal Park	8W-6	5-7
5.	Elysian Fields West	7E-3	4-1
6.	Bear Park	5E-13	3-19
7.	Sluiskin Mountain	6W-7	
8.	Fawn Ridge	1-8	
9.	Slide Mountain	3-6	
10.	No Name Park	3-2	

Fremont Lookout North Ground Truth and Accuracy Assessment

Field work for ground data collection was conducted in September, 1986 at the Fremont Lookout North photo-plot. An overlay of delineated elk trails was produced and removed from the photograph before the field trip. The field method involved a complete canvassing of the entire Fremont Lookout North photo-plot. Each trail that was discovered was delineated on the photo enlargement. Oblique 35mm photographs were acquired for each trail. Trail width measurements were taken at points five meters from the ends of each trail and at the approximate midway point between the ends of each trail. The line intercept method was used to record the extent of any vegetation that intercepted the tape measure as it lay across each trail.

The results of the trail measurements are shown in Appendix B-II for each trail arc in the Fremont Lookout North photo-plot. The average trail width was found to be 55.8cm with an average vegetation intercept width of 10.4cm. The overall average vegetation width (intercept) determined from the previous year's study (1986) of five elk trail enumeration areas was 4.0cm. The greater amount of vegetation on the Fremont Lookout North trails indicates that these trails may be recent features. This also supports the evidence provided by the differences in apparent trails on the 1985 and the 1986 aerial photography.

An accuracy assessment was conducted by comparing results of laboratory mapping to the results of field mapping at the Fremont Lookout North plot. Seventy-six percent (76%) of the trails were

interpreted correctly, with a 12% commission error and a 12% omission error. It was discovered that the commission was caused by interpreting decayed logs as trails, and the omissions were a result of little contrast between vegetation and elk trails on xeric sites.

Transfer of Results to Rainier Park

Completed results from the 1985 elk trail enumerations including original aerial photographs were sent to Mount Rainier National Park on March 31, 1987. See Appendix B-III for a copy of the correspondence.

Photo Index Maps

Photo index maps were constructed for the 1985 and 1986 flights over Mount Rainier National Park. Copies of these maps are shown in Appendix B-IV.

Systematic Sampling for Elk Trails

The aerial photography from both 1985 and 1986 was used to conduct a survey of elk trails within the project area in the northeast part of Mount Rainier National Park. The objectives were 1) to obtain baseline data on the extent of elk trails, and 2) to show relative differences in elk trail impacts by geographic area.

Methods. A quantification of elk trails visibly present on the aerial photography was obtained by placing a two-by-two grid centered on the principal point of every other photograph for every flight line (Figure 2). The dimension of each grid cell was

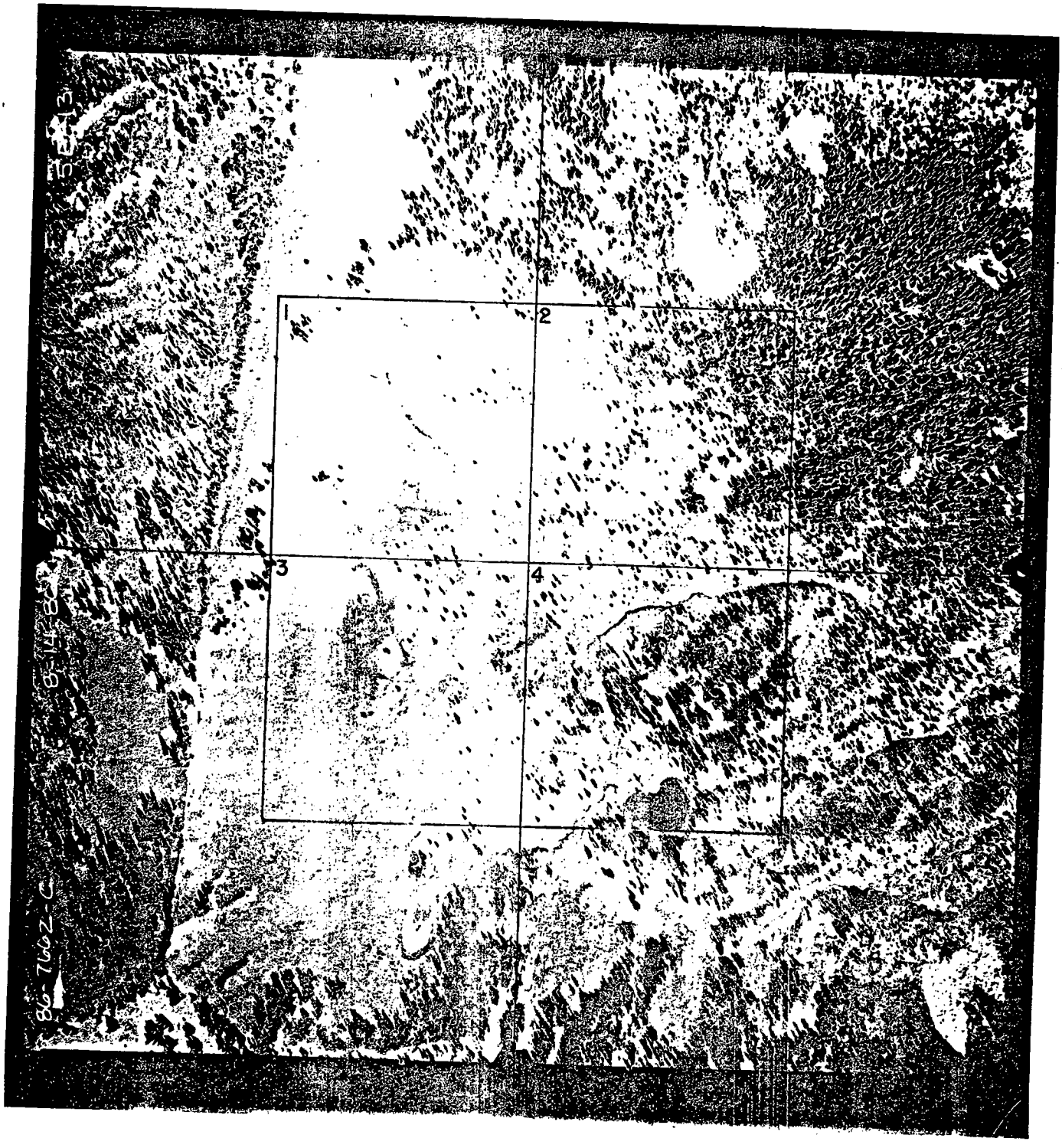


Figure 2. Example of grid used to quantify the presence of elk trails using the aerial photography from 1985 and 1986.

6cm by 6cm. The presence, or absence, of visible elk trails was determined for each of the four grid cells on the photographs (Appendix B-V). An ocular estimate of percent forest canopy cover was also recorded for each grid cell. Presence values for each of the sampled photographs ranged from "0" through "4" -- a value of "0" indicated elk trails were visibly absent from all cells, while a value of "4" indicated the visible presence of elk trails in all four grid cells per photograph.

Results. The results from the 1985 photography indicate a relatively low presence of elk trails at Grand Park, Cold Basin, and Elysian Fields (Figure 3). Few elk trails were found near human developments, such as Sunrise Road and the Sunrise Ranger Station. A high quantity of elk trails were seen at Bear Park, Brown Peak, Burn Park, Green Park Ridge, Fremont Lookout, Vernal Park, and the area north of the Sourdough Mountains (Figure 3).

Compilation results from the 1986 aerial photography indicate a significantly high level of elk trails in the area between Bear Park and Fawn Ridge, including the Slide Mountain area (Figure 4). Numerous elk trails were also found in the Tyee Peak, Windy Gap, and Sluiskin Mountain areas.

The frequency of elk trails were also displayed in relation to percent forest canopy cover for both the 1985 and 1986 aerial photography (Figure 5). The visible presence of elk trails was highest in areas with substantial patches of both hiding/thermal cover (forested areas) and forage habitat (open areas). On the

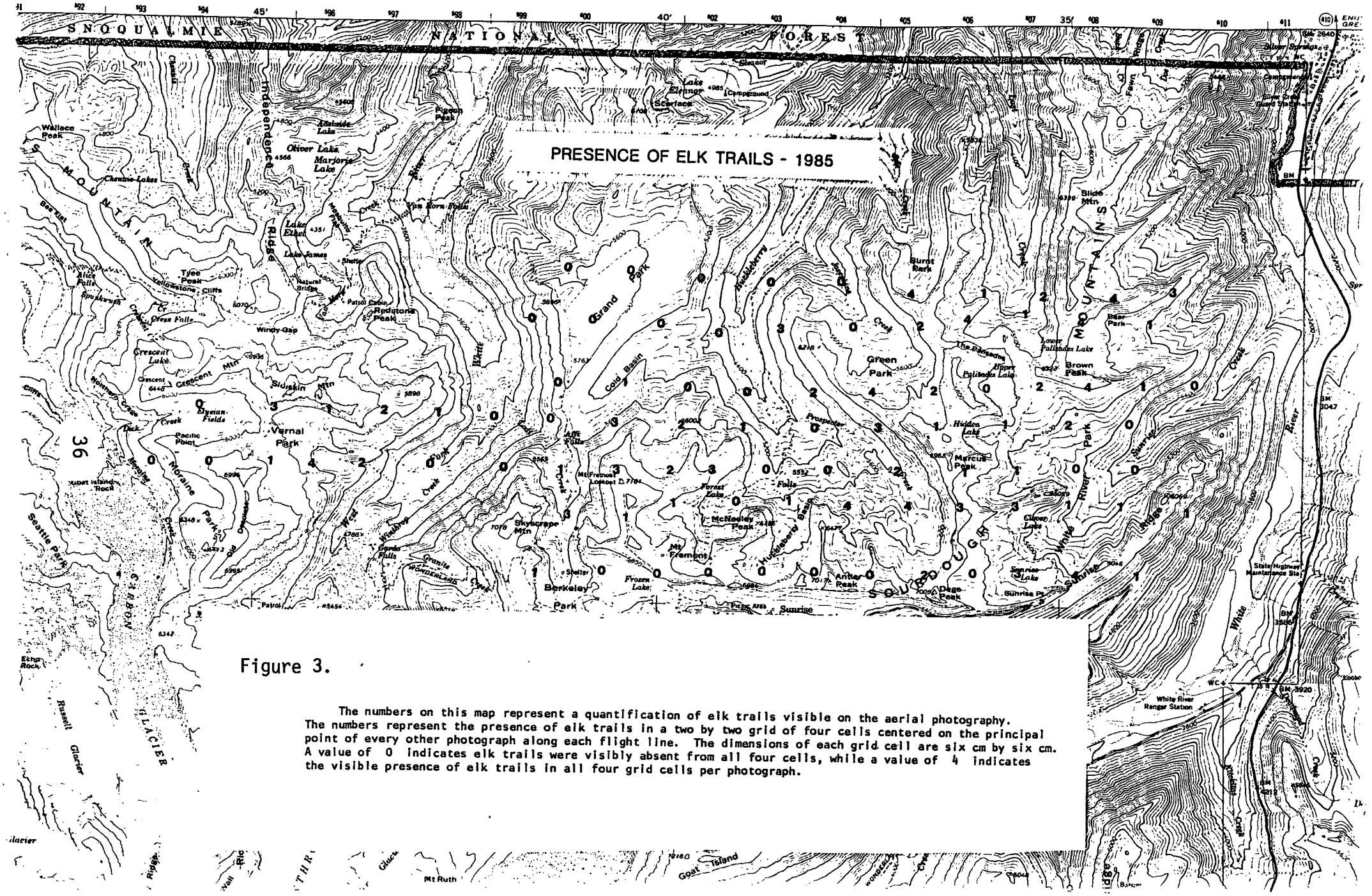


Figure 3.

The numbers on this map represent a quantification of elk trails visible on the aerial photography. The numbers represent the presence of elk trails in a two by two grid of four cells centered on the principal point of every other photograph along each flight line. The dimensions of each grid cell are six cm by six cm. A value of 0 indicates elk trails were visibly absent from all four cells, while a value of 4 indicates the visible presence of elk trails in all four grid cells per photograph.

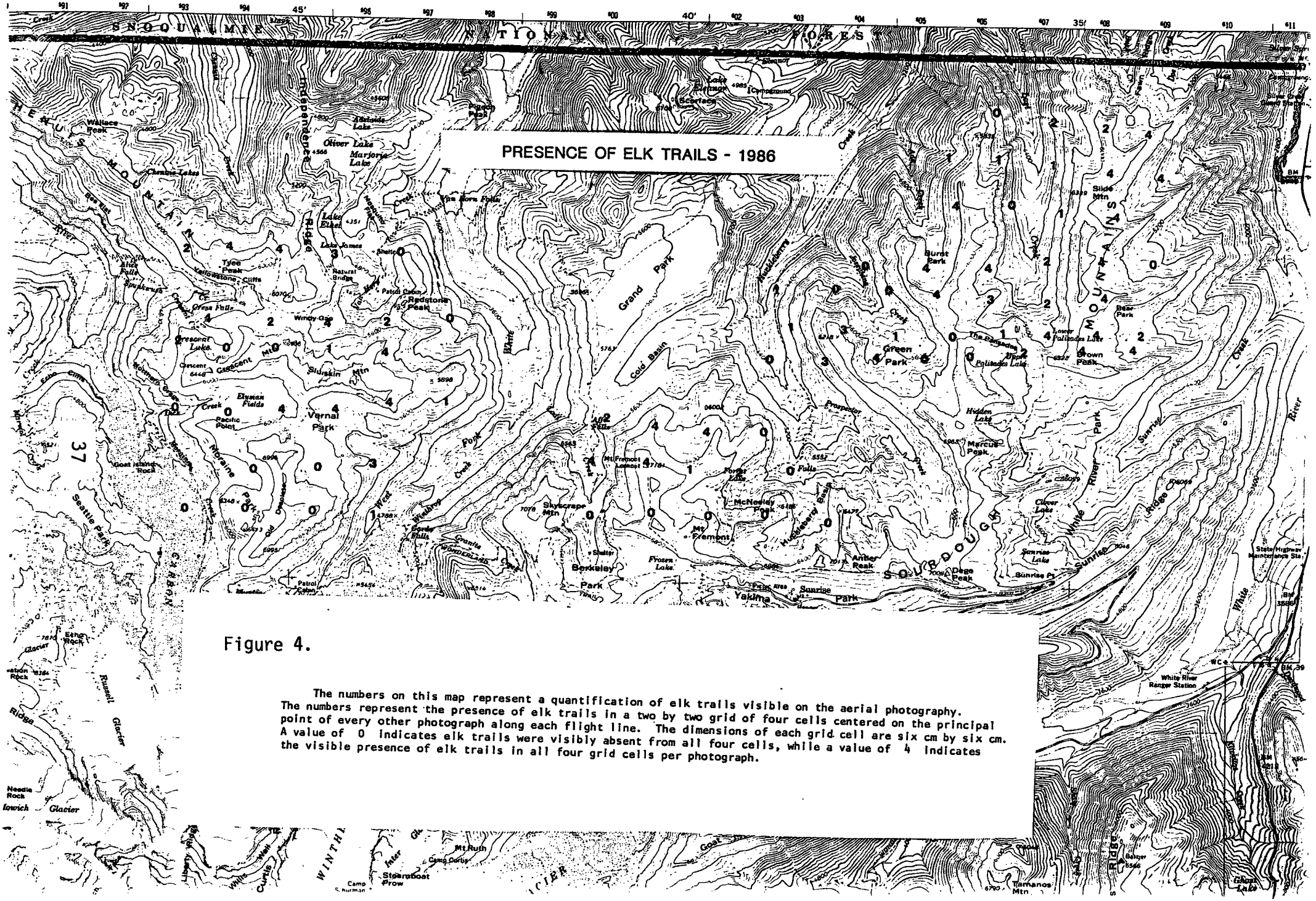


Figure 4.

The numbers on this map represent a quantification of elk trails visible on the aerial photography. The numbers represent the presence of elk trails in a two by two grid of four cells centered on the principal point of every other photograph along each flight line. The dimensions of each grid cell are six cm by six cm. A value of 0 indicates elk trails were visibly absent from all four cells, while a value of 4 indicates the visible presence of elk trails in all four grid cells per photograph.

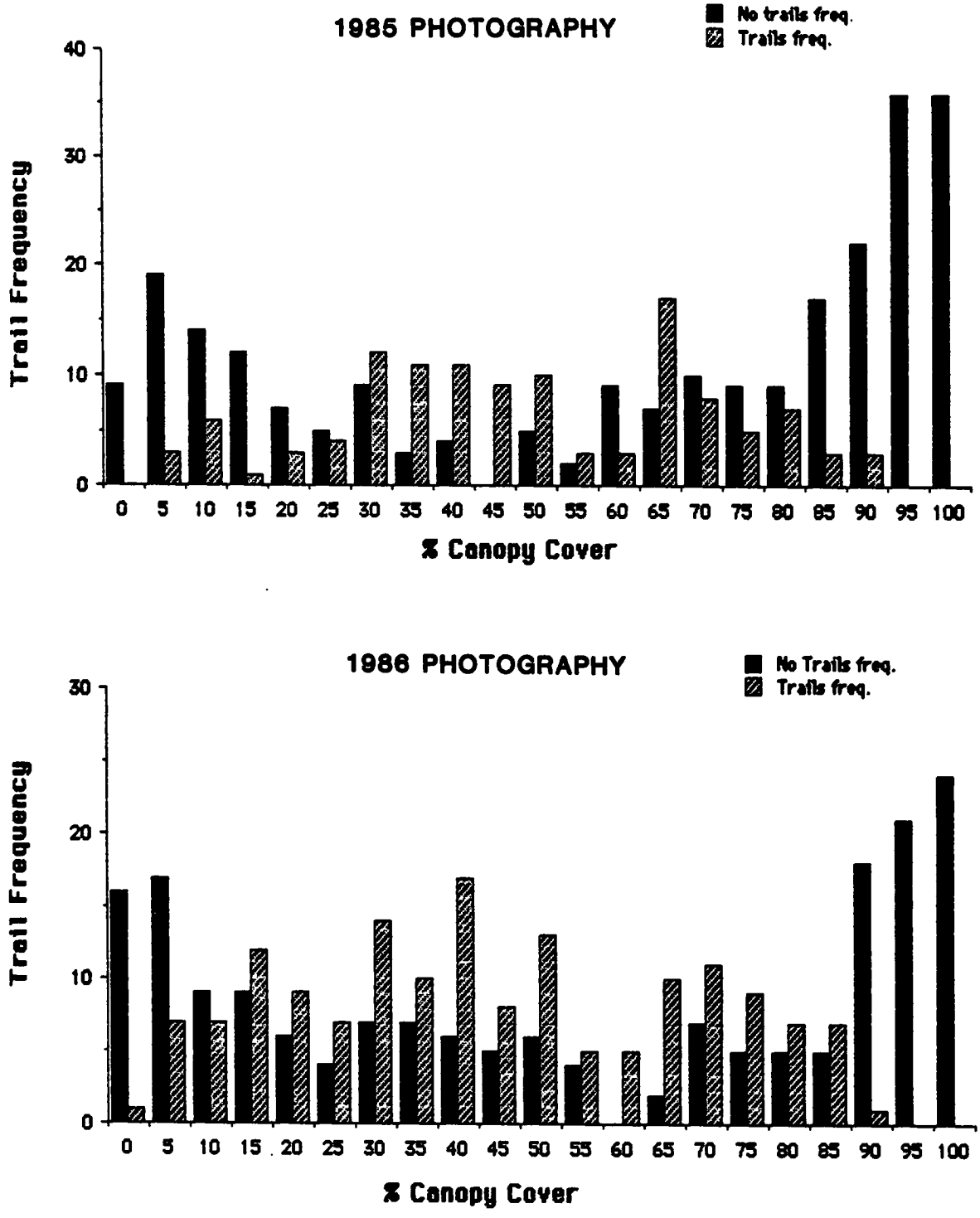


Figure 5. Bar graphs showing percent forest canopy cover on the x-axis, and on the y-axis, the frequency of trails both observed and not observed within the grid cells.

1985 photography, visible trails were most frequent in areas of 65, 30, amd 35/40 percent forest canopy cover. The 1986 photography showed elk trail frequencies highest at sites of 40, 30, and 50 percent canopy cover. It should be noted that it was not possible to estimate the quantity of elk trails below tree canopies from the aerial photography, and forest canopy coverage of greater than 90 percent obscured nearly all elk trails.

CONCLUSIONS

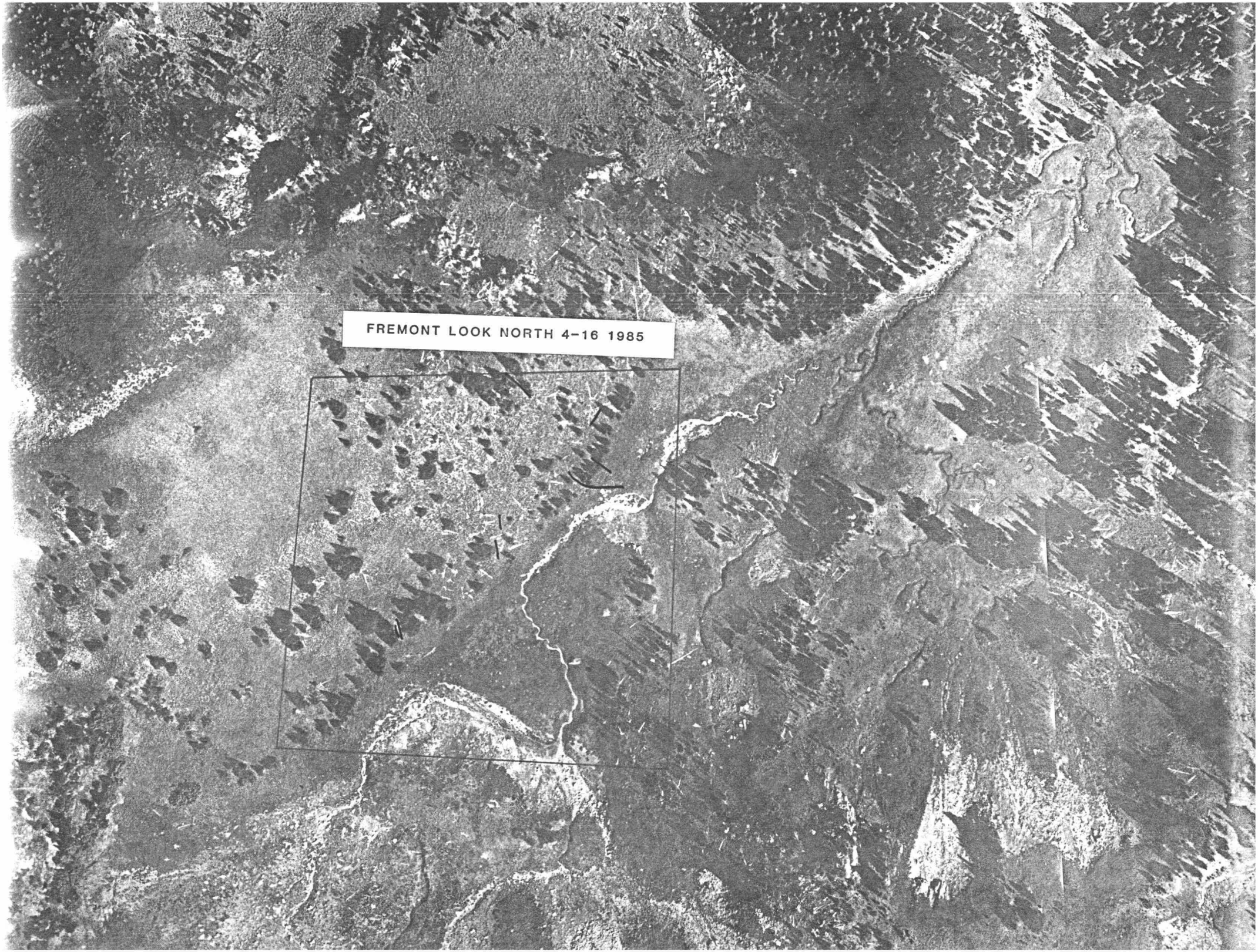
Additional baseline data for the elk trail monitoring system were collected and analyzed during the period of August 1, 1986 through July 31, 1987. Both detailed and general baseline data sets were obtained. The detailed data consisted of ten permanent photo-plots on the 1986 aerial photography and six corresponding photo-plots on the 1985 photography. Ground truth data for the Fremont Lookout North photo-plot was collected in September 1986. The general data set resulted from the systematic sampling for elk trails using the entire set of aerial photography from both 1985 and 1986. The visible presence of elk trails on the aerial photography was tabulated, mapped, and graphed in relation to percent forest canopy cover.

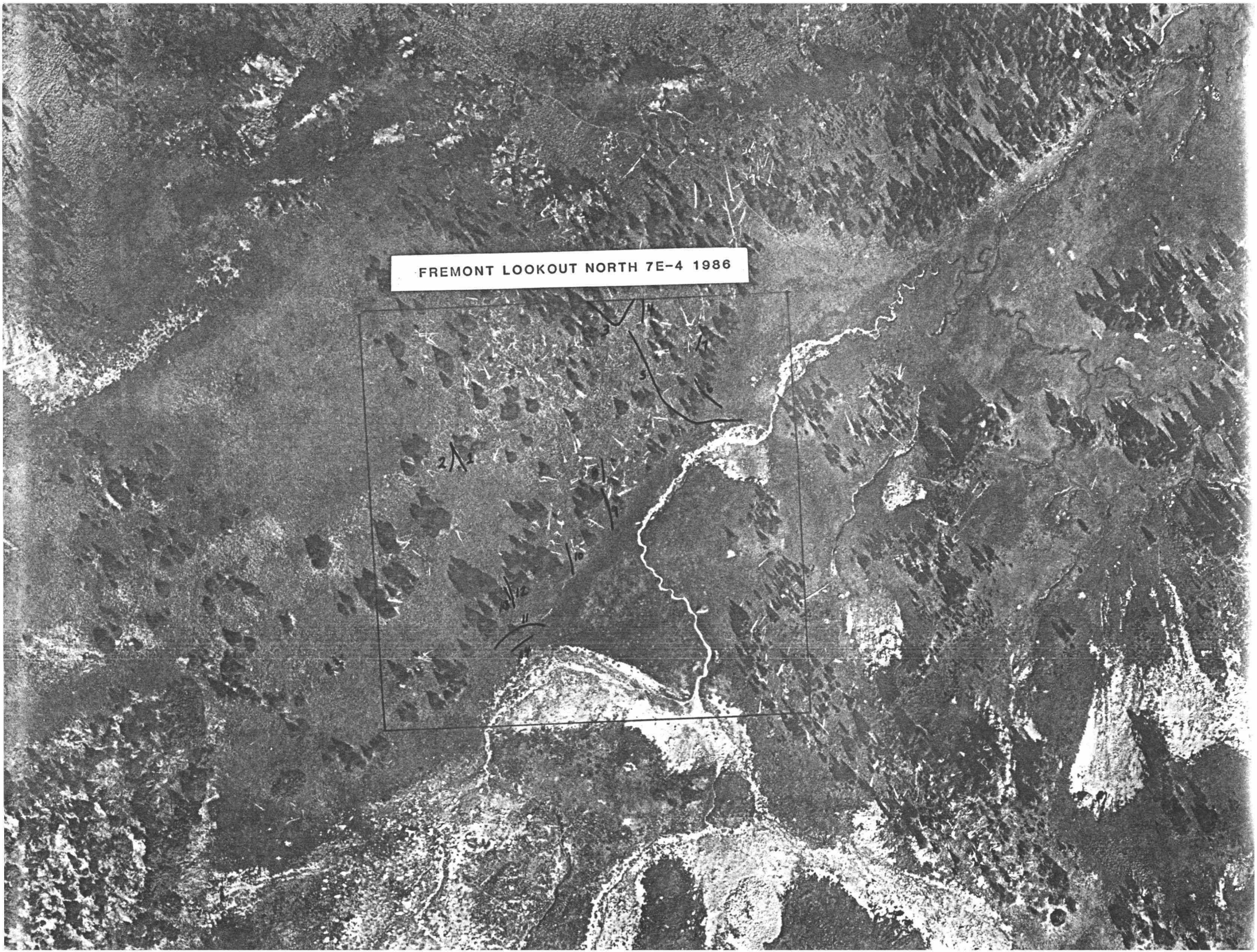
APPENDIX B-I

Photo-Plots Associated With

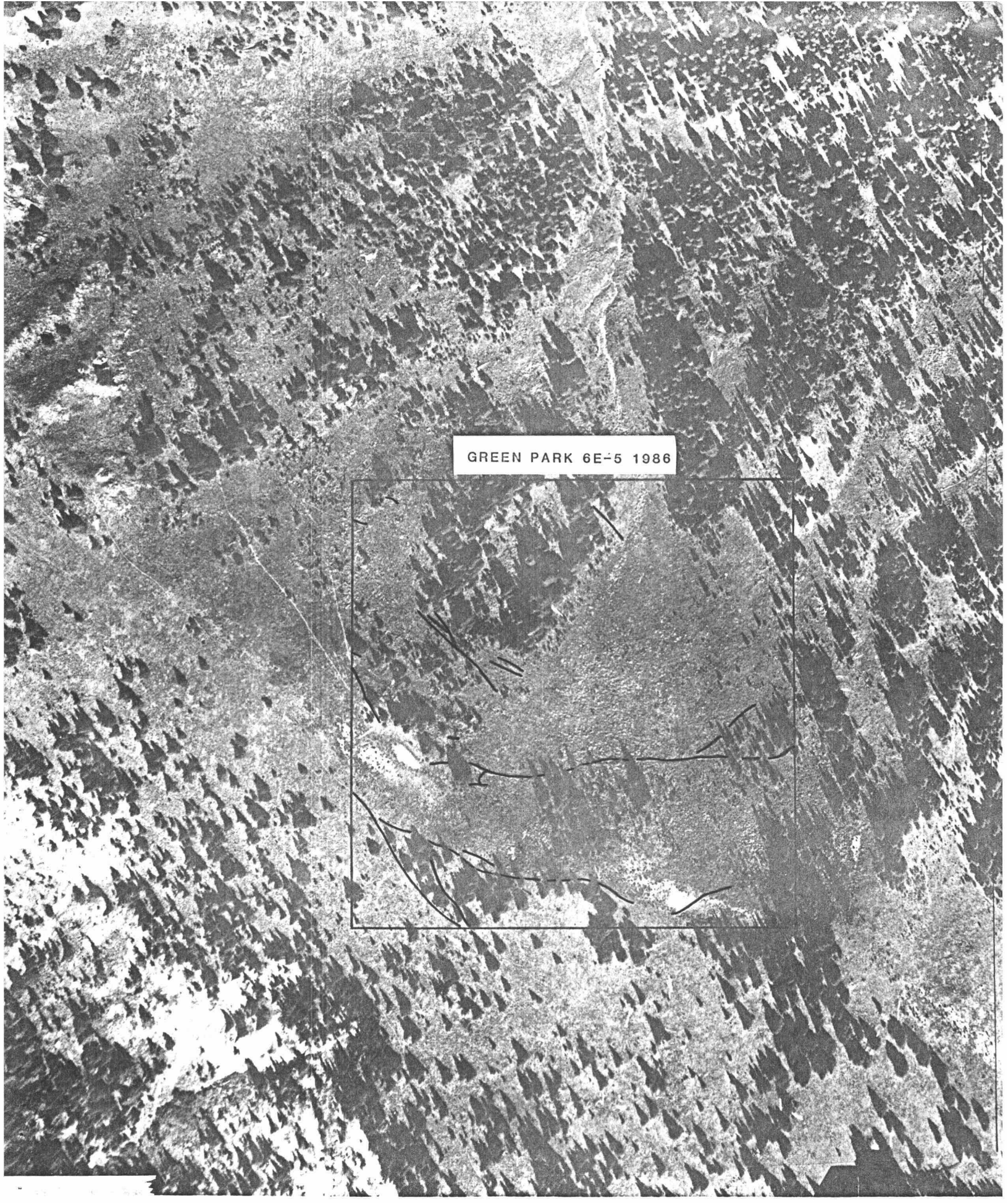
Ten Sites

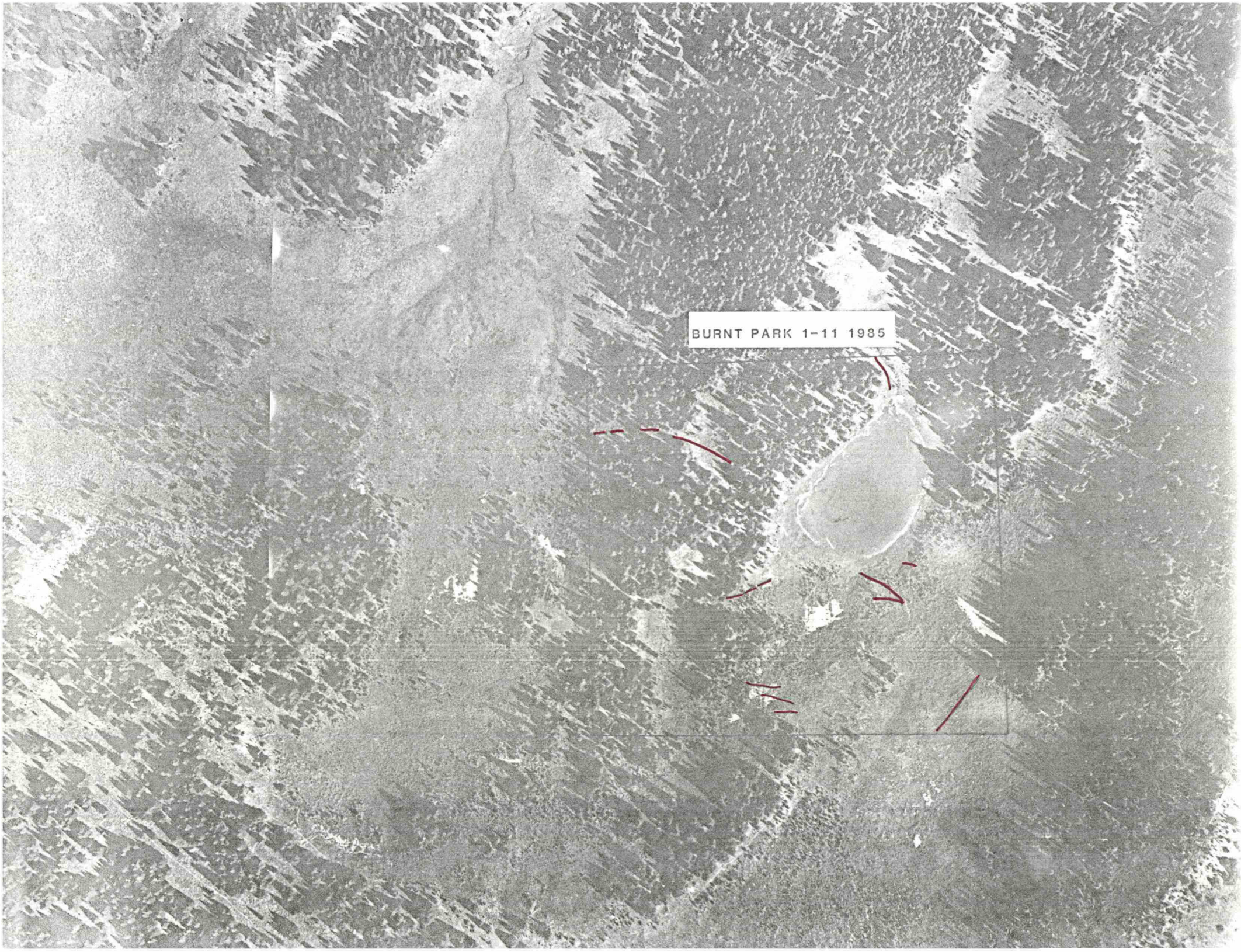
for Monitoring Elk Trails

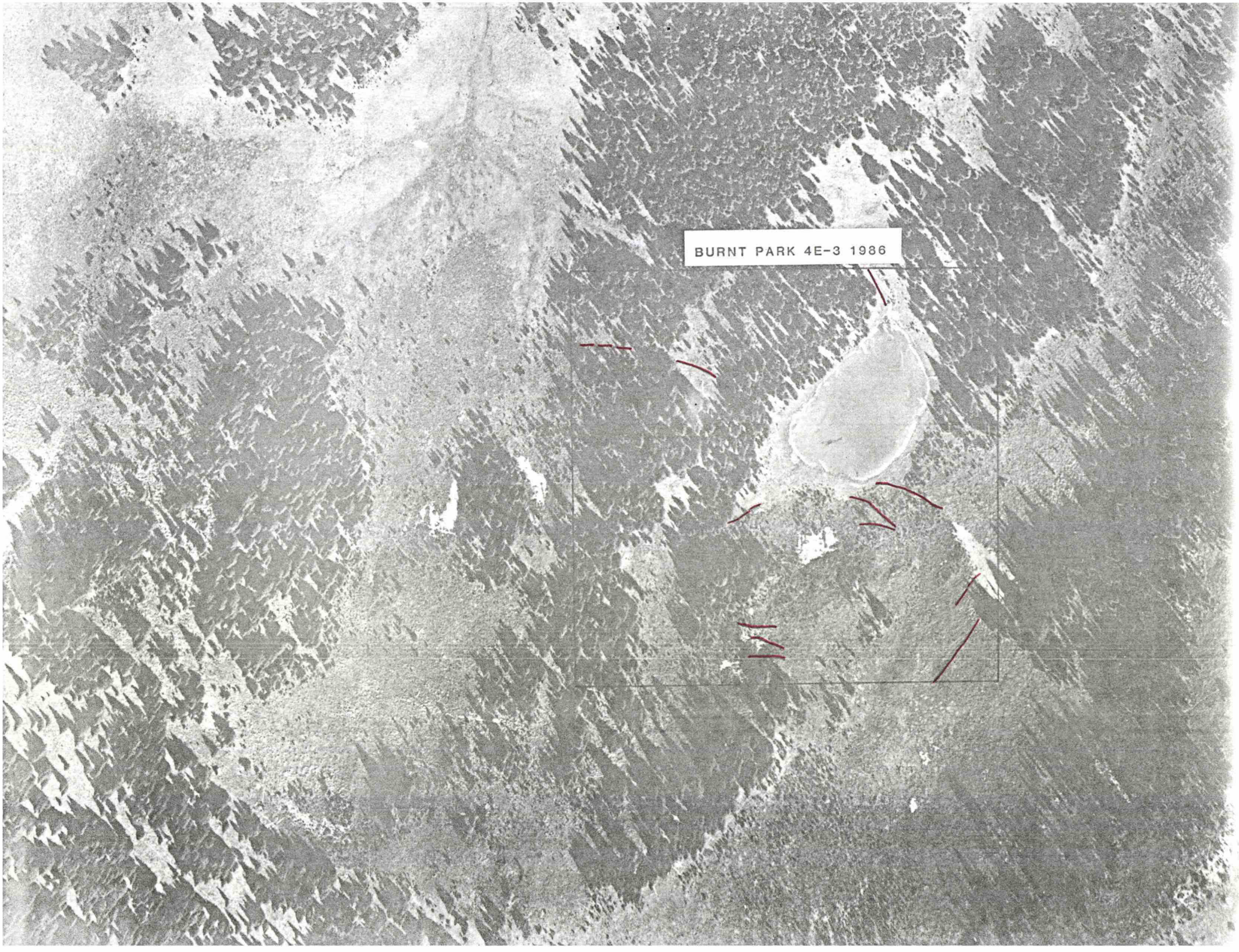

FREMONT LOOK NORTH 4-16 1985


FREMONT LOOKOUT NORTH 7E-4 1986

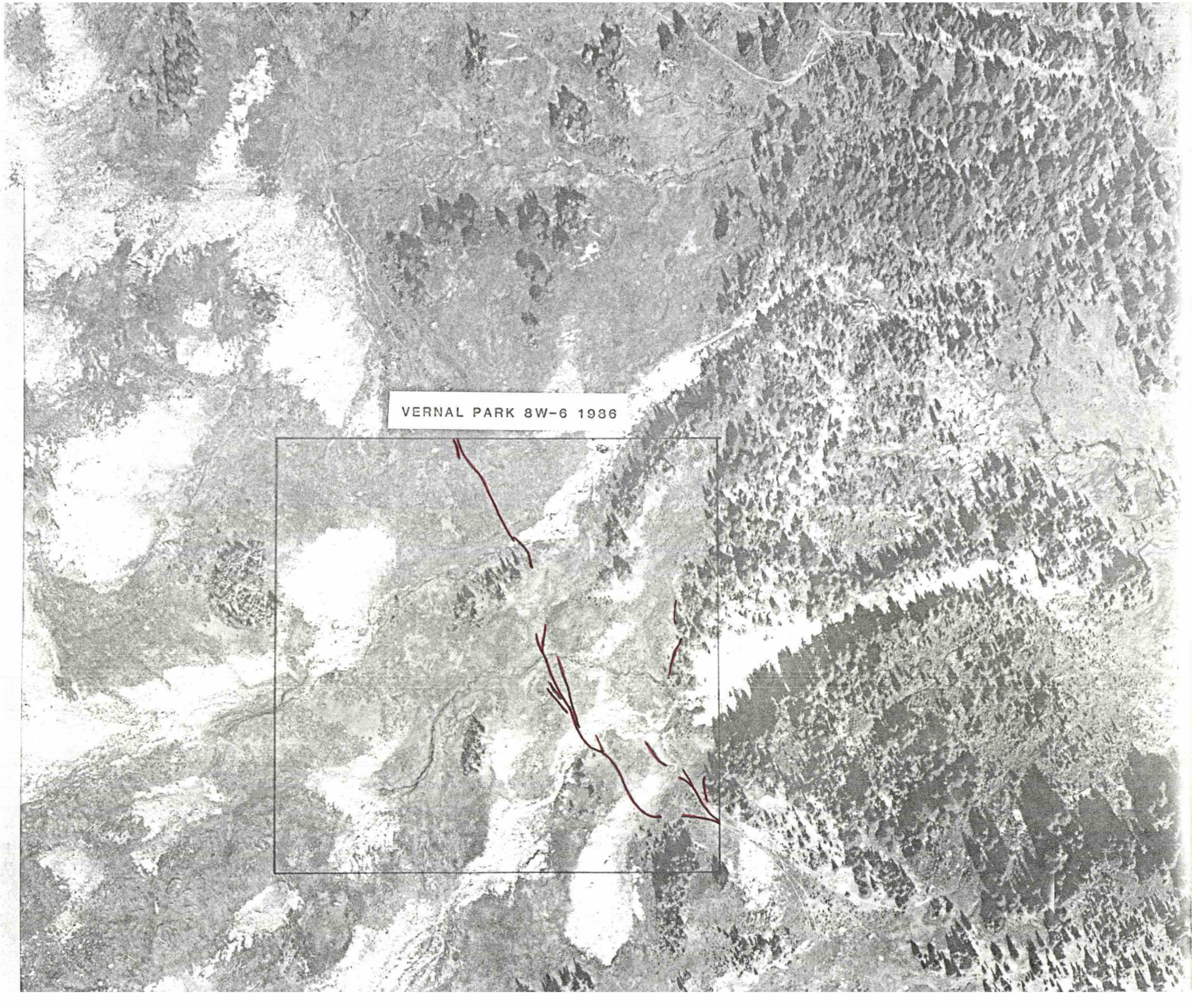

GREEN PARK 3-10 1985


GREEN PARK 6E-5 1986

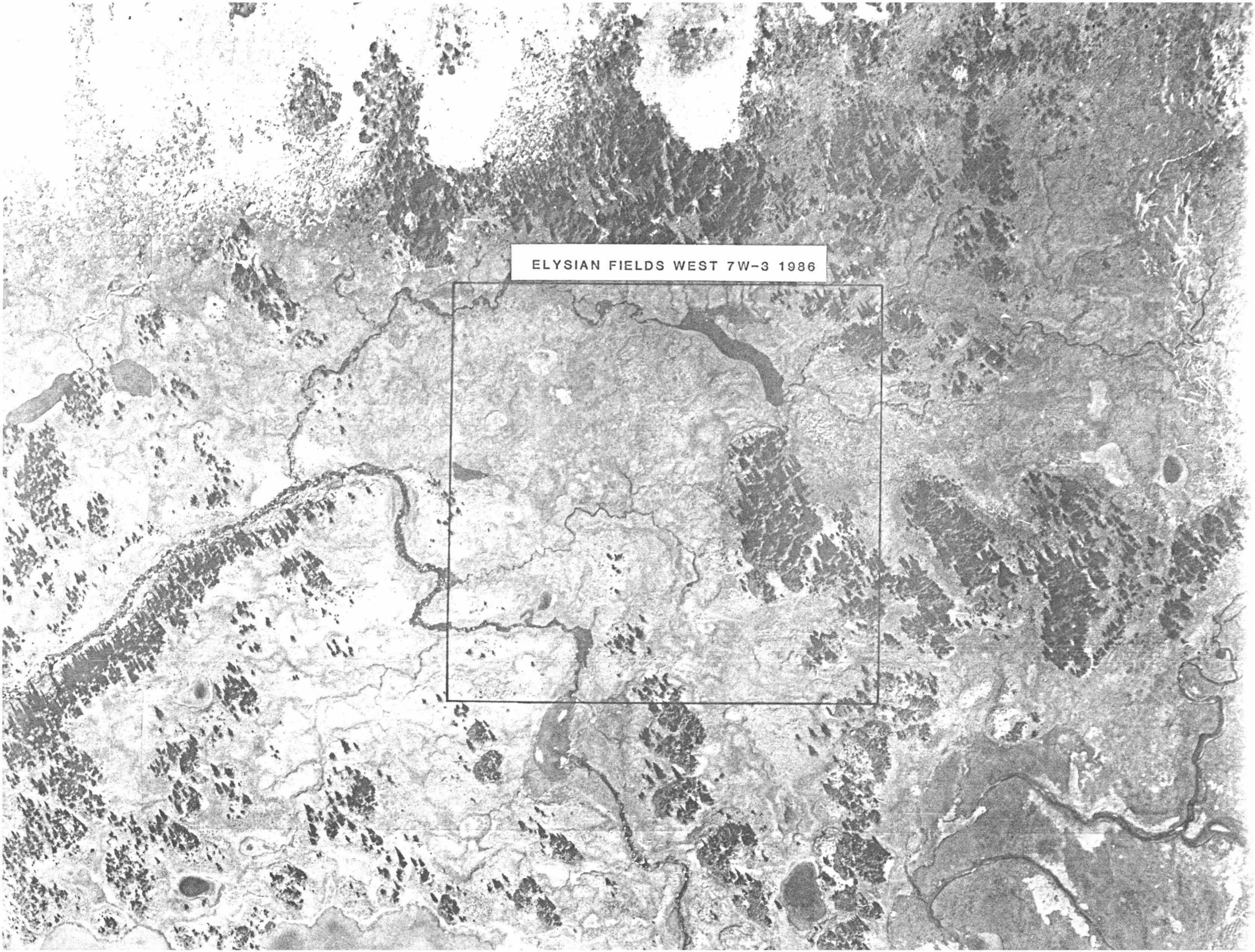

BURNT PARK 1-11 1985

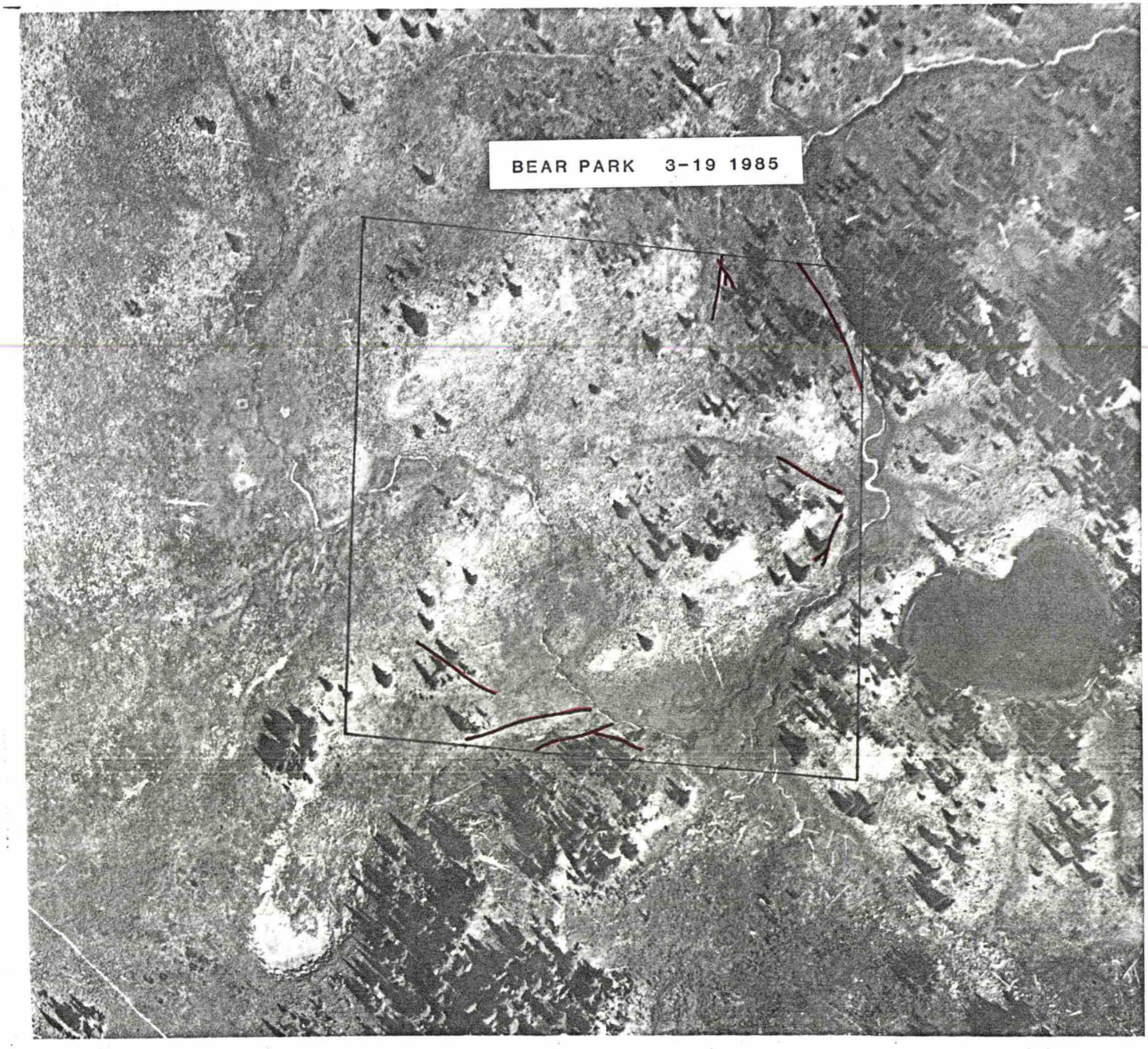

BURNT PARK 4E-3 1986

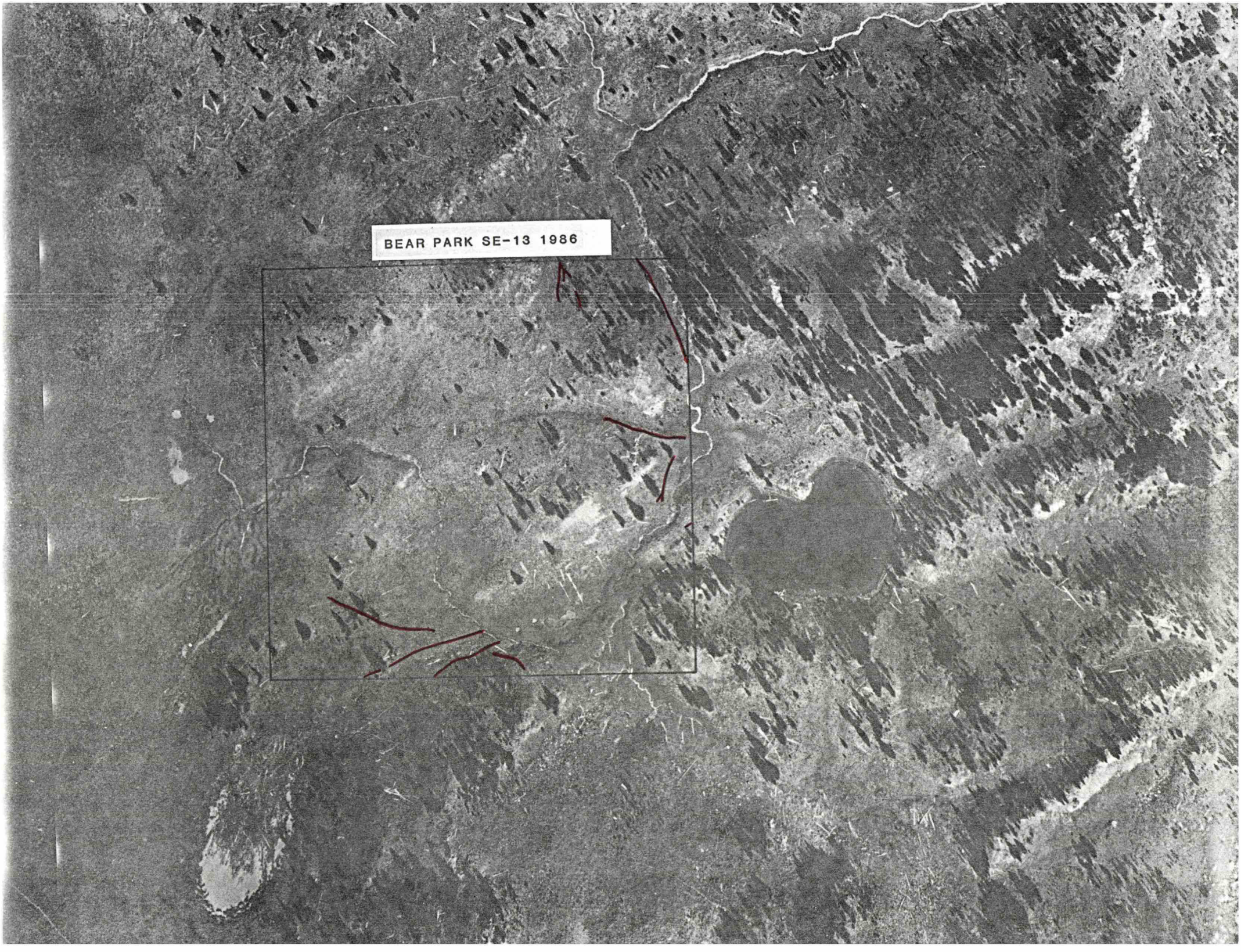

VERNAL PARK 5-7 1985

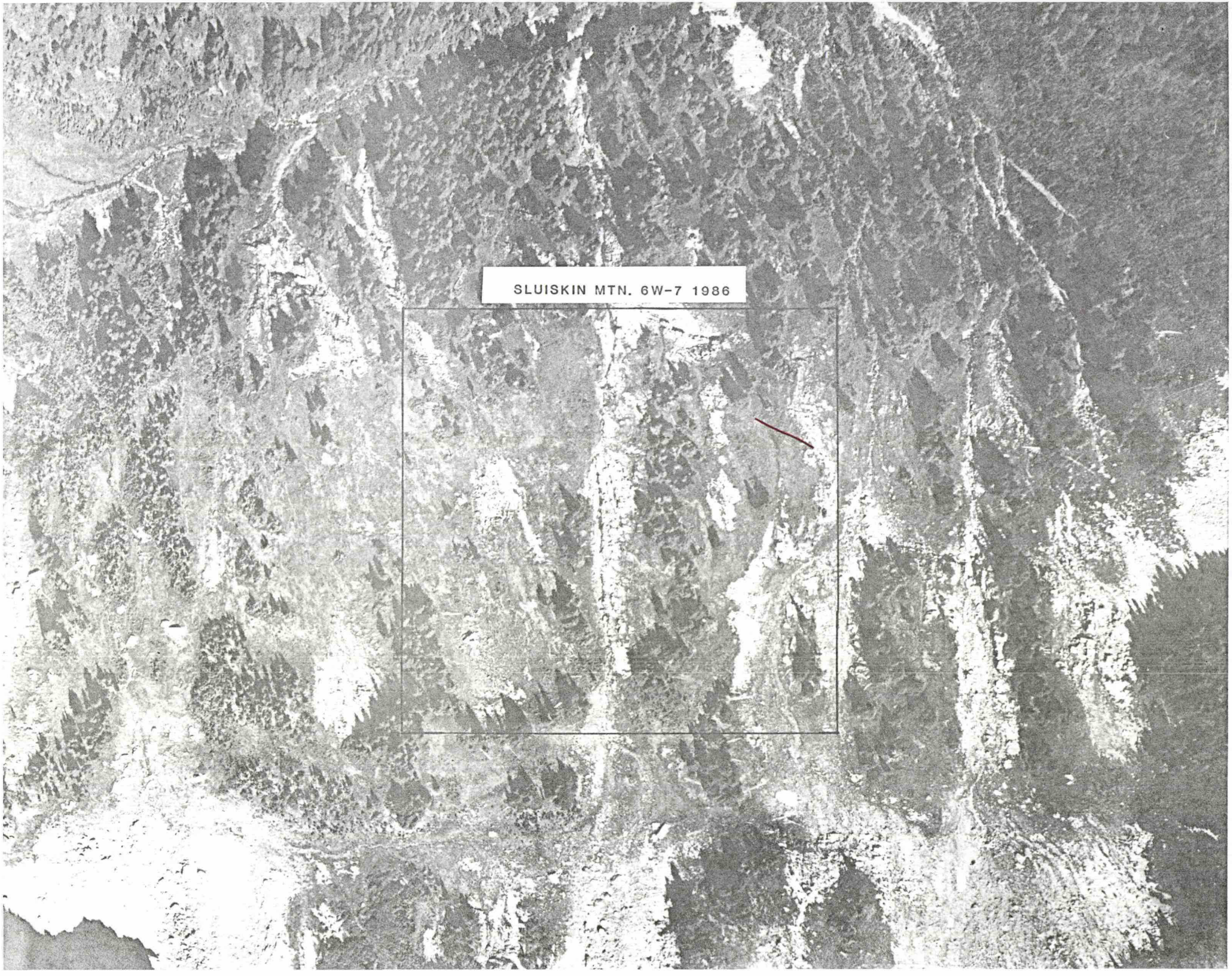

VERNAL PARK 8W-6 1986


ELYSIAN FIELDS WEST 4-1 1985


ELYSIAN FIELDS WEST 7W-3 1986

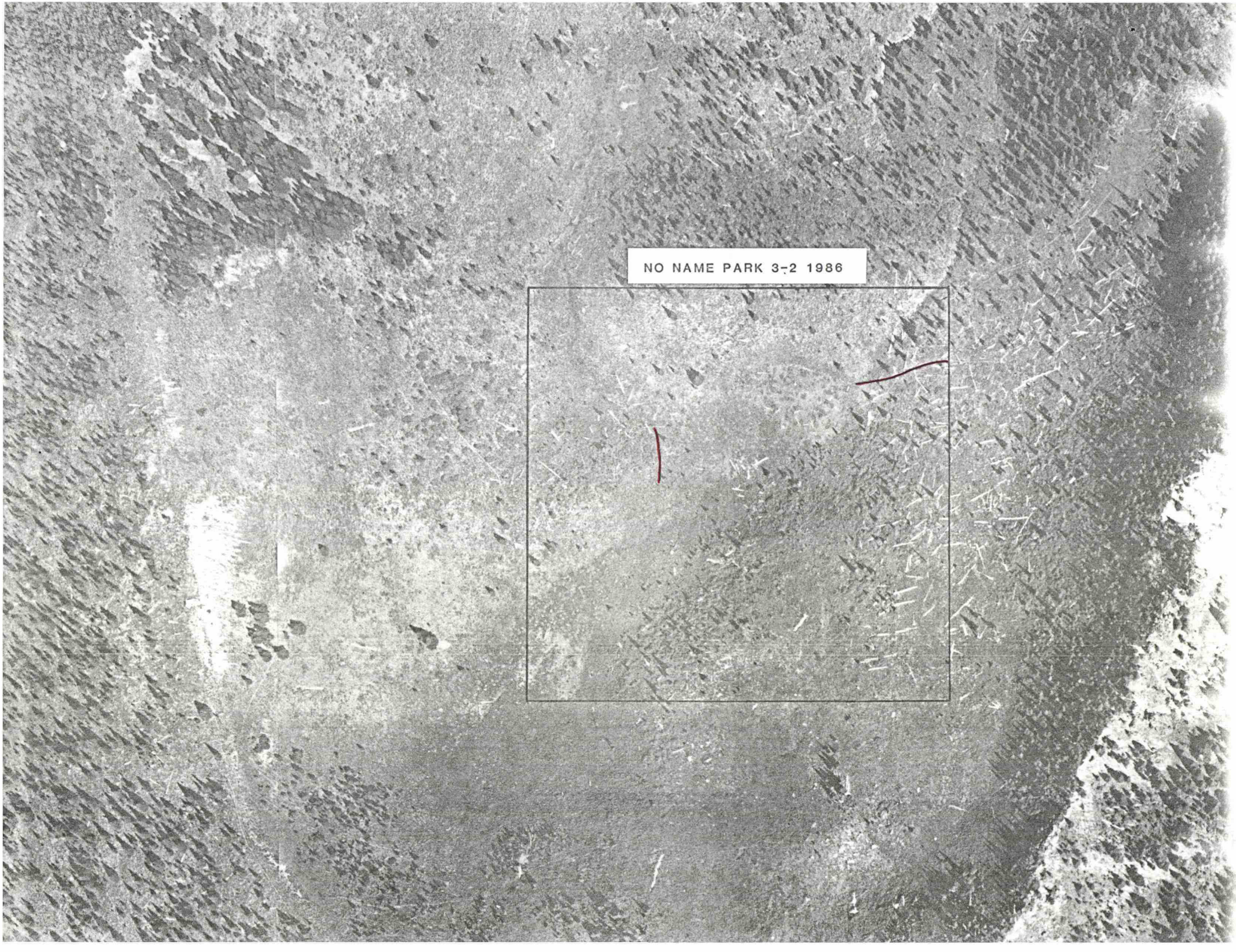

BEAR PARK 3-19 1985


BEAR PARK SE-13 1986


SLUISKIN MTN. 6W-7 1986


FAWN RIDGE 1-8 1986


SLIDE MOUNTAIN 3-6 1986


NO NAME PARK 3-2 1986

APPENDIX B-II

Trail and Vegetation Widths

for

Fremont Lookout North Plot

1986

FREMONT LOOKOUT NORTH 1986

Arc	Observation	Trail Width (cm)	Vegetation Width (cm)	Photo
1	a	85	3	#23
	b	75	5	Looking northwest
	c	60	4	
	$\bar{x}$	73.3	4.0	
2	a	63	2	#24
	b	63	0	Looking northwest
	c	59	6	
	$\bar{x}$	61.7	2.7	
3	a	49	6	#1
	b	60	4	Looking north-northwest
	c	70	0	
	$\bar{x}$	59.7	3.3	
4	a	34	20	#3
	b	38	18	Looking north
	c	49	23	
	$\bar{x}$	40.3	20.3	
5	a	70	2	#4 looking north-northwest
	b	71	14	#5 looking north-northwest
	c	35	25	#6 looking west
	$\bar{x}$	58.7	13.7	
6	a	50	7	#8 looking south
	b	48	10	
	c	38	18	#9 looking south
	$\bar{x}$	45.3	11.7	
7	a	55	18	#10
	b	73	3	Looking north
	c	69	4	
	$\bar{x}$	65.7	8.3	
8	a	65	8	#12
	b	80	2	Looking south
	c	78	0	
	$\bar{x}$	74.3	3.3	
9	a	42	3	#13
	b	53	12	Looking north
	c	50	9	
	$\bar{x}$	48.3	8.0	
10	a	44	21	#14
	b	60	12	Looking north
	c	39	21	
	$\bar{x}$	47.7	18.0	
11	a	50	25	#15
	b	40	30	Looking southwest
	c	55	28	
	$\bar{x}$	48.3	27.7	
12	a	60	2	#16
	b	50	15	Looking north
	c	53	5	
	$\bar{x}$	54.3	7.3	
13	a	43	3	#17
	b	54	10	Looking north
	c	48	8	
	$\bar{x}$	48.3	7.0	
14	No measurements due to snow storm			

Average trail width 55.8cm

Average vegetation width 10.4cm

APPENDIX B-III

Project Correspondence

Environmental Remote Sensing Applications Laboratory (ERSAL)

Oregon State University

Corvallis, Oregon 97331-6703 (503) 754-3056

31 March 1987

Mr. Bob Dunnagan
Mr. Stan Schlegal
Mt. Rainier National Park
Tahoma Woods, Star Route
Ashford, WA 98304

Dear Bob and Stan;

Under separate cover I am sending some of the completed results from the 1985-1986 remote sensing of elk impact activities. You will find original color photographs with the five elk trail enumeration areas outlined on acetate overlays. These areas, with their spatial extent of soil exposed by elk trails, include Upper Huckleberry Basin (0m/km^2), Sunrise Lake (1,568m/km^2), Bear Park (6,575m/km^2), Clover Lake (13,007m/km^2), and Lower Huckleberry Basin (14,502m/km^2). These quantitative estimates apply only to the areas outlined on the photographs. These enumeration areas should provide you with permanent baseline elk impact data. Please store these photographs in your archives, along with the enclosed report, which describes trail characteristics for each elk trail enumerated.

Also enclosed, please find the following enlarged prints from the 1985 aerial survey: Fremont Lookoet (5-17), Cold Basin (3-2), Fremont Lookout East (5-19), and Elysian Fields East (4-3).

Stan, I suggest that you try delineating elk trails on these enlargements. I think the Elysian Fields East and Fremont Lookout East photographs would be the most appropriate for delineating elk trails.

Please feel free to contact me if I can provide you with any additional information at this time.

Sincerely,

Bill

William Ripple
Research Associate

WJR/vd
Encs.

cc: Ed Starkey
Barry Schrumpf

APPENDIX B-IV

Photo Index Maps

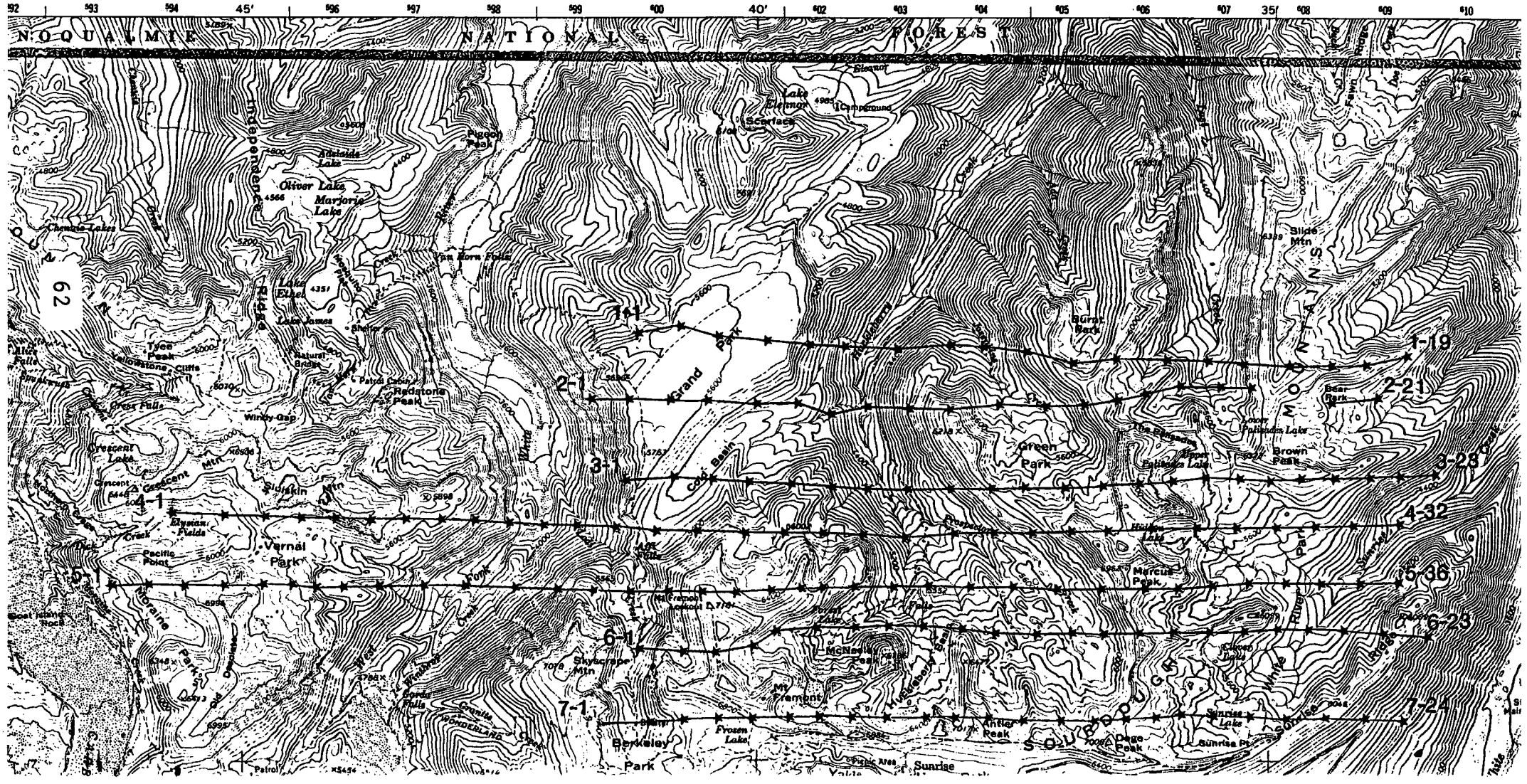
for

1985 and 1986 Flights

ELK IMPACTS STUDY

AUGUST 6 & 12, 1985 AERIAL PHOTOGRAPHY

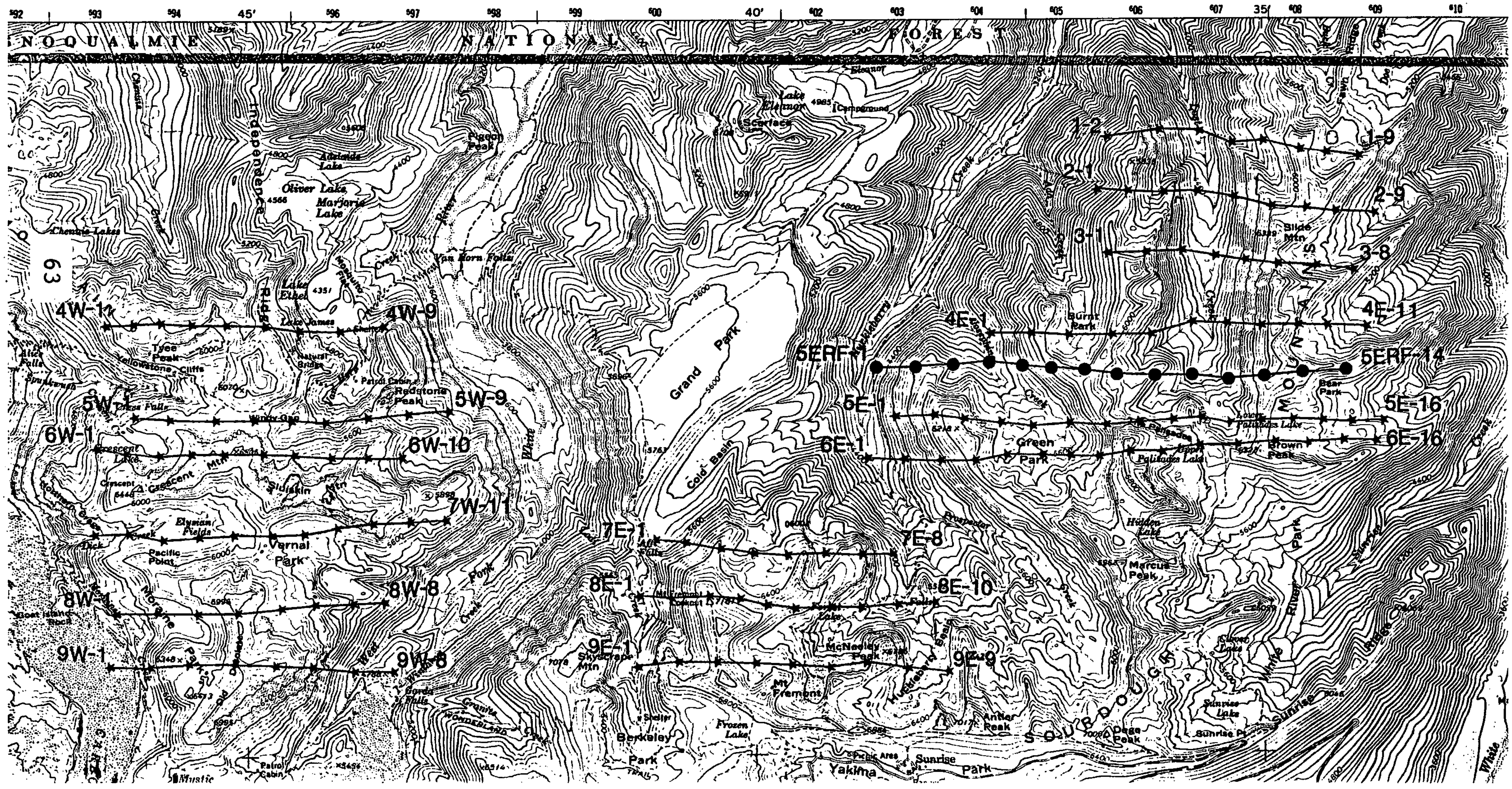
MT. RAINIER NATIONAL PARK



ELK IMPACTS STUDY

AUGUST 14 & SEPTEMBER 9, 1986 AERIAL PHOTOGRAPHY

MT. RAINIER NATIONAL PARK



APPENDIX B-V

Presence and Absence

of Elk Trails

from Aerial Photography

1985 PHOTOGRAPHY
ELK TRAIL SAMPLING

PHOTO #	Cell # 1		Cell # 2		Cell # 3		Cell # 4	
	%cover	trails	%cover	trails	%cover	trails	%cover	trails
1-1	95	no*	85	no	85	no	60	no
1-3	10	no	30	no	10	no	20	no
1-5	50	no	95	no	85	no	95	no
1-7	100	no	100	no	100	no	100	no
1-9	100	no	100	no	100	no	100	no
1-11	35	yes	65	yes	70	yes	30	yes
1-13	65	no	95	no	65	yes	60	no
1-15	80	no	25	yes	95	no	35	yes
1-17	45	yes	80	yes	35	yes	50	yes
1-19	90	no	70	yes	40	yes	50	yes
2-1	95	no	95	no	95	no	95	no
2-3	5	no	10	no	15	no	60	no
2-5	35	no	80	no	90	no	100	no
2-7	100	no	100	no	100	no	100	no
2-9	55	yes	50	yes	100	no	65	yes
2-11	95	no	95	no	80	no	90	no
2-13	90	yes	35	yes	90	no	85	no
2-15	45	yes	35	yes	40	yes	30	yes
2-17	85	no	90	no	70	no	80	yes
2-19	30	yes	35	yes	5	yes	40	yes
2-21	55	yes	75	no	80	no	100	no
3-1	90	no	65	no	80	no	90	no
3-3	40	yes	95	no	90	no	85	no
3-5	100	no	95	no	95	no	90	no
3-7	100	no	100	no	100	no	100	no
3-9	90	no	35	yes	95	no	85	yes
3-11	75	yes	80	yes	40	yes	65	yes
3-13	85	yes	40	no	40	yes	40	no
3-15	15	no	10	no	5	no	5	no
3-17	15	yes	25	yes	30	no	65	no

* "no" indicates that elk trails were visibly absent within the cell and "yes" indicates that elk trails were visibly present within the cell.

PHOTO #	Cell # 1		Cell # 2		Cell # 3		Cell # 4	
	%cover	trails	%cover	trails	%cover	trails	%cover	trails
3-19	30	yes	35	yes	40	yes	40	yes
3-21	65	yes	85	no	90	no	75	no
3-23	95	no	95	no	95	no	95	no
4-1	5	no	10	no	10	no	10	no
4-3	10	yes	5	no	50	yes	5	yes
4-5	5	no	5	no	35	yes	10	no
4-7	10	yes	50	yes	50	no	85	no
4-9	70	yes	80	no	90	no	90	no
4-11	70	no	85	no	85	no	100	no
4-13	90	no	60	no	100	no	90	no
4-15	95	no	90	yes	65	yes	60	yes
4-17	80	yes	70	no	35	yes	30	no
4-19	95	no	95	no	45	yes	70	no
4-21	100	no	95	no	100	no	100	no
4-23	45	yes	50	yes	80	yes	85	no
4-25	20	yes	65	no	30	no	15	no
4-27	15	no	25	no	30	no	65	yes
4-29	75	yes	75	no	75	yes	85	no
4-31	100	no	90	no	100	no	100	no
5-1	95	no	25	no	60	no	55	no
5-3	10	no	15	no	15	no	15	no
5-5	15	no	20	yes	5	no	5	no
5-7	30	yes	50	yes	20	yes	65	yes
5-9	75	yes	75	yes	85	no	95	no
5-11	75	no	80	no	75	no	85	no
5-13	100	no	100	no	95	no	70	no
5-15	95	no	95	no	55	no	65	yes
5-17	30	yes	10	yes	30	yes	0	no
5-19	25	no	25	yes	0	no	5	yes
5-21	20	no	25	yes	10	yes	55	yes
5-23	60	no	100	no	85	no	90	no
5-25	100	no	95	no	95	no	95	no

PHOTO #	Cell # 1		Cell # 2		Cell # 3		Cell # 4	
	%cover	trails	%cover	trails	%cover	trails	%cover	trails
5-27	70	yes	80	no	75	no	45	yes
5-29	5	no	5	no	30	yes	50	no
5-31	65	yes	80	no	70	no	75	no
5-33	75	no	90	no	65	no	70	no
5-35	100	no	95	no	100	no	90	no
6-1	65	yes	70	yes	40	yes	40	no
6-3	30	yes	0	no	30	no	5	no
6-5	5	no	10	yes	5	no	35	no
6-7	60	no	75	no	70	no	70	no
6-9	90	no	85	no	65	no	40	yes
6-11	90	yes	80	yes	65	yes	65	yes
6-13	60	yes	65	yes	70	yes	45	yes
6-15	45	yes	40	yes	45	yes	10	no
6-17	50	yes	65	yes	45	yes	65	no
6-19	35	yes	70	no	90	no	90	no
6-21	100	no	95	no	95	no	70	yes
6-23	30	yes	50	no	65	no	85	no
7-1	30	yes	60	no	15	no	60	no
7-3	35	no	20	no	15	no	10	no
7-5	0	no	0	no	0	no	0	no
7-7	5	no	10	no	15	no	15	no
7-9	25	no	40	no	5	no	10	no
7-11	30	no	30	no	0	no	0	no
7-13	20	no	20	no	5	no	5	no
7-15	30	yes	20	no	10	yes	5	no
7-17	30	no	25	no	10	no	20	no
7-19	70	yes	65	yes	65	yes	50	no
7-21	85	yes	80	yes	50	yes	60	yes
7-23	50	yes	95	no	95	no	100	no

1986 PHOTOGRAPHY
ELK TRAIL SAMPLING

PHOTO #	CELL # 1		CELL # 2		CELL # 3		CELL # 4	
	%cover	trails	%cover	trails	%cover	trails	%cover	trails
1-3	95	no*	90	no	15	no	30	no
1-5	95	no	45	yes	95	no	70	yes
1-7	25	yes	25	no	20	no	25	yes
1-9	30	yes	40	yes	15	yes	35	yes
2-1	95	no	85	yes	100	no	100	yes
2-3	75	yes	55	no	75	no	70	no
2-5	95	no	40	yes	90	no	50	no
2-7	10	yes	20	yes	20	yes	15	yes
2-9	70	yes	70	yes	60	yes	85	yes
3-1	75	yes	10	yes	85	yes	55	yes
3-3	50	no	50	no	60	no	70	no
3-5	55	no	40	yes	5	no	5	no
3-7	25	yes	50	yes	30	yes	50	yes
4E-1	100	no	95	no	100	no	95	no
4E-3	35	yes	75	yes	30	yes	80	yes
4E-5	25	yes	50	yes	40	yes	85	yes
4E-7	90	no	85	no	80	yes	70	yes
4E-9	25	yes	40	yes	25	yes	30	yes
4E-11	95	no	100	no	90	no	90	no
4W-1	90	no	45	yes	100	no	70	yes
4W-3	40	yes	40	yes	15	yes	10	yes
4W-5	45	yes	40	yes	5	yes	10	yes
4W-7	70	yes	75	no	35	yes	40	yes
4W-9	95	no	100	no	95	no	100	no
5E-1	95	no	75	yes	100	no	90	no
5E-3	50	yes	70	no	35	yes	50	yes
5E-5	95	no	95	no	70	yes	85	no
5E-7	85	no	30	no	90	no	50	no
5E-9	35	no	75	no	10	no	30	yes
5E-11	70	yes	50	yes	65	yes	40	yes
5E-13	5	yes	30	yes	5	yes	35	yes
5E-15	80	no	100	no	50	yes	90	yes

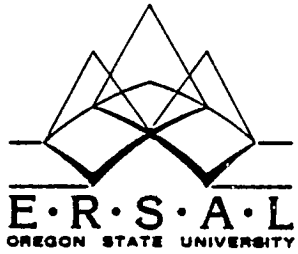
* "no" indicates that elk trails were visibly absent within the cell and "yes" indicates that elk trails were visibly present within the cell.

1986 PHOTOGRAPHY
ELK TRAIL SAMPLING

PHOTO #	CELL # 1		CELL # 2		CELL # 3		CELL # 4	
	%cover	trails	%cover	trails	%cover	trails	%cover	trails
5ERF-1	100	no	95	no	100	no	65	yes
5ERF-3	100	no	100	no	95	no	100	no
5ERF-5	90	no	90	no	100	no	95	no
5ERF-7	45	yes	40	yes	70	yes	40	yes
5ERF-9	85	yes	90	no	55	yes	65	yes
5ERF-11	85	no	60	yes	95	no	55	yes
5ERF-13	30	yes	50	yes	40	yes	65	yes
5W-1	75	yes	60	yes	45	yes	15	yes
5W-3	30	yes	20	yes	0	no	10	no
5W-5	10	yes	75	yes	20	yes	40	yes
5W-7	70	no	40	no	70	yes	50	yes
5W-9	70	no	100	no	95	no	100	no
6E-1	100	no	100	no	100	no	100	no
6E-3	80	yes	20	yes	95	no	75	yes
6E-5	65	yes	75	yes	50	yes	75	yes
6E-7	90	no	95	no	85	no	80	no
6E-9	30	no	5	no	10	no	0	no
6E-11	20	no	50	yes	10	yes	25	no
6E-13	15	yes	5	yes	35	yes	40	yes
6E-15	55	yes	65	yes	25	yes	80	yes
6W-1	90	no	35	yes	65	yes	30	no
6W-3	10	no	10	no	0	no	10	no
6W-5	5	no	5	no	15	no	30	no
6W-7	20	no	30	yes	5	no	5	no
6W-9	20	yes	30	yes	15	yes	45	yes
7E-1	65	yes	75	no	90	no	80	yes
7E-3	65	yes	15	yes	15	yes	15	yes
7E-5	45	yes	35	yes	15	yes	30	yes
7E-7	60	no	80	no	20	no	55	no
7W-1	45	no	35	no	80	no	40	no
7W-3	40	no	15	no	10	no	15	no
7W-5	40	yes	55	yes	30	yes	30	yes
7W-7	5	yes	15	yes	20	yes	50	yes
7W-9	10	yes	30	yes	20	yes	35	yes
7W-11	65	yes	90	no	95	no	90	no

1986 PHOTOGRAPHY
ELK TRAIL SAMPLING

PHOTO #	CELL # 1		CELL # 2		CELL # 3		CELL # 4	
	%cover	trails	%cover	trails	%cover	trails	%cover	trails
8E-1	80	yes	80	yes	60	yes	70	yes
8E-3	15	yes	5	yes	35	yes	0	yes
8E-5	0	no	5	yes	0	no	10	no
8E-7	20	yes	50	yes	45	no	80	no
8E-9	90	no	100	no	45	no	90	no
8W-1	70	no	60	yes	25	no	70	no
8W-3	15	no	15	no	15	no	20	no
8W-5	0	no	5	no	5	no	5	no
8W-7	40	yes	85	yes	85	yes	100	no
9E-1	45	no	35	no	50	no	35	no
9E-3	5	no	5	no	5	no	0	no
9E-5	5	no	40	no	0	no	0	no
9E-7	55	no	45	no	15	no	25	no
9E-9	35	no	30	no	40	no	35	no
9W-1	5	no	50	no	0	no	10	no
9W-3	5	no	5	no	30	no	0	no
9W-5	0	no	0	no	0	no	0	no
9W-7	45	yes	75	no	40	no	20	no



Environmental Remote Sensing
Applications Laboratory
Oregon State University
Corvallis, OR 97331-6703