E7.3 10306

CR-130718

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
3		

4. Title and Subtitle	5. Report Date
Identification, definition and mapping of terrestrial ecosystems in interior Alaska	February 28, 1973
	6. Performing Organization Code
7. Author(s): J. H. Anderson	8. Performing Organization Report No.
9. Performing Organization Name and Address: Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska 99701	10. Work Unit No.
	11. Contract or Grant No.: NAS 5-21833
12. Sponsoring Agency Name and Address: National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Maryland 20771, Technical Monitor: Edward C. Crump, Code 430	13. Type of Report and Period Covered: II and 8/1/72 - 1/31/73
	14. Sponsoring Agency Code

15. Supplementary Notes

One of 12 ERTS-1 Projects conducted by the University of Alaska
ERTS-1 Project GSFC No. 110-3
Principal Investigator GSFC ID No. UN 592

16. Abstract

The overall objective of the project is to identify and analyze vegetation types in as great of detail as possible on ERTS imagery and to classify and delineate them through mapping. The chief objective during the reporting period was to develop an analytical and interpretive capability for meeting the overall objective.

ERTS and NASA aircraft imagery for 12 test areas was received, surveyed and filed. A vegetation analysis and mapping exercise was conducted with an MSS scene of the western Seward Peninsula, and a spruce beetle infestation study of the Cook Inlet area is under way. Intensive analysis of imagery covering three test areas in interior Alaska was begun. Analytical procedures include study of photographic products, color-key images, color additive viewer displays and digital CRT displays. A comprehensive revised data handling plan was prepared for the rest of the project.

Major conclusions are (a) the ERTS system is useful as a tool for regional vegetation studies, (b) ERTS imagery resolution is adequate for meeting certain primary objectives in vegetation research, including the definition and delineation of major vegetation types and analysis of certain vegetation-environment relationships, (c) the ERTS system should permit detailed vegetation and ecosystem mapping of the State and (d) the U of A ERTS program is beginning to serve as a source of vegetation information for resource managers and land-use planners.

17. Key Words (Selected by Author(s))	18. Distribution Statement
ERTS imagery Remote Sensing Alaskan environment Vegetation Plant ecology	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
unclassified	unclassified	26	$3.50

26

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INTRODUCTION

This report summarizes work performed and conclusions reached during the first six months (August 1 through January 31) of contract no. NAS5-21833, ERTS-1 Project 110-3, Identification, definition and mapping of terrestrial ecosystems in interior Alaska.

A variety of preparatory activities involving obtaining imagery and development of interpretive capabilities have been conducted and one early study has been completed and another is under way. In July the principal investigator accompanied two NASA-Houston aerial photography flights in the NP3-A aircraft. Aerial photographs arrived in September, and these were all surveyed and filed, and some frames were cut out for stereoscopic viewing. ERTS imagery began arriving in August, and scenes obtained through November 5 have now been received. All imagery was surveyed and filed systematically, and several scenes were selected for intensive analysis. Using one of the earliest ERTS multispectral scanner scenes, No. 1009-22095, a vegetation analysis and mapping exercise was conducted for the western Seward Peninsula. A spruce beetle infestation study is currently under way in the Cook Inlet area of Alaska. Both of these studies are summarized in this report. These various preparatory and research activities led to the development of a comprehensive revised data handling plan which was recently submitted to NASA and which is summarized in this report. Another activity during the reporting period, which did not involve project time, was the preparation of an ERTS-B proposal titled Application of ERTS-B imagery to the analysis, classification and mapping of Alaskan vegetation.

Work during the reporting period is the basis of the following general conclusions: (1) The ERTS system is and should continue to be highly valuable as a means of conducting broad scale, regional studies of Alaskan vegetation. (2) The resolution of ERTS imagery (specifically MSS imagery) is sufficient for meeting certain primary objectives in vegetation research, including the identification and delineation of major vegetation types, determination of the distribution and areal importance of these types and analysis of certain vegetation-environment relationships. (3) The ERTS system should ultimately permit mapping of the entire state in considerably more detail than has been possible to date. (4) Because of these capabilities, the University of Alaska ERTS program (emphasizing here the vegetation research aspects) is beginning to serve as a key source of information for resource managers and land use planners in several federal, state and local government agencies, and the prospects for an increasing and continuing role in this area are very significant.

STATUS OF PROJECT

A. Objectives

The overall objective of the project is to identify and analyze vegetation types in as great of detail as possible on ERTS imagery and to classify and delineate them through mapping. It is believed that thorough pursuit of this objective would effectively lead to meeting the four objectives set forth in the original proposal, which are:

(1) development of a capacity for the identification and delineation of interior Alaskan ecosystems on ERTS-A imagery through correlation of spectral signatures with vegetation, landform units and other ecosystem components represented in the test areas

(2) development of a capacity for the recognition of diagnostic features useful in defining interior Alaskan ecosystems, including vegetation structure and composition and time of onset of plant growth, leaf development and cessation of growth (phenology)

(3) development of a capacity for producing a map of interior Alaska showing the areal distribution and extent of ecosystem types represented in the test areas using ERTS-1 data covering the rest of the region

(4) Secondarily, the evaluation of the usefulness of ERTS-1 imagery for determining certain parameters and biological processes in ecosystems is of interest. Parameters to be considered will include (a) moisture conditions in the vegetation and soil, (b) nutritional status of the vegetation, (c) effects on vegetation and soil of disturbances resulting from construction activities, fire, disease and overgrazing, (d) standing crop biomass and (e) climatological factors, including, at least, snow cover. Biological process determinations for which the usefulness of ERTS-1 imagery will be studied include (a) primary productivity and (b) recovery from disturbance and short-term plant succession.

Regarding the ecosystem orientation of these original objectives, it is emphasized that the vegetation type or plant community is considered the basis of recognition of the ecosystem.

The primary objective during the reporting period has been to develop a capability for meeting the overall objective through the analysis of selected imagery using several procedures comparatively. As it has turned out, one completed vegetation analysis and mapping project has been completed (Anderson and Belon 1973) and a forest beetle infestation study is under way (Weber et al 1973).

B. Accomplishments during the reporting period.

1. Preliminary investigations.

a. ERTS imagery.

The first ERTS imagery was received in late August, and early inspection showed resolution and quality to be excellent. Imagery for the period August 1 through November 5 is now at hand. A request has been submitted for imagery obtained prior to August 1. The latter is considered especially important because of a general high incidence of cloud cover, resulting in only a few usable scenes of the test areas. Of nine areas north of the Alaska Range, adequate imagery for at least one date during the snow-free season is available for only three. It is hoped that coverage of the rest of the areas, with some repetition on different dates, will be obtained during the 1973 season.

The early shutdown of the RBV system was somewhat disappointing at first. However, it soon became apparent that MSS imagery would be adequate for meeting project objectives. It has been decided that should RBV imagery again become available, only a few select scenes will be requested by retrospective order for comparison purposes.

Until recently examination of ERTS imagery was necessarily limited to direct visual examination of photographic products. Considerable delays were incurred in the construction of the color additive viewer and receipt of components for the digital data color display unit. To date the principal investigator has relied on intensive examination of the MSS 9-1/2 inch bulk black and white prints received from NASA and reconstituted simulated color-infrared photographic prints and color-key images produced by U of A ERTS-1 Project 110-1.

b. Aerial photography.

Aerial photography was obtained by NASA-Houston in support of the project in July 1972, at the time of launching of ERTS-1. Most of the photography requested was accomplished. In addition, low level flights were conducted along two flight lines at the request of the principal investigator during the mission. The principal investigator accompanied two of the flights.

Processed photographs arrived in September. These were examined and found of excellent quality except for a few frames which were over- or under-exposed, presumably because of temporary camera maladjustment. Such frames were not enough to constitute an important gap in the adequacy of coverage. One major disappointment was the loss of a few frames of low level, large scale photography of a key ground truth site, the Eagle Summit Research Area, due to local cloudiness. The regular, higher altitude photography of this area, as of the other areas, is of excellent quality.

Many frames covering areas of immediate interest were cut from the film rolls for stereoscopic viewing and filed separately. A Dietzgen stereoscope, with magnifying eye pieces, and a light table were purchased with project funds for this purpose. It is intended eventually to cut out all frames and file them individually for convenient access during study of ERTS images.

c. Ground truth activities.

Because of uncertainty until later in the summer season as to when ERTS project funding would actually begin, no program of field activities specifically for obtaining ERTS ground truth data could be undertaken. However, work on an ongoing separate project involving vegetation studies in the Eagle Summit Research Area, which is a within-test area ERTS intensive training site, yielded data which should be useful in this regard. These data are for the detailed characterization of vegetation types occurring here and the analysis of vegetation-environment relationships. Computer processing and analysis and interpretation of these data are currently under way.

It is noted that field studies by the principal investigator and his colleagues in other years in other areas which have been selected as ERTS test areas have yielded similar first-hand data. This is particularly the case with the Bonanza Creek Experimental Forest near Fairbanks and the Wiseman area on the south flank of the Brooks Range.

A summer program of field studies specifically oriented toward the ERTS project is being designed for the 1973 season. The precise locations to visit and the nature of observations to be made are being determined on the basis of questions which arise in working with the spacecraft and aircraft imagery.

2. Applicability of ERTS-1 imagery to project objectives.

ERTS-1 imagery will permit the identification, delineation and mapping of major vegetation types. This has been shown through the use of scene 1009-22095 of the western Seward Peninsula, in reconstituted simulated color-infrared format, whereupon seven broadly defined vegetation types have been identified and mapped (see below). It is believed that air photo or field studies, designed on the basis of the ERTS image study, would permit the identification of several more types. Anderson et al (1972) identified four major vegetation types and associated geologic materials and permafrost distribution patterns on scene 1003-21355 covering an area in northwestern Alaska. Studies of scenes 1049-20505 and 1103-20513, covering the Cook Inlet area, show promise for distinguishing healthy spruce vegetation from that affected by the spruce beetle (Weber et al 1973). The principal investigator has selected for intensive analysis in the near future scenes 1017-21115, 1029-20381 and 1033-21011 covering, respectively, the Wiseman, Steese Highway-Eagle Summit and Fairbanks-Bonanza Creek Experimental Forest test areas in interior Alaska. The black and white prints and a color-key image of these scenes permit the discerning of major vegetation types as previously determined through field studies. It is expected that study of enlarged simulated color-infrared prints, now being prepared, and digital data CRT displays will enable the differentiation of somewhat more narrowly defined vegetation types and the discerning of greater detail in their spatial distribution.

The NASA aerial photography is essential for interpretation of the ERTS imagery in most areas. Actual field observations of the principal investigator are limited relative to the size of Alaska, or even of the test areas, and the diversity of vegetation types. Use of the air photography is therefore a matter of economy, particularly in the context of the multistage sampling procedure adopted by this project. In most cases vegetation types and some habitat factors, such as slope, aspect and general soil moisture status, can be determined directly from the aerial photography. The natural color and color-infrared photographs have been used more than the multispectral black and white photographs and infrared scanner imagery to date. Where there is uncertainty in interpretation of aerial photography, field observations will be made.

Work during the report period has led to the preparation of a comprehensive data analysis plan for the remainder of the project which has been submitted separately. The rest of this section comprises a summary of this plan, which is illustrated in Figure 1.

MSS imagery will continue to be obtained from NASA via ERTS-1 Project 110-1. A standing order for bulk 9-1/2 inch black and white paper prints and corresponding bulk 70 mm positive and negative transparencies is in effect. Restrospective data requests will be submitted later for a few reconstituted color 9-1/2 inch transparencies, 9-1/2 inch black and white positive transparencies, computer compatible digital tapes and possibly some RBV imagery.

The initial activity upon receipt of imagery is examination and screening of the black and white prints, aided by a good light, a magnifying glass and reference to maps. This is for locating test areas and other areas of interest and for determining the extent to which information may be derived in this fashion. In some cases MSS and RBV scenes in all bands may be compared for determining relative information content.

Black and white enlargements will be made from the negative transparencies for selected scenes for which especially high quality imagery is available. This will be done in such a way as to increase contrasts or otherwise to enhance the imagery to emphasize vegetation features. Recent work by U of A ERTS-1 Project 110-1 personnel indicates the potential of this approach.

Color-key images are being prepared using 9-1/2 inch positive transparencies. These are examined for vegetation types and related environmental

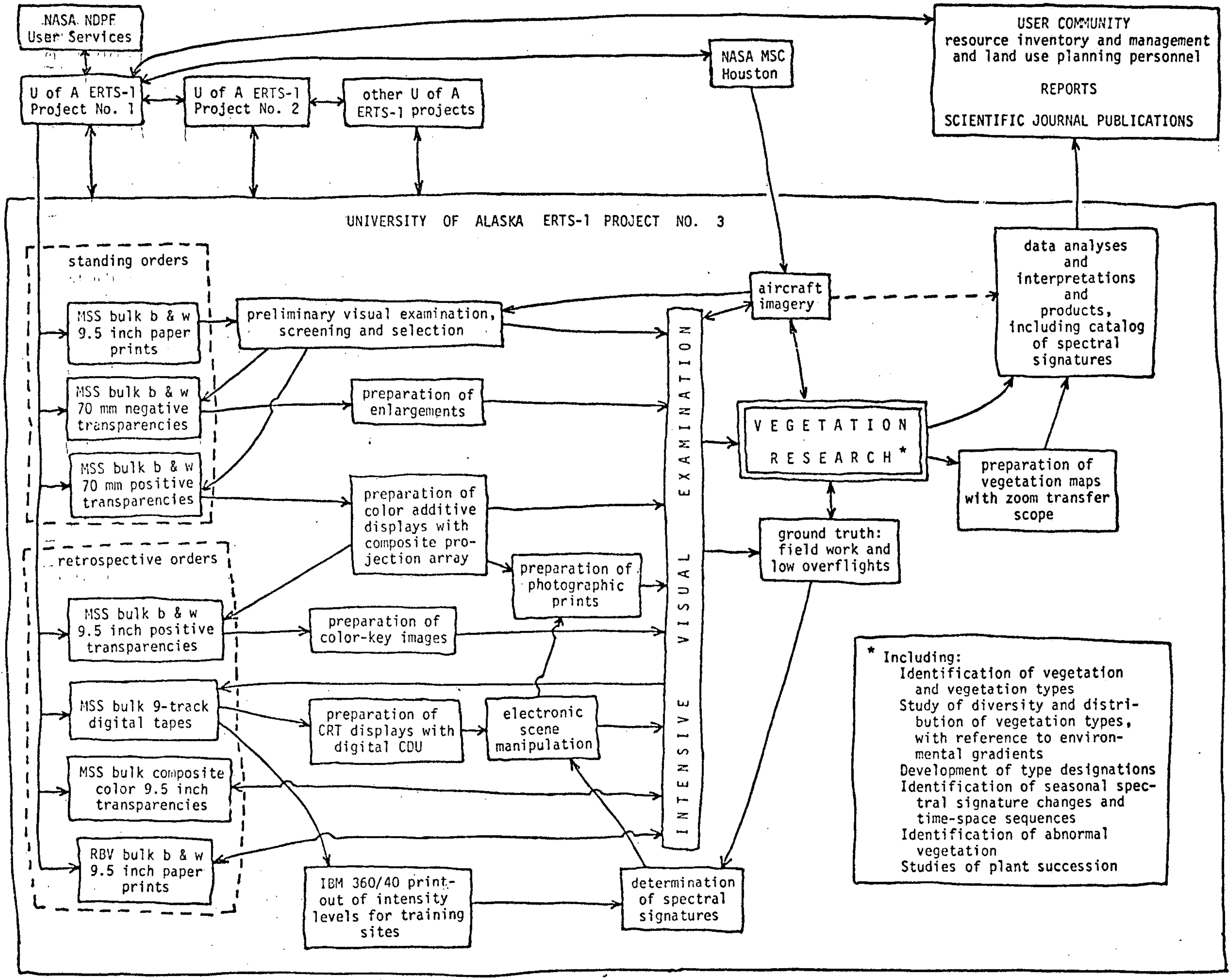

Figure 1. Data flow chart for University of Alaska ERTS-1 Project 110-3.

features. The four screens constituting these images are examined individually and in various combinations to determine what information is available. It is proposed that most color-key images continue to be made from MSS products, with a few made from RBV products for comparative purposes if these become available again.

Positive transparencies in the 70 mm format will be mounted in the composite projection array for color additive viewing. The image produced in this manner will be compared with the black and white products and the digital CDU-200 scenes. The magnification provided by the color additive viewing system and the variety of possible filter combinations will be used for experimentation with color balance. The results of this will be given primary consideration in preparing orders for color-key images.

MSS digital tapes will be requested for the intensive training sites in cases that the probability of particularly good data is judged high. These will be converted to CDU-compatible digital tapes on the University of Alaska IBM 360/40 computer. Tapes already obtained by U of A ERTS-1 Project 110-2 are being used for test areas 1-3 south of the Alaska Range. CDU work will include color coding and false color displays, interchannel ratio studies, maximum likelihood analyses and detection of changes in image spectral characteristics with time.

Aerial photography obtained from NASA and other sources is being consulted for identification of objects included in the scenes prepared by these various methods. Shape, relative size and pattern are chief attributes permitting direct comparisons of spacecraft and aircraft imagery. According to the multistage sampling procedure, reference to aerial photography is made only after initial attempts directly to identify objects on the spacecraft imagery have been made.

Available ground truth information, chiefly that in the literature, on existing small scale vegetation maps and in field books of the principal investigator, is being consulted. A schedule of test area and training site visits for low overflights in light aircraft and on-the-ground observations is being developed for the 1973 field season. This is being done only as the spacecraft imagery and aerial photography are studied and areas needing visitation are identified.

Vegetation maps are being drawn by tracing on acetate overlays of ERTS images, enlarged to appropriate scales. A reconstituted, simulated color-infrared scene in the 9-1/2 inch format has already been used for this purpose in a study of vegetation on the western Seward Peninsula. It is hoped that a Bausch and Lomb zoom transfer scope will be obtained later for use in preparing larger scale and more detailed and accurate vegetation maps, in most cases using U.S. Geological Survey 1:250,000 topographic sheets as base maps. The information content of the master image selected for mapping is thoroughly established prior to the start of mapping, and interpretations during mapping are supported by reference to images in other formats, including CDU-200 displays.

The feasibility of automatically producing vegetation maps from digital data by computer plotting will be examined in cooperation with the investigators on Project 110-2 who intend to attempt a large amount of computer mapping. This will involve (i) reconciliation of computer plotting technology with the possibly numerous vegetation types which may be recognized, (ii) preparation of a program whereby boundaries between types or through transitional vegetation could be properly positioned, (iii) attempts to adjust computer plots, or to transfer information from them, to appropriate base maps and (iv) evaluation of the cost effectiveness of this type of map relative to types prepared by regular methods.

A few lantern slides are being made in the interest of illustrating results of the research in the lecture room.

3. Results.

a. Summary report on an early project activity dealing with the study and mapping of vegetation on the western Seward Peninsula (see Anderson and Belon 1973).

Background and definition of problem

One of the most urgent needs in Alaska today is a capability for environmental surveys and resource inventories on a scale suitable for regional land-use planning. This need is presently confronting many state and federal agencies concerned with resource management and it has led to the establishment by act of Congress through the Native Land Claims Settlement Act of 1971 of the Federal-State Land-Use Planning Commission.

Alaska is so vast and the arctic-subarctic environment so varied that the required surveys cannot be obtained in an adequate, timely and cost effective manner by conventional means. The Earth Resources Technology Satellite, with its capabilities for rapid and economical surveys can assist greatly in this task. This potential would be further enhanced if it could be demonstrated that a resource specialist equipped with ERTS imagery and limited ground truth data, but otherwise unaided by sophisticated equipment and techniques, could produce regional environmental surveys and resource inventories with the required spatial resolution and accuracy.

Vegetation is a primary component of most landscapes and ecosystems and is one of the most important land resources. Knowledge of the composition, structure, distribution and environmental relationships of vegetation or vegetation types is therefore a key requisite in approaching land resource problems. In Alaska vegetation knowledge is sparse. The ERTS-1 project of which the activity reported here is a part is designed to develop imagery interpretation capabilities, to increase vegetation knowledge and thus to contribute to the handling of land resource problems.

It was decided that in the early stages of the project, prior to the availability of analytical equipment, an exercise would be conducted with one of the first ERTS images to determine the extent to which interpretations could be made by direct visual examination. In view of the fact that minimial ground truth may be available to some users, it was decided to use in this exercise only that information most readily available. In addition, it was believed that vegetation mapping should be limited to tracing directly from the image in an attempt further to establish the usefulness of ERTS imagery to the relatively unequipped user.

Approach

An ERTS multispectral scanner scene of the western Seward Peninsula, No. 1009-22095, obtained August 1, 1972, was selected for vegetation study. The format used was a reconstituted, simulated color-infrared photographic print prepared from bands 4, 5 and 7. Ground truth was limited to reference to the four existing published vegetation maps and the few pieces of literature (see references) and fire records of the U.S. Bureau of Land Management. Interpretations were based on the following assumptions: (1) Most of the western Seward Peninsula is covered by vegetation and this is therefore chiefly responsible for the spectral reflectance registered on the image. (2) Different vegetation types have different spectral characteristics, and color, color intensity and textural patterns on the image therefore depict different vegetation types and their distribution. (3) Positive identification of spectral signatures according to vegetation type depends on one or more of the following forms of ground truth: aerial photography; field observations, including low overflights in light aircraft; and information in the literature, including vegetation maps. (4) The resolution of ERTS imagery permits definition of vegetation types at a level useful for the plant ecological and resource analysis questions addressed.

Results

Seven distinct colors were recognized on the image. Four were identified through matching of their general distribution patterns with those of vegetation types on the existing maps: Bright red - shrub thicket; light gray-red - upland tundra; medium gray-red - wet tundra; gray - alpine barrens. In the bright red color two phases, violet and orange, were recognized and tentatively ascribed to differences in species composition in the shrub thicket type. Significantly more detail in the distribution of these types, particularly of small units or stands, could be seen on the image than could feasibly have been depicted on the maps at the scales used. Some of this detail is shown on the new map presented here, which was drawn at the same scale as the image (Fig. 2). The three colors having no map unit equivalents were tentatively interpreted through reference to the literature and general plant ecological knowledge as follows: Pink - grassland tundra; dark gray-red - burn scars; light orange-red - senescent

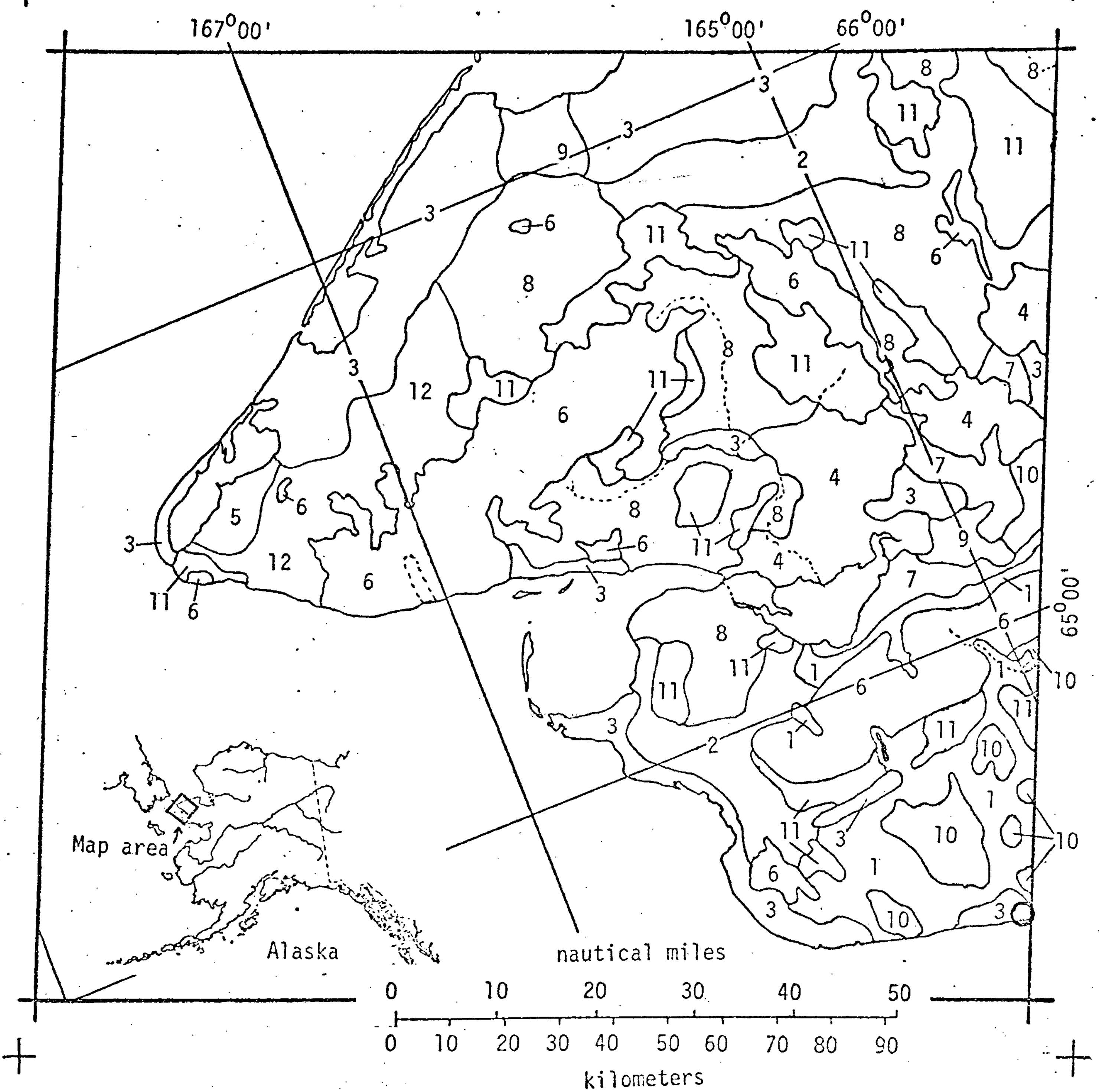

Figure 2. Vegetation map of the western Seward Peninsula, Alaska

Traced from an ERTS-1 image

1. Shrub thicket
2. Upland tundra
3. Wet tundra
4. Fire scar
5. Senescent vegetation (?)
6. Alpine barrens
7. Grassland tundra (?)
8. Shrub thicket/Upland tundra mosaic
9. Shrub thicket/Wet tundra mosaic
10. Shrub thicket/Alpine barrens mosaic
11. Shrub thicket/Upland tundra/Alpine barrens mosaic
12. Upland tundra with some senescent vegetation

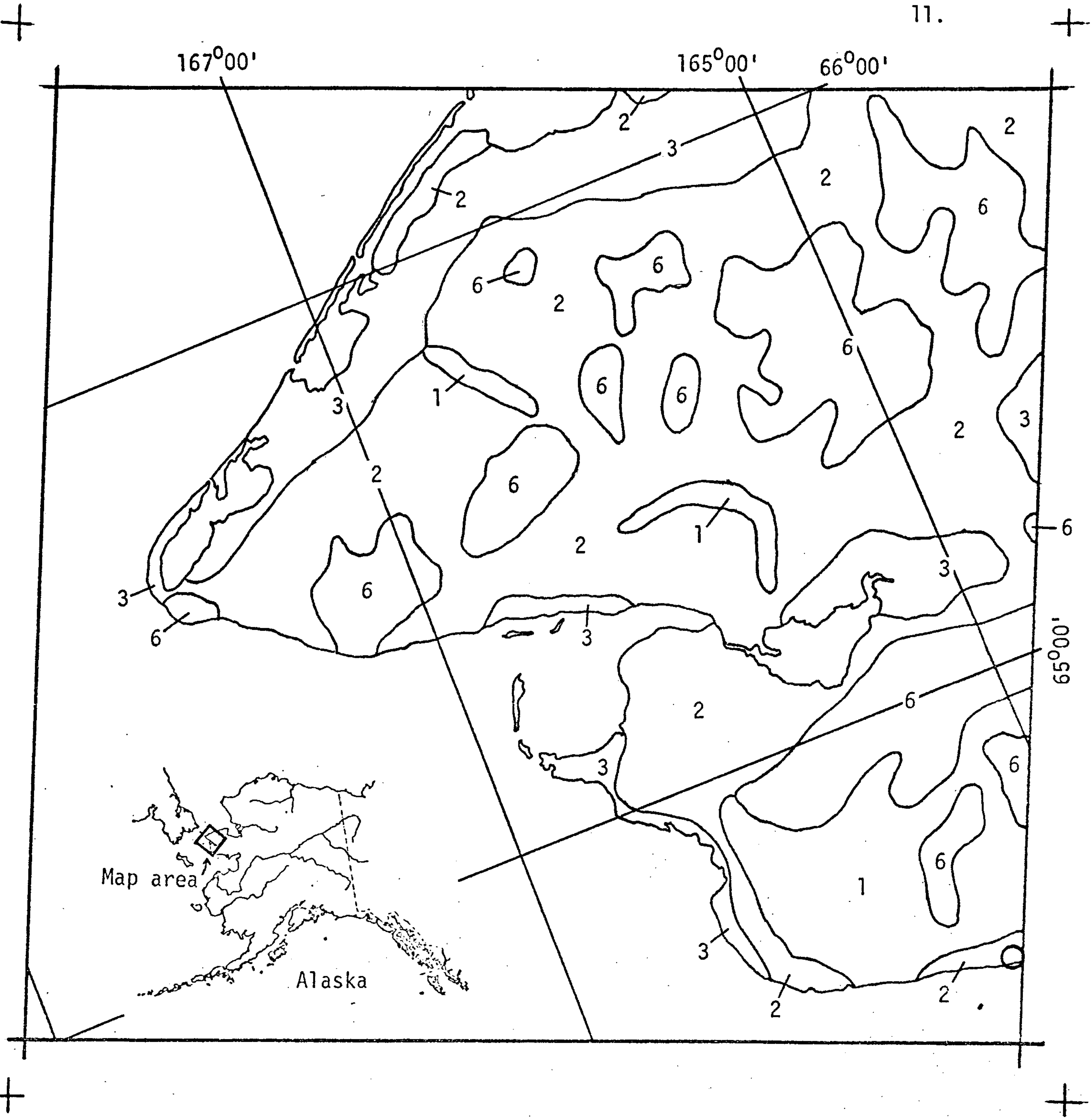

Figure 3. Vegetation map of the western Seward Peninsula traced and enlarged from Spetzman's (1963) map of Alaskan vegetation. This is provided for comparison with Figure 3. The map units designated by Spetzman and their approximate equivalents as termed in this paper are: 1. High brush - Shrub thicket; 2. Moist tundra - Upland tundra; 3. Wet tundra and coastal marsh - Wet tundra; 6. Barren and sparse dry tundra - Alpine barrens.

vegetation. The interpretation of dark gray-red as indicating areas of former vegetation fires was subsequently confirmed by records of the U.S. Bureau of Land Management.

Figure 2 is the new vegetation map of the western Seward Peninsula, drawn by tracing on an acetate overlay of the image. Besides the seven colors discussed above, five additional map units are shown. These represent mosaics of color units too small feasibly to map individually at the scale of the unenlarged ERTS image. Figure 3 is a tracing of part of an existing vegetation map (Spetzman 1963), enlarged to the same scale, which may be compared with the new map to emphasize the increase in mappable information derived from the image. The new map required only about ten man-hours to draw and label. It is believed that considerably more detailed and accurate maps than this one will be possible using the various image enhancement and digital data processing techniques which are becoming possible with ERTS imagery.

Besides the promise this exercise shows for delineating and mapping vegetation types with ERTS imagery, promise is also shown for surveying phenological developments and vegetation fires using sequential imagery.

Practical applicability

Knowledge of the distribution and relative areal importance of vegetation types, particularly as shown on the new map, may be applicable in the areas listed below. In each case the capability of the ERTS system for broad geographic or synoptic coverage is of primary importance.

1) Geology. Geomorphic features and bedrock types may be interpreted on the basis of known vegetation relationships. Permafrost distribution may be studied on the same basis.

2) Hydrology. Stream patterns may be examined through the recognition of riparian vegetation types, i.e. the shrub thicket type in part, and areas of poor drainage or standing water and of excessive drainage may be recognized, at least in a general way, from the occurrence of certain vegetation types.

3) Soil science. The close relationship between soil and vegetation development could permit study of the distribution of soil types through examination of the vegetation map.

4) Plant ecology. Besides the immediate scientific, plant ecological interest of the knowledge resulting from this exercise, a basis for further study of relationships between vegetation and environmental factors is provided.

5) Meteorology. Vegetation is responsive to meteorological and climatological conditions. Therefore study of the image and the map from this standpoint could provide an indication of conditions over broad and more or less remote areas where no weather stations are located.

6) Wildlife biology and management. Study of the distribution of vegetation types is essentially a study of the availability and distribution of habitat and food materials for wildlife. Knowledge of species preferences could enable an analysis of the distribution of animal populations and to some extent the estimation of their abundance. Insight into the nature of migration patterns may also be obtained, particularly through the study of sequential imagery and the determination of a vegetation phenology schedule.

7) Land-use planning. A land-use planning team could use knowledge of the presence and distribution of vegetation types (a) to help in locating areas containing representative ecosystems for preservation, (b) for identifying and delineating, for example, caribou (upland tundra), moose (shrub thicket) and waterfowl (wet tundra) ranges and determining areas to be managed primarily for sustaining populations of these animals, (c) for delineating areas suitable for certain recreational activities, including mechanized and non-mechanized forms, (d) for delineating areas with agricultural potential which might be opened to homesteading, or areas supporting substantial populations of fur bearers which should be managed to include trapping, and (e) similarly, for identifying and delineating areas for use in meeting various other human needs or desires.

Users

The main report on this work (Anderson and Belon 1973) was requested by and delivered to Mr. John L. Hall of the Alaska Land Use Planning Commission and Mr. Enzo Becia of the Alaska Department of Natural Resources. The report is available at the University of Alaska to any other inquirers and soon will be avilable from the U.S. National Technical Information Service.

b. Study of areas of spruce beetle infestation in the Cook Inlet area (see Weber et al 1973).

Background and definition of problem

Aerial surveys conducted during the past three summers by the U.S. Forest Service have permitted identification of a severe spruce beetle infestation in an approximately 200,000 acre region west of Cook Inlet near the Tyonek Indian Reservation and in additional areas in the Kenai Moose Range and on adjacent state and private lands east of Cook Inlet. An estimated two billion board feet of white spruce has been killed or damaged by the spruce beetle, but the large areal extent of the spreading infestation presents a difficult task in maintaining surveillance of the extent of affected trees.

Approach

Techniques are being developed for mapping three major categories or degrees of spruce stand beetle damage: (a) non-stressed stands, (b) newly infested stands where there is severe bark damage but normal spruce needle turgor and (c) older infested stands wherein there has been almost a total kill of the medium sized and larger spruce. ERTS scenes 1049-20505 and 1103-20513 have been selected and are being studied in black and white print and color-key image formats. The senior author has digitized one scene at the U.S. Forest Service Remote Sensing Laboratory in Berkeley, California, and is proceding with an electronic-numerical analysis there. Digital tapes of these scenes have been ordered from NASA and will be used on the U of A CDU-200 equipment. NASA aerial photography was not obtained for the region of heaviest infestation, lying west of Cook Inlet. However, ground truth in the form of hand-held color and color-infrared photography has been provided by U.S. Forest Service personnel.

Results

This study is still under way. The findings to date, however, show promise for a capability for regionally surveying and monitoring spruce beetle infestation, at least in the more advanced stages, with the ERTS system.

It is clear that the spectral characteristics of trees bearing dead foliage are considerably altered and that the presence of such trees in a stand at some minimum density will cause that stand to be distinguishable on ERTS imagery from others containing chiefly healthy trees. On the color-key image of one of the scenes, obtained in November, there is a large area of distinct color and intensity which matches very closely the area of major infestation as plotted on a map from field studies. On an earlier scene, obtained in September prior to leaf fall, the spectral signature for this area is somewhat different, although the match in shape is still close. It is hypothesized (a) that the area is indeed uniquely apparent on the ERTS scene as one of more or less heavy spruce beetle infestation, (b) that the forest in this area contains in many places a major admixture of deciduous species and (c) that the overall color change may be explained on a phenologic basis. This hypothesis will be tested by further visual studies of the materials at hand, but possibly more conclusively through the use of digital data which will permit quantitative spectrophotometric measurements and comparisons with areas of spruce and spruce-deciduous forest known to be unaffected.

PLANS FOR THE NEXT REPORTING PERIOD

Activities planned for the next reporting period, February 1 through July 31, 1973, are outlined:

1. Intensive analysis of scenes 1033-21011 (Fairbanks-Bonanza Creek Experimental Forest test area), 1029-20381 (Steese Highway-Eagle Summit test area) and 1017-21115 (Wiseman test area).

a. Direct visual examination of bulk black and white prints.

b. Production and study of false color displays with color additive viewer and experimentation with color balance for image enhancement.

c. Preparation and study of color-key images.

d. Preparation, including enlargement, and study of simulated color-infrared images.

e. Ordering of digital tapes covering intensive training sites in these test areas; production of CDU-compatible tapes; production and study of images on CRT unit, including electronic manipulations for image enhancement.

2. Preparation of vegetation maps for these test areas.

3. Preparation of computer produced vegetation maps of intensive training sites for comparison with maps drawn by hand.

4. Analysis of feasibility of automated vegetation mapping over entire test areas and much larger portions of Alaska.

5. Study of additional 1972 imagery covering parts of these test areas.

6. Selection of early summer 1973 imagery, if any, covering the Mt. McKinley National Park test area and at least one area on the North Slope.

7. Initial analyses of these images by the methods listed under 1, above.

8. Preparation of schedule of test area visits and observations for obtaining ground truth data; pursuit of the first two months of this work.

9. Selection and hiring of one student assistant for the summer, primarily for ground truth activities.

10. Consultation with colleagues on companion project 110-2 on activities in test areas 1, 2 and 3 in two or three all-day work sessions in Palmer and Fairbanks.

11. In conjunction with 10, consultation with Mr. Sam Rieger of the U.S. Soil Conservation Service on soil-vegetation relationships.

12. Preparation of interim scientific reports, similar to the one on the western Seward Peninsula study (Anderson and Belon 1973), dealing with work on the three test areas mentioned in 1, above.

CONCLUSIONS

Conclusions based on work during the reporting period are limited to the following general statements at this time: (1) The ERTS system is and should continue to be highly valuable as a means of conducting broad scale, regional studies of Alaskan vegetation. (2) The resolution of ERTS imagery (specifically MSS imagery) is sufficient for meeting certain primary objectives in vegetation research, including the identification and delineation of major vegetation types, determination of the distribution and areal importances of these types and analyses of certain vegetation-environment relationships. (3) The ERTS system is a feasible vegetation and ecosystem mapping tool and should ultimately permit mapping of the entire state in considerably more detail than has been possible to date. (4) Because of these capabilities, the University of Alaska ERTS program (emphasizing here the vegetation research aspects) is beginning to serve as a key source of information for resource managers and land use planners in several federal, state and local government agencies, and the prospects for an increasing and continuing role in this area are very signficiant.

PUBLICATIONS

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Weber, F. P., R. C. Beckwith, J. H. Anderson, J. M. Miller and E. E. Becia. 1973. A survey of spruce beetle infestations in the Cook Inlet Basin, Alaska, using ERTS-1 imagery. Paper to be presented at the NASA/GSFC ERTS-1 Symposium, March 5-9, 1973.

APPENDICES

Third Bi-Monthly Progress Report

University of Alaska
ERTS Project 110-3

January 31, 1973

APPENDIX A - Change in Standing Order Forms

None.

APPENDIX B - ERTS Data Request Forms

See following.

Removed from document.
Illegible

APPENDIX C - ERTS Image Descriptor Forms

See following.

ERTS IMAGE DESCRIPTOR FORM

(See Instructions on Back)

NDPF USE ONLY
D ______
N ______
ID ______

DATE February 28, 1973

PRINCIPAL INVESTIGATOR J. H. Anderson

GSFC UN 592

ORGANIZATION Inst. Arctic Biology, University of Alaska

PRODUCT ID (INCLUDE BAND AND PRODUCT)	FREQUENTLY USED DESCRIPTORS*			DESCRIPTORS
1017-2115, 4,5,6,7 bulk b&w prints & transparencies 1029-20381, 4,5,6,7 bulk b&w prints & transparencies 1033-21011, 4,5,6,7 bulk b&w prints & transparencies				Aerial imagery used Braided stream Brush Conifer Deciduous Forest Ground truth used Hardwood forest Highway Lake Mature vegetation Meander Muskeg River Timberline Tundra Urban area Vegetation

*FOR DESCRIPTORS WHICH WILL OCCUR FREQUENTLY, WRITE THE DESCRIPTOR TERMS IN THESE COLUMN HEADING SPACES NOW AND USE A CHECK (✓) MARK IN THE APPROPRIATE PRODUCT ID LINES. (FOR OTHER DESCRIPTORS, WRITE THE TERM UNDER THE DESCRIPTORS COLUMN).

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APPENDIX D - SIGNIFICANT RESULTS

1. Vegetation analysis and mapping of the western Seward Peninsula.

An ERTS multispectral scanner scene of the western Seward Peninsula, No. 1009-22095, obtained August 1, 1972, was selected for vegetation study. The format used was a reconstituted, simulated color-infrared photographic print prepared from bands 4, 5 and 7. Ground truth was limited to reference to the four existing published vegetation maps, the few pieces of available literature and fire records of the U.S. Bureau of Land Mangement.

Seven distinct colors were recognized on the image. Four were identified through matching of their general distribution patterns with those of vegetation types on the existing maps: Bright red - shrub thicket; light gray-red - upland tundra; medium gray-red - wet tundra; gray - alpine barrens. In the bright red color two phases, violet and orange, were recognized and tentatively ascribed to differences in species composition in the shrub thicket type. Significantly more detail in the distribution of these types, particularly of small units or stands, could be seen on the image than could feasibly have been depicted on the maps at the scales used. The three colors having no map unit equivalents were tentatively interpreted through reference to the literature and general plant ecological knowledge as follows: Pink - grassland tundra; dark gray-red - burn scars; light orange-red - senescent vegetation. The interpretation of dark gray-red as indicating areas of former vegetation fires was subsequently confirmed by records of the U.S. Bureau of Land Management.

A new vegetation map of the western Seward Peninsula was drawn by tracing on an acetate overlay of the image. Besides the seven colors discussed above, five additional map units are shown. These represent mosaics of color units too small feasibly to map individually at the scale of the unenlarged ERTS image. An enlarged tracing of part of an existing vegetation map was made for comparison with the new map to emphasize the increase in mappable information derived from the image. The new map required only about ten man-hours to draw and label. It is believed that considerably more detailed and accurate maps than this one will be possible using the various image enhancement and digital data processing techniques which are becoming possible with ERTS imagery.

Besides the promise this exercise shows for delineating and mapping vegetation types with ERTS imagery, promise is also shown for surveying phenological developments and vegetation fires using sequential imagery.

2. Study of areas of spruce beetle infestation in the Cook Inlet area.

Techniques are being developed for mapping three major categories or degrees of spruce stand beetle damage: (a) non-stressed stands, (b) newly infested stands where there is severe bark damage but normal spruce needle turgor and (c) older infested stands wherein there has been almost a total kill of the medium sized and larger spruce. ERTS scenes 1049-20505 and 1103-20513 have been selected and are being studied in black and white print and color-key image formats. One scene has been digitized at the U.S. Forest Service Remote Sensing Laboratory in Berkeley, California, and an electronic-numerical analysis is under way there. Digital tapes of these scenes have been ordered from NASA and will be used on the U of A CDU-200 equipment. NASA aerial photography was not obtained for the region of heaviest infestation, lying west of Cook Inlet. However, ground truth in the form of map plots of the distribution of infected stands and low level, hand-held color and color-infrared photography has been provided by U.S. Forest Service personnel.

Although the study is still under way, the findings to date show promise for a capability for regionally surveying and monitoring spruce beetle infestations, at least in their more advanced stages, with the ERTS system.

It is clear that the spectral characteristics of trees bearing dead foliage are considerably altered and that the presence of such trees in a stand at some minimum density will cause that stand to be distinguishable on ERTS imagery from others containing chiefly healthy trees. On the color-key image of one of the scenes, obtained in November, there is a large area of distinct color and intensity which matches very closely the area of major infestation as plotted on a map from field studies. On an earlier scene, obtained in September prior to leaf fall, the spectral signature for this area is somewhat different, although the match in shape is still close. It is hypothesized (a) that the area is indeed uniquely apparent on the ERTS scene as one of more or less heavy spruce beetle infestation, (b) that the forest in this area contains in many places a major admixture of deciduous species and (c) that the color change may be explained on a phenologic basis. This hypothesis will be tested by further visual studies of the materials at hand, but possibly more conclusively through the use of digital data which will permit quantitative spectrophotometric measurements and comparisons with areas of spruce and spruce-deciduous forest known to be unaffected.

3. Revised data handling plan.

A revised data handling plan was prepared and submitted recently. This plan is summarized as follows:

MSS imagery will continue to be obtained from NASA via ERTS-1 Project 110-1. A standing order for bulk 9-1/2 inch black and white paper prints and corresponding bulk 70 mm positive and negative transparencies is in effect. As indicated above, restrospective data requests will be submitted later for a few reconstituted color 9-1/2 inch transparencies, 9-1/2 inch black and white positive transparencies, computer compatible digital tapes and possibly some RBV imagery.

The initial activity upon receipt of imagery is examination and screening of the black and white prints, aided by a good light, a magnifying glass and reference to maps. This is for locating test areas and other areas of interest and for determining the extent to which information may be derived in this fashion. In some cases MSS and RBV scences in all bands will be compared for determining relative information content.

Black and white enlargements will be made from the negative transparencies for selected scenes for which especially high quality imagery is available. This will be done in such a way as to increase contrasts or otherwise to enhance the imagery to emphasize vegetation features. Recent work by U of A ERTS-1 Project 110-1 personnel indicates the potential of this approach.

Color-key images are being prepared using 9-1/2 inch positive transparencies. These are examined for vegetation types and related environmental features. The four screens constituting these images are examined individually and in various combinations to determine what information is available. It is proposed that most color-key images continue to be made from MSS products, with a few made from RBV products for comparative purposes if these become available again.

Positive transparencies in the 70 mm format will be mounted in the composite projection array for color additive viewing. The image produced in this manner will be compared with the black and white products and the digital CDU-200 scenes. The magnification provided by the color additive viewing system and the variety of possible filter combinations will be used for experimentation with color balance. The results of this will be given primary consideration in preparing orders for color-key images.

MSS digital tapes will be requested for the intensive training sites in cases that the probability of particularly good data is judged high. These will be converted to CDU-compatible digital tapes on the University of Alaska IBM 360/40 computer. Tapes already obtained by U of A ERTS-1 Project 110-2 are being used for test areas 1-3 south of the Alaska Range CDU work will include color coding and false color displays, interchannel ratio studies, maximum likelihood analyses and detection of changes in image spectral characteristics with time.

Aerial photography obtained from NASA and other sources is being consulted for identification of objects included in the scenes prepared by these various methods. Shape, relative size and pattern are chief attributes permitting direct comparisons of spacecraft and aircraft imagery. According to the multistage sampling procedure, reference to aerial photography is made only after initial attempts directly to identify objects on the spacecraft imagery have been made.

Available ground truth information, chiefly that in the literature, on existing small scale vegetation maps and in field books of the principal investigator, is being consulted. A schedule of test area and training site visits for low overflights in light aircraft and on-the-ground observations is being developed for the 1973 field season. This is being done only as the spacecraft imagery and aerial photography are studied and areas needing visitation are identified.

Vegetation maps are being drawn by tracing on acetate overlays of ERTS images, enlarged to appropriate scales. A reconstituded, simulated color-infrared scene in the 9-1/2 inch format has already been used for this purpose in a study of vegetation on the western Seward Peninsula. It is hoped that a Bausch and Lomb zoom transfer scope will be obtained later for use in preparing larger scale and more detailed and accurate vegetation maps, in most cases using U.S. Geological Survey 1:250,000 topographic sheets as base maps. The information content of the master image selected for mapping is thoroughly established prior to the start of mapping, and interpretations during mapping are supported by reference to images in other formats including CDU-200 displays.

The feasibility of automatically producing vegetation maps from digital data by computer plotting will be examined in cooperation with the investigators on Project 110-2 who intend to attempt a large amount of computer mapping. This will involve (i) reconciliation of computer plotting technology with the possibly numerous vegetation types which may be recognized, (ii) preparation of a program whereby boundaries between types or through transitional vegetation could be properly positioned, (iii) attempts to adjust computer plots, or to transfer information from them, to appropriate base maps and (iv) evaluation of the cost effectiveness of this type of map relative to types prepared by regular methods.

A few lantern slides will be made in the interest of illustrating results of the research in the lecture room.