IDAHO CROP IDENTIFICATION KEY

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STATISTICAL REPORTING SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

FEBRUARY 1971

Introduction

In many agricultural situations there is a need for mapping crop species and soil conditions over large areas. Remote sensing offers an excellent method for covering large geographic areas in a relatively short period of time. Black and white photography allows qualitative comparisons between the gray tones on a photograph and the spectral characteristics of the material.

Nature of Project

This project was designed to study the possibility of using remote sensing techniques to identify and distinguish potatoes from other crops.

On June 24, 1970 three flight lines running from Rupert to Minidoka Idaho, a distance of approximately thirteen miles, were photographed by the United States Air Force. The first flight centered over highway twenty-four, while the second and third flights were approximately one mile east and west of the highway, respectively. The scale of the film was 1:5000, i.e., one inch on the photograph represents 5000 inches on the ground.

From these flights high quality black-and white positive prints, positive transparencies, and negative transparencies were received.

The primary objective of this study was to prepare a key, setting forth photo-recognition features that differentiate each crop from all others and from non-cropland. More specifically, in this study one is interested in identifying, early in the season, those fields planted in potatoes. The key also outlines procedures which permit one to identify the following additional crops and non-crops: corn, beans, beets, grain, hay, pasture, waste, and farmsteads.

Key Description

The key is an abbreviated decision chart which closely resembles a flow chart used in Fortran programming. The key is structured around distinguishing different gray tones in conjunction with characteristic crop patterns.

In reading the key one starts at the top and after each decision box follows the arrow to the appropriate alternative until this process terminates in the choice of a particular crop or non-crop.

One should note, however, that the crop identification key is not intended to be used alone. By a cursory examination of the crop key, (Exhibit 1) one is readily aware of the vagueness involved in many of the relative terms. For example, what is the difference between gray and dark gray or between fine checks and fine rows? Hopefully these and similar questions will be answered by the supplementary picture key (Exhibit 2) and field enlargements.

The picture key is intended to give representative examples of each of the terms used in the crop key, which in turn may be used as a base when comparisons between terms is needed. In some instances the photo interpreter will be able to make positive identification of field use by using only one of the three sources, although most of the time at least two or all three sources will be needed.

Key Operation

An attempt will be made to talk through the crop key and explicate its operation in conjunction with the picture key and transparency enlargements.

Farmsteads: One typically looks at a black and white print of an unknown field and checks if any buildings, usually accompanied by trees, are present.

If this is the case, the field will be identified as a farmstead. Usually no ambiguity is involved at this initial stage. An example is given in Figure 3. Since farmsteads do not resemble any of the other field uses, they are omitted from the crop key.

Grain, Pasture, and Waste: Given that the unknown field is not a farmstead, on must determine if the field is dark gray. This is the basic criterian used to dichotomize the crop key.

Consider the case where the field is dark gray, i.e. the field has the color of field in Figure 4 or Figure 5. Following our crop key one must decide if the field is dark gray and smooth. Thus, if the field is not smooth--it is rough--the crop key identifies this field as waste. Figure 5 is a typical example of a waste field. On the other hand, if the field is smooth and dark gray one reaches decision box three and must decide if fine lines are present. A field which is dark gray, smooth, and has fine lines is identified as grain. Figure 4 on the picture key is a grain field. On a print, grain fields have almost a black appearance. One immediately observes that if fine lines are not present the field is a pasture. A further aid in distinguishing between waste and pasture is the presence of livestock paths or trails in pastures. This may be seen more clearly by looking at an enlargement of the transparency of this field. The enlargements of waste fields will resemble those of E.1-E.3 and pastures should look like E.4-E.6. The above discussion has exhausted the case where a field is dark gray.

Beans: Consider the alternative and more difficult situation, namely if the field is not dark gray. Proceeding along the "No arrow" from decision box one, one now asks himself if the field is gray (lighter than dark gray), even, and smooth. If the print of this field meets the above criteria it should resemble Figure 6 on the picture key. From the crop key, this field is identified as a bean field. For enlargements of bean fields see E.7, E.9, and E.10.

Sugar Beets and Hay: Proceeding from decision box four, if the answer is no, i.e. if the field is not gray, even, and smooth, but is light gray, even (decision box five) and has fine checks (decision box six), one identifies this field as sugar beets.

The corresponding print should look like Figure 7. Examples of beet field enlargements are E.11-E.14. Referring to the crop identification key, one sees that if fine checks are not present, although the field is light gray and even, the terminal decision changes from beets to hay. Although the prints in Figures 8 and 9 are both hay fields, the only difference is that the hay in Figure 8 has been cut while the hay in Figure 9 has been cut and raked into windrows. Even with the two types of hay fields, there is usually no difficulty in identifying them. Sometimes due to differences in maturity of crops one has difficulty distinguishing between beans and sugar beets. Looking at the enlargement prints of both crops, one notices that the black dots representing the bean plants are more uniform and heavier than the rows in the beet fields.

Potatoes and Corn: Returning to decision box five, one observes that if the response was No - if the print of the field was light gray with many light areas, one identifies the field as either corn or potatoes. These patchy light areas over the light gray background possessing the appearance of high broken clouds, are the defining characteristics of corn and potatoes. Comparing the prints alone, the only difference between corn and potatoes is that the rows in a corn field appear to be closer than the rows in a potato field. Figures 11 and 13 are examples of potato fields, and Figures 10 and 12 are examples of corn fields. Again one should use the enlargements, E.15-E.17 for corn and E.18-E.21 for potatoes, as collaborating evidence to positively identify the field use. The primary difference, when looking at the enlargements, is that the dots representing the potato plants are much darker and larger than those representing corn plants. Potatoes have the definitive character of heavy black clumps while corn is much lighter and more fine grained.

A final helpful note is that in general, the sugar beet rows are finer than potato rows, but not as fine as corn rows.

Statistical Data Analysis

This is a rather qualitative analysis approach since the classification scheme relies entirely on the discriminatory power of the photo interpreter.

In addition to the prints and transparencies, ground truth designating the specific land use for 286 fields bordering the center flight line was obtained. With this information a random sample of nineteen fields was taken to test the crop identification key.

The test results are summarized in Table 1 showing for each land use the total number of fields designated for analysis, the percent of correct classifications of these fields, and the classification of fields by interpreters. Table 1 is a summarization of results for three photo interpreters, one experienced and two non-experienced.

There are two types of classification errors which can be studied when using this table. The first is found by moving in a horizontal direction across the section showing the number of fields classified into each category and which should have been classified as beets, for example. The number of fields which have been incorrectly classified are given. This is a false exclusion or Type I error. In other words, there are some fields which should have been classified as beets, but which were excluded from the beet category and incorrectly classified as grain, beans, potatoes, or corn. Moving in vertical direction down the column, one may observe a false assignment or Type II error, i.e. identifying a field as potatoes when in fact it was something else. Considering potatoes as our example, there were eight fields correctly classified as potatoes. However, an additional four fields were classified as potatoes which should have been classified as grain, hay, pasture, and beans.

A basic understanding of these two types of errors is essential in analyzing such classification results. The crop identification key could be modified to increase or decrease either type of error. For example, one could classify anything that even remotely resembles potatoes as being potatoes. If this were done, one might always identify 100 percent of the potato fields, but there would also be many fields of corn, beans, hay, et cetera which would have been erroneously included in the potato category. This is because each field can only be classified into one category.

On the other hand, if the crop identification key is modified to classify as potatoes only those fields that have an extremely high probability of belonging to the potato class, there will be many fields which should be classified as potatoes, but which will be erroneously excluded from this category.

The procedures described in this paper are designed so that both the Type I and Type II errors are minimized. One should not be pessimistic when evaluating the results of Table 1. Although the overall percentage of fields correctly classified is only about 72 percent, one is encouraged when looking at the overall classification results by interpreter found in Table 2. One notes a significantly better performance for the experienced potato interpreter. Thus with proper training the overall percentage of fields correctly classified should approach the 95 percent level.

<u>Suggested Research and Conclusions</u>: The crop identification key developed in this paper is based solely upon visual discrimination and is therefore subject to much interpretation on the part of the interpreter. An attempt has been made to reduce the ambiguity involved in the discrimination process by using the picture key and enlargements in conjunction with the flow chart.

Certainly the identification procedures can be standardized by using electronic instrumentation which would quantify the relative terms of our key. At the present time it is not clear what factors will give the best model in terms of identification of crop use. Research is currently being conducted at The University of Michigan; the University of California at Berkeley; The ARS Remote Sensing Laboratory, Weslaco, Texas; The Laboratory for Applied Remote Sensing (LARS) Purdue University; the Center of Research, Incorporated (CRES), University of Kansas; and elsewhere.

It seems to the author that if the Department of Agriculture attempts to use the Idaho crop identification key for large areas that the cost factor involved for the time required to interpret the photographs would be prohibitive. Furthemore this key merely identifies the field use but says nothing about estimating the areas.

An approach similar to that used at CRES or at LARS has also given better experimental results and is capable of handling vast volumes of data rapidly.

Exhibit 1

Idaho Crop Identification Key

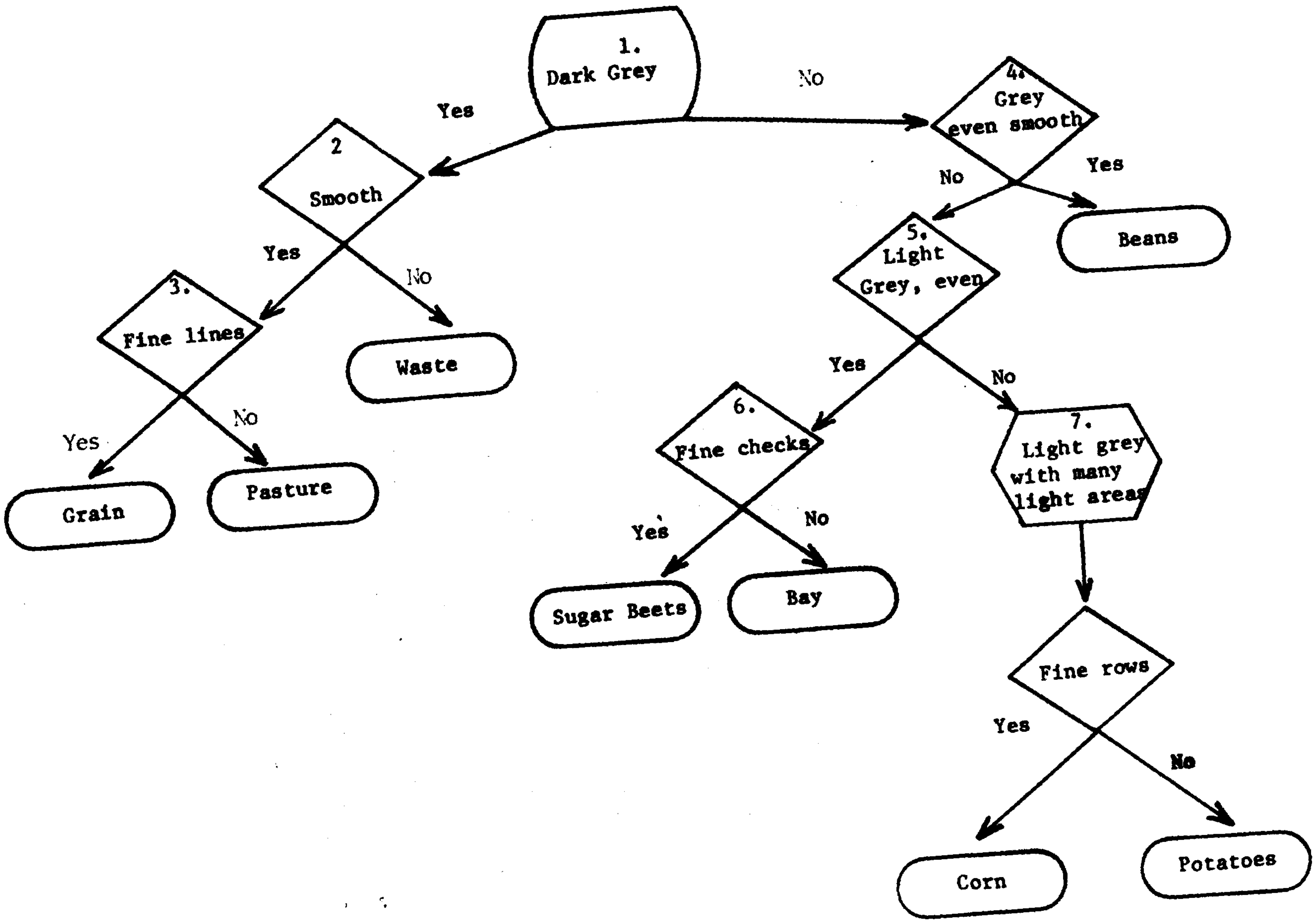

Table 1.--Field Classifications, Number of Fields Classified into:

Cover Type	Percent Correct Classification	Total No. of Fields	Grain	Hay	Pasture	Waste	Beans	Beets	Potatoes	Corn	F.S.
Grain	66.7	3	2	0	0	0	0	0	1	0	0
Hay	91.7	12	0	11	0	0	0	0	1	0	0
Pasture	77.8	9	0	0	7	0	0	0	1	1	0
Waste	66.7	3	0	1	0	2	0	0	0	0	0
Beans	83.3	6	0	1	0	0	5	0	0	0	0
Beets	33.3	9	1	0	0	0	2	3	1	2	0
Potatoes	66.7	12	0	1	0	0	0	0	8	3	0
Corn	-	0	0	0	0	0	0	0	0	0	0
Farmstead	100.0	3	0	0	0	0	0	0	0	0	3
Overall	71.9	57	3	14	7	2	7	3	12	6	3

Table 2.--Photo-Interpreter Classifications

Interpreter	Percentage Correct Classification
Experience Interpreter	94.7
Non-Experienced I	68.4
Non-Experienced II	63.2

Idaho Picture Key
Exhibit 2

Figure 3
FARMSTEAD

Figure 4
Dark gray to black
with fine lines
GRAIN

Figure 5
Dark gray and rough
WASTE

Figure 6
gray, even smooth
BEAMS

Figure 7
gray, fine checks
SUGAR BEETS

Figure 8
gray, fine lines
HAY

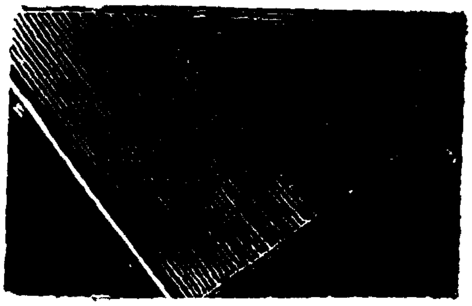

Figure 9
Light gray with
distinct wide rows
WINDROWED HAY

Idaho Picture Key
Exhibit 2

Figure 10
many light areas
very fine rows
CORN

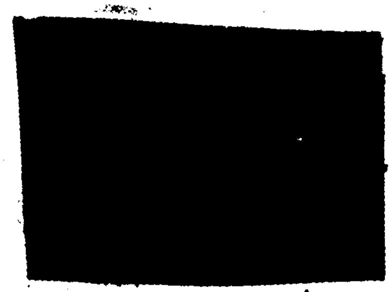

Figure 11
Light gray with
many light areas
fine rows
POTATOES

Figure 12
Light areas with
a few gray areas
very fine rows
CORN

Figure 13
Light areas with
a few gray areas
fine rows
POTATOES

References

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