REMOTE SENSING IN IOWA AGRICULTURE

Identification and classification of Iowa crop lands using ERTS-1 and complimentary underflight imagery

Dr. R.E. Carlson, Assistant Professor
Department of Agronomy

and

Dr. J.P. Mahlstede, Associate Director
Iowa Agriculture Experiment Station

Iowa State University
Ames, Iowa 50010

March 1973
Type II report for the six month period
ending February 28, 1973

Prepared for

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland 20771

TECHNICAL REPORT STANDARD TITLE PAGE

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

4. Title and Subtitle	5. Report Date
REMOTE SENSING IN IOWA AGRICULTURE Identification and classification of Iowa crop lands using ERTS-1 and complimentary underflight imagery	March 14, 1973
	6. Performing Organization Code MMC #249
7. Author(s) Dr. R.E. Carlson Dr. J.P. Mahlstede	8. Performing Organization Report No. two
9. Performing Organization Name and Address Iowa State University Agriculture Experiment Station Ames, Iowa 50010	10. Work Unit No.
	11. Contract or Grant No. NAS5-21839
	13. Type of Report and Period Covered Type II Report 6 mos. end Feb. '73
12. Sponsoring Agency Name and Address Goddard Space Flight Center Greenbelt, Maryland 20771 Stonesifer, G. Richard X2856 Code 430	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This paper reports the results of preliminary analysis of ERTS-1 imagery covering Iowa. Major emphasis is placed on the identification and classification of Iowa crop lands at four sites. Cloud cover, atmospheric haze and resolution due to small field size have been problems which have limited the successful classification of Iowa crop lands using the Sept.-Oct. ERTS-1 imagery. During August 1972, Iowa was essentially cloud free over major portions when ERTS-1 was overhead. This imagery was only recently received, however, initial analysis using additive color procedures appears the most promising to date. Examples of this imagery are presented in this report.

17. Key Words (Selected by Author(s))	18. Distribution Statement
crop identification and classification, ERTS-1 imagery	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
		13	3.00

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

COLOR ILLUSTRATIONS REPRODUCED IN BLACK AND WHITE

PREFACE

a) Objective

The objectives of this investigation are as follows:

1. To evaluate how remote sensing data can be utilized in Iowa to better or more economically define the soil and plant parameters that are important in production and marketing of agricultural crops.
2. To analyze how these data can be utilized in decision-making processes involving optimum utilization of our natural resources.

b) Scope of work

The research effort at Iowa State includes researchers in plant pathology, agricultural climatology, soil classification and morphology, forestry and photography and their associated problems related to remote sensing. The work reported here will be restricted to identification and classification of crops using ERTS-1 and related underflight imagery at three pre-selected sites in Iowa.

c) Conclusions

The following difficulties have been encountered to date with respect to crop identification and classification using ERTS-1 imagery in Iowa agriculture: 1) resolution due to small field size, 2) general cloud cover and cloud cover over specific test sites, 3) apparent reduced resolution due to atmospheric haze, 4) scanning lines present on some imagery and 5) lack of contrast on all multi-spectral bands. These difficulties were most evident on the imagery received covering the September-October 1972 time frame. Imagery recently received (February 1973) covering Iowa during mid-August 1972 shows that many of these difficulties have been minimized except for #1. Image contrasts are evident on all four ERTS-1 wavelengths for this time frame suggesting the possibility of multi-spectral classification techniques. On this imagery major delineations can also be made between forest, river and agriculture lands.

d) Summary of recommendations

Because the August 1972 ERTS-1 imagery was not received until just recently, analysis of these data is in the initial stages. These data appear the most promising to date because information is present on all wavelengths per set. Small field sizes in portions of Iowa will, however, be a problem in maximizing the amount of crop information extractable (identification and acreage estimates). Initial examination indicates that most major crops in Iowa have a fairly unique spectral response at this time which can be used to enhance identification using multi-band procedures.

BODY OF REPORT

Introduction

Interest in the natural resources of Iowa is currently a concern among many individuals in various agencies throughout Iowa. The increasing stresses which are placed on the limited natural resources present require methods by which these resources can be accounted. In addition, it is desired that conservation, development and the use of these resources should be managed so that adequate supplies can be produced, marketing efficiency can be improved, adjustments due to new technology can be facilitated and the capacity to disseminate new knowledge can be improved.

Recent developments in remote sensing techniques lend themselves as tools to achieve these ends. This paper reports the preliminary results of research directed toward an evaluation of the feasibility of obtaining an inventory of the agricultural lands in the state of Iowa, utilizing the data provided by the ERTS-1 satellite and the associated NASA provided underflights flown during August 1972.

Methods of Analysis

Three locations with differing soils and cropping patterns were chosen in Iowa for experimentation. These sites are located at outlying agricultural research experiment stations in Lyon, Story, Boone and Buchanan counties. Areas located adjacent to these stations are also included. Ground truth data (crop inventory by fields) were established in these areas to interpret the capabilities of the ERTS-1 satellite for this purpose. In addition to this ground truth, NASA provided underflights over these test sites on August 12, 1972 which were flown at altitudes ranging from 8,000 to 13,000 feet. This imagery includes the following: 9-inch regular color and color infrared positive transparencies, 4 sets of black and white 4½ inch transparencies filtered to wavelength regions compatable to the ERTS-1 imagery and black and white transparencies representing the thermal infrared (8-12μ: RS-14 scanner). It should be noted that this underflight imagery is of

excellent quality and is essentially cloud free. This imagery has been indispensable in the acquisition and extension of the ground truth. This imagery is also being used to assess crop and tree disease incidence and to develop multi-band crop identification and inventory procedures.

At Iowa State the analysis of the ERTS-1 imagery has been confined to date to crop identification studies using the following procedures: 1) direct enlargement of the 70 mm positive transparencies, 2) additive color photo interpretation procedures using 2½-inch projectors fitted with selected filters and 3) additive color and density slicing procedures using the Miniadcol and the Digicol systems located at and with the permission of the Iowa State Geologic Survey-Remote Sensing Center at Iowa City, Iowa.

Each 70 mm transparency from each set of four is visually analyzed in a gross manner to ascertain its usefulness for crop inventory purposes (e.g. cloud cover, atmospheric haze, resolution, identification of major units and contrast in the film density of fields within each transparency). If the image is acceptable, major observable units (e.g., rivers, roads and cities) are delineated. Selected fields within the ground truth are then examined by one of the first two previously mentioned methods. This examination is directed to answer the following questions: 1) "Is the field observable?", 2) "Does the field have distinct boundaries?" and 3) "Does the field have a distinct grey scale designation (spectral response)?" This analysis is directed toward the development of classification keys. In areas where fields meet this criteria, multi-band additive color and single band density slicing procedures are employed using either the Miniadcol or the Digicol system to determine if an automatic inventory procedure can be developed.

Results and Discussion

Analysis of the underflight imagery provided by NASA during August 1972 has proceeded toward the development of either a single-band or a multi-band pattern recognition system for major Iowa crop types and to enlarge the size of the ground truth areas. This imagery has, also, provided information

as to the actual field configuration within each section. To date the color infrared imagery appears to be the best single-band product. Problems exist as to the separation of soybean fields from uncut alfalfa fields using this product, but this problem could be easily eliminated with sequential flights planned to coincide with critical or discriminating crop development periods.

Preliminary analysis of the thermal scanner black and white imagery combined with the black and white multi-band photography appears to have potential for crop identification. At the time of these underflights, the thermal imagery strongly discriminates fields with respect to the amount of vegetation present (Figure 1). Separation of corn fields from soybean fields was not possible on this imagery, but other field types were readily distinguishable from the corn and soybean fields (e.g., pasture, oats stubble, recently mowed alfalfa, etc.). Black and white filtered imagery (#89B) revealed that corn and soybean fields were readily separatable (Figure 2). Thus, utilization of a multi-band technique has provided a means to identify major crop types in Iowa and, therefore, extend the amount of ground truth data available to analyze ERTS-1 imagery. This imagery was flown at altitudes between 8,000 and 13,000 feet, but using these sensors at higher altitudes may be useful for crop identification studies when larger areas are under investigation.

The following difficulties were noted using the ERTS-1 imagery analysis procedures outlined in the methods section: 1) resolution due to small field size, 2) general cloud cover and cloud cover over specific test sites, 3) reduced resolution due to apparent atmospheric haze and 4) scanning lines present on some imagery. This was true for much of the imagery received during the September-October time frame; however, the imagery provided covering mid-September over the Ames (central Iowa) area showed some promise as atmospheric hinderances were minimal. At this time MSS5 (#1057-16325-5) revealed the most detail and major units could be delineated. The remaining three wavelength regions provided very little

information by themselves. The following points were observed on MSS5: 1) major river systems and lakes, most cities and towns and major highways could be located, 2) forestry land, urban land and agricultural land could be separated and 3) larger fields in the ground truth area could be separated; however, accuracy of identification was limited. The MSS5 70 mm positive transparency was enlarged to a 16" by 20" print and this print was overlayed with a transparent acetate on which section lines were outlined in the ground truth area. A 35 mm slide camera provided additional enlargement (Figure 3) so that comparisons could be made with available ground truth. In this figure soybean fields yielded a light response and the darker areas corresponded to corn fields, but field boundary lines were not distinct. It should be noted, however, that using this single-band product other field types could not be classified. This points out the necessity for variable spectral responses in all ERTS-1 wavelength regions to enhance classification.

A large farm system (Shinrone Farms) was observed in the northwest quadrant of this imagery. These fields were section-size so ground truth was requested and obtained from the crop production specialist for that area. An examination of this area using the Miniadcol and the Digicol systems showed that these large fields could be classified. Differences in some areas within the farm could not, however, be explained using the available ground truth. Grasslands were in various stages of growth and portions of some crop fields were being cut for silage. ERTS-1 imagery analyzed using the Miniadcol system for August (#1021-16324-4 through 7 - only recently received) showed that many of the discrepancies in the crop fields of the Shinrone Farm are not present as ensiling had not begun before August 13, 1972 (Figure 4). Ground truth is provided on the print. These two sets of imagery for this area (August and September) may provide answers as to how the spectral response changes over time for these field types. A similar vegetation analysis of the September imagery for the Ames area was attempted using the Digicol and the Miniadcol systems but resolution was a problem due to

small field sizes and apparent atmospheric haze. This problem relating to small field size is illustrated in Figure 5 by the Miniadcol analysis of the August ERTS-1 imagery covering the Ames area. The analysis of this data is continuing.

The most contrasting and detailed imagery received before February 1973 which provided good film density contrast between fields in wavelength regions other than MSS5, covered an area west of Iowa City in east-central Iowa on October 4, 1972 (#1073-16212 - 4 through 7). Unfortunately, this imagery was 50% covered by dense clouds located over available ground truth. Ground truth is unavailable at this time, but an examination of fields located near an easily distinguishable airport revealed that film density differences between wavelengths should provide a multi-band pattern recognition system for some field types. This imagery was examined using the Miniadcol system (Figure 6) to determine if color separation between fields could be achieved. This figure illustrates that at least five distinct colors can be designated to fields near the airport and most field boundaries are quite distinct. This area will be intensely investigated when ground truth becomes available. The influence of soil association differences is pointed out in this imagery. Differences in the cropping pattern and field response are probably caused by the influence of soils, topography and drainage systems which, in combination, determine the crops suitable for production. It was, however, difficult to map the soil association differences accurately using available soil association maps for that area.

One part of Iowa appears very promising for crop inventory. This area is the flood plain of the Missouri River in western Iowa and portions of this area are illustrated in Figure 7 (#1022-16382 - 4 through 7). This area was not included as a test site so only limited ground truth is available at this time. This portion of Iowa is characterized by a flat flood plain which is conducive to larger field sizes. This, of course,

increases the probability of correct classification using the ERTS-1 imagery.

As previously stated, August 1972 ERTS-1 imagery was not received until just recently. Major portions of Iowa were cloud-free during this period and the analysis of this imagery has just been initiated. Points noted from this imagery to date are as follows: 1) resolution appears improved over the September imagery as atmospheric haze appears minimal, 2) resolution due to small field size may still be a problem with respect to crop identification and determination of acreages within each field, 3) there are areas in Iowa (the Shinrone Farm and much of the Missouri River flood plain) where larger field size distributions produce better discrimination possibilities and 4) this imagery appears to provide crop inventory information in wavelength bands besides MSS5, although MSS6 and MSS7 appear to have very similar responses.

Listing of Figures

Figure 1. A black and white image from the positive transparency representing the thermal infrared (8-12 μ:RS-14 scanner). This imagery was flown at an altitude of 13,000 feet on August 12, 1972. It covers the Agronomy Farm located six miles west of Ames, Iowa. White areas on this print indicate areas which have higher effective surface temperatures. Ground truth for section #16 is given in Figure 2.

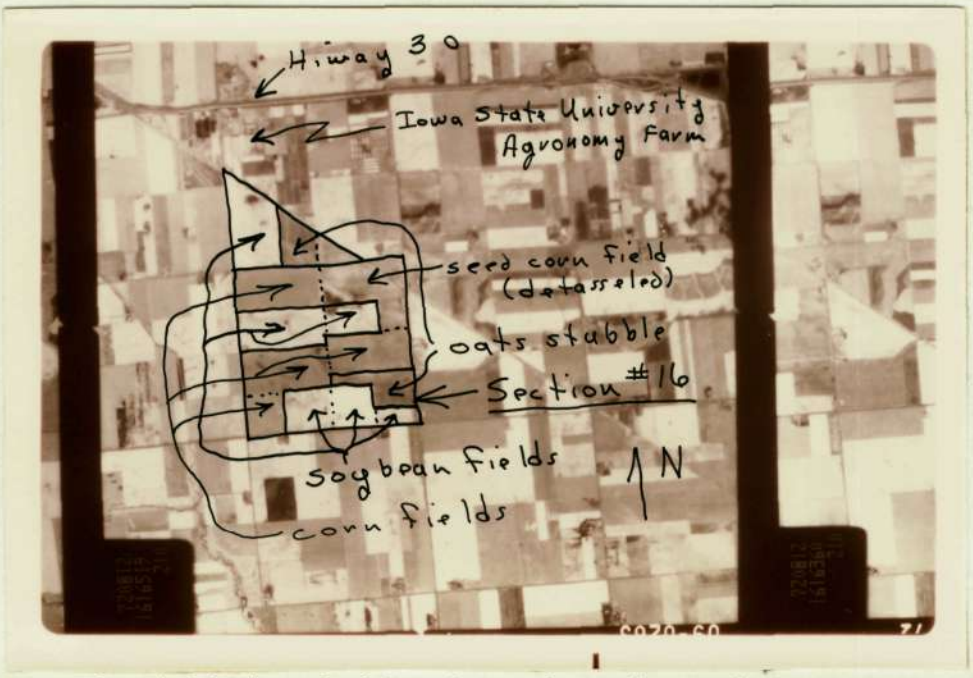

Figure 2. A black and white image from the positive transparency representing the near-infrared (filtered with a #89B filter). This imagery was flown at an altitude of 13,000 feet on August 12, 1972. It covers the Agronomy Farm located six miles west of Ames, Iowa. Selected ground truth for section #16 is noted.

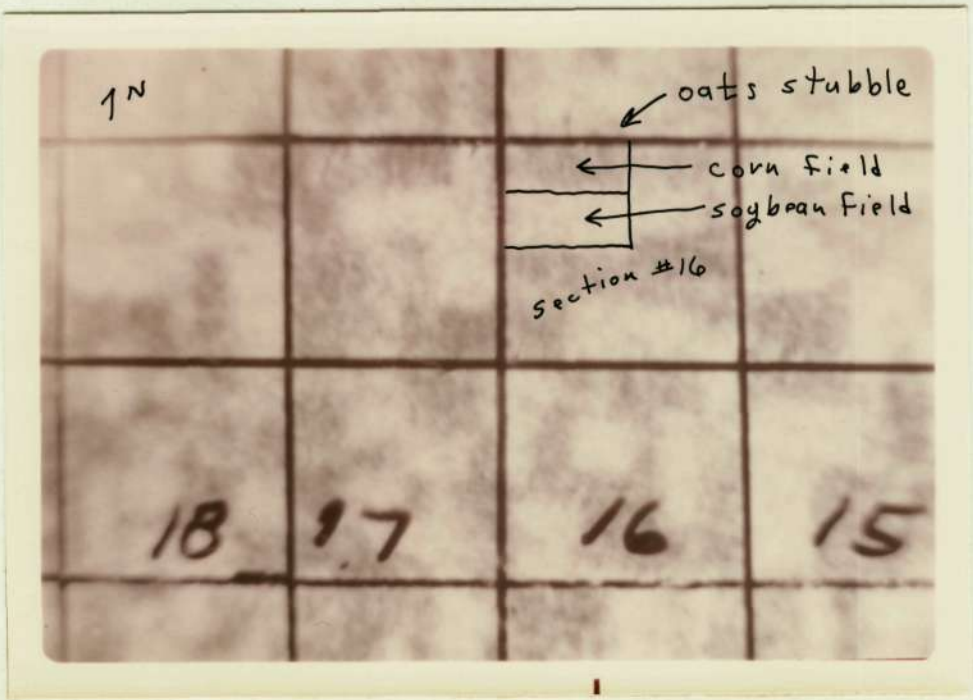

Figure 3. A black and white image printed from a 35 mm slide taken from a 16" by 20" enlargement of MSS5 (#1057-16325-5) in the Ames, Iowa area. Section lines (one mile by one mile) are superimposed over ground truth areas. Ground truth for section #16 is given in Figure 2.

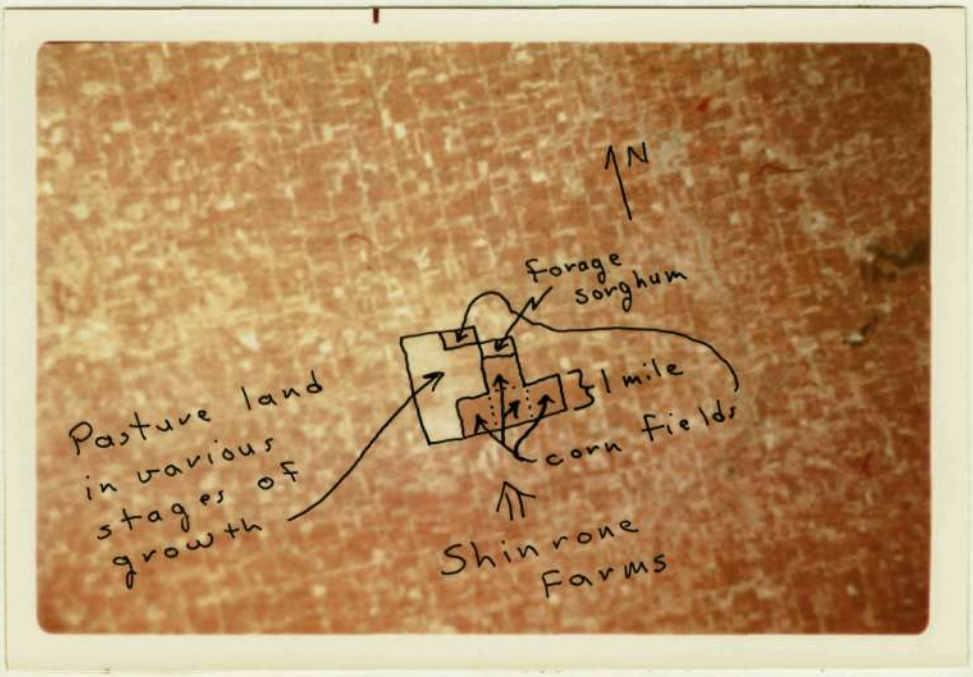

Figure 4. A false color image printed from a 35 mm slide taken from the screen of the Miniadcol system. This imagery was produced from #1021-16324 using wavelengths 5 and 6 with the following color filters, respectively, green and red. The Shinrone Farm system is designated with some available ground truth.

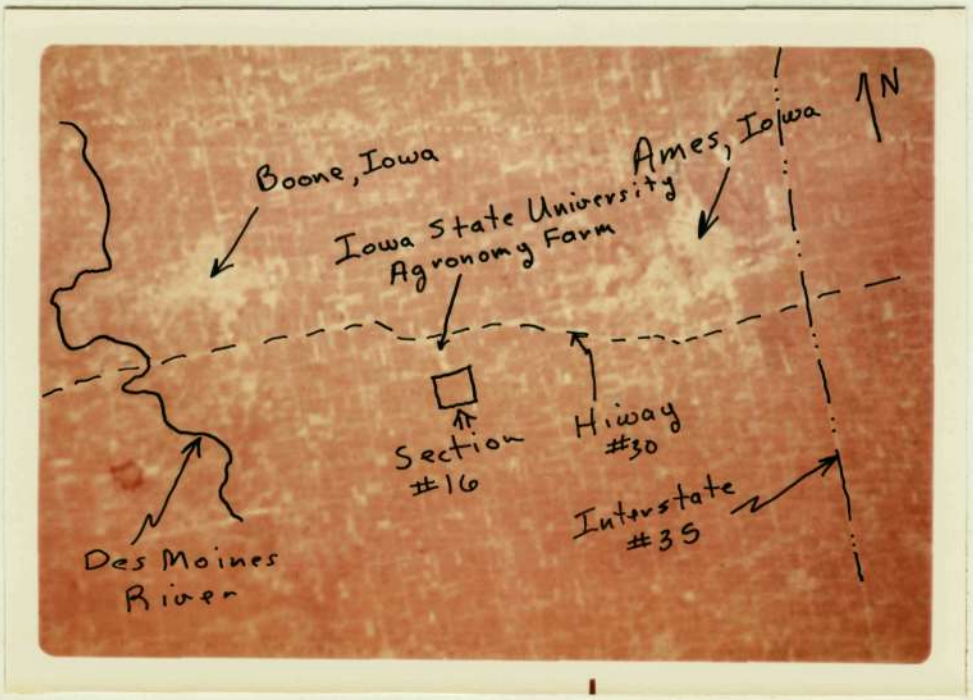

Figure 5. A false color image printed from a 35 mm slide taken from the screen of the Miniadcol system. This imagery was produced from #1021-16324 using wavelengths 5 and 6 with the following color filters, respectively, green and red. The print covers the Ames, Iowa area on August 13, 1972. Major reference points are delineated. Ground truth for section #16 is given in Figure 2.

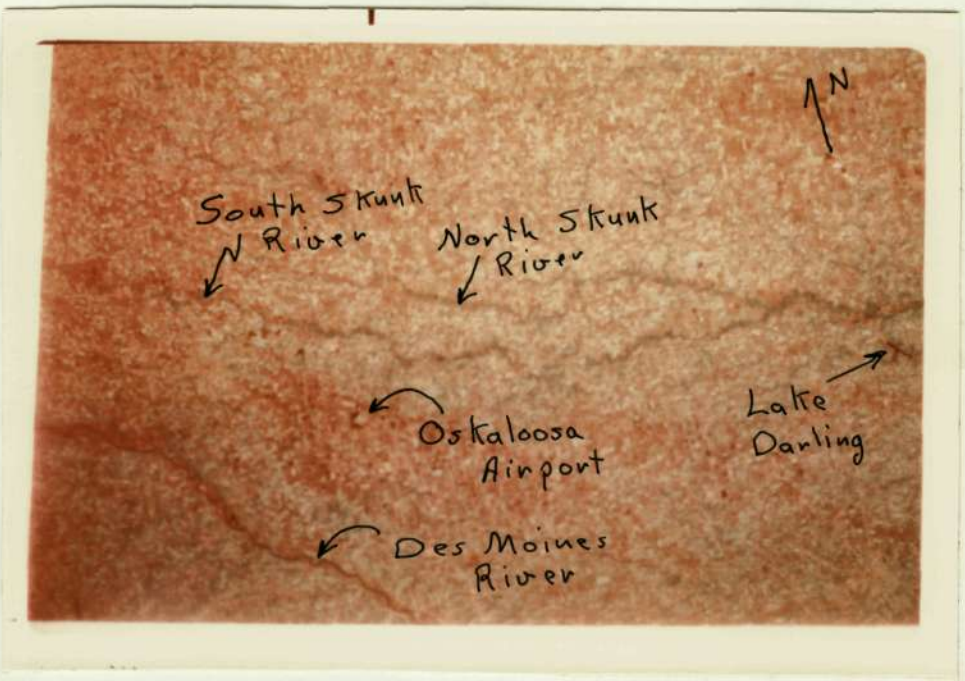

Figure 6. A false color image printed from a 35 mm slide taken from the screen of the Miniadcol system. This imagery was produced from #1073-16212 using wavelengths 5, 6 and 7 with the following color filters, respectively, red, blue and green. The print covers a portion of southeastern Iowa on October 4, 1972. Major reference points are delineated.

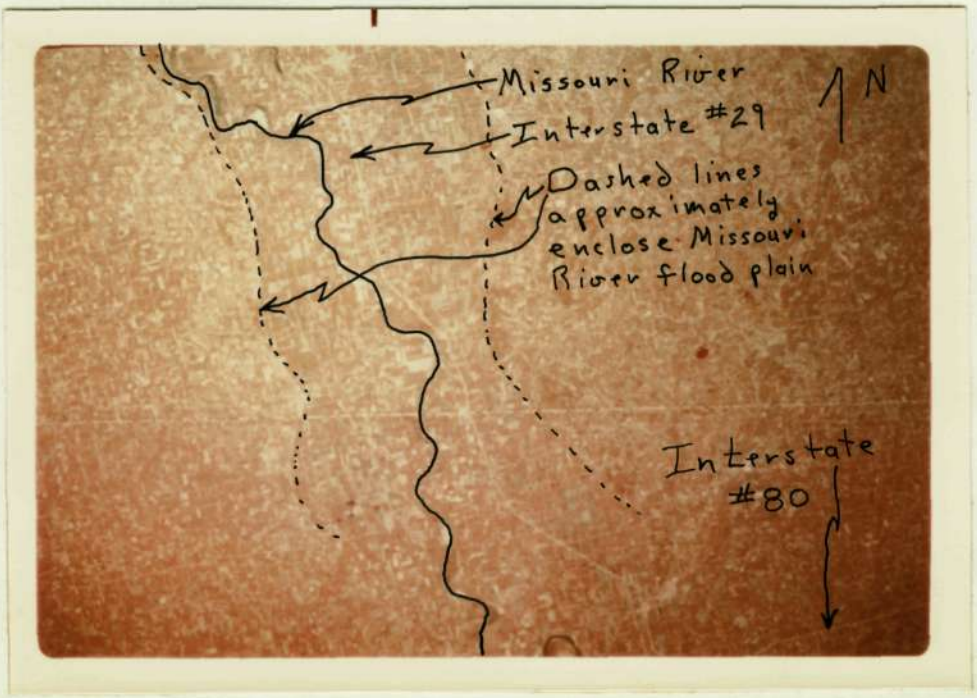

Figure 7. A false color image printed from a 35 mm slide taken from the screen of the Miniadcol system. This imagery was produced from #1022-16382 using wavelengths 5 and 6 with the following color filters, respectively, green and red. The print covers a portion of the Missouri River Valley north of Council Bluffs in western Iowa on August 14, 1972. Major reference points are delineated.