A PRELIMINARY TRAINING GUIDE FOR UTILIZING HIGH-ALTITUDE, COLOR-INFRARED PHOTOGRAPHY IN COMPILING SOIL MAPS

Job Order 75-315

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Prepared By

Lockheed Electronics Company, Inc.
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Houston, Texas
Contract NAS 9-15200

For

EARTH OBSERVATIONS DIVISION
SPACE AND LIFE SCIENCES DIRECTORATE

National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

April 1977

LEC-8283

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PREFACE

This guide presents some technical analysis procedures and methods for compiling a soil resources inventory using high-altitude (small scale), color-infrared photography. It is designed to be used by individuals who are not accustomed to using small-scale, color-infrared photography and as an aid to management in setting forth procedures for indoctrinating less experienced personnel.

The authors acknowledge D. G. Aydelott, P. E. Avers, I. E. Duggan, and Dr. F. P. Weber of the United States Department of Agriculture, Forest Service, for the benefit of their inputs, suggestion, and general discussion concerning the preparation of this guide.

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TABLES

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1. INTRODUCTION

This guide is intended to provide instruction for acquiring and analytically processing small-scale color-infrared photography to perform a soil resources inventory over forests of the U.S. Department of Agriculture (USDA) Forest Service, Southern Region.

A Soils Resource Inventory Guide (ref. 1) was used as the model to determine the procedures described in this document. The Southern Region (Region 8) of the Forest Service contains three subregions: Coastal Plain, Piedmont, and Mountains. There are differences in the topography, climatology, geology, and soils among the three subregions, but the principles described herein will apply with minor deviations to each of the subregions. Throughout this document, the Chattahoochee National Forest, a mountains subregion forest, will be used as an example. Consequently, principles, methods, and tools discussed will apply only to that forest or subregion. Nevertheless these procedures may be used as fairly direct guidelines for adapting to other forests in the Southern Region. Similarly, the general procedures should be valid for other regions, although descriptions and categories of the components will undoubtedly undergo modification to fit the specific environmental setting.

The guide is divided into four major sections.

a. Planning and preparation: This section discusses planning the project; acquiring aerial photography, materials, equipment, supplemental data; and preparing the photography for analysis.

b. Photointerpretation: This section discusses the procedures for preparing ancillary and primary component overlays and explains the use of correlation charts and dichotomous keys for mountain landforms, water regime, and vegetation.

c. Preparation of base map: This section discusses the selection of the base map and its enlargement and the rectification of a photograph with the base map.

d. Evaluation of mapping accuracy: This section discusses the method of evaluating accuracy by observation and by statistical sampling.

This document was prepared by Lockheed Electronics Company, Inc. for the nationwide Forestry Applications Program, a cooperative program of the National Aeronautics and Space Administration (NASA), Lyndon B. Johnson Space Center, and the U.S. Department of Agriculture.

2. PLANNING AND PREPARATION

2.1 PLANNING THE PROJECT

2.1.1 LOCATION AND SIZE

After the project area has been defined, the boundaries should be delineated on a small-scale map. A good scale would be approximately 1:250 000. The latitude and longitude of each corner of the project or study area can be determined (fig. 2-1). These coordinates will be needed when ordering photographic data.

2.1.2 AERIAL PHOTOGRAPHY

Aerial photographs can be ordered from governmental repositories which keep photographs in stock, or new photographs can be acquired by contracting the work from a commercial aerial survey company.

2.1.2.1 EROS Data Center

Aerial photography has been available for years from various governmental agencies; however, within the past few years there has been an effort to consolidate NASA-generated aerial film and other remotely sensed data and aerial film at a central location. This repository is known as the EROS Data Center. Located at Sioux Falls, South Dakota, the EROS Data Center is administered by the U.S. Department of the Interior, Geological Survey. The primary functions of the center are data storage, data reproduction, user assistance, and training. A central computer keeps track of more than 5 million images and photographs of the Earth's surface. Data storage and retrieval are based on a location system of latitude and longitude coordinates with additional information as to image quality, cloud cover, and type of product.

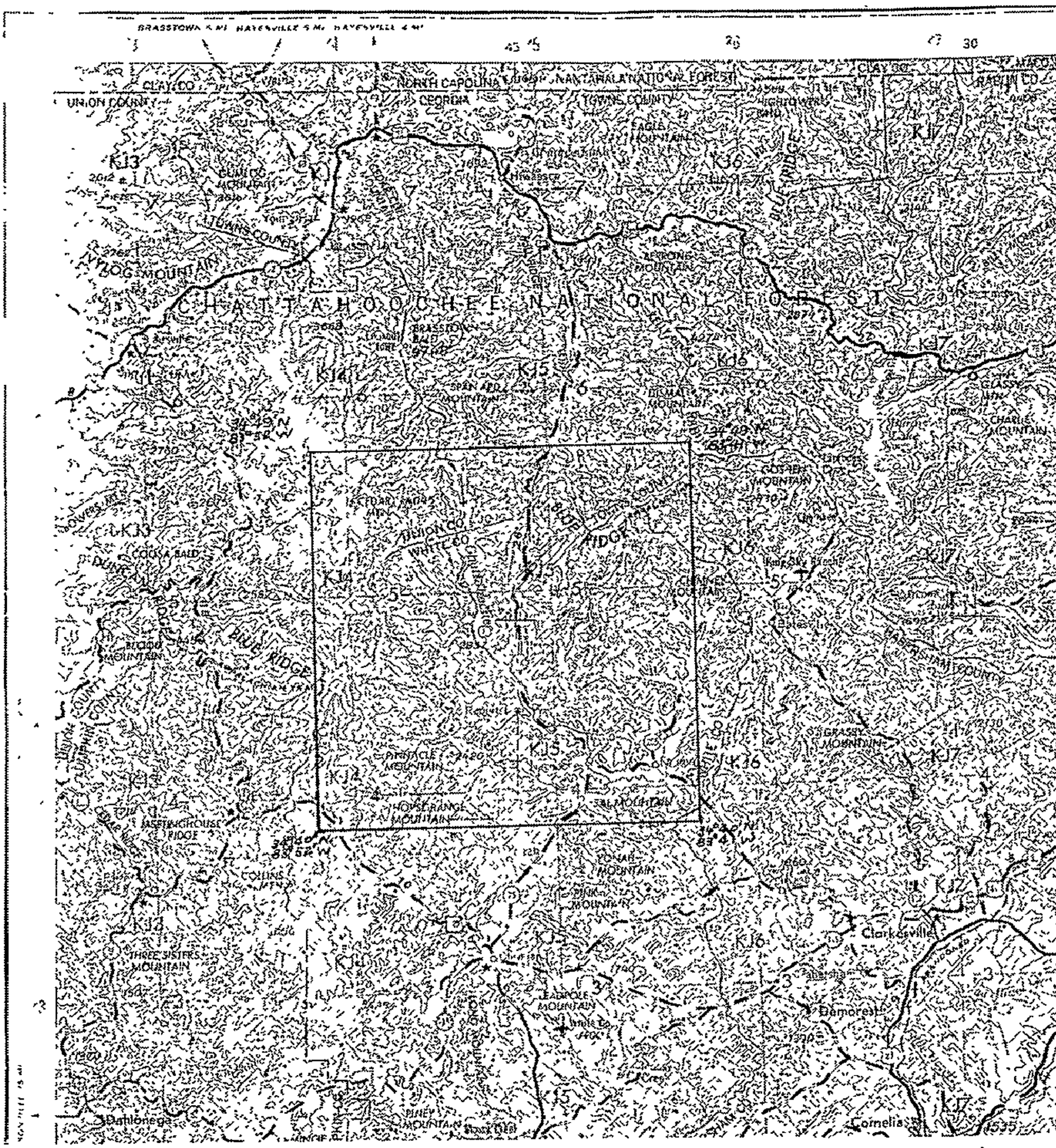


Figure 2-1.– Determination of latitude and longitude of the project area.

The EROS program provides access to NASA Land Satellite (Landsat) imagery, aerial photographs acquired by the U.S. Department of the Interior, and photography and imagery acquired by NASA research aircraft and from the Skylab, Apollo, and Gemini spaceflights.

To place an order, or to inquire about the availability of data, contact:

User Service Unit
EROS Data Center
Sioux Falls, South Dakota 57198
Phone: (605) 594-6511, extension 151
FTS: (605) 594-6151

The data retrieval system is capable of conducting a computer search of the type of data requested, based on the area described by latitude and longitude coordinates. Figures 2-2 and 2-3 provide the instructions for initiating an inquiry and search.

EROS has established reference files at several facilities in the continental United States. Microfilm copies are available at these facilities, thereby providing an opportunity for viewing the data before placing an order.

Order forms are available for the type of photography or imagery desired (figs. 2-4 and 2-5). Current price lists for all standard products are also available (figs. 2-6 and 2-7). The addresses for EROS Data Reference Files in the southeastern United States are:

EROS Data Reference File
State Topographic Office
Lafayette Building
Koger Office Center
Tallahassee, Florida 32304
Phone: (904) 488-2168
Hours: 8:15 a.m. to 5:15 p.m.

EROS Data Reference File
Maps and Surveys Branch
Tennessee Valley Authority
20 Honey Building
311 Broad Street
Chattanooga, Tennessee 37401
Phone: (615) 755-2133
Hours: 8 a.m. to 4 p.m.

INQUIRY FORM

GEOGRAPHIC COMPUTER SEARCH

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DATE ______

NAME MR / MS ______ (FIRST) (INITIAL) (LAST)   ACCOUNT NO ______ (IF KNOWN)

COMPANY ______ (IF BUSINESS ASSOCIATED)   PHONE (Bus.) ______

ADDRESS ______   PHONE (Home) ______

CITY ______   Your Ref No ______ (P.O., GOVT ACCT OR OTHER)

TO INITIATE AN INQUIRY AND COMPUTER GEOSEARCH COMPLETE THE FOLLOWING

POINT SEARCH

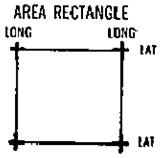
Imagery with any coverage over the selected point will be included

	POINT #1	POINT #2	POINT #3
Latitude	° ' N or S	° ' N or S	° ' N or S
Longitude	° ' E or W	° ' E or W	° ' E or W

Landsat Only (Worldwide Reference System)

Path ______	Path ______	Path ______	Path ______	Path ______
Row ______	Row ______	Row ______	Row ______	Row ______

AREA RECTANGLE



Imagery with any coverage over the selected area will be included

	AREA #1	AREA #2	AREA #3
Lat	° ' N or S to	° ' N or S to	° ' N or S to
Lat	° ' N or S	° ' N or S	° ' N or S
Long	° ' E or W to	° ' E or W to	° ' E or W to
Long	° ' E or W	° ' E or W	° ' E or W

If the above geographic coordinates cannot be supplied please specify area by GEOGRAPHIC NAME AND LOCATION (include a map if possible)

PREFERRED TYPE OF COVERAGE

	Black & White	Color or Color Infrared
☐ Landsat	☐	☐
☐ Skylab	☐	☐
☐ Nasa Aircraft	☐	☐
☐ Aerial Mapping Photography (Minimum color available)		

PREFERRED TIME OF YEAR

Check maximum of three

☐ JAN MAR
☐ APR-JUNE
☐ JULY SEPT
☐ OCT DEC

☐ All coverage
☐ Latest coverage
☐ SPECIFIC DATES ______

NOTE Seasonal coverage normally applies only to Landsat coverage

MINIMUM QUALITY RATING ACCEPTABLE

☐ 0 2 (VERY POOR) ☐ 3 4 (POOR) ☐ 5 6 (FAIR) ☐ 7 9 (GOOD)

MAXIMUM CLOUD COVER ACCEPTABLE

☐ 10% ☐ 30% ☐ 50% ☐ 80% ☐ 100%

NOTE Classification of percent of cloud cover is subjective and is relative to the amount of clouds appearing on the imagery and not to their location

APPLICATION AND INTENDED USE ______

FORM 9 1936
(Jan 1977)

Return completed form to the facility nearest you.

NCIC HEADQUARTERS
U.S. Geological Survey
507 National Center
Reston, VA 22092
FTS 928-6045
COMM 703-860-6045

EROS APPLICATIONS FACILITY
NSTL
U.S. Geological Survey
Bay St Louis, MS 39520
FTS: 494-3541
COMM 688-3472

NCIC MID-CONTINENT
U.S. Geological Survey
1400 Independence Rd
Rolla, MO 65401
FTS: 276-9107
COMM 314-364-3680

EROS DATA CENTER
U.S. Geological Survey
Sioux Falls, SD 57198
FTS: 784-7151
COMM. 605-594-6511

NCIC ROCKY MOUNTAIN
U.S. Geological Survey
Stop 510, Box 25046
Denver Federal Ctr.
Denver, CO 80225
FTS: 234-2326
COMM: 303-234-2326

NCIC WESTERN
U.S. Geological Survey
345 Middlefield Rd.
Menlo Park, CA 94025
FTS 467-2427
COMM 415-323-2427

Figure 2-2.— Inquiry form for EROS geographic computer search.

HOW TO REQUEST A GEOGRAPHIC SEARCH

This form is used to request a computer search for imagery over a point or area of interest.

Data from this inquiry sheet will be used to initiate a computer Geosearch. The results will be returned on a computer listing along with a decoding sheet, from which imagery can be selected and ordered.

Complete the form as follows:

A. Enter your NAME, ADDRESS, and ZIP CODE clearly. If you have had previous contact with that facility, include your ACCOUNT number. Enter a PHONE number where you can be reached during business hours.

B. Complete the required information for either the POINT SEARCH, or AREA RECTANGLE inquiry, which includes the geographic LATITUDE and LONGITUDE coordinates. If coordinates are not available, please supply the GEOGRAPHIC NAME AND LOCATION or a map with the area of interest identified. It is beneficial that you minimize your area of interest, thereby allowing for a faster and more critical retrieval of information.

C. Complete all other information.

D. Complete the APPLICATION AND INTENDED USE portion of the inquiry. e.g. Will it be used for identifying buildings or will it be framed and placed on a wall. This information will assist our technicians in determining whether the products available will satisfy your requirements.

E. Return completed form to the FACILITY NEAREST YOU.

NOTE: If an inquiry is made for Landsat Data, and the Worldwide Reference of PATH and ROW numbers are available, please insert them in the appropriate locations. Otherwise, geographic coordinates will suffice.

Figure 2-3.– Instructions for requesting an EROS geographic search.

ORDER FORM

NASA AIRCRAFT PHOTOGRAPHY

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

DATE ______________

NAME MR/MS ______________ (FIRST) ______ (INITIAL) ______ (LAST) ACCOUNT NO ______ (IF KNOWN)

COMPANY ______________ (IF BUSINESS ASSOCIATED) PHONE (Bus.) ______

ADDRESS ______________ PHONE (Home) ______

CITY ______ STATE ______ ZIP ______ Your Ref No ______ (P.O. GOVT ACCT OR OTHER)

PLEASE TYPE OR PRINT PLAINLY

PHOTO IDENTIFICATION NO.	PRODUCT CODE	FRAMES FIRST	FRAMES LAST	NO OF FRAMES	NO OF COPIES	QTY.	UNIT PRICE	TOTAL PRICE

TOTAL ABOVE	A
TOTAL FROM PREVIOUS SHEETS	B
TOTAL COST.	C

STANDARD PRODUCTS

FILM SOURCE

BLACK & WHITE PRODUCTS	B & W 70MM	B & W 5 IN	B & W 9 IN	B & W 9 X 18 IN
55.8mm (2.2 in.) FILM POSITIVE	11	[illegible]	[illegible]	[illegible]
55.8mm (2.2 in.) FILM NEGATIVE	01	[illegible]	[illegible]	[illegible]
55.8mm (2.2 in.) PAPER	[illegible]			[illegible]
11.4cm (4.5 in.) PAPER		22	[illegible]	
11.4cm (4.5 in.) FILM POSITIVE		12	[illegible]	[illegible]
11.4cm (4.5 in.) FILM NEGATIVE	[illegible]	02	[illegible]	[illegible]
22.9cm (9 in.) PAPER	23	23	23	
22.9cm (9 in.) FILM POSITIVE			13	[illegible]
22.9cm (9 in.) FILM NEGATIVE			3	
22.9x45.7cm (9x18 in.) PAPER				31
22.9x45.7cm (9x18 in.) FILM POSITIVE				14
22.9x45.7cm (9x18 in.) FILM NEGATIVE				04
45.7cm (18 in.) PAPER	24	24	24	
68.6cm (27 in.) PAPER		23	25	
91.4cm (36 in.) PAPER		28	28	

FILM SOURCE

COLOR PRODUCTS	COL 70MM	COL 5IN	COL 9IN	COL 9 X 18IN
55.8mm (2.2 in.) FILM POSITIVE	51	[illegible]	[illegible]	[illegible]
55.8mm (2.2 in.) PAPER	[illegible]			
11.4cm (4.5 in.) PAPER		62		
11.4cm (4.5 in.) FILM POSITIVE		52		
22.9cm (9 in.) PAPER	63		63	
22.9cm (9 in.) FILM POSITIVE			53	
22.9x45.7cm (9x18 in.) PAPER				69
22.9x45.7cm (9x18 in.) FILM POSITIVE				54
45.7cm (18 in.) PAPER	64	64	64	
68.6cm (27 in.) PAPER		65	65	
91.4cm (36 in.) PAPER		66	66	

NOTE NUMBERS IN OPEN BLOCKS REFLECT PRODUCT CODES

Please refer to current price list for cost determination.

PAYMENT MADE BY:

- CHECK, MONEY-ORDER ☐
- PURCHASE ORDER ☐
- GOVT. ACCOUNT ☐

COMMENTS: ______________

FORM 9-1940 (Jan 1977)

Return completed form to the facility nearest you.

NCIC HEADQUARTERS
U.S. Geological Survey
507 National Center
Reston, VA 22092
FTS: 928-6045
COMM. 703-860-6045

EROS APPLICATIONS FACILITY
NSTL
U.S. Geological Survey
Bay St. Louis, MS 39520
FTS: 494-3541
COMM: 688-3472

NCIC MID-CONTINENT
U.S. Geological Survey
1400 Independence Rd.
Rolla, MO 65401
FTS: 276-9107
COMM: 314-364-3680

EROS DATA CENTER
U.S. Geological Survey
Sioux Falls, SD 57198
FTS: 784-7151
COMM: 605-594-6511

NCIC ROCKY MOUNTAIN
U.S. Geological Survey
Stop 510, Box 25046
Denver Federal Ctr.
Denver, CO 80225
FTS: 234-2326
COMM: 303-234-2326

NCIC WESTERN
U.S. Geological Survey
345 Middlefield Rd.
Menlo Park, CA 94025
FTS: 467-2427
COMM: 415-323-2427

Figure 2-4.– Order form to obtain NASA aircraft photography.

HOW TO ORDER NASA AIRCRAFT PHOTOGRAPHY

This order form is to be used for ordering all NASA AIRCRAFT PHOTOGRAPHY. Photo Identification numbers can be transcribed directly from a computer listing. When ordering from other reference sources, be sure to specify the MISSION, ROLL, and FRAME NUMBER for the desired photograph(s)

Please provide the following information in the indicated areas of the order form·

A. List your complete NAME, ADDRESS, ZIP CODE, and name of your COMPANY if applicable.

B. List a PHONE NUMBER where you can be contacted during business hours

C. If you have had previous business with THAT FACILITY, please list your ACCOUNT NUMBER, if known.

D. Enter the complete PHOTO IDENTIFICATION NUMBER. This can be transcribed directly from the COMPUTER LISTING. If the source of information is from another source, specify the MISSION, ROLL NUMBER and FRAME NUMBER.

E. Review the STANDARD PRODUCTS TABLE on the order form and determine the type of product desired. CARE must be exercised in insuring that the FILM SOURCE reflected in the tables correlates with the FILM SOURCE listed on the COMPUTER LISTING.

F. Enter the PRODUCT CODE of the type product being ordered from the STANDARD PRODUCTS TABLE.

G. Enter the FRAME NUMBER in the FIRST FRAME column. (See instructions for interpolation of a frame from a PHOTO STRIP) If two or more consecutive frames are being ordered, enter the FIRST FRAME of the series in the FIRST FRAME column and the LAST FRAME in the LAST FRAME column.

H. Enter the NUMBER OF UNIQUE FRAMES being ordered. Example: FIRST FRAME - 116; LAST FRAME - 119; NO. OF FRAMES is 4.

I. Enter the NO. OF COPIES being ordered of the FRAMES you have identified.

J. The COMMENTS portion is completed only when a CUSTOM PRODUCT is desired and you want to specify the parameters. Refer to the current price list for custom product cost determination.

K. Multiply the NO. OF FRAMES by the NO. OF COPIES and enter the result in the QUANTITY column.

L. Enter the UNIT PRICE of the product as reflected on the current PRICE LIST.

M. Multiply the figure in the QUANTITY column by the figure in UNIT PRICE column and ENTER the result in the TOTAL PRICE column.

N. REPEAT the above for each product ordered.

O. TOTAL the costs of all products ordered on that order form and enter the NET result in BLOCK A. TOTAL ABOVE.

P. If more than one order form is required, enter the sum of the figures in BLOCKS A in BLOCK B of the last order form.

Q. Enter the SUM of BLOCK A and BLOCK B in BLOCK C, TOTAL COST.

R. Indicate the TYPE of payment being made with a CHECK MARK. Make all drafts payable to U.S. GEOLOGICAL SURVEY. DO NOT SEND CASH.

S. MAIL ORDER FORM(S) and PAYMENT to the FACILITY NEAREST YOU If payment has been previously forwarded, the order form(s) must be mailed to the same facility.

Figure 2-5.– Instructions for ordering NASA aircraft photography.

AIRCRAFT DATA

AERIAL MAPPING

IMAGE SIZE	PRODUCT FORMAT	BLACK and WHITE UNIT PRICE	BLACK and WHITE PRODUCT CODE	COLOR UNIT PRICE	COLOR PRODUCT CODE
22.9cm (9.0 in.)	Paper	$ 3.00	23	$ 7.00	63
22.9cm (9.0 in.)	Film Positive	5.00	13	15.00	53
22.9cm (9.0 in.)	Film Negative	6.00	03		
45.7cm (18.0 in.)	Paper	10.00	24	25.00	64
68.6cm (27.0 in.)	Paper	15.00	25	30.00	65
91.4cm (36.0 in.)	Paper	20.00	26	50.00	66

PHOTO INDEXES

IMAGE SIZE	PRODUCT FORMAT	BLACK and WHITE UNIT PRICE	BLACK and WHITE PRODUCT CODE	FILM SOURCE
25.4x30.5cm (10x12 in.)	Paper	$ 5.00	36	B & W – Size A
OTHER	Paper	5.00	37	B & W – Size B

NASA RESEARCH

IMAGE SIZE	PRODUCT FORMAT	BLACK and WHITE UNIT PRICE	BLACK and WHITE PRODUCT CODE	COLOR UNIT PRICE	COLOR PRODUCT CODE
55.8mm (2.2 in.)	Film Positive	$ 3.00	11	$10.00	51
55.8mm (2.2 in.)	Film Negative	4.00	01		
11.4cm (4.5 in.)	Paper	3.00	22	7.00	62
11.4cm (4.5 in.)	Film Positive	4.00	12	12.00	52
11.4cm (4.5 in.)	Film Negative	5.00	02		
22.9cm (9.0 in.)	Paper	3.00	23	7.00	63
22.9cm (9.0 in.)	Film Positive	5.00	13	15.00	53
22.9cm (9.0 in.)	Film Negative	6.00	03		
22.9x45.7cm (9x18 in.)	Paper	6.00	31	20.00	69
22.9x45.7cm (9x18 in.)	Film Positive	10.00	14	30.00	56
22.9x45.7cm (9x18 in.)	Film Negative	12.00	04		
45.7cm (18.0 in.)	Paper	10.00	24	25.00	64
68.6cm (27.0 in.)	Paper	15.00	25	30.00	65
91.4cm (36.0 in.)	Paper	20.00	26	50.00	66

MISCELLANEOUS

MICROFILM

FORMAT	BLACK and WHITE ROLL PRICE	BLACK and WHITE PRODUCT CODE	COLOR ROLL PRICE	COLOR PRODUCT CODE
16mm (30.5m/100 ft.)	$15.00	72	$40.00	73
35mm (30.5m/100 ft.)	20.00	72	45.00	73

KELSH PLATES

FORMAT	BLACK and WHITE UNIT PRICE	BLACK and WHITE PRODUCT CODE
Contact Prints on Glass. Specify thickness (0.25 or 0.06 inch) and method of printing (emulsion to emulsion or through film base)	$12.00	70

TRANSFORMED PRINTS

FORMAT	BLACK and WHITE UNIT PRICE	BLACK and WHITE PRODUCT CODE
From convergent or transverse low oblique photographs	$ 8.00	71

VIEWING SLIDES

FORMAT	COLOR UNIT PRICE	COLOR PRODUCT CODE
35mm mounted duplicate of available printing master	$ 1.00	50

NOTE 35mm original will require additional $5.00 not to include cost of mounted duplicate

Complete roll reproduction delivered in roll format carries a 50% reduction in frame pricing.
Custom processing of non-standard products is available at three times the standard product price. If a non standard size is desired, the cost is three times the next larger standard product price.
Priority service with guaranteed five working days shipment is offered for standard products only, at three times the standard product price.
Extra care should be taken to insure that monies and related order forms are forwarded to the same facility.

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Figure 2-6.— Price list for aircraft products.

STANDARD REMOTE SENSING DATA

U. S DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

JANUARY 1, 1977

SATELLITE DATA

STANDARD LANDSAT

IMAGE SIZE	NOMINAL SCALE	PRODUCT FORMAT	BLACK and WHITE UNIT PRICE	BLACK and WHITE PRODUCT CODE	COLOR UNIT PRICE	COLOR PRODUCT CODE
55.8mm (2.2 in.)	1:3169000	Film Positive	$8.00	11		
55.8mm (2.2 in.)	1:3369000	Film Negative	10.00	01		
18.5cm (7.3 in.)	1:1000000	Paper	8.00	23	$12.00	63
18.5cm (7.3 in.)	1:1000000	Film Positive	10.00	13	15.00	53
18.5cm (7.3 in.)	1:1000000	Film Negative	10.00	03		
37.1cm (14.6 in.)	1:500000	Paper	12.00	24	25.00	64
74.2cm (29.2 in.)	1:250000	Paper	20.00	26	50.00	66

COLOR COMPOSITE GENERATION		$50.00	59

NOTE 1) Portrayed in false color (infrared) and not true color
2) Cost of product from this composite must be added to total cost

COMPUTER COMPATIBLE TAPES (CCT)

TRACKS	b p i	FORMAT	SET PRICE	PRODUCT CODE
7	800	Tape Set	$200.00	82
9	800	Tape Set	200.00	83
9	1600	Tape Set	200.00	84

SELECTED COVERAGE

IMAGE SIZE	FORMAT	BAND(S)	BLACK and WHITE UNIT PRICE	BLACK and WHITE PRODUCT CODE	COLOR UNIT PRICE	COLOR PRODUCT CODE
18.5cm (7.3 in.)	Paper	5	$8.00	41	$12.00	46
18.5cm (7.3 in.)	Paper	4, 5, 6, 7	32.00	45		
37.1cm (14.6 in.)	Paper	5	12.00	42	25.00	47
74.2cm (29.2 in.)	Paper	5	20.00	43	50.00	48

MANNED SPACECRAFT DATA

SKYLAB S190A

IMAGE SIZE	NOMINAL SCALE	PRODUCT FORMAT	BLACK and WHITE UNIT PRICE	BLACK and WHITE PRODUCT CODE	COLOR UNIT PRICE	COLOR PRODUCT CODE
55.8mm (2.2 in.)	1:2850000	Film Positive	$8.00	11	$10.00	51
55.8mm (2.2 in.)	1:2850000	Film Negative	10.00	01		
16.3cm (6.4 in.)	1:1000000	Paper	8.00	23	12.00	63
32.5cm ([illegible])	1:500000	Paper	12.00	24	25.00	64
65.0cm (25.6 in.)	1:250000	Paper	20.00	26	50.00	66

SKYLAB S190B

IMAGE SIZE	NOMINAL SCALE	PRODUCT FORMAT	BLACK and WHITE UNIT PRICE	BLACK and WHITE PRODUCT CODE	COLOR UNIT PRICE	COLOR PRODUCT CODE
11.4cm (4.5 in.)	1:950000	Paper	$6.00	22	$8.00	62
11.4cm (4.5 in.)	1:950000	Film Positive	8.00	12	12.00	52
11.4cm (4.5 in.)	1:950000	Film Negative	10.00	02		
21.8cm (8.6 in.)	1:500000	Paper	8.00	23	12.00	63
43.4cm (17.1 in.)	1:250000	Paper	12.00	24	25.00	64
86.9cm (34.2 in.)	1:125000	Paper	20.00	26	50.00	66

APOLLO/GEMINI

IMAGE SIZE	NOMINAL SCALE	PRODUCT FORMAT	BLACK and WHITE UNIT PRICE	BLACK and WHITE PRODUCT CODE	COLOR UNIT PRICE	COLOR PRODUCT CODE
55.8mm (2.2 in.)	Variable	Film Positive	$8.00	11	$10.00	51
55.8mm (2.2 in.)	Variable	Film Negative	10.00	01		
22.6cm (8.9 in.)	Variable	Paper	8.00	23	12.00	63
45.5cm (17.9 in.)	Variable	Paper	12.00	24	25.00	64

1

Figure 2-7.— Price list for satellite products.

2.1.2.2 Commercial Aerial Survey Companies

Several commercial firms that take high altitude aerial photographs are located in the United States. Most advertise in the publication *Photogrammetric Engineering and Remote Sensing*. Many have aircraft that can fly at altitudes of 9144 meters (30 000 feet) with a 15.25-centimeter (6-inch) focal length camera.

Contract specifications for the acquisition of aerial photography are essentially standard. Chapter V of The Manual of Photogrammetry (ref. 2) discusses this subject in detail.

2.1.2.3 Ordering Film or Prints

Ordered photographs will usually be in a 22.86- by 22.86-centimeter (9- by 9-inch) format and at a scale of 1:60 000. Prints will normally be on semimatte paper and transparencies can be film or glass plates. It is impractical to order reduction from original sizes because the image quality is likewise reduced. It is also impractical to order extreme enlargements. When ordering any of the above from EROS, none will be rectified (see appendix D).

2.1.2.4 Photographic Data Requirements: Scale, Overlap, and Type of Film

Experience gained by the authors indicate that the optimum scale of the photographs will be 1:60 000; however, adaptions can be made to accommodate other small scales. For 1:60 000 scale, the photographs may be obtained with a 30.48-centimeter (12-inch) focal length camera at an altitude of 18 288 meters (60 000 feet) or a 15.24-centimeter (6-inch) focal length camera at an altitude of 9144 meters (30 000 feet). The scale will be approximately 2.54 centimeters = 1524 meters (1 inch = 5000 feet); if an effective area on one photographic frame is considered to be

17.78 by 17.78 centimeters (7 by 7 inches), it will cover 114 square kilometers (44 square miles) or approximately 11 323 hectares (28 000 acres).

In some locations, the only small-scale photography available from a government film repository is the 1:120 000 scale. A scale of 1:120 000 can be used for landforms only where there is fairly prominent relief because of vertical exaggeration geometry.

Aerial photographs should have between 54 and 60 percent forward overlap and 20 percent sidelap to ensure adequate stereoscope viewing.

Color infrared film registers all healthy and turgid vegetation in various shades or degrees of magenta which is advantageous for high altitude work. Photographs taken in the late spring or early summer, showing full leaf-on conditions, are recommended because the false color is heightened and is of value in the interpretation process.

Because of the small scale and even with leaf-off conditions, the ground or soil may not show through the tree canopy enough to allow soil interpretations to be made directly. Because color infrared film can discriminate between deciduous trees and evergreens when the deciduous are in the leaf-on condition, that discrimination provides some inference as to soil moisture at the time the photograph was taken. Water tolerant vegetation shows up well on color-infrared film also. The more turgid the vegetation is, the brighter the red is on the film. Water registers in various shades of blue, depending on its purity, concentration, temperature, and depth. It appears that leaf-on conditions are the best for acquiring the photography.

2.1.3 PROJECT WORK DIRECTIVE

The preparation of a project work directive, outlining the following, is recommended:

a. Project description

b. Project objectives and purpose

c. A description of each phase of the operation

d. Time allocated for each phase of the work

e. Personnel assigned and responsibilities

f. Final products required

The directive can be distributed to each individual associated with the project. The directive should be clear and concise and written so that everyone thoroughly understands his assignment and responsibilities. This will save time and effort by eliminating any misunderstandings at the beginning of the project.

2.2 EQUIPMENT AND MATERIALS

The following is a list of equipment and materials that should be furnished for each photointerpreter.

2.2.1 EQUIPMENT

a. Light table with an illuminated viewing area large enough to accommodate the stereoscope and to provide a suitable working area, such as the Richards model GFL-3040[1] (fig. 2-8). If prints are used, the light table is not necessary. Transparencies are superior to prints as far as clarity, resolution, color rendition, and general sharpness are concerned.

[1]This model is used for identification purposes only and does not constitute a recommendation.

b. Stereoscope, simple lens type

c. Stereoscope, scanning type with a magnification system of 4.5X, such as the Old Delft[1] scanning stereoscope (fig. 2-9). A scanning stereoscope is recommended because of its versatility, but more simple instruments such as a pocket stereoscope can do the job. The efficiency which can be achieved using a scanning stereoscope may justify its greater cost.

d. Rectifying enlarging projector with a table for hand drafting, such as the Kargl type, when it is advisable to rectify mechanically (desirable, but not mandatory)

e. Technical fountain pen set, should include pens with 1, 0, 00, and 000 points

f. Engineering scale, 30.48 centimeters (12 inches) with 50 graduations to the inch

g. Scale graduated in millimeters

h. Drafting equipment: triangles, protractor (360° azimuth), template, metal eraser shield, and electric eraser

i. Scissors

j. Straight edge, metal, 91.44 centimeters (36 inches)

k. File and map cabinets for storing photographic products and maps.

2.2.2 MATERIALS

a. Stabilene film, clear ink surface, base thickness of 0.005 inch (0.13 mm) which is available in 21.59 by 27.94 centimeters (8-1/2 by 11 inches), for making photo-overlays. (This most nearly fits the air photograph format size)

b. Frosted acetate, 0.005 inch (0.13 mm) thick, for making base map overlays

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[1] This model is used for identification purposes only and does not constitute a recommendation.

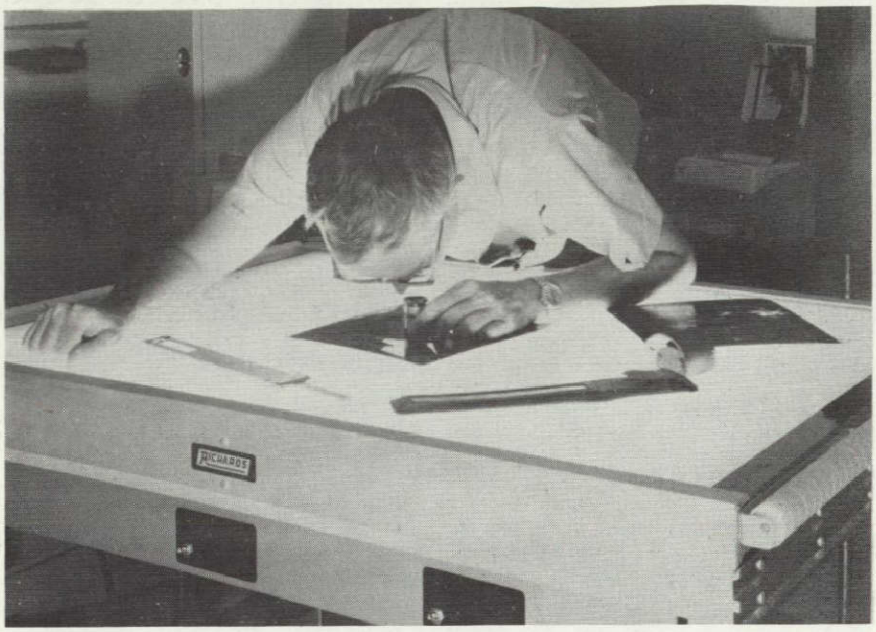


Figure 2-8.— Richards model GFL-3040 light table.

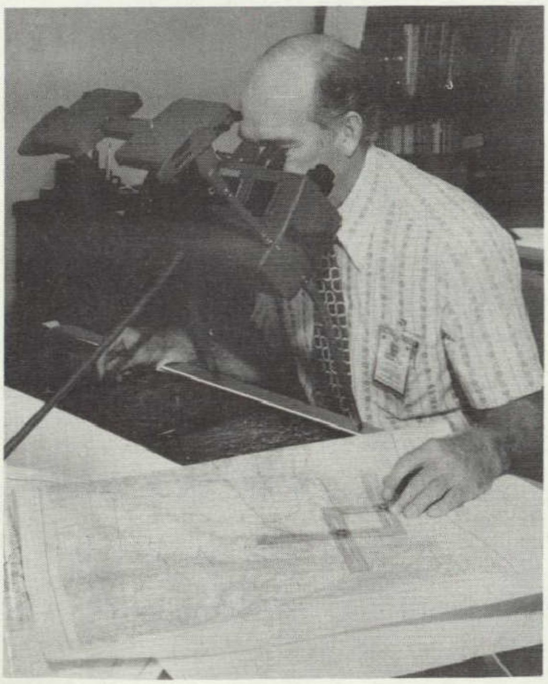


Figure 2-9.— Old Delft scanning stereoscope.
and the parallax bar.

c. Document protectors, clear plastic, 22.86 by 27.94 centimeters (9 by 11 inches), used to protect the phototransparencies

d. Cotton gloves for handling film

e. Rubber cement

f. Masking tape

g. Coloring pencils

h. China-marking or wax-type pencils

i. Lens-cleaning tissue

2.3 SUPPLEMENTAL DATA

Supplemental data consists of maps, reports, and documents which provide information pertinent to a particular project area. All supplemental data should be acquired prior to the start of a project, if possible. The material can be collected during the period in which the photographs are being acquired, thus saving time.

A partial list of public agencies providing supplemental data and the method of obtaining the data are given below.

2.3.1 1:24 000-SCALE TOPOGRAPHIC MAPS

The Geological Survey topographic maps, at a 1:24 000 scale, can be used as base maps. The Geological Survey has issued a catalog which shows all available topographic map coverage throughout the United States. The catalog and the topographic maps may be ordered from:

U.S. Department of Interior
Geological Survey
Washington, D.C. 20242

2.3.2 1:250 000-SCALE TOPOGRAPHIC MAPS

The Defense Mapping Agency produces maps at a scale of 1:250 000 which are useful for delineating project boundaries and for preparation of photographic indexes. Information regarding these maps may be obtained from:

U.S. Corps of Engineers
Chief of Engineers Office
Department of the Army
Washington, D.C.

2.3.3 GEOLOGICAL MAPS

Geological maps are important because they provide information related to dominant rock types and structures. Geological maps may be obtained from the Geological Survey in Washington, D.C., state agencies such as the Bureau of Mines or the Bureau of Natural Resources, and state universities. Geologic mapping has been performed by graduate students of many universities and is available in term papers, theses, and dissertations stored in libraries of the universities.

2.3.4 SOIL SURVEY MAPS

Soil survey maps may be purchased from:

Cartographic Division
Soils Conservation Service
U.S. Department of Agriculture
Washington, D.C. 20250

2.3.5 HYDROLOGICAL MAPS AND INFORMATION

Hydrological maps, investigations, and information may be obtained from the Geological Survey. The U.S. Corps of Engineers has information related to waterflow on navigable rivers and tidal information. State agencies such as the Bureau of Natural Resources may be able to provide some hydrological information about some areas.

2.3.6 METEOROLOGICAL DATA

Statistics on precipitation, average temperatures, percentage of possible sunshine, and other information such as weekly weather predictions and statistics may be obtained from:

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Washington, D.C.

U.S. Department of Agriculture
Statistical Reporting Service
Washington, D.C.

Respective State Climatologist

2.3.7 FOREST SERVICE MAPS

The Forest Service administrative maps, at a scale of 1.27 centimeters = 1609.3 meters (1/2 inch = 1 mile), show delineations of national forest lands. These maps or information regarding these maps may be obtained from the regional Forest Service office or,

U.S. Department of Agriculture
Forest Service
324 25th Street
Federal Building
Attention: Map Sales
Ogden, Utah 84401
Phone: (801) 399-6121

If additional information is required, also check the Land Status Atlas in the respective district or regional forest supervisor's office.

2.3.8 GEODETIC CONTROL

If additional horizontal and vertical control is desired or if more topographic sheets are required, they may be obtained from the following sources.

a. Geological Survey

b. The National Oceanic and Atmospheric Administration

c. U.S. Corps of Engineers

2.4 PREPARATION OF MAP INDEXES AND AERIAL PHOTOGRAPHS

Aerial photographs will be positive transparencies or positive paper prints. They may be individual photographs or part of a roll. There are certain precautions to observe and procedures to follow before the actual photointerpretation process begins.

2.4.1 PREPARATION OF THE MAP INDEX

Photographic indices may be available; if not available, they should be constructed. The map index will provide a quick reference to the location of each photograph. The map index shows any gaps in the photocoverage and may also be used to assign work. Also, the index can be useful in recording the progress of the project. The suggested procedure to follow is:

a. Delineate the boundaries of the project on a 1:250 000-scale map.

b. If the film is on a roll, place it on a light table and find the first photograph; then, by matching the detail in the photograph to the corresponding map details, delineate the outline of the photograph. Continue, photograph by photograph, until each photograph has been outlined on the map. It is important that the number of each photograph is recorded on the map. It is good practice to place the photograph number on the side corresponding to the direction of flight (fig. 2-10). To avoid confusion, use a different color pencil or ink to delineate each separate flight line.

c. Some analysts or interpreters may prefer the "effective area" type of photographic index. This is essentially the same thing except that the indexed photograph is identified by an outline that encompasses all points that are closer to its principal point than it is to any other photographic principal points. (See section 2.4.3 below and fig. 2-11A.) Another definition, quoted from reference 3, is

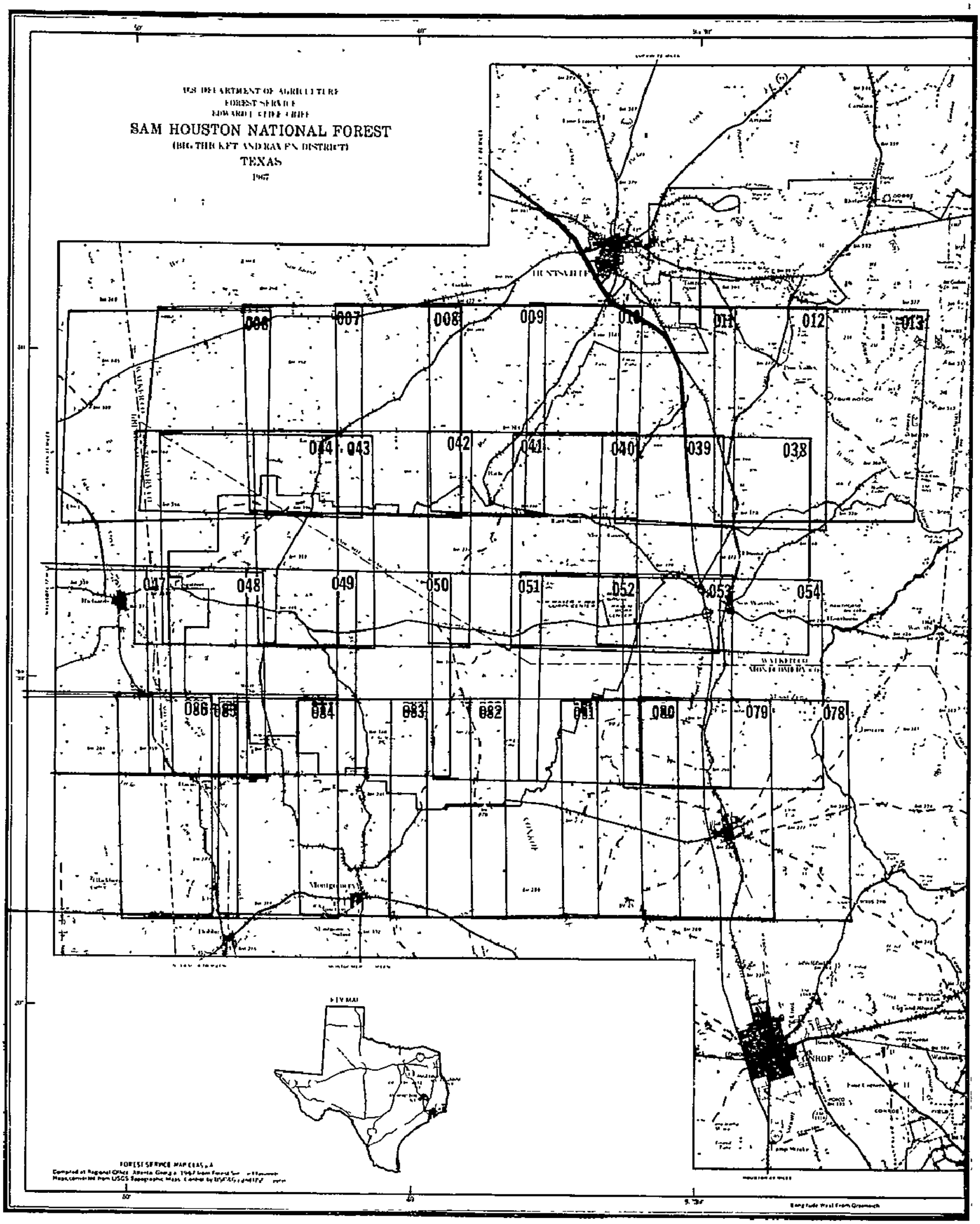
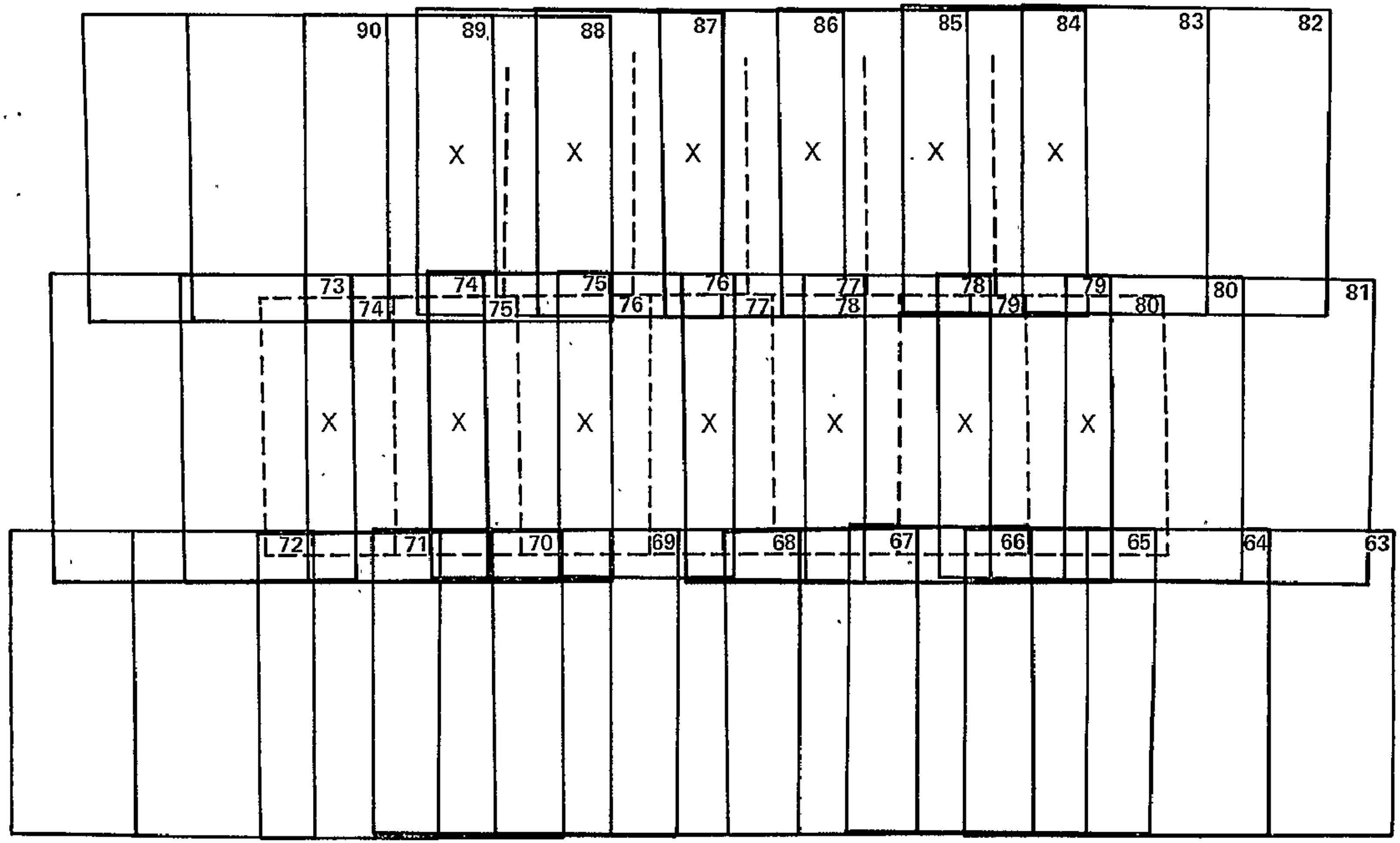
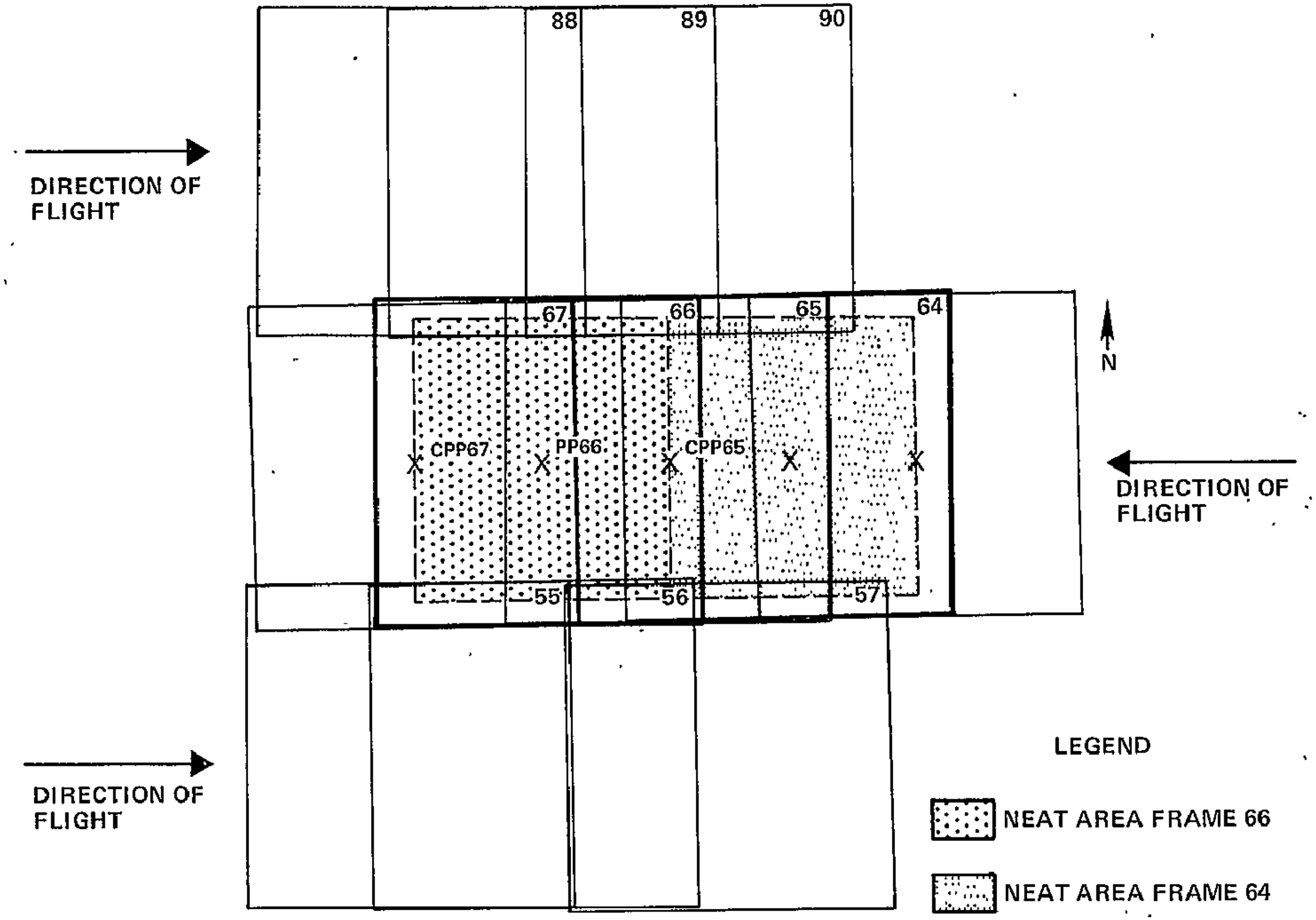


Figure 2-10.— Construction of photoindex map.



(a) Diagram showing the effective area index. The red dashed line rectangles represent the effective areas and the solid black lines show the entire frame area. Notice that the effective area lines are not straight lines. They represent radial distortions caused by image displacement or differential parallax which in turn is caused chiefly by differential relief. For more detailed information, see reference 1.

Figure 2-11.— Schematic showing the rectangular portion of a frame that is to be delineated to prevent duplication of effort.



(b) "Neat model" index. Note that "neat areas" of frames 64 and 66 are contiguous.

Figure 2-11.— Concluded.

For any aerial photograph that is one of a series in a flight strip, that central part of the photograph delimited by the bisectors of overlaps with adjacent photographs. On a vertical photograph, all images within the effective area have less displacement than their conjugate images on adjacent photographs.

d. Another type of index is the "neat model" type. It is similar to the effective area type but, by definition, it "approximates a rectangle whose width equals the airbase and whose length equals the width between flights" (ref. 3). Its area lies between the two conjugate principal points in one direction and between the two overlap bisectors in the other direction (fig. 2-11b). This is a very practical index, and it will save mapping time because it shows that only every other frame requires annotating rather than every frame.

e. With the completion of the index, the next step will be to cut each photograph from the roll. Be sure to use cotton gloves when handling the film because the natural oils of the skin will produce smudges. Each photograph is placed in a clear document protector. Since the standard glassine document protector is 8-1/2 by 11 inches, it is necessary to trim the borders of the photoframe that lack frame and mission data. Usually 1/4-inch can be trimmed from two sides without destroying any of the image portion. This will make the frame 8-1/2 by 9 inches which can easily fit inside the protector. When the photograph is in the document protector, it should remain there throughout the project.

Each photograph should be filed by mission number, flight line, and frame number for access.

2.4.2 PROCEDURE FOR LOCATING THE PRINCIPAL POINTS AND THE CONJUGATE PRINCIPAL POINTS

a. Securely place an overlay with tape on each of the photographs.

b. With a 00 technical fountain pen, draw in the four fiducial marks (see glossary).

c. Draw a north arrow on the margin of the overlay and indicate the photograph number.

d. Determine the principal point of each photograph by extending lines diagonally from the four fiducial marks; the intersection point in the center of the photograph is the principal point.

e. Transfer the principal point to its corresponding image on the adjacent photograph; this is the conjugate principal point. There will be one principal point and two conjugate principal points on each photograph.

f. Mark the principal points and conjugate principal points in ink on the overlay with a distinctive symbol. Continue in this manner until each photograph within the working area is completed. The principal point and conjugate principal points will be of value in preparing the effective area.

g. A further description of this process is given in volume I, chapter XI, of the Manual of Photogrammetry (ref. 2).

2.4.3 PREPARATION OF THE EFFECTIVE AREA

Delineate the effective area [figs. 2-11(a) and (b)] on the pertinent frames as is described in the USFS Basic Photo Interpretation Workshop Unit 10 (ref. 4).

3. PHOTOINTERPRETATION

Photointerpretation is the process of analyzing photographs in order to understand the collective significance of specific features recognized in the photographs.

The photointerpretation for soils is divided into two phases. Phase I treats the ancillary components: drainage, geology, slope, and vegetation. Phase II treats the primary components: landforms, source of material, texture, water regime, and modifiers and special symbols.

A separate overlay is prepared for each component by:

a. Registering the overlay to the 23- by 23-centimeter (9- by 9-inch) positive transparency by inking in the four fiducial marks. Cotton gloves should always be used when working with the overlay or the positive transparency.

b. Placing the north arrow and other pertinent information on the margin.

c. Setting up a filing system so that the positive transparencies and the overlays can be retrieved quickly and efficiently.

3.1 PHASE I — ANCILLARY COMPONENTS

3.1.1 DRAINAGE

3.1.1.1 Preparation

Prepare the drainage overlay first; this will allow the interpreter to become familiar with the terrain.

Use a 00 technical fountain pen in order to produce as fine a line width as possible.

The drainage overlay may also be used in the preparation of the final map if orthophotography or a mosaic is used as the base map.

3.1.1.2 Delineation Procedures

The following procedures may prove helpful to the photointerpreter:

a. Show both shorelines of all rivers and leave no loose ends in lakes and ponds delineations.

b. Ink in the drainage with a solid line.

c. Begin with the major streams and work towards the smaller tributaries.

d. Always annotate streams and tributaries to the farthest recognizable point upslope.

e. In attempting to delineate streams in heavily wooded areas, the landform and slope should be considered and the most probable stream course followed.

3.1.1.3 The Drainage Pattern

Drainage patterns will become evident as the drainage delineation progresses. A pattern may occur in small areas or may appear throughout the scene. There may be sudden angular turns that are the result of geologic structural influence. Depending on the scale, a pattern may be coarser or finer, each of which denotes a particular surface runoff situation based on the infiltration rate and the permeability of the soils. Such may indicate gross soil differences or types of parent material.

Drainage patterns may be complex or simple depending on the climatic conditions, types of parent material, permeability of the soil, geologic structure, slope, and topography. See appendix A for general drainage patterns.

3.1.2 GEOLOGY

3.1.2.1 Preparation

The preparation of the geology overlay usually is derived from geology maps which are published by governmental agencies such as the USGS or State Bureaus of Natural Resources. In many places, published geologic maps may be inadequate for detailed soil surveys. If the required information is available, the procedure for the preparation of the overlays is as follows:

a. Match the scale of the geology map to that of the photograph. The quickest and most efficient method of enlarging the geology map is to use some type of enlarging equipment such as a zoom transferscope or a projector system.

b. Register the planimetric detail on the geology map with that of the photograph.

c. Place an overlay over the photograph.

d. Ink in the fidicual marks and trace the geological interpretation and symbolize.

3.1.2.2 Analysis

When the geology overlay is completed, compare it with the drainage overlay by registering the fiducial marks. It will be apparent that there is a relationship between the geology and the drainage. Structure will affect stream orientation, and the type of material will be reflected by the drainage pattern.

3.1.3 SLOPE OVERLAY

Slope plays an important role in land management and is usually expressed by percent gradient.

It will provide data that may be used, when combined with other data, to interpret soil related ecological management unit components. It may provide clues to erosion prone areas, water regime characteristics, and texture.

3.1.3.1 Methods of Determining Slope

a. The true slope of each sample site should be determined with an Abney hand level or similar instrument during a field-orientation trip. Plot this true slope directly on the photograph or use a transparent overlay for this. The true slope can be shown on an overlay by drawing a line in the direction of the measurement and terminating the line at points where the slope changes. If the field map or photograph is different from the stereopair used for interpretation, it will be necessary to transfer these data to the stereomodel overlay when returning to the office.

b. When viewing a stereomodel, heights and elevated terrain are usually exaggerated; likewise, the slopes are usually exaggerated. These exaggerated slopes are called "apparent slopes." Therefore, the apparent slope, as it appears in the stereomodel, is usually greater than the true slope.

   The field-measured true slopes provide a basis for determining the exaggeration factor which, when applied to the apparent slope values, should give a good estimation of the true slope of all apparent slopes throughout the stereomodel.

   Example:

   Estimated apparent slope gradient = 25 percent
   True slope gradient = 10 percent

   $\frac{25}{10} = 2.5$ vertical exaggeration factor

   For each subsequent estimated apparent slope, divide by the vertical exaggeration factor to obtain the true slope. This system will result in approximate true slope gradients. With practice, reasonable accuracy should be attained.

Each interpreter should figure his own vertical exaggeration factor because every individual views the stereoscopic scene in a slightly different manner.

During the photointerpretation process, the true slope overlay should be referred to periodically in order to maintain the standard.

c. The engineers' scale is easily adapted to the making of a slope map from a topographic map. For example, on a 1:24 000-scale map, one-twentieth of an inch equals 100 feet. It is easy then to place the index mark on one contour line and to measure the span of equally spaced contour lines to determine the total horizontal distance of uniform slope. The gradient is then found as follows.

$$\frac{\text{(number of equally spaced contour lines - 1)(contour interval)}}{\text{horizontal distance}} \times 100 = \text{percent gradient}$$

d. True slopes can also be determined with the parallax bar and the stereoscope. See reference 1 for instructions on using this instrument.

3.1.4 VEGETATION

A vegetation overlay may be useful because native vegetation tends to be correlated with different soil and moisture regimes and may provide a guide to soil types. The correlations will vary, depending on the subregion. In East-Central Texas, the hardwoods tend to occupy areas which have moist soils, whereas pines will tend to occupy sandy or droughty soils. (Croplands and pasture are usually found in the alluvial valleys and terraces and are also found in the uplands that are relatively flat.)

3.1.4.1 Preparation

The overlay is prepared in the same manner as the drainage overlay as discussed in section 3.1.1.1.

3.1.4.2 Classification

Generally, conifers, hardwoods, mixed stands, pasture and croplands, and forest cutover areas provide sufficient spectral differences to make them readily identifiable for classification or categorizing.

On color infrared film, depending on extent of variations in processing, hardwoods are seen as a bright magenta, conifers as a darker purple hue, and croplands and pasture will vary from white to pink to red, depending on the stage of growth of the vegetation (section 3.4).

The smallest practical area to work with when identifying and delineating vegetation at the scales being discussed in this document is approximately 16.19 hectares [(40 acres) fig. 3-1)].

Individual mapping units may be given a code number as shown in the Soils Resource Guide (ref. 1), such as 1 for hardwood and 2 for conifers. These codes should appear in the legend on the overlay.

3.1.4.3 Analysis

The drainage, geology, slope, and vegetation overlays can be combined into one generalized map if the details are not too conjested. The next step is an on-the-ground inspection of selected sample plots to evaluate the accuracy of the photointerpretation.

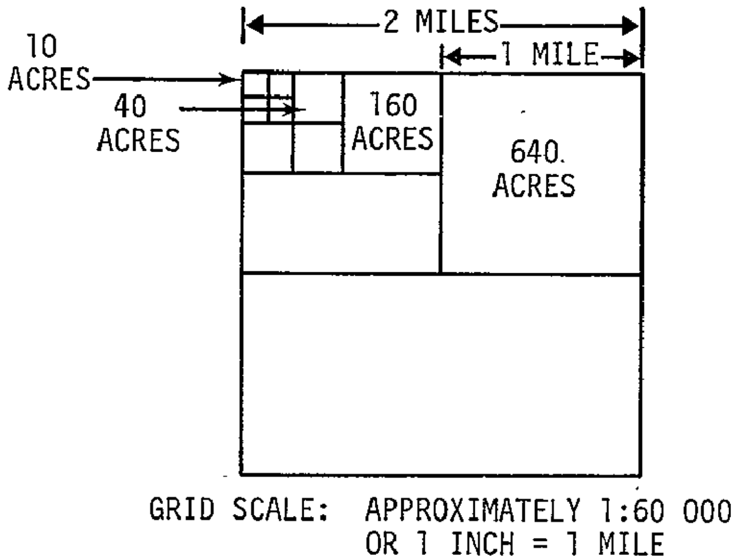


Figure 3-1.— Relative sizes of various acreages increments at approximately 1:60 000 scale.

3.1.5 FIELD ORIENTATION

Plan a field trip by labeling the areas to be visited on the compiled map. Good planning must be exercised in deciding the areas to check. Pay particular attention to those areas that gave trouble in the office. A complete set of notes is a must if the trip is to be cost-effective. In addition to verifying the interpretation accuracy, notes should be taken on soil profiles and on any unusual features observed.

Make annotations and corrections on the spot rather than rely on memory. After returning to the office, information gained from the sampled points can be used to improve the compiled map.

The resulting map should show broad patterns of soil occurrence on characteristic landscapes. The map has limited value for soil interpretations, but it provides the framework for making a detailed soil survey.

3.2 PHASE II — PRIMARY COMPONENTS

This guide describes the use of 1:60 000 color infrared photography, but there are occasional needs for larger scale photographs. The 1:60 000 photographs can be enlarged to 1:24 000 scale, or 1:6000 scale if the cost is justified and if a plywood mirror stereoscope is built to fit the scale desired. This may not be a practical method because of two important reasons.

a. Breaking the enlarged frame into segments that will be compatible with the stereoscope will increase the problem of data handling. One of the advantages of the 1:60 000 frame is the decrease of data handling.

b. The increased grain in the image will result in a loss of resolution, confusion in discriminating the color gradations, and an increase in eye fatigue.

3.2.1 LANDFORM

A landform is the most easily recognized ecological management unit component and, in essence, helps determine other ecological management unit components. Each landform has specific characteristics that are identifiable on stereophotography. Since the drainage overlay is closely associated with landforms and since it has already been developed, time and effort may be saved by developing the landform overlay directly on the drainage overlay. Landforms are determined by these steps:

a. Register the overlay to the positive transparency. Place a north arrow, frame number, and legend in the margin.

b. Begin the delineation of the landform subcomponents with a flood plain or the lowest elevation and work upward. Place the appropriate subcomponent code number within the area which comprises the subcomponent. The code number should be written enough times within the delineation so that there is no question as to the landform identity. Work with one specific landform at a time. In this manner, the identification will remain in the interpreters mind and, consequently, the chance of error is decreased.

c. It will be up to the interpreter to determine the detail or size of plots. A 0.041-square kilometer (10-acre) plot may be useful for the minimum mapping unit size.

d. Mountain landform subcomponents are divided into elevation ranges as shown in table 3-1. Because it is difficult to categorize these elevation zones during the delineation phase of the work, it is recommended that the code number corresponding to the median elevation be used. When the final map is prepared, the elevation ranges can be annotated. The method is explained in detail in section 5.

TABLE 3-1.– IDENTIFICATION KEY AND SPECIAL SYMBOLS

[From ref. 3]

A	LANDFORMS*	B	SOURCE OF MATERIAL	C	TEXTURE	D	WATER REGIME	E	MODIFIERS
00	Flood Plain	0	Transported	0	Lithic	0	Waterlogged	0	None
01	Stream Terrace	1	Dominantly Sandstone	1	Skeletal	1	Wet	1	Erosion Critical
02	Bench	2	Dominantly Shale	2	Coarse	2	Moist	2	Steepness Critical
03	Cove and/or Colluvial Toeslopes	3	Mixed Sandstone-Shales	3	Sandy	3	Dry	3	Stoniness Critical
04	Northerly Aspect Slopes <2500′ elevation	4	Phyllites	4	Loamy	4	Droughty	4	Bedrock Critical
05	Northerly Aspect Slopes 2500-4500′ elevation	5	Dominantly Gneiss	5	Silty	5	Very Droughty	5	Depth to Restrictive Layer Critical
06	Northerly Aspect Slopes >4500′ elevation	6	Micas	6	Medium			6	Cherty
07	Southerly Aspect Slopes <2500′ elevation	7	Novaculites	7	Fine			7	Extremely Alkaline
08	Southerly Aspect Slopes 2500-4500′ elevation	8	Mafics	8	Very Fine			8	Extremely Acid
09	Southerly Aspect Slopes >4500′ elevation	9	Calcareous	9	Organic			9	Steep Stony Uneven Slopes
10	Ridge and Upper Slope <2500′ elevation								
11	Ridge and Upper Slope 2500-4500′ elevation								
12	Ridge and Upper Slope > 4500′ elevation								

**Landform identifies those manageable segments of the landscape.*

SPECIAL SYMBOLS

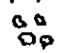
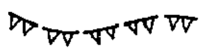
Characteristic Recognized	Shown on Map as		Characteristic Recognized	Shown on Map as	
Borrow pit and/or Quarry		Black	Mine dump		Black
Wet spot		Blue	Rock outcrop		Black
Swamp or marsh		Blue	Stoniness		Black
Bedrock Escarpment		Black	Chert		Black
Mountain peak		Black	Critical erosion		Red

TABLE 3-1.– Concluded.

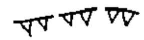
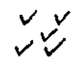
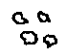
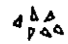
UNDERSTANDING THE KEY

Using the 5 components, the soil scientist has a key to delineate the individual **ecological management unit.** The components are coded in this order: A. Landform. B. Source of Material. C. Texture. D. Water Regime. E. Modifiers. All codes require 6 digits. An area delineated as $\frac{061432}{XXXXXX}$ on the base map can be decoded from the Key as:

> Soils on northerly aspect slopes at elevations above 4500 feet, developed from sandstone. Soil texture is loam. The site is dry. Also, the slopes are steep enough to preclude soil disturbance by mechanized ground equipment.

In addition to the 5-component, 6-digit code, the soil scientist will use special symbols on areas too small to delineate on maps. Several are listed. Other standard symbols may be used but must be properly identified for the planning team. Unusual features such as Indian mounds or unusual geological formations should be identified for VIS interpretive purposes.

SPECIAL SYMBOLS

Characteristic Recognized	Shown on Map as:	
Borrow pit and/or Quarry		Black
Wet Spot		Blue
Swamp or marsh		Blue
Bedrock escarpment		Black
Mountain peak		Black
Mine dump		Black
Rock outcrop		Black
Stoniness		Black
Chert		Black
Critical erosion		Red

e. Edit the work and check thoroughly to ensure that all lines and the code numbers are readable. Scan the model area and look for landforms that may have been overlooked or misidentified.

f. Remove the overlay from the transparency and compare it with the ancillary overlays. The study of the combined overlays is beneficial in the analysis process.

3.2.2 SOURCE OF MATERIAL

The source-of-material map is developed by combining the geological overlay with additional photointerpretation.

a. To prepare the source-of-material overlay, tape a piece of overlay material over the landform overlay. Register to the fiducial marks and ink in the pertinent information (frame number, north arrow, etc.) in the margin.

b. From the landform overlay copy the flood plains, steam terraces, benches, and coves and colluvial (see appendix D) toe slopes. When the delineation is complete, label these subcomponents with the code number that corresponds with transported material.

c. Remove the landform overlay and substitute the geology overlay and register to the fiducial marks. Delineate the various rock material as shown by the geology overlay, and when completed, label the material in accordance with the subcomponent code numbers.

d. It is good practice to register the overlay to the transparency and to check stereoscopically to see if the material is recognizable.

3.2.3 TEXTURE

By definition (ref. 1), texture is based on the average of the most significant horizons within 152 centimeters (60 inches).

Texture cannot be directly interpreted from the 1:60 000-scale photographs. However, texture inferences can be made by a thorough study of drainage patterns and geology. A texture overlay can be completed after field work.

Drainage patterns can provide some texture information. A dendritic pattern, for example, indicates a homogeneous, uniform soil and rock materials and its source of material may be soft sedimentary rocks, volcanic tuff, glacial till, or old dissected coastal plains (ref. 4). Although this information does not provide a specific identification, it does narrow the identification process.

3.2.4 SOIL MOISTURE REGIME

The water regime, vegetation, and landforms are interrelated, and each provides a clue to the soil moisture condition (see section 3.4).

For example, if the landform is a swamp, it is obvious that the water regime is waterlogged; if the photographic feature imagery is a bright red with a bluish tint showing through, it is probable that the vegetation is a water-tolerant type and that the soil is wet. Careful consideration must also be given to the possibility of a recent rain; but if the vegetation growth is ample and is a lush red color, then the inference is that the soil normally is wet. Other combinations of landforms and vegetation and their study may lend support in identifying other water regime subcomponents. When the combinations indicate more than one possibility, a field check may be the only way to solve the problem.

When the water regime has been delineated and the code numbers placed in the proper subcomponent, the overlay should be placed on the phototransparency. Then another check is made stereoscopically to verify the water-regime classifications.

3.2.5 MODIFIERS

Modifiers are those conditions that will affect normal forest management practices. Some subcomponents such as stoniness critical, bedrock critical, depth to restrictive layer critical, cherty, extremely alkaline, and extremely acid *cannot* be *identified* from photographs. For example, a sparseness of vegetation will infer any of these, which means that a field check is necessary for a specific classification.

The subcomponents which *can be delineated* from the photograph are erosion critical; steepness critical; and steep, stony and uneven slopes.

a. In preparing the modifier overlay, place a clean overlay over the landform overlay and register to the fiducial marks.

b. From the landform overlay, delineate the flood plain, the stream terraces, benches, and the cove and colluvial toe slopes. Delineate only the perimeter of the combined landforms. This delineation identifies the subcomponent "none." When completed, label with the appropriate designated code number.

c. Remove the modifier overlay, place it on the transparency for detecting the eroded areas. Delineate those eroded areas that are visible.

d. Place the slope overlay over the transparency with the modifier overlay on top and search out the steep slopes by referring to the slope overlay. Steep slope criteria may vary, depending on the geographic area or subregion.

e. Examine the stereomodel to detect slopes that are broken up to the extent that a dominant aspect is impossible to delineate. More than likely, these will be the "steep, stony, uneven slopes" subcomponent.

Upon completion of those subcomponents that may be seen stereoscopically, the modifier overlay is finished as far as office procedures are concerned. The remainder of the subcomponents must be delineated in the field.

3.2.6 SPECIAL SYMBOLS

Special symbols are those that identify features that are too small to delineate or that have a special or supplementary characteristic that should be shown on the Soils Resource Inventory (SRI) map. (Table 3-1 provides examples of the special symbols.)

The interpreter is not confined to the list of special symbols used in table 3-1 but may devise other symbols as required; however, all symbols used must be shown in the legend (see appendix B).

3.2.7 COMPILING A PRELIMINARY SOILS MAP FROM THE PRIMARY COMPONENT OVERLAYS

The overlays that have been made should now be combined into one master overlay. This may require some modification of lines in order to get an acceptable fit. Two rules that must be applied are:

a. The controlling lines are landforms and drainage.

b. All other features are subservient to these.

This does not mean that a category such as source of material cannot extend across more than one landform. When such a situation occurs, the code for source of material should be repeated within each landform on which it occurs to avoid confusion.

3.3 CORRELATION CHARTS

Correlation charts can be developed from published knowledge and past experience in each subregion, district, or forest. From these, the interrelationships of the various components may be predicted or inferred. An example of a correlation chart is presented in table 3-2. This example is applicable to the mountains region of Georgia only. It is not intended for other areas, nor is it exempt from revision. It is only an example of how such a tool could be developed for each forest.

Assume, for example, that the landform is a stream terrace in a mountains subregion. By referring to the table and following the line connecting the code columns, the inferred source of material is "transported"; the inferred texture is "loamy"; the inferred water regime is "moist"; and the modifiers are either "none" or "erosion critical." The last column in the table, vegetation, is not a subcomponent but is a feature that can be correlated to the other subcomponents and therefore may be useful in the overall mapping task. For that reason, it is included in this example to help the user increase speed and accuracy.

After the map is completed, a stereoscopic review of the photographs is recommended for checking exceptions to correlations, necessity for adding delineations, and for making general improvements in the compilation.

3.4 PHOTOINTERPRETATION KEYS

Another useful tool is the dichotomous photointerpretation key. A dichotomous key is one in which the graphic or word description refers to a series of pairs of contrasting characteristics, which permit progressive elimination of all but one feature or condition of the group under consideration. The remaining feature or condition then provides the identification (ref. 4).

TABLE 3-2.— CORRELATION OF SUBCOMPONENTS

SRI code	Landforms (subcomponent)	SRI code	Source of material (subcomponent)	SRI code	Texture (subcomponent)	SRI code	Water regime (subcomponent)	SRI code	Modifiers (subcomponent)	SRI code	Vegetation (subcomponent)
00	Flood plain	0	Transported	0	Lithic	0	Waterlogged	0	None	0	Upland hardwood
01	Stream terrace	1	Dominantly sandstone	1	Skeletal	1	Wet	1	Erosion critical	1	Hardwood
02	Bench	2	Dominantly shale	2	Coarse	2	Moist	2	Steepness critical	2	Conifer
03	Cove and/or colluvial toeslopes	3	Mixed sandstone/ shale	3	Sandy	3	Dry	3	Stoniness critical	3	Mixed hardwood and conifer
04	Northerly aspect slopes, <762 m (<2500 ft)	4	Phyllites	4	Loamy	4	Droughty	4	Bedrock critical	X	Nonforest
05	Northerly aspect slopes 762 to 1371.6 m (2500 to 4500 ft)	5	Dominantly gneiss	5	Silty	5	Very droughty	5	Depth to restrictive layer critical	C	Cutover
06	Northerly aspect slopes >1371.6 m (>4500 ft)	6	Micas	6	Medium			6	Cherty		
07	Southerly aspect slopes <762 m (<2500 ft)	7	Novaculites	7	Fine			7	Extremely alkaline		
08	Southerly aspect slopes 762 to 1371.6 m (2500 to 4500 ft)	8	Mafics	8	Very fine			8	Extremely acid		
09	Southerly aspect slopes >1371.6 m (>4500 ft)	9	Calcareous	9	Organic			9	Steep, stony, uneven slopes		
10	Ridge and upper slope <762 m (<2500 ft)										
11	Ridge and upper slope 762 to 1371.6 m (2500 to 4500 ft)										
12	Ridge and upper slope >1371.6 m (>4500 ft)										

TABLE 3-2.— Continued.

SRI code	Landforms (subcomponent)	SRI code	Source of material (subcomponent)	SRI code	Texture (subcomponent)	SRI code	Water regime (subcomponent)	SRI code	Modifiers (subcomponent)	SRI code	Vegetation (subcomponent)
00	Flood plain	0	Transported	0	Lithic	0	Waterlogged	0	None	0	Upland hardwood
01	Stream terrace	1	Dominantly sandstone	1	Skeletal	1	Wet	1	Erosion critical	1	Hardwood
02	Bench	2	Dominantly shale	2	Coarse	2	Moist	2	Steepness critical	2	Conifer
03	Cove and/or colluvial toeslopes	3	Mixed sandstone/ shale	3	Sandy	3	Dry	3	Stoniness critical	3	Mixed hardwood and conifer
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TABLE 3-2.— Continued.

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TABLE 3-2.– Continued.

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TABLE 3-2.– Concluded.

SRI code	Landforms (subcomponent)	SRI code	Source of material (subcomponent)	SRI code	Texture (subcomponent)	SRI code	Water regime (subcomponent)	SRI code	Modifiers (subcomponent)	SRI code	Vegetation (subcomponent)
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12	Ridge and upper slope >1371.6 m (>4500 ft)										

The key helps an inexperienced photointerpreter to identify a certain feature, such as landform, vegetation, water regime, etc.

In this guide, three dichotomous keys are presented as examples. These are meant to illustrate the utility of dichotomous keys only. Similar keys may be developed for any region or area. There is a landforms key (table 3-3), a vegetation key (table 3-4), and a water regime key (table 3-5). The explanation below and table 3-3 serve to illustrate how the key works.

Assume that the interpreter is looking at a bench on a side slope but does not know in what category to place it. After reviewing the stereomodel, he refers to item 1 in the key. A choice must be made between the two descriptions labeled with 1. He must decide if the feature is relatively flat or if the feature is hilly or mountainous. Always read both choices. If he decides on the former, the key refers him to items or lines numbered with a 2 (shown on right margin). If he decides on the latter, the key refers him to items or lines numbered with a 6. (There are always two lines labeled with the same number, indicating that there is always a decision to be made. When the choice selection in the decision process indicates a name or word at the right margin, the interpretation process has ended. If a number is indicated, then the process is continued.) Assume that the decision is the former and he proceeds to the number 2 items in the key. He decides, in this case, that the feature does not contain the lowest point in elevation and is not often subjected to flooding. The key refers him to items labeled 3. The interpreter then determines that the feature does not border a flood plain, and the key refers him to items labeled 4. If the choice is that the feature is a gentle, flat, step-line interruption in a side slope, then the feature is called a "bench" (right-hand side of the margin).

TABLE 3-3.— DICHOTOMOUS KEY FOR MOUNTAIN LANDFORMS

1. Terrain is relatively flat. 2

1. Terrain is hilly to mountainous 6

   2. Landform is a plain or nearly level area along permanent or intermittent stream courses that is subject to overflow or flooding, is the lowest landform in elevation view, is often used for agriculture, and may be a magenta color. . . . . Flood plain

   2. Landform does not contain the lowest point in elevation and is not often subject to flooding. . . . 3

3. Landform is flat or an undulating plain bordering a flood plain, is the second lowest landform in stereovision, is usually free from flooding, is probably used for agriculture, and may be a red color. . . . . Stream terrace

3. Landform is not bordering a flood plain 4

   4. Landform is a gentle, flat, step-line interruption in a side slope. . . . . Bench

   4. Landform is not an interruption of a side slope . . . 5

5. Landform is the flat to gently sloping, elongated crest and upper slope of a hill or mountain, is the highest landform in stereovision, is probably covered by trees (mixed pine and hardwood), and may have rock outcrops. . . . . .Ridge and upper slope

5. Landform is not flat. 6

   6. Landform contains a drainageway 7

   6. Landform does not contain a drainageway 8

TABLE 3-3.— Concluded.

7. Landform is a side slope containing a stream, gully, or drain in a V-shaped valley; may be the concave portion of a hill when viewed in stereovision; usually containing lush hardwood, hemlock, or white pine vegetation. Cove and colluvial toe slope

7. Landform contains no significant stream, gully, or drain 8

   8. Landform is a side slope between the ridge and drainageway facing northwest, east, or north thereof and usually contains hardwood trees . . North aspect slope

   8. Landform does not face northwest, east, or north thereof 9

9. Landform is a side slope between the ridge and drainageway facing south, northwest, or east and usually contains southern yellow pine and drier-site hardwoods . . . . South aspect slopes

9. Landform is not sloping 1

TABLE 3-4.– DICHOTOMOUS KEY FOR VEGETATION COVER

1. Area is bright red to purple to blue green, has a rough texture, and appears to be raised from the surrounding terrain (forested land). 2

1. Area does not appear to be raised from the surrounding terrain. 7

   2. Texture is uneven; area is predominantly dark violet 3

   2. Area is not dark violet. 4

3. Rows are apparent. . . . . Conifer plantation

3. No rows are apparent . . . . Conifer forest

   4. Area is predominantly red or pink; texture is uneven; area is usually in low drainage areas. 5

   4. Area is not predominantly one color. 6

5. Rows are apparent. Orchard

5. No rows are apparent . . . . Hardwood forest

   6. Area varies from red to violet with neither being dominant . . . . Mixed forest

   6. Area does not have a forest cover. 7

7. Area is white or very light red; is surrounded by forest land; has a speckled appearance; or small, red, widespread rows may be visible. . . . . Clearcut

7. Area is not necessarily surrounded by forest and evidence suggests that it is not a clearcut 8

   8. Area is flat to rolling; is white, blue, green, or red; texture is smooth; is usually systematically laid out (agricultural land). 9

   8. Area is not agricultural land. 1

TABLE 3-4.– Concluded.

9. Area is some shade of red; texture may be from smooth to speckled or mottled; trees may or may not be apparent; there may or may not be a systematic layout. . . . . Pasture

9. Area is not pasture land. 10

   10. Area has an uneven texture; trees appear to be in rows; there is a systematic layout; trees are bright red . . . . Orchard

   10. Area is free of trees. 11

11. Area may be blue, white or brown, but the dominant color is red; the texture is relatively smooth; there is a systematic layout; no trees are evident; contour lines or rows may be visible. . . . . Cultivated land

11. Area is blue or white with a very mottled appearance; waterways may be close by; there is a systematic layout; contours may or may not be visible . . . . Irrigated agricultural land

TABLE 3-5.— DICHOTOMOUS KEY FOR MOUNTAIN WATER REGIME[a]

1. Water regime contains drain.	2
1. Water regime does not contain a drain.	6
2. Water regime is on a flat landform	3
2. Water regime is on a sloping landform.	5
3. Water regime is on a flat or possibly dish-shaped landform; water is at or near the surface 9 months or more during most years; vegetation is sparse and is made up of water tolerant species (cypress, water tupelo, algae, etc.); color is a brilliant pink with possible blue mottling; a permanent stream or water body should be near; when stereoviewed, it will be the lowest point; and it will not be used for agriculture or any other development.	Waterlogged
3. Water regime is not at or near the surface for 9 months and is probably not mottled; vegetation is denser and land may be developed.	4
4. Water regime is at or near the surface for significant periods; vegetation is denser than waterlogged and trees are larger; landform is flat and may be developed, is often used for agricultural purposes, and a permanent stream is probably nearby	Wet or moist
4. Water regime is not on a flat landform	5
5. Water regime is on a side slope containing a drain in a cove; vegetation is lush hardwood or white pine. . . .	Moist
5. Water regime is on a landform not containing a drain . . .	6

[a]There are many exceptions to this classification; however, this key should serve as a guide to the general trend of the water regime.

TABLE 3-5.– Concluded.

6. Water regime is on a side slope not containing a drain and faces northwest, east, or north thereof, hardwoods will dominate. . . . . Dry

6. Slope does not face northwest, east, or north thereof. 7

7. Water regime is on a side slope not containing a drain and faces south of northwest or east; vegetation is yellow pine and dry-site hardwoods . . . . Droughty

7. Water regims is on a landform with no significant vegetation 8

8. Water regime is on a landform that has extreme runoff, such as rock outcrop or paved areas, or extreme infiltration, such as coarse sand terraces . . . . Very droughty

8. Water regime is not on a landform that has extreme runoff or extreme infiltration 1

In using the key, suppose that all choices have been tried and the interpreter is now down to the last items (choices) in the process. If the first choice of this last item does not fit, then there is only one other possibility. This possibility indicates that a wrong decision has been made in one of the previous choices because it calls for the process to be repeated; i.e., go back to number 1. If the choices made in the repeated process are all identical to the choices made the first time through the process, then the interpreter will be in a repeating cycle. Consequently, somewhere along the process a decision, different from the original, must be made in order to reach the final identification of the feature.

4. BASE MAPS

Up to this point, the interpretations and compilations have been made at a 1:60 000-photographic scale. It is now time to consider the scale of the finished product and the base map which is to be used. Two types of base maps will be discussed below. They are the Geological Survey 1:24 000-scale topographic maps and the 1:24 000-scale orthophoto maps.

4.1 GEOLOGICAL SURVEY 1:24 000-SCALE TOPOGRAPHIC MAPS

The 1:24 000-scale Geological Survey topographic map is suitable for a base sheet. There are advantages and disadvantages in using this map for this purpose, but the advantages outweigh the disadvantages.

The advantages of using this map are numerous. The scale is 1:24 000 which will conform closely with Forest Service maps. These USGS maps are prepared photogrammetrically and represent a true ground scale. Contours are shown and represent true elevation. Rivers and stream courses are portrayed. Planimetric features, roads, trails, tracks, and urban development are in true position. Gross vegetation is shown. Latitude and longitude, plus a coordinate grid system, are shown.

The disadvantage is that planimetric features shown may not be current.

4.2 ORTHOPHOTOS

An orthophoto is made by an instrument which electronically scans a stereoscopic model made from two overlapping photographs. The instrument removes image displacement caused by relief and produces a photograph on unexposed negative film. The orthophoto looks like the original photograph in image quality but has the planimetric accuracy of a map. Orthophotos are produced commercially by a number of aerial survey companies.

From a series of orthophotos, a mosaic may be prepared and the reproduced mosaic may be used as a base map. Contours, coordinates, and other auxiliary information may be added as required.

The orthophoto mosaic has an advantage as a base map in that the photographic imagery with its attendant detail will make work easier for the land manager. The new photograph also provides current planimetry.

4.3 ENLARGEMENT AND RECTIFICATION OF THE AERIAL PHOTOGRAPHS AND THE COMPONENT OVERLAYS

At this point in the process, the photograph can be rectified and enlarged to a scale of 1:24 000.

a. Using a 1:24 000-scale USGS topographic map as a base sheet, identifiable features which correspond to image points on the photograph are selected.

b. The photograph is placed in the rectifying projector and the map is placed on the easel below. By adjusting the easel, the photographic image is enlarged and adjusted to fit the identifiable features on the map. When the fit is close enough, the map is replaced by unexposed photographic paper which, when exposed and developed, becomes the rectified print at the desired scale.

c. Using the same projector settings, the component overlays are reproduced.

d. It is imperative that the fiducial marks on both the enlarged photograph and the enlarged overlays are visible to ensure proper registration. Figure 4-1 illustrates a rectifying projector.

Figure 4-1.- Rectifying projector.

4.4 PROCEDURES FOR COMPILING OVERLAYS

4.4.1 MASTER OVERLAY

A master overlay is one that is to become the final overlay. It is the one that will eventually contain all the EMU's, their components and general annotations, and managerial data. Master overlays are prepared in the following manner:

a. Upon receipt of the overlays at a scale of 1:24 000, cut a sheet of stable-base, frosted acetate to the size of the enlarged overlay.

b. Tape the acetate sheet over the landform overlay. Using pencil, register the acetate sheet to the four fiducial marks.

c. Copy all landforms to the acetate sheet (master overlay).

d. Place the double-digit landform code number in each area, leaving sufficient space to add in four additional numbers to identify the remaining components.

e. Place the master overlay over the 1:24 000-scale topographic map using the best possible fit. Record the elevations between 761 and 1371 meters (2500 and 4500 feet), and record the code numbers as given in the Soil Resource Inventory Guide (ref. 1).

4.4.2 ADDITIONAL OVERLAYS

Place the master overlay over an enlarged and rectified component overlay. Again register to the fiducial marks and delineate from this overlay to the master overlay. Repeat this for each component overlay.

4.4.3 FINAL MASTER OVERLAY

The final master overlay is prepared in the following manner:

a. When the overlays have been combined on the master overlay, it should be thoroughly edited and checked to determine that all ecological management units and all code numbers are complete.

b. A title, legend, scale, and north arrow should be added to the master overlay.

c. The map and overlay are now ready for final drafting. When this is completed, the soils resource map and the base map, which may be either a USGS 1:24 000-scale topographic map or an orthophoto, are reproduced as a composite.

Appendix C illustrates the preparation of the soils resource map using two overlays.

5. EVALUATION OF MAP ACCURACY

Because this procedure allows for the compilation of a soils resources map by personnel with limited training and experience in map compilation, it also means that a fast and efficient method of evaluating the map accuracy is required. Obviously, it would defeat the purpose to have an experienced soil scientist review 100 percent of the work after having the lesser trained personnel compile the map. However, a reliable check can be made using a statistical method that requires only a small portion of a 100-percent review. This section describes one statistical method that can be employed to accomplish this evaluation.

As has been described before, the Soils Resource Guide calls for the identification of several components which, when combined, form the ecological management unit. In order to explain this statistical method, only one component (landforms) is used to illustrate the procedure.

The statistical method is based on a two-class probability distribution system. For example, the landform "flood plain" is either a flood plain, or it is something else (other); and the classification is either right or wrong.

The objective of the statistical method is to estimate the map accuracy and its confidence interval when given a confidence level. An explanation of these terms is given below.

5.1 ESTIMATED ACCURACY (A_e)

As an example, assume that the manager decided he could spare an experienced soil scientist for 5 days to make a check comparison of the map area. Within this time, he estimates that only 65 points can be checked. As a result of the check, he has found that 50 points were correctly classified. This provides the data for determining the estimated accuracy.

Example:
$$A_e = \frac{\text{Number of samples correctly classified}}{\text{Number of sample points}}$$
$$= \frac{50}{65}$$
$$= 76.9\%$$

5.2 CONFIDENCE INTERVAL

A confidence interval is the range in which the true accuracy (not the estimated accuracy) will be found at a prescribed confidence level. The formula for this is:

$$\left.\begin{array}{l}\text{Lower limit of interval} = A_e - \Delta \\ \text{Upper limit of interval} = A_e + \Delta\end{array}\right\}$$

where

Δ = midpoint of confidence interval and is found by:

$$\Delta = t\sqrt{\frac{A_e(1 - A_e)}{\text{Number of sample points}}}$$

and where t is an increasing function of the confidence level. [See table 5-1 for the value of t at various confidence levels (ref. 8).]

TABLE 5-1.— T-VALUES FOR CONFIDENCE LEVELS

Confidence level, %	99	97.5	95	90	85	80	75	68
t-values	2.58	2.24	1.96	1.64	1.43	1.28	1.15	1.0

Since the confidence interval is a function of t and t is a function of the confidence level, then the confidence interval cannot be determined until the confidence level has been designated.

5.3 CONFIDENCE LEVEL

The confidence level is a figure that is determined by management requirements. It tells the manager how many times out of a hundred the true accuracy will fall within the confidence interval. If the manager decides that he needs to rely on the accuracy occurring within the confidence interval 90 percent of the time, then he would designate it as such. If he needs to rely on the accuracy occurring within the confidence interval 68 percent of the time, he would so decide. As the confidence level approaches 100 percent, the interval becomes greater or longer. For example, the confidence interval for a confidence level of 90 percent for an A_e of 76.9 percent will be 68.3 to 85.5 percent, whereas the confidence interval for a 75 percent confidence level with the same A_e will be 70.9 to 82.9 percent. The confidence level is clarified in the following by using a problem similar to the one cited in section 5.1.

A soil resources map, covering 20 000 hectares (49 420 acres), has been completed. The manager wants to know the accuracy of the compilation and has decided that he can spare one experienced soil scientist for 5 days to field-check the map. He estimates that as a result of terrain conditions and property boundaries 65 points can be checked in this time. His next decision is to locate the 65 points so that the check will provide an unbiased and representative picture of the overall compilation.

A grid is provided such that it covers the completed map in its entirety, and the spacing of the grid lines is such that they provide grid cells that are equal to or smaller than the smallest features that are classified on the map. Each horizontal space or row is identified by a number, starting with zero; and each vertical space is labeled in the same manner. This provides a coordinate system for identifying and locating any grid cell within the entire map area.

To randomly select the 65 points or cells, a random numbers generator or a random numbers table can be used. The first pair of random numbers will denote the row and column location of the first sample. The second pair of random numbers will be used for the second sample, continuing until all random numbers are paired with all samples. (Inaccessibility problems can be overcome by moving the point to a place that is accessible as long as the point remains within the same delineated area. If this does not suffice, a new random pair of numbers is generated.) In the field, the soil scientist found that of the 65 landforms checked 50 were classified correctly and 15 were classified incorrectly.

$$A_e = \frac{\text{Number of correctly classified samples}}{\text{Number of samples checked}} = \frac{50}{65} = 0.769$$

The manager wants to know the interval within which the true accuracy figure lies 90 percent of the time. Therefore, the confidence level is 90 percent.

Table 5-1 indicates that the t-value at a 90-percent confidence level is 1.64 and the confidence interval is:

$$\text{Lower limit} = A_e - \Delta; \text{ Upper limit} = A_e + \Delta$$

where

$$\Delta = t\sqrt{\frac{A_e(1 - A_e)}{\text{Number of sample points}}}$$

$$= 1.64\sqrt{\frac{0.769(1 - 0.769)}{65}}$$

$$= 1.64\sqrt{\frac{(0.769)(0.231)}{65}} = (1.64)(0.0523)$$

$$= 1.64\sqrt{\frac{0.178}{65}} = (1.64)(0.523)$$

$$= 0.0857$$

$$\text{Lower limit} = A_e - \Delta$$
$$= 0.769 - 0.0857$$
$$= 0.6832 \text{ or } 68.3\%$$

$$\text{Upper limit} = A_e + \Delta$$
$$= 0.769 + 0.0857$$
$$= 0.855 \text{ or } 85.5\%$$

Therefore, the confidence interval is written 68.3 to 85.5 percent or (68.3, 85.5 percent), at a confidence level of 0.90.

From this solution, the manager knows that 90 percent of the time the true accuracy of the classification will be between 68.3 and 85.5 percent.

To determine the accuracy of each of the other subcomponents classified in the map, the same procedure is applied until an accuracy figure for each landform mapped has been determined. After the accuracy of all the landform subcomponents has been determined by the above procedure, the overall accuracy of landform classification can be computed by the following formula:

$$P = 1/2\left[A_{e_1} + A_{e_2} + \cdots + A_{e_m} - (m - 2)100\right]\%.$$

where

P = overall classification accuracy of landforms

A_{e_1} = accuracy of the first landform subcomponent

A_{e_2} = accuracy of the second landform subcomponent

A_{e_m} = accuracy of the *mth* landform subcomponent

m = total landform subcomponents

P is a figure comparable to the original A_e in each of the above, except that it represents the accuracy of the whole group of landforms. Now a new confidence interval can be computed using the selected confidence level and the value of P in the following formula.

$$\text{Lower limit} = P - \Delta; \text{ Upper limit} = P + \Delta$$

where

$$\Delta = t \frac{P(1 - P)}{\text{Number of sample points}}$$

The number of sample points must be the same in all cases.

Again, the t-value is found in table 5-1, and the number of sample points is still the same as before. From table 5-1, the manager will know that 90 percent of the time, the accuracy of landforms interpretation will fall between the two percentage limits (P - Δ and P + Δ).

This completes the calculation of the overall accuracy of landforms; the other components can be computed in the same manner.

After the overall accuracy of all components has been computed, the overall mapping technique accuracy can be determined by the simple averaging method. When calculating the P for landforms, the P for texture, and the P for source of material, the sum of all the P's is divided by the number of P's and this gives the overall accuracy of the map.

The statistical method explained in this section is a method which can be used for determining the accuracy of an SRI map as compared to actual or ground-truth data. Detailed explanations of statistical evaluations may be found in references 3 and 5 through 13.

APPENDIX A

GENERAL DRAINAGE PATTERNS

APPENDIX A

GENERAL DRAINAGE PATTERNS

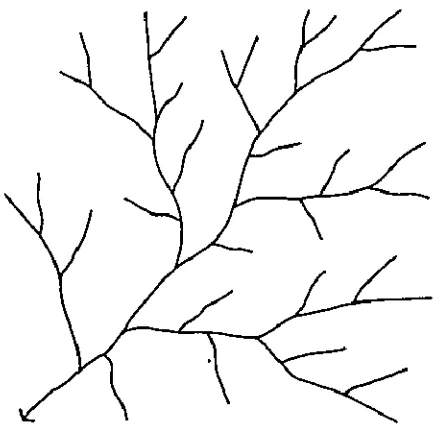
Drainage pattern analysis is probably the most important single indicator of landforms because it provides useful information about the geology and soils materials. In this appendix, 15 general drainage patterns (figs. A1 through A15; ref. 12) are presented as an aid to the soil scientist in his interpretations. Each pattern includes a diagram, a description of the pattern, and what it indicates or infers about the terrain or soil.

Drainage patterns are classified by Way (ref. 12) as regional or local, depending upon the scale of the studied image. In addition, Way classifies patterns by their density of dissection, or texture, and by their type of pattern form. The texture is indicated here by three categories (fine, medium, and coarse) based upon the appearance in 1:20 000-scale photographs. These patterns can still be detected at 1:60 000 scale. The categories are described as follows.

a. Fine-Textured (fig. A15) — Fine-textured patterns are those whose average spacing between tributaries and first-order streams is less than 1/4 inch. Fine-textured patterns typically indicate high levels of surface runoff, impervious bedrock, and soils of low permeability.

b. Medium-Textured (fig. A1) — Medium-textured patterns describe channel spacing in which most first-order streams are from 1/4 to 2 inches apart. The amount of runoff is medium, compared to that associated with fine and coarse textures. Soil textures are typically neither fine nor coarse but contain mixtures of materials.

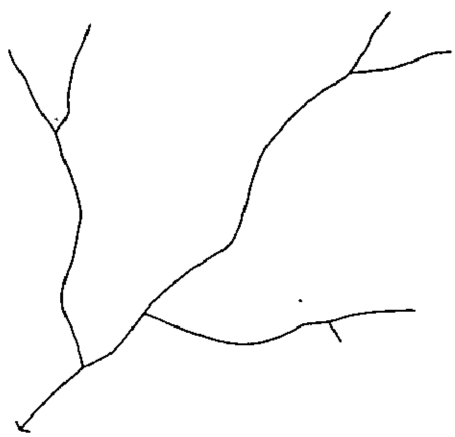
c. Coarse-Textured (fig. A2) — Coarse-textured patterns have first-order streams that are over 2 inches apart and carry relatively little runoff. These textures also generally indicate a more resistant bedrock which is permeable and which weathers to form coarse, permeable soils.



Description: Medium texture surface runoff. Soil texture neither fine nor coarse. Contains mixtures of materials.

Indication: Shaly sand or sandy shale.

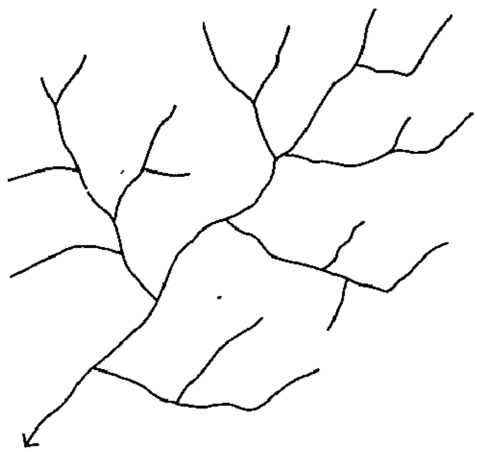
Figure A1.— Dendritic pattern (medium textured).



Description: More resistant bedrock which is permeable and which weathers to form coarse permeable soils. Relatively little surface runoff.

Indication: Sand or sandstone.

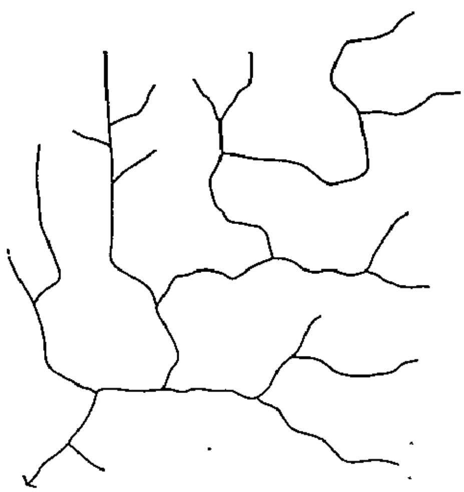
Figure A2.— Dendritic pattern (coarse textured).



Description: Tributaries join main stream at right angles as a result of bedrock jointing, fracturing, and folding. The harsher, the thinner the soil cover.

Indication: Formed in slate, schist, gneiss, resistive sandstone in arid climates and in sandstone in humid climates.

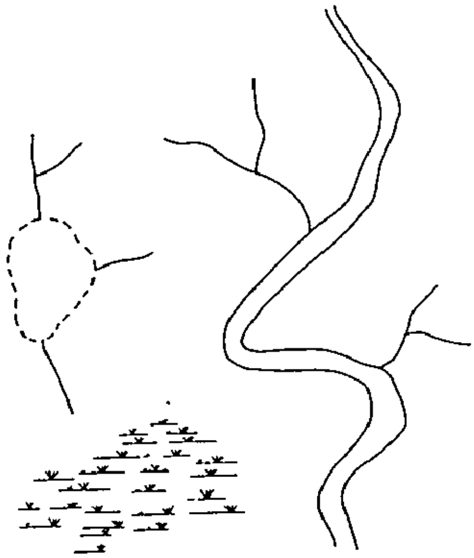
Figure A3.— Rectangular pattern.



Description: Sharp angulate bends common in main streams. A variation of dendritic or trellis in which faults, fractures, and joints have modified the pattern.

Indication: Type and directions of angulations may indicate the specific rock type. Sandstone tends to develop parallel jointing; limestone develops joints that intercept one another at acute angles.

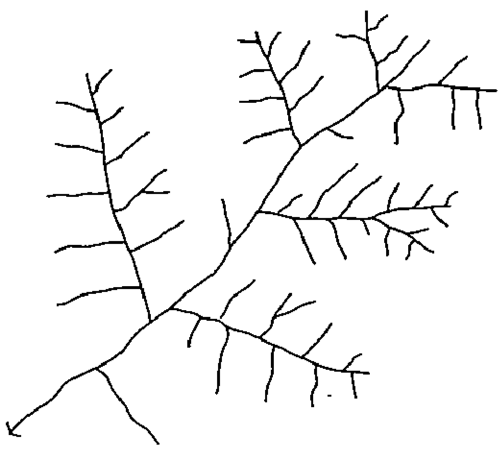
Figure A4.— Angulate pattern.



Description: A nonintegrated drainage system resulting from a relatively young landform having flat or undulating topographic surface and a high water table. Depressions are swamps, bogs, ponds, and lakes.

Indication: Commonly occur on young, thick, till plains; end moraines; and flood plains. Regional streams may meander through area but do not influence its drainage.

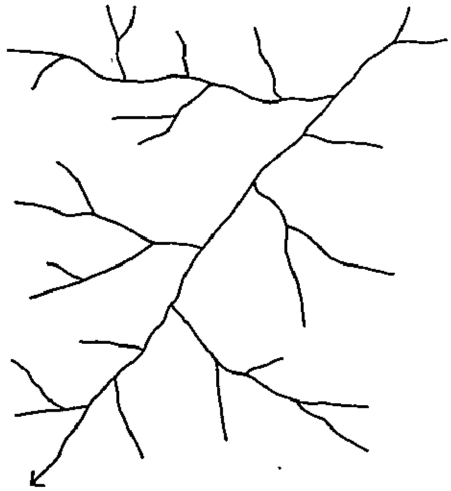
Figure A5.— Deranged Pattern.



Description: Modified dendritic. Tributaries intersect main streams at acute angles and are essentially parallel to each other so as to present a feather-like appearance.

Indication: A high silt content of the soil such as might be found in loess or fine-textured flood plains.

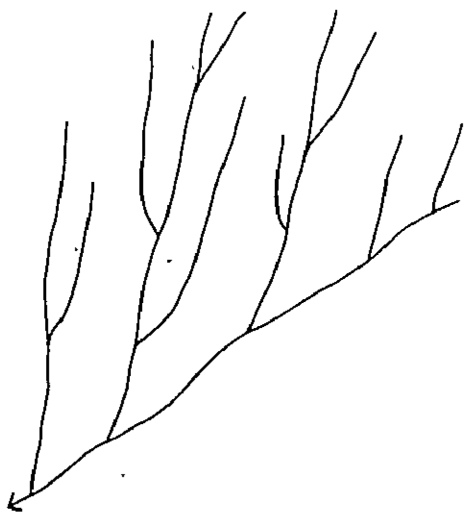
Figure A6.— Pinnate pattern.



Description: Occurs within other systems that have been modified by warping or topographic uplift.

Indication: Modified pattern.

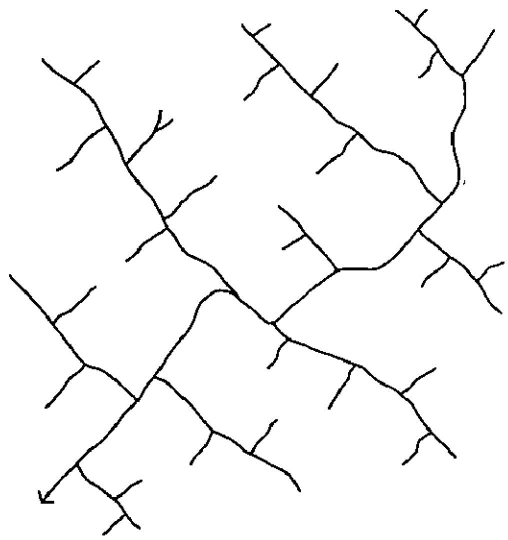
Figure A7.— Barbed pattern.



Description: Tributaries join main stream at same angle. Develops on homogeneous, gentle, uniformly sloping surfaces whose main collector streams may indicate a fault or fracture.

Indication: Young coastal plains and large basalt flows.

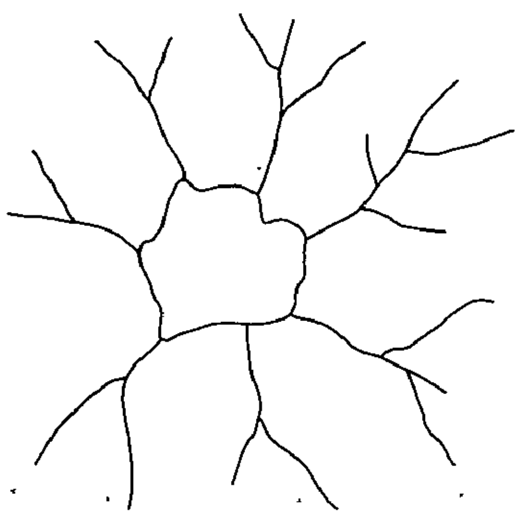
Figure A8.— Parallel pattern.



Description: Parallel tributaries and gullies intersecting at right angles.

Indication: Bedrock structure rather than type of bedrock; tilted, interbedded sedimentary rocks, whereas the main parallel channels follow strike of beds.

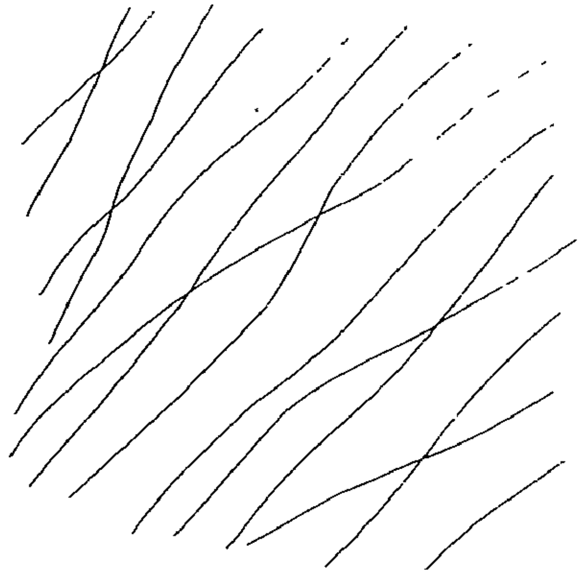
Figure A9.— Trellis pattern.



Description: Drainage downward into a basin.

Indication: Basin, sink, or the end of an eroded syncline or anticline.

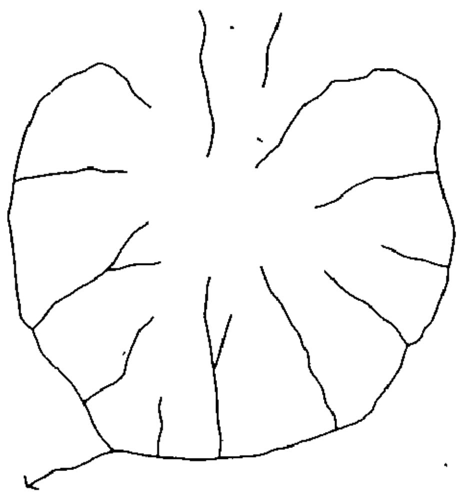
Figure A10.— Centripedal pattern.



Description: Develop locally in bottom of major stream channels.

Indication: Coarse soil materials and unstable shifting channels.

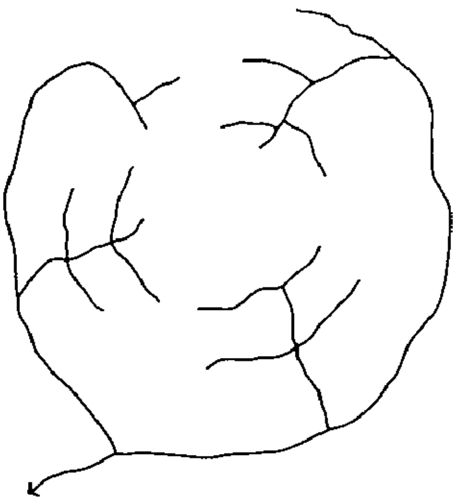
Figure A11.— Braided patterns.



Description: Circular network flowing away from central high point to collection stream.

Indication: Domes with no stratigraphic control, volcanoes, isolated hills, etc.

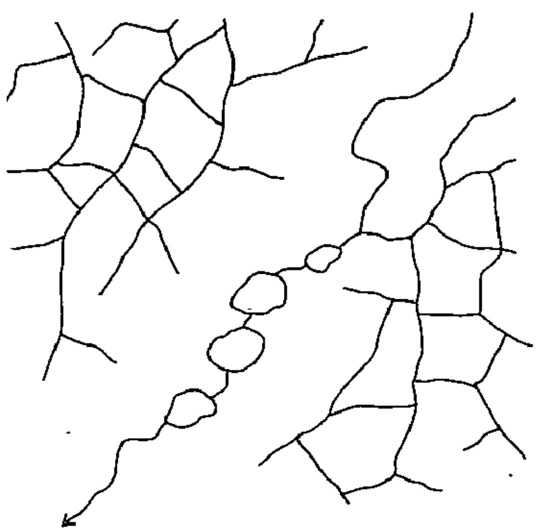
Figure A12.— Radial pattern.



Description: Bedrock joints or fracturing control the parallel tributaries.

Indication: Granite or sedimentary domes with stratigraphic control.

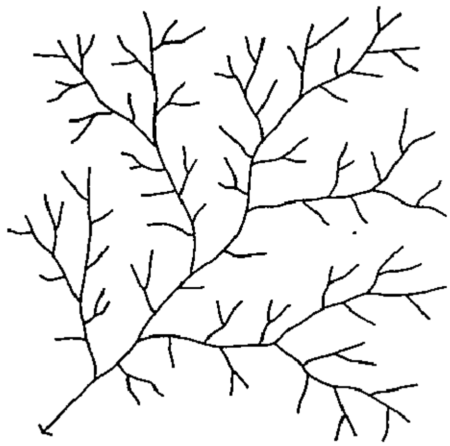
Figure A13.– Annular pattern.



Description: Develop in poorly drained fine-grained sediments and in organic materials of permafrost. Thawing causes slumping, settlement, and depressions; gives a beaded appearance.

Indication: Existence or previous existence of permafrost features.

Figure A14.– Thermokarst pattern.



Description: Impervious bedrock, soils of low permeability, and high levels of surface runoff.

Indication: Clay soil on shale.

Figure A15.– Dendritic pattern (fine textured).

APPENDIX B

PHOTOINTERPRETATION OVERLAY EXAMPLES

APPENDIX B

PHOTOINTERPRETATION OVERLAY EXAMPLES

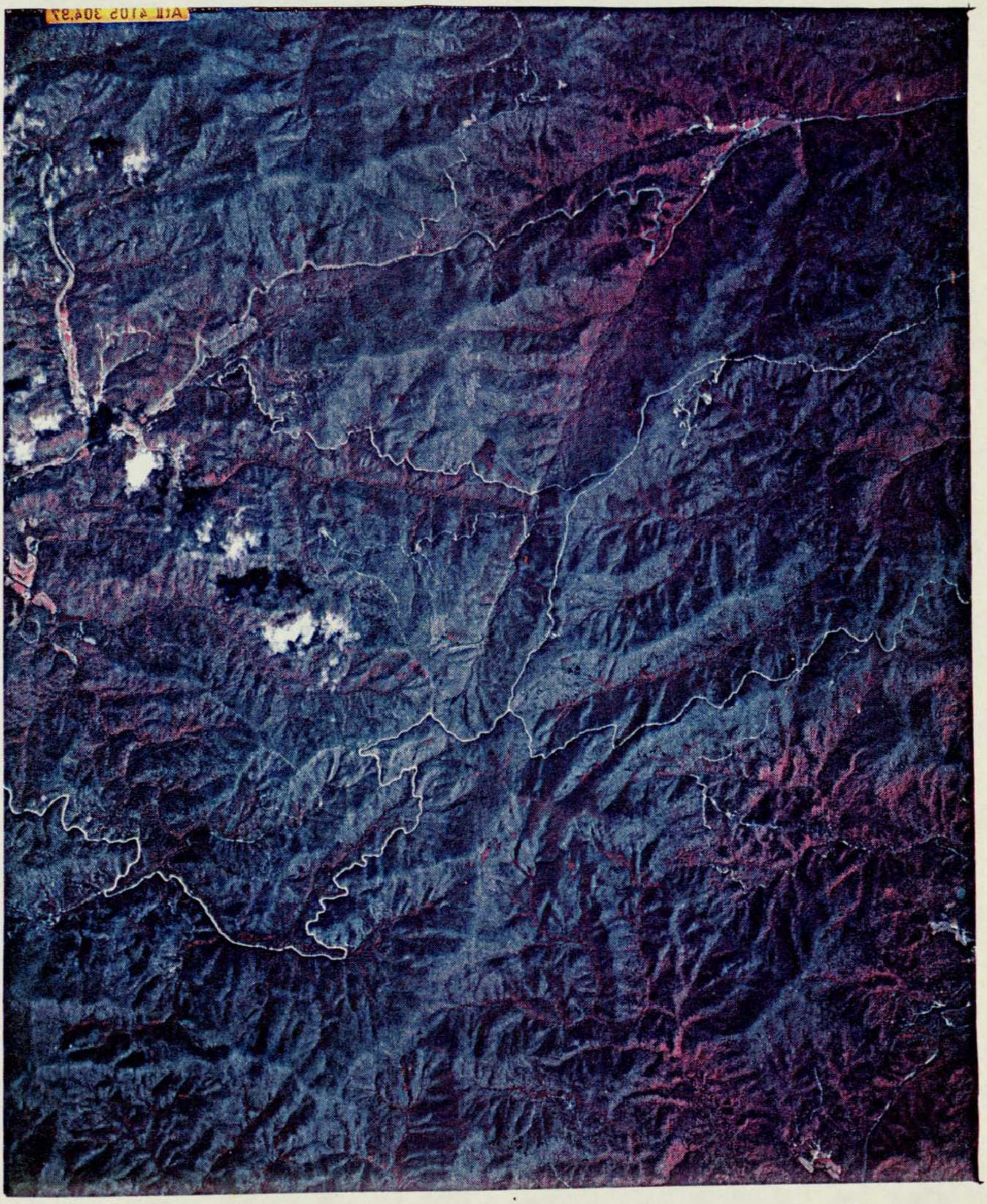
In this appendix, three positive prints (fig. B1) and examples of the primary and selected ancillary component overlays (fig. B2) are included as an aid to the photointerpreter.

(a) Mission 66, roll 2, frame 8545.

Figure B1.- Positive transparency.

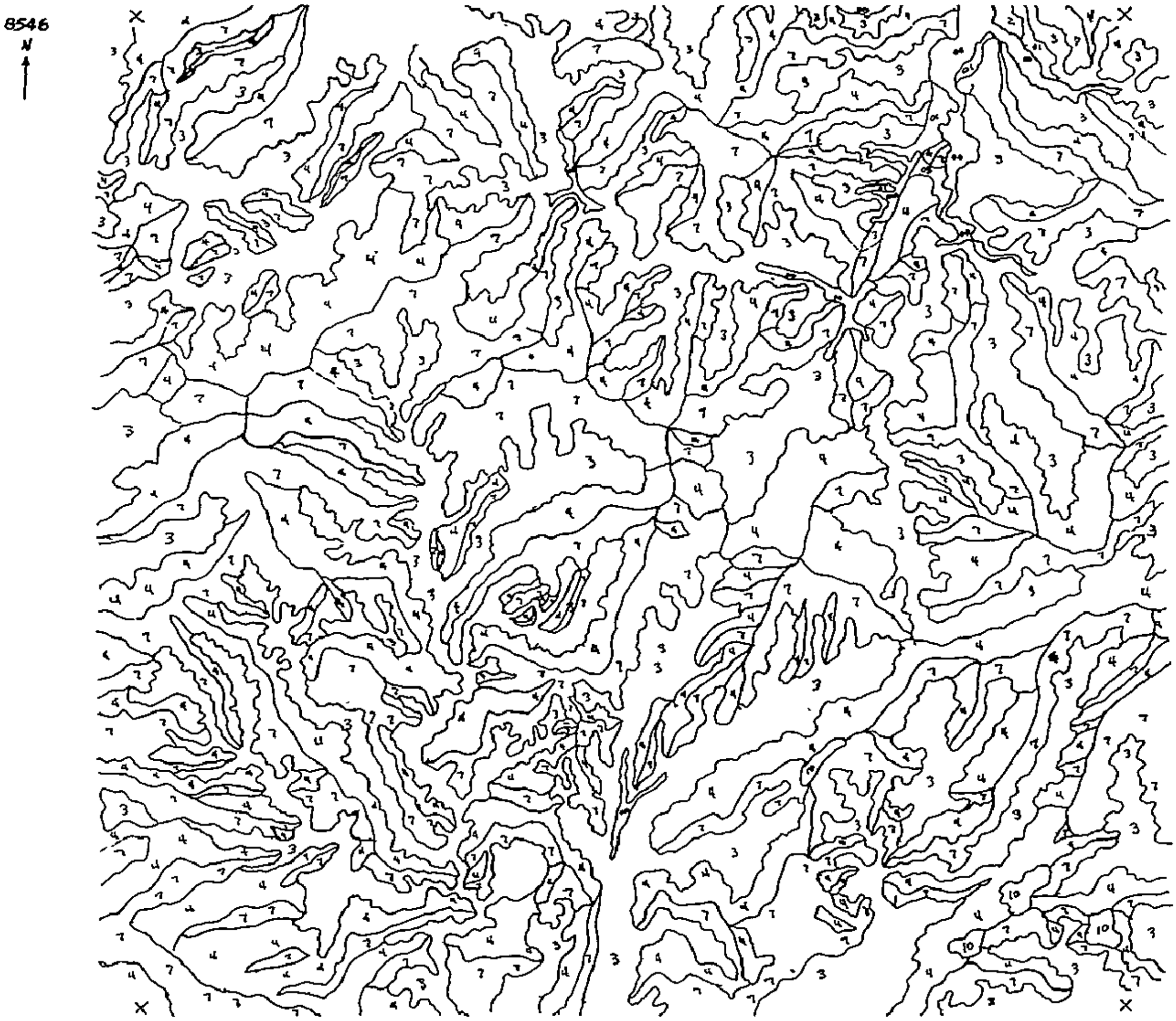
(b) Mission 66, roll 2, frame 8546.

Figure B1.- Continued.



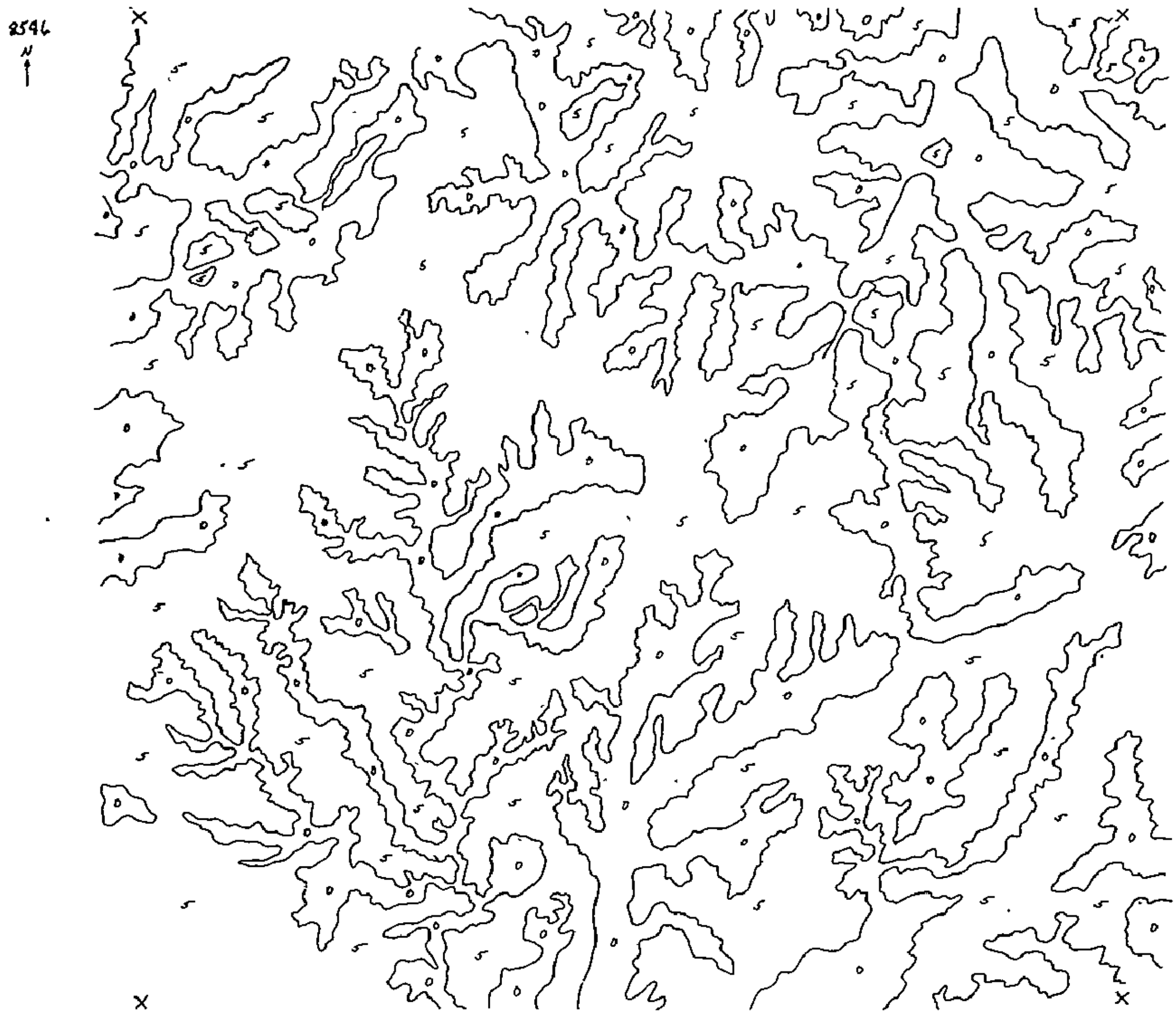
(c) Mission 66, roll 2, frame 8547.

Figure B1.– Concluded.



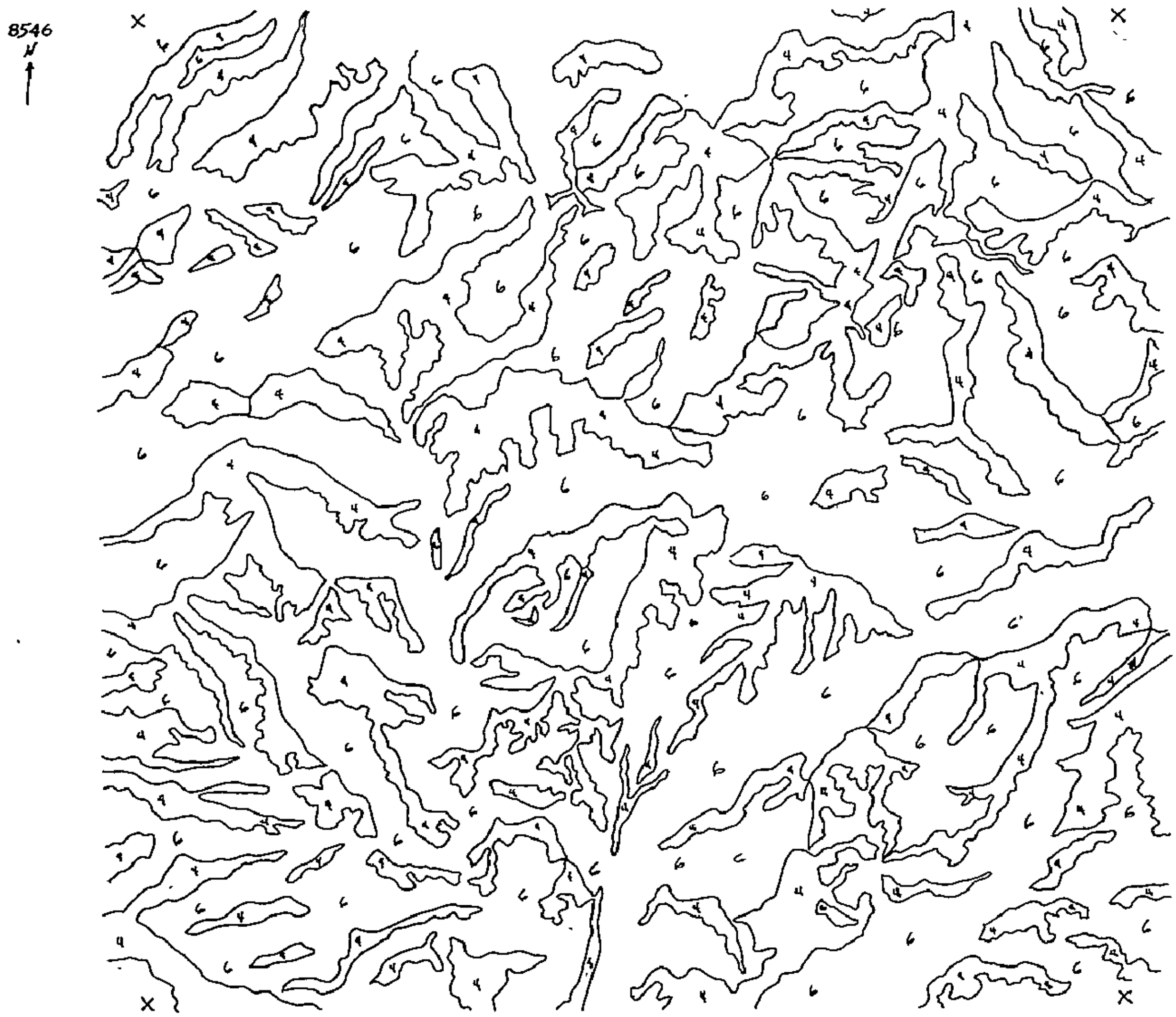
(a) Landforms
00 — Flood plain
01 — Stream terrace
03 — Colluvial
04 — North aspect
07 — South aspect

Figure B2.— Primary and selected ancillary component overlays.



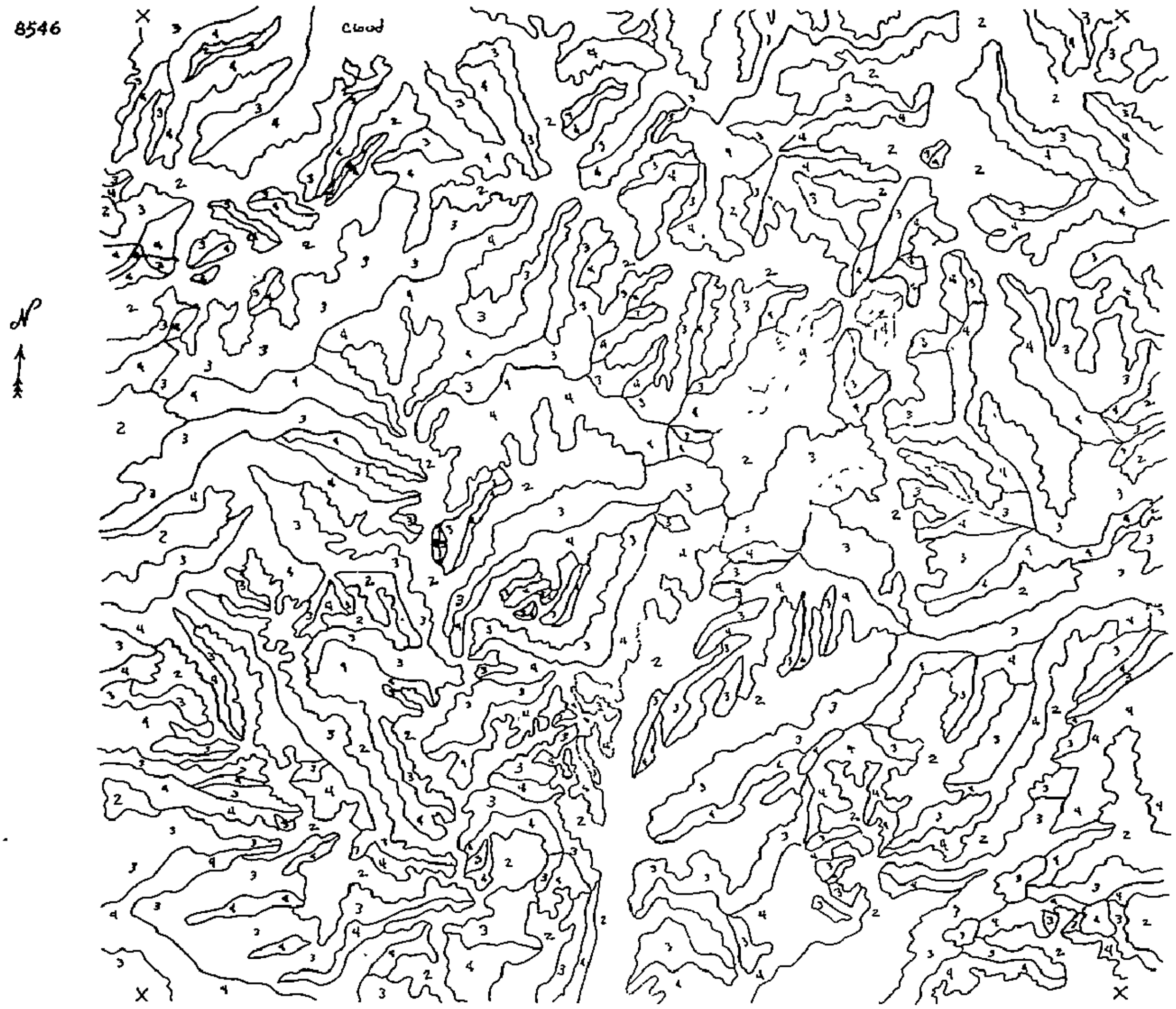
(b) Source of material
5 — Basic gneiss
0 — Transported

Figure B2.— Continued.



(c) Texture
4 — Loamy
6 — Medium

Figure B2.— Continued.

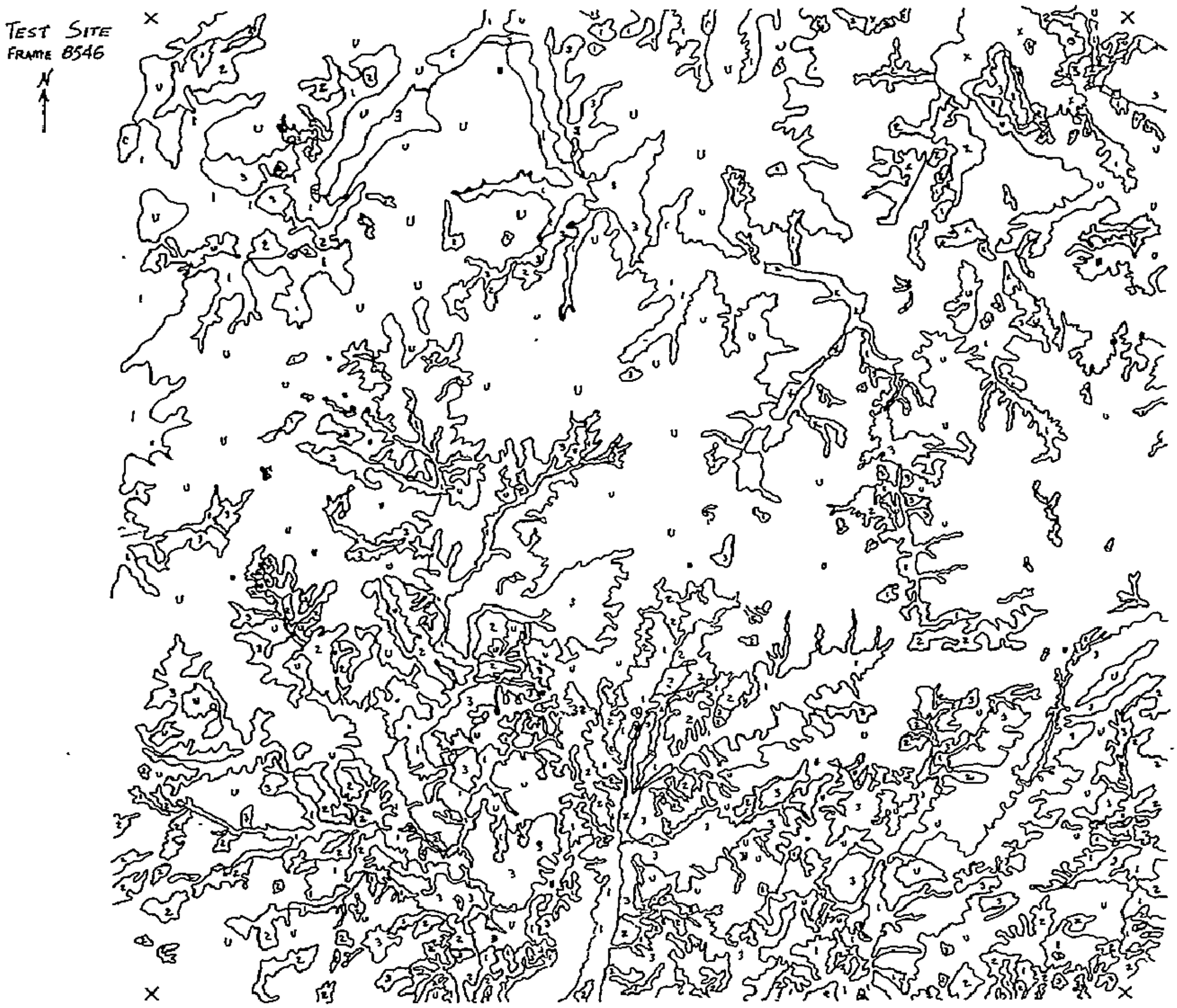


(d) Water regime
1 – Wet
2 – Moist
3 – Dry
4 – Droughty

Figure B2.– Continued.

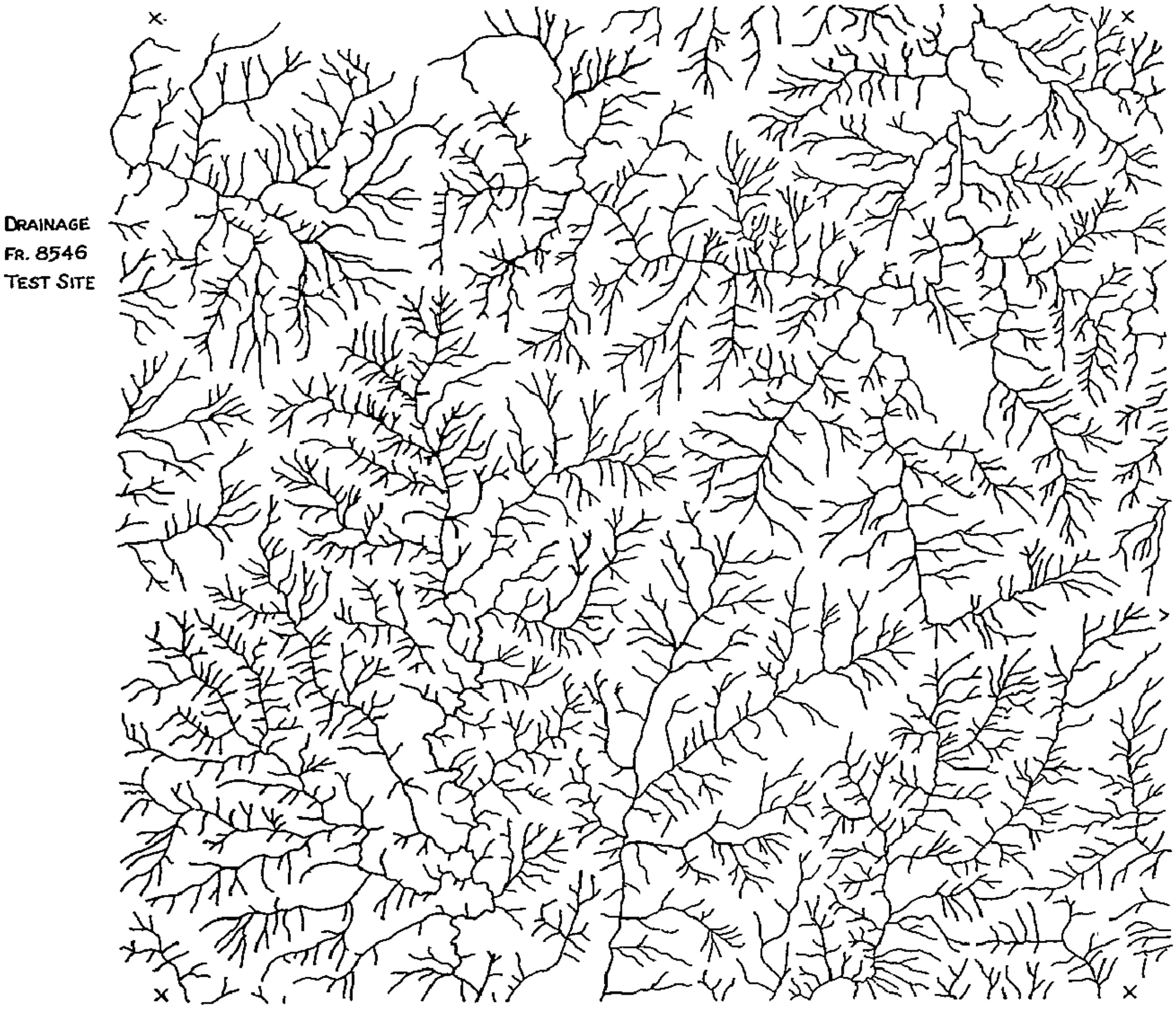
(e) Modifiers and special symbols
9 — Steep, stony, uneven slope
2 — Steepness critical
0 — None

Figure B2.— Continued.



(f) Vegetation
U — Upland hardwood
1 — Cove hardwood
2 — Pine
3 — Mixed pine hardwood
X — No vegetation

Figure B2.— Continued.



(g) Drainage

Figure B2.— Concluded.

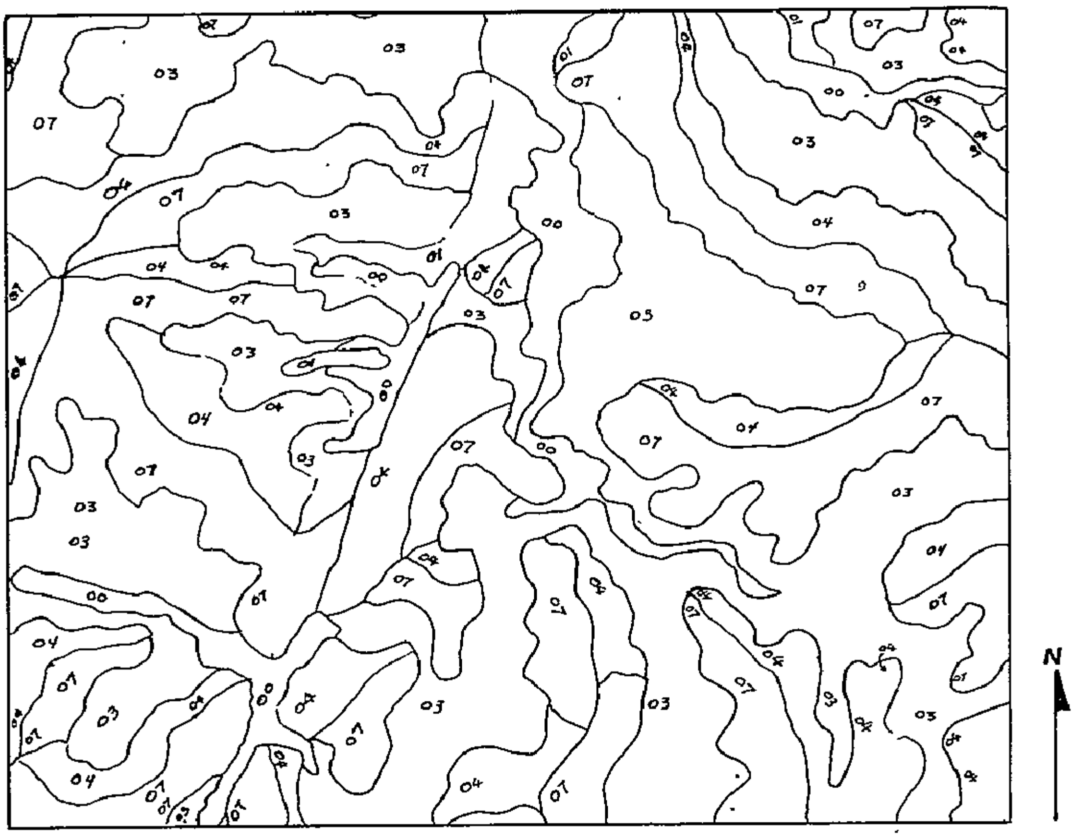
APPENDIX C

COMPILATION OF THE SOILS RESOURCE MAP

APPENDIX C

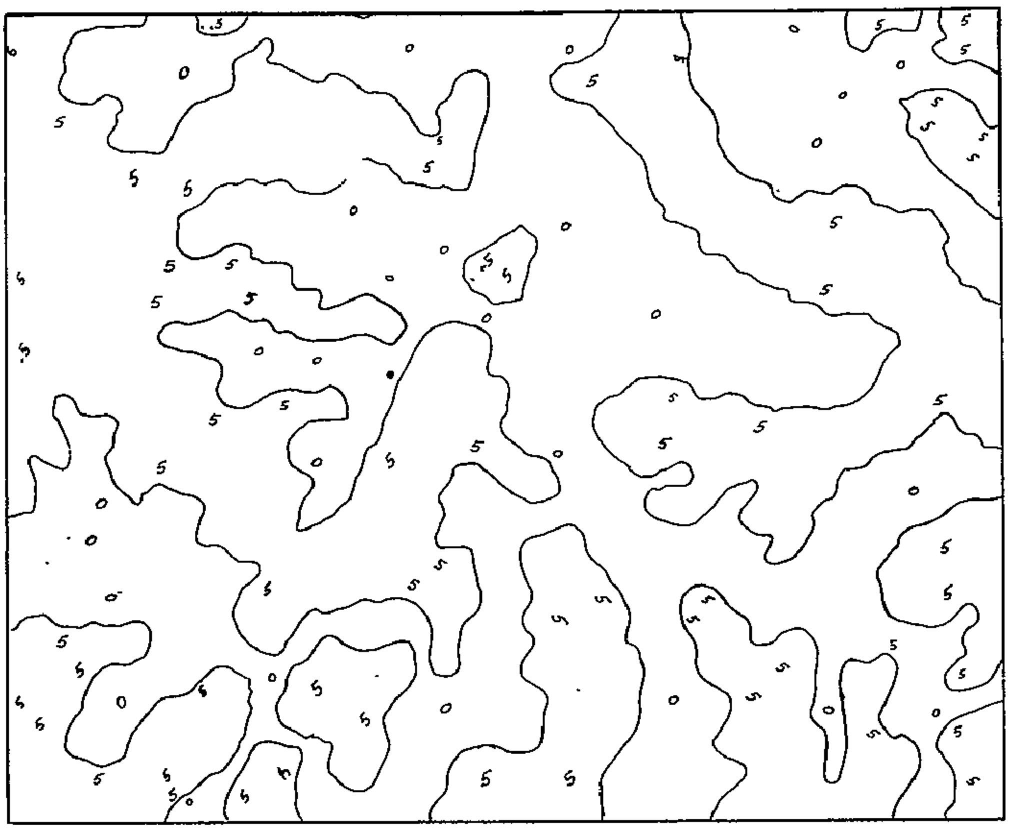
COMPILATION OF THE SOILS RESOURCE MAP

In this appendix, the method of preparing the soils resource map is illustrated with five overlays. By overlaying each in the order landforms, source of material, texture, water regime, and modifiers, one can see readily how each, when combined with the others, creates the total ecological management unit and the SRI map.



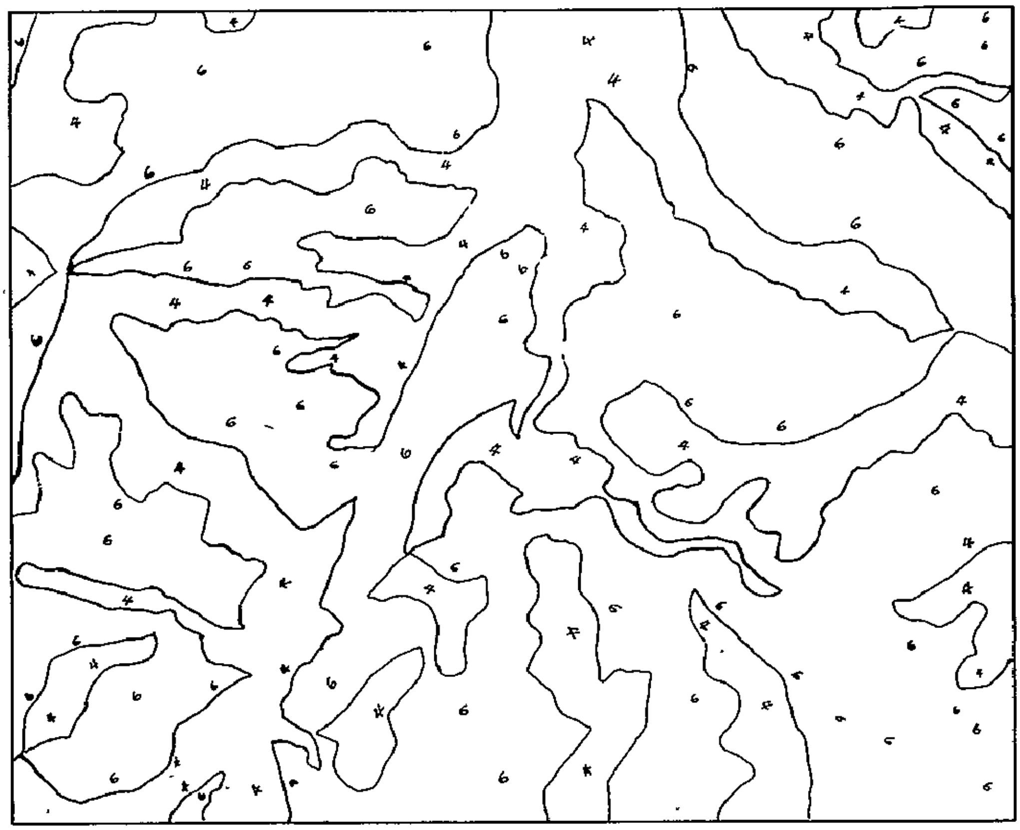
(a) Landform
- 00 – Flood plain
- 01 – Stream terrace
- 03 – Colluvial
- 04 – North aspect
- 07 – South aspect

Figure C1.– Soils resource map preparation.



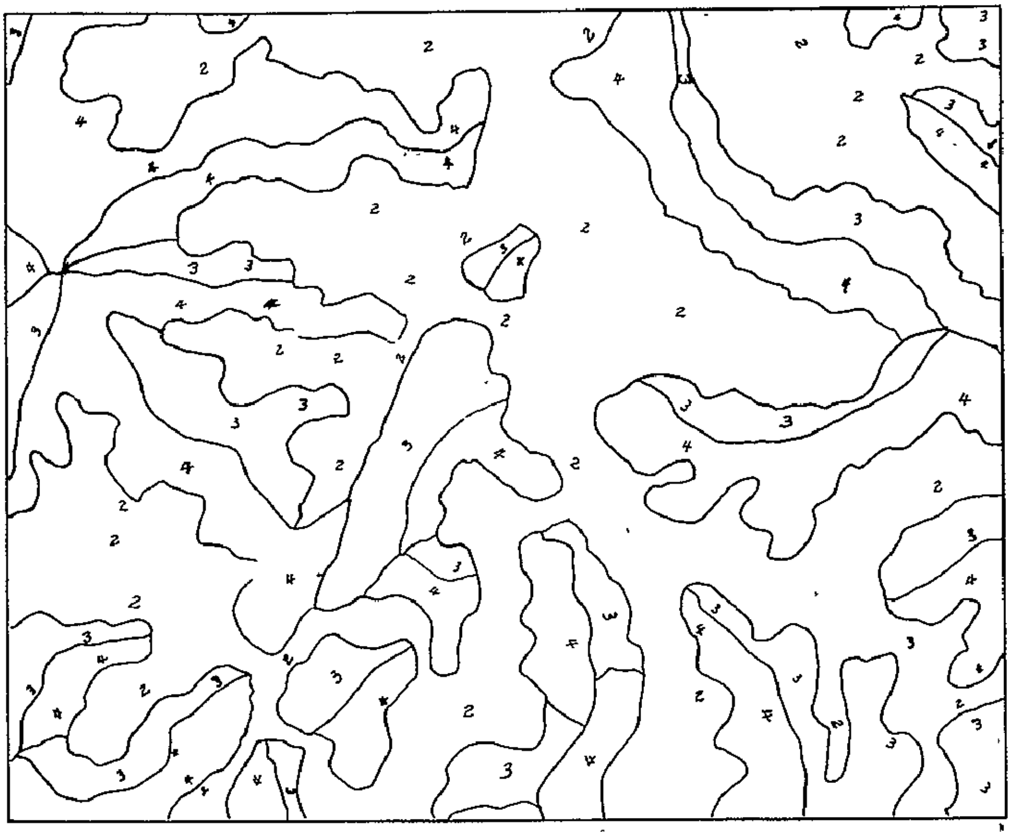
(b) Source of material
0 — Transported
5 — Dominantly gneiss

Figure C1.— Continued.



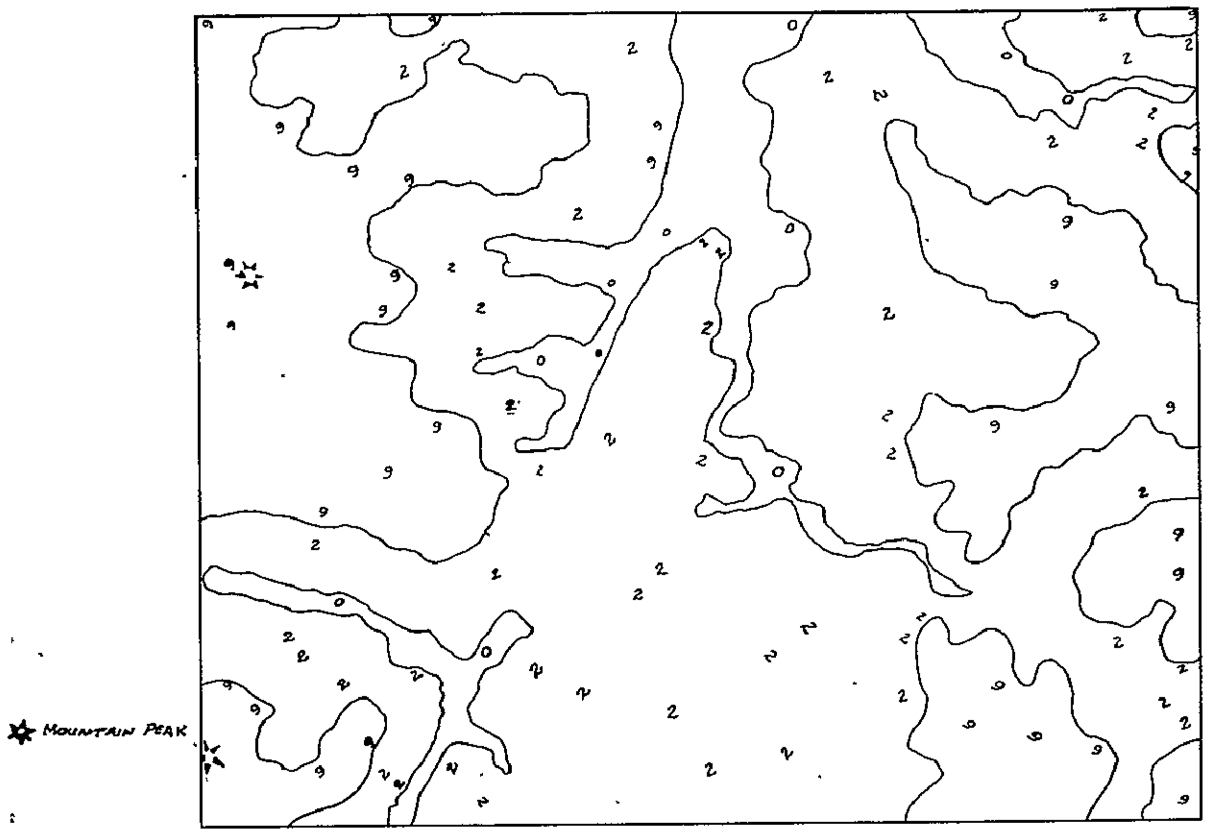
(c) Texture
4 — Loamy
6 — Medium

Figure C1.— Continued.



(d) Water regime
2 — Moist
3 — Dry
4 — Droughty

Figure C1.— Continued.



(e) Modifiers and special symbols
- 0 — None
- 2 — Steepness critical
- 9 — Steep, stony, uneven slope

Figure C1.— Concluded.

APPENDIX D

GLOSSARY

APPENDIX D

GLOSSARY

AERIAL PHOTOGRAPH: Any photograph taken from the air; sometimes called aerial photo or air photograph. (For convenience, this text presupposes all direct photographs as being vertical.)

AMS: Army Map Service; now referred to as the U.S. Army Topographic Command.

ANNOTATION: Any marking on illustrative material for the purpose of clarification; sometimes called delineation.

COLLUVIAL: Sediments consisting of alluvium in part and also containing angular fragments of the original rocks. Also talus and cliff debris.

CONTACT PRINT: A print made from a negative or a diapositive in direct contact with sensitized material.

CONTROL: A system of accurate measurements used to determine the distances and directions or differences in elevation between points on the Earth.

CONTROL, GEODETIC: Control which accounts for the size and shape of the Earth. Geodetic implies a reference spheroid representing the geoid, and horizontal and vertical control data.

CONTROL, HORIZONTAL: Control which determines horizontal positions only, with respect to parallels and meridians or to other lines of reference.

CONTROL, VERTICAL: Control which determines positions with respect to elevation.

COORDINATES, GEOGRAPHIC: A system of spherical coordinates for describing the positions of points on the Earth. The declinations and polar bearings in this system are the latitudes and the longitudes, respectively.

CCP: Conjugate Principal Point: The point on a photograph that corresponds to the Principal Point (PP) of an adjacent photograph.

COVE: Small areas of plain or valley that extend into mountains or plateaus. Cirque-like opening at the head of a small steep valley produced by erosion of shale below thick landstone.

DELINEATION: See ANNOTATION.

DICHOTOMOUS KEY: A key to classification based on a choice between two alternative characters.

EFFECTIVE AREA: For any aerial photograph that is one of a series in a flight strip; that central part of the photograph delimited by the bisectors of overlaps with adjacent photographs.

ENLARGEMENT: A negative, diapositive, or print made at a larger scale than the original.

EROS: Earth Resources Observation Systems.

FIDUCIAL MARKS: Index marks which are rigidly connected with the camera lens through the camera body and which form images on the negative. The marks are arranged so that the intersection of lines drawn between opposite fiducial marks defines the principal point.

FILM, INFRARED: Film carrying an emulsion especially sensitive to near infrared and blue light. Blue light is cut out by use of a deep red filter. It is used to photograph through haze because of the penetrating power of infrared light.

GLOSSY PRINT: Print made on photographic paper with a shiny surface. It will not take ordinary graphite markings.

IMAGE: The representation of an object produced by optical or chemical means, or both.

INDEX, PHOTO: An index map showing photographic coverage; made by arranging the individual photographs in their relative positions and photographing the montage at a reduced scale or by plotting photoframe coverage areas on a map or map overlay.

KEY, PHOTOINTERPRETATION: A device designed to aid in the rapid, accurate identification of an object and in judging its significance from the study of its photoimage.

LANDSAT: Unmanned earth resources satellite (Land Satellite).

LINE, FLIGHT: A line drawn on a map or chart to represent the track over which an aircraft has been flown or is to fly; the line connecting the principal points of vertical aerial photographs.

MAP, BASE: A map showing certain fundamental information; copies are used to compile additional specialized data.

MAP, SCALE: A map drawn to a particular ratio or proportion.

MAP, TOPOGRAPHIC: A map which presents the vertical and horizontal positions of features in measurable form.

MOSAIC: An assembly of overlapping aerial photographs whose edges have been matched to form a continuous photographic representation of a portion of the Earth's surface.

NASA: National Aeronautics and Space Administration.

NEAT MODEL: The portion of the gross overlap of a pair of photographs that is actually utilized in photogrammetric procedures. Generally, the neat model approximates a rectangle whose width equals the air base and whose length equals the width between flight lines (ref. 3).

NEGATIVE: A photographic image on film, plate, or paper in which the tones are reversed.

ORTHOPHOTO: A photographic copy in which image displacement caused by tilt and relief has been removed.

OVERLAP: The amount by which one photograph includes the same area covered by another (customarily expressed as percentage). Overlap between aerial photographs in the same flight is called "forward lap"; overlap between photographs in adjacent parallel flights is called "sidelap."

OVERLAY: (1) A transparent sheet giving information to supplement that shown on the underlying maps. When the overlay is laid over the map on which it is based, its details will supplement the map. (2) A tracing of selected details on a photograph, mosaic, or map to present the interpreted features and the pertinent detail.

PHOTOGRAMMETRY: The science or art of obtaining reliable measurements by means of photography.

PHOTOGRAPHIC ANALYSIS (Photo analysis): A general term used to describe the examination of photography for either photo-interpretation or photogrammetric purposes.

PHOTOGRAPHIC INTERPRETATION (Photointerpretation): The act of examining photographic images for the purpose of identifying objects and judging their significance.

POSITIVE TRANSPARENCY: A positive image on a transparent medium (usually film) which must be viewed by transmitted light.

PP: Principal Point: The foot of the perpendicular from the interior perspective center to the plane of the photograph. See FIDUCIAL MARKS.

PRINT, SEMIMATTE: A photographic print made on paper with a semidull finish.

PROJECTOR: An optical instrument which throws the image of a negative or print upon a viewing surface, usually at a larger scale.

RECTIFICATION: The process of converting a tilted or oblique photograph to the plane of the vertical by projecting it onto a horizontal reference plane, with the angular relationship determined by using control points recognizable on the photograph and by using an accurate map.

STEREOSCOPIC VISION (stereovision): That application of binocular vision which enables the observer to view an object simultaneously from two different perspectives to obtain the mental impression of a three-dimensional model.

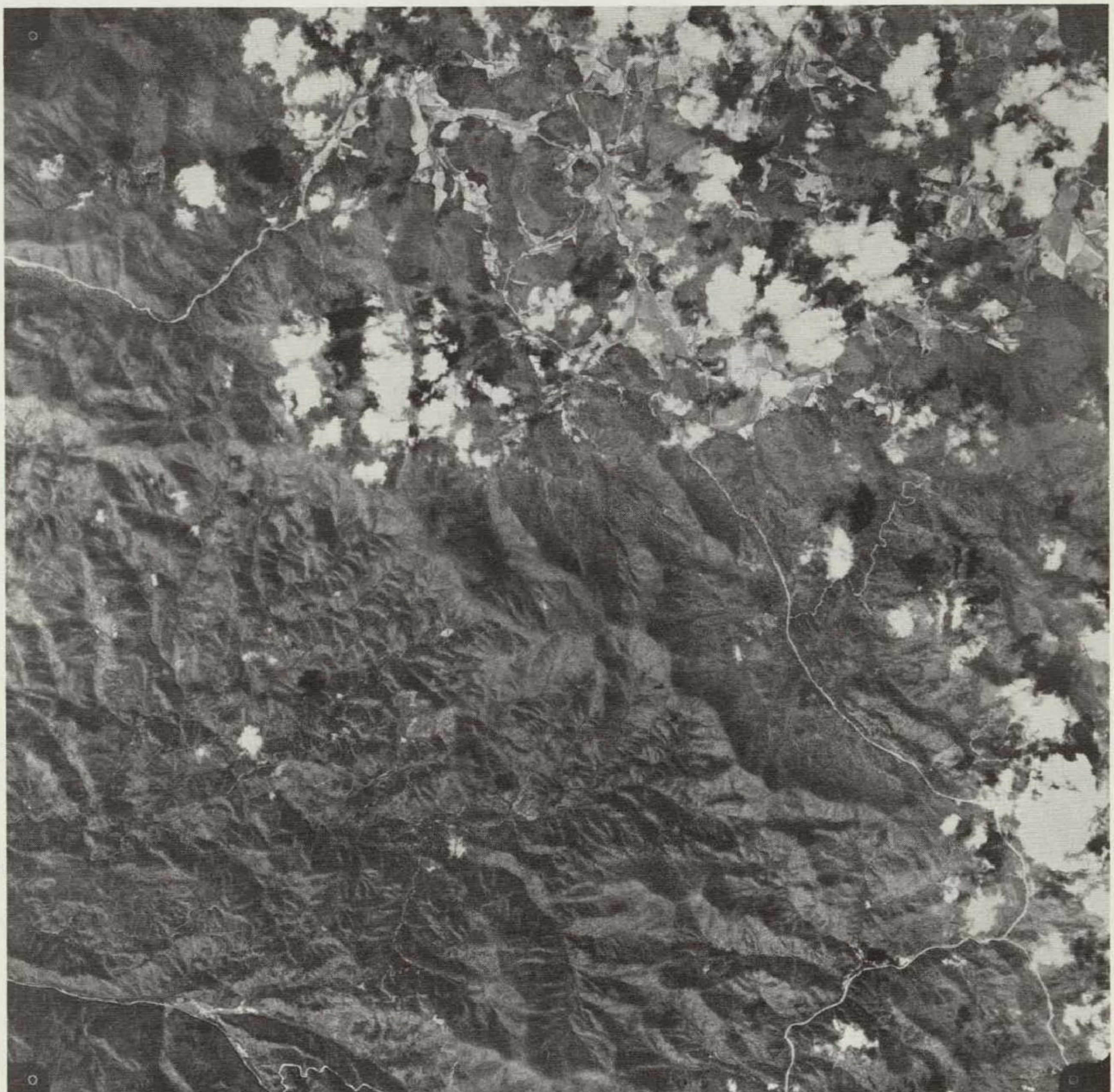
STEREOSCOPY: The science or art which deals with three-dimensional effects and the methods by which these effects are produced.

APPENDIX E

BLACK-AND-WHITE PRINT FROM COLOR INFRARED NEGATIVE

APPENDIX E

BLACK-AND-WHITE PRINT FROM COLOR INFRARED NEGATIVE



APPENDIX F

REFERENCÉS

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