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CR-133818

INVENTORY AND MONITORING OF NATURAL VEGETATION AND RELATED RESOURCES IN AN ARID ENVIRONMENT

A Comparative Evaluation of ERTS-1 Imagery

Barry J. Schrumpf, James R. Johnson, David A. Mouat and William T. Pyott

Rangeland Resources Program
Oregon State University
Corvallis, Oregon 97331

September 20, 1973
Type II Progress Report for Period March 1, 1973 - August 31, 1973

Prepared for
GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland 20771

(E73-11021) INVENTORY AND MONITORING OF NATURAL VEGETATION AND RELATED RESOURCES IN AN ARID ENVIRONMENT: A COMPARATIVE EVALUATION OF ERTS-1 IMAGERY (Oregon State Univ.) 14 p HC $3.00 CSCL 08F

N73-31325

Unclas
G3/13 01021

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

4. Title and Subtitle INVENTORY AND MONITORING OF NATURAL VEGETATION AND RELATED RESOURCES IN AN ARID ENVIRONMENT - A Comparative Evaluation of ERTS-1 Imagery

5. Report Date 20 September 1973

6. Performing Organization Code

7. Author(s) Barry J. Schrumpf, James R. Johnson, David A. Mouat, and William T. Pyott

8. Performing Organization Report No. N/A

9. Performing Organization Name and Address
Rangeland Resources Program
Oregon State University
Corvallis, Oregon 97331

10. Work Unit No.

11. Contract or Grant No. NAS5-21831

12. Sponsoring Agency Name and Address
Goddard Space Flight Center
Greenbelt, Maryland 20771

Technical Monitor: Edward W. Crump

13. Type of Report and Period Covered
Type II Progress Report; March 1, 1973-August 31, 1973

14. Sponsoring Agency Code

15. Supplementary Notes

N/A

16. Abstract

A comparative evaluation of an ERTS-1 MSS color reconstitution and an Apollo 6 and Gemini IV color photograph for information content was conducted. A greater variety of image detail was indicated for the Apollo 6 imagery. A study of terrain feature variable-vegetation relationships has been concluded. However, there were no substantial differences among space photo types when macrorelief classes were interpreted. Vegetation distribution is influenced in varying degrees by characteristics of the terrain, some of which are quite apparent on ERTS imagery and, therefore, provide the means for inferring possible vegetation types for a specified location. Spectral signatures have been determined for some natural vegetation systems from the ERTS-1 MSS data. Those signatures have been used to classify ERTS-1 data for a portion of the study area.

Work continues on multistage sampling for natural vegetation, terrain feature identification on ERTS-1 photographs, plant phenology, and spectral signature studies.

17. Key Words (Selected by Author(s))
natural vegetation, vegetation inventory, automatic data processing

18. Distribution Statement

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
N/A	N/A		

*For sale by the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

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Preface

This study has been designed to provide the basis for evaluating several alternatives for incorporating ERTS-I data into vegetation inventory procedures. Additionally, some comparative evaluations with other forms of satellite imagery and multidate high altitude aircraft imagery are included.

A test site in southeastern Arizona has been chosen which includes vegetation types representative of Sonoran and Chihuahuan Desert shrub, grassland, chaparral, mixed needleleaf and broadleaf woods, and needleleaf forests. The work includes characterizing the level of interpretive detail in repetitive ERTS imagery, characterizing vegetation-physical terrain feature relationships, comparing macrorelief interpretations using low sun angle monoscopic versus high sun angle stereoscopic techniques, detecting plant phenological changes recorded in multidate ERTS data, utilizing ERTS and other satellite imagery in multistage sampling schemes, and determining spectral signatures for some vegetation types from ERTS-I MSS data.

An evaluation of space imagery types for information content relevant for mapping of landform and natural vegetation features revealed that Apollo 6 color photography was significantly more complex than either an ERTS-I color reconstitution or Gemini IV color photography. When interpreting landform classes, however, interpreters' performances varied more with macrorelief classes than with imagery type. Spectral signatures were determined for some natural vegetation systems from the ERTS-I MSS data. Those signatures have been used to classify ERTS data for a portion of southeastern Arizona which supports several similar shrub and herbaceous vegetation types.

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INTRODUCTION

This report conveys work and progress for the second six months of investigations utilizing ERTS-1 data acquired over southern Arizona for inventorying and monitoring natural vegetation and related resources. During this reporting period, work has been conducted on all phases of this investigation. Information content of ERTS, Apollo 6, and Gemini IV imagery has been evaluated. Terrain feature-vegetation relationships have been investigated and the study concluded. Interpretation testing of some terrain features on ERTS imagery was initiated, as well as plant phenology studies utilizing ERTS and aircraft multidate imagery. Development of statistical techniques has progressed for use in a multistage sampling scheme to determine kinds and amounts of vegetation types in a selected area. Spectral signatures of some natural vegetation types have been determined and used in classification of ERTS-1 MSS digital data.

REPORT OF RESEARCH

Objective 1. Imagery Information Content Evaluation.

The contract statement calls for production of maps and a comparison of those maps to reveal relative levels of interpretive detail and mapping refinement associated with several imagery types. Modification of the approach to the objective has taken place as previously reported, to the extent that we have not incurred the task of map production. However, the intent of the objective remains the same.

The approach developed involved sorting selected images into groups of similarity, without the participants being necessarily aware of the subject-image relationship under examination. This type of testing facilitates analysis of test results in a more easily understood fashion than can be done with mapping comparisons. The approach is designed to address the question of relative levels of interpretative detail available in various imagery types. The results of the analysis can be used to infer levels of mapping refinement (generalizing and complexing) appropriate for the imagery being compared.

It would appear that for judging photography suitability, imagery complexity testing and image groupability by subject testing both have a value. For example, based on results of the testing, Apollo 6 color photography is seen to have greater image diversity than a single date ERTS-1 color photo reconstitution or Gemini IV color photography. Yet, when images from the three types of space imagery were related to a resource subject (in this case, macrorelief), there was no clear advantage for either Apollo or ERTS, except that both are apparently superior to Gemini (Schrumpf, 1973c). This would suggest that image complexity evaluations alone may not yield the best index for selecting photography. Rather, some evaluation which indicates the relative degree of image-subject relationship may be essential. Therefore, the selection of the most suitable photography may often be based on rather specific subject-image examinations.

Objective 2. Terrain Feature - Vegetation Relationships

This study was carried to conclusion with the consideration of soil color as a terrain feature (Schrumpf, 1973b). A complete report is in preparation. Results of this study have been presented in Mouat, 1972; Schrumpf, 1973a; and Schrumpf, Johnson and Mouat 1973.

Objective 3. Terrain Feature Interpretation Testing

The study of the interpretation of terrain variables on ERTS imagery and on high altitude photography is well underway. The testing of the ability of interpreters to map elevational contours on ERTS imagery has been completed. The determination of accuracy will involve comparison of topographical cross-sections. That work is underway.

Objectives 4 and 5. Plant Phenology Studies

Plant phenological patterns (specifically the seasonal timing of foliation and defoliation) are being studied in southern Arizona to evaluate the potential of utilizing the ability to detect phenological changes in a vegetation inventory procedure. Most of the plant species occurring in the test site exhibit one of three phenological patterns: that of 1) evergreen, 2) cool season deciduous, or 3) warm season deciduous. A unique pattern of change is associated with each phenological pattern type. The condition of having green leaves during certain parts of the year qualifies a plant as a representative of one of the three pattern types. That condition is also sometimes apparent on aerial and satellite remote sensing imagery. Reconstituted color composites made from several dates (summer, winter, and spring) of ERTS-1 MSS data reveal the phenological condition of some groups of plants at different times of the year. From these color reconstitutions it is easy to recognize the phenological pattern type of some vegetation types.

Analysis of ERTS data is being conducted utilizing both the MSS digital data and photographic reconstitutions. The latter are being analyzed densitometrically. Small scale aerial photography is also being analyzed densitometrically. Several areas within the test site were identified from ground data and aerial photography, as supporting vegetation examples of each phenological pattern type. The vegetation type at each location was also determined. Apparent spectral signatures for each of the vegetation types are being determined from multidate ERTS-1 MSS digital data. Relative spectral reflectances are being determined densitometrically for those same vegetation types from ERTS photographic reconstitutions and aerial photography. Assemblage of this raw data is now in progress. Results of this investigation will be reported on a later date.

Objective 6. Multistage Sampling Of Vegetation Types

ERTS-1 photographic reconstitutions and Apollo 6 photography are being compared to determine their relative suitability for drawing first stage samples in a multistage sampling scheme designed to examine the kind and areal extent of selected natural vegetation types. Statistical techniques are currently being developed for the sampling scheme. Stratification of images has been completed for an ERTS scene and an Apollo 6 photograph of the same region. Images were stratified into classes determined by the image groups established in the testing procedure described under Objective 1. Ground sampling locations are currently being selected.

Objective 7. Digital Data Analysis

ERTS MSS data from a portion of frame 1030-17271 in the vicinity of Tombstone, Arizona, were analyzed using the computer and display facilities of the Center for Remote Sensing Research (CRSR), University of California, Berkeley. The CALSCAN computer program package was used to determine spectral signatures of given vegetation classes, classify the ERTS data for the study area, and display the results in computer line printer map form.

The spectral signatures were determined from training fields selected from the MSS data for each vegetation class. The training fields (and test fields to be used as a check on the classification) were selected by displaying the MSS data (bands 4, 5, 7) on a color monitor driven by a NOVA computer ("Bells & Whistles" program). The training fields were based on ground sampling done by Garcia-Moya in 1969 and 1970. The vegetation classes used here resulted from his subsequent computer vegetation classification (Garcia-Moya, 1972).

The CALSCAN analyses were done on a CDC 7600 computer to which CRSR has access (Lawrence Radiation Laboratory, Berkeley). Preliminary results (class divergences and training field performance summaries from classification of selected sample areas) indicated that grouping of some of Garcia-Moya's vegetation classes was appropriate. Comparison of vegetation writeups and visual interpretation of available ground photographs confirmed the groups suggested by CALSCAN.

Grouping vegetation classes considerably improved overall training field performance from 43.1 percent to 69.3 percent and average performance per class from 43.2 percent to 74.4 percent (Table 1). Also contributing to improvement in performance of training fields was reclassification by a nearest neighbor algorithm.

Test fields for all the vegetation classes were selected to provide a more definitive determination of the separability of the classes than evaluation of training field performance. This is because the latter has some

Table 1. Training Field Performance

Summarized by Class

Original Class	Typifying Species	New Class 1/	% Performance: Original Classes 2/ — By Original Class	Original Classes 2/ — With Reclassification	With Grouping 3/ — By Original Class	With Grouping 3/ — By New Class
A	*Panicum hirticaule*		82.5	92.5	80.0	
B	*Rhus microphylla*	ACACIA	16.4	16.4	43.6	60.9
K	*Fouquieria splendens*		4.0	-0-	37.8	
C	*Gutierrezia sarothrae*		75.0	100.0	87.5	
D	*Menodora scabra*	BOER	33.3	40.0	54.3	77.8
E	*Hilaria belangeri*		46.3	34.1	90.2	
G	*Hilaria mutica*	HIMU	-0-	-0-	68.4	68.4
A1a 4/	PAHI-*Prosopis juliflora*		84.6	92.3	100.0	
F	*Gilia rigidula*	PRJU	-0-	-0-	21.4	75.3
H	*Haplopappus tenuisectus*		29.2	8.3	100.0	
I	*Ayenia pusilla*		57.1	78.6	69.4	
J	*Cnidoscolus angustidens*	AGAVE	35.0	55.0	54.0	61.4
L	*Agave palmeri*		3.2	-0-	63.4	
M	*Mortonia scabrella*	MOSC	85.0	85.0	79.2	79.2
Brush Clearings	Grasses	BRCLR	95.8	95.8	97.9	97.9
Overall Performance			43.1	44.2	69.3	69.3
Average Per Class			43.2	46.5	69.8	74.4

Table 1. Training Field Performance (Continued).

Footnotes:

1/ New class names are connotative of integrating vegetation characteristics: ACACIA=*Acacia* species; BOER=*Bouteloua eriopoda*; HIMU=*Hilaria mutica*; PRJU=*Prosopis juliflora*; AGAVE=*Agave* species; MOSC=*Mortonia scabrella*; BRCLR=Brush Clear.

2/ Original and original with reclassification was of selected sample areas only.

3/ Reclassification by nearest neighbor algorithm for total study area.

4/ This is a variant of A with *Prosopis juliflora*; PAHI=*Panicum hirticaule*, an annual grass.

elements of circular reasoning since the vegetation classes were defined for CALSCAN by their respective training fields. However, test field performance was such--50.5 percent overall and 55.6 percent average per class (Table 2)--as to render ambiguous this interpretation. This result was unexpected since test fields were selected along with training fields for each vegetation class. The only explanation we can offer is that we were not as careful in defining the test field boundaries as we were with the training fields.

These results indicate the integrative nature of the ERTS data for some kinds of vegetation (with low contrast images). However, these results also seem to suggest that a detailed vegetation classification, based to some extent on annual species from data collected in only two consecutive years, should be reexamined.

Three classes, two vegetation associations and a cultural treatment were discriminated in the ERTS data as originally given. They were Associations G (*Hilaria mutica,* tobosa bottoms) and M (*Mortonia scabrella,* sandpaper bush shrubland) and brush clearings. These classes are apparently as distinct in the ERTS data as they are in aerial photography (1:120,000 color IR and 1:30,000 black and white) and on the ground.

Table 2. Test Field Performance.

Summarized by Class

Class	Performance
ACACIA	49.1
BOER	35.5
HIMU	57.1
PRJU	61.5
AGAVE	26.0
MOSC	66.7
BRCLR	93.5
Overall Performance	50.5
Average Per Class	55.6

PROGRAM FOR NEXT REPORTING INTERVAL

Analysis will be completed of interpretation test results of elevation contouring on an ERTS-I photographic reconstitution. Elevation contouring accomplished monoscopically, necessitates photo interpretation of slopes, aspects, drainage patterns, etc. These are terrain features which discriminate vegetation types. Photo interpretation of parent material from ERTS-I photo reconstitutions will be considered.

Analysis of multidate ERTS-I and aerial photographic imagery for plant phenological pattern detection will be continued. Techniques, with and without overlaying multidate ERTS data, will be compared for determining spectral signatures of vegetation types representing the various phenological pattern types. The ability to discern a temporal pattern of spectral signatures for some vegetation types will be investigated.

The ground sampling step of a multistage sampling scheme to determine kinds and amounts of vegetation types in a selected area will be accomplished. Vegetation data for the entire selected area will then be compiled utilizing the statistics determined by the sampling scheme.

Interpretation of the vegetation classes suggested by the results of the analysis of the ERTS digital data in relation to surface physical features of the environment will be carried out for the Walnut Gulch Experimental Watershed since we have such information for that area (Gelderman, 1970). Also, reassessment of Garcia-Moya's vegetation classification will be done by numerically determining the similarities and differences among his vegetation classes in the context of the new groupings suggested by the results of analysis of the ERTS data.

CONCLUSIONS

A standard ERTS-1 MSS color composite representing an arid/semi-arid region contained less image variety than did an Apollo 6 color photograph of the same area, but more detail than a Gemini IV color photograph. This was evidenced by the avarage number of image groups recognized by several photo interpreters. When image samples were grouped according to macrorelief types, interpreters' performances showed no distrinct advantage to utilizing any one of the three imagery types.

Some vegetation types occurring in an arid region and classified at the plant community level display unique spectral signatures. Some vegetation types which are similar floristically also have similar signatures. Some vegetation types displaying similar physiognomics have distinctly different spectral signatures.

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