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FILE REPORT 46

Methods of Image Analysis of Boreal Wetlands in Ontario

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Ministry of Natural Resources | Ministère des Richesses naturelles

This file report is an unedited, unpublished report submitted as partial fulfilment of NODA/NFP Project #4222, "Image analysis of wetlands in Northwestern Ontario".

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Methods of Image Analysis of Boreal Wetlands in Ontario

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Introduction

Conventional black and white aerial photographs have been taken since the early 1900s in Ontario. Apart from being available for a relatively long time, black and white photographs are cheap compared to other kinds of aerial photographs and imagery and are more readily interpreted by non-specialists. Another real advantage is resource managers can compare changes over time of specific areas, which they could not do without permanent field plot data. For these reasons we are attempting to develop new techniques for classifying and mapping wetland communities for ecological land classifications. This note introduces basic image scanning techniques, outlines methods for manipulating the scanned images (filtering), and reports the results of a test set of reference signatures we have acquired from an extremely variable peatland in northern Ontario.

Acquisition of Photographs

Aerial photography is present in most Ministry of Natural Resources offices as well as through federal government agencies. Most older archival (historical) photography is available on a limited basis from the Canadian National Archives, the Archives of Ontario and other private and government agencies. A complete collection of every aerial photograph taken of Canada by provincial or federal government agencies is available through the United States National Archives in Washington, D.C.

Image Scanning Methods

An image scanner samples an image at a certain intensity usualled referred to as dots per square inch (dpi) or dots per square centimeter. If an image is scanned at, say 80 dpi, this means that each square in inches of image is divided in 80 small squares. These tiny squares are referred to as pixels and the computer records one intensity value for each of the pixels, or in the 80 dpi case, 80 intensity measurements per square inch. This leads to a basic but critical question: how many dots (pixels) do I need to represent a unit area, or how large do I want each dot (pixel)?

Let us consider the following problem in an attempt to answer this question. Landsat images frequently have single pixel sizes which represent squares 30 by 30 meters on the ground. Assuming a black and white aerial photograph is at a scale of approximately 1:15000 a single pixel would have to be 2 cm by 2 cm in size to replicate the equivalent land area represented by the landsat pixel size. Scanning such a photograph would record one intensity number for every 30 m by 30 m of ground area. For wetland classification, 30 by 30 m pixels are not appropriate for detecting small wetland patches of a size which coincides with ecologically-based wetland classifications.

Scanning Examples

Figures 1,2 and 3 represent the same image scanned at 400, 100 and 50 dpi respectively. Depending on the purpose of the classification, at first glance, all three images may seem to be acceptable scans. However, what the human eye sees and what a computer can classify are often quite different. Thus the obvious question is: what is the difference in the accuracy of classifications produced from different scanning intensities? One simple test would be to perform an unsupervised classification. Such a method divides the image into a specified number of classes based on the variance observed in the overall image. Figures 4, 5 and 6 are the results of an unsupervised classification of these images, in which 12 clusters or classes are recognized.

Let us assess the results of the unsupervised classification. Of the three images, it is clear that the 100 dpi effort produces a classified image which is probably more realistic than the other two when compared to the original photograph. The 400 dpi image seems to have been classified on a scale too fine to separate the differences between the treed and non-treed portions of the photograph. The 50 dpi, while separating some of the features, is on too coarse a scale. In the sections that follow we will discuss manipulative methods to enhance both low and high intensity scans.

Computer Aided Classifications and Variance Removal

Classification is the method of grouping items with similar attributes. Human beings classify on the basis of similarities and variabilities in daily life. Computer algorithms operate similarly, classifying on the mean and the variance. The unsupervised classification described above operates in precisely this way. In general, the reason 100 dpi scans might seem to classify better than the 400 dpi is probably due to less variance between larger sized pixels, however this can be misleading. The 50 dpi scan has pixels so large that the image itself lacks the detail to separate clearly.

The 400 dpi scan produces a raw image in great detail, which as stated above is too detailed to classify. Several methods exist for removing detail, generally known as low pass filtering. The simplest form of low pass filtering is area averaging. A number of pixels in a square area are averaged with the average value being used. For example one can average groups of nine pixels and produce a low pass filtered image. Filtering our 400 dpi scan and reclassifying it with the unsupervised algorithm produced the image shown Figure 7 . The results of the filtered 400 dpi scan produced the clearest classification.

Optimum Classification Methods

A second test involves a supervised classification which uses an algorithm compares pixel intensities and variances to those represented in a set of training sites (signatures or seeds). Training sites are developed prior to running a supervised classification, usually by some expert manually digitizing a few examples of each site type on a reference image or images. These signatures are stored in a small image file data base and can be used to classify photographs. In this case the Canadian Forest Service at Sault Ste. Marie and the Wetlands Research Centre at the University of Waterloo have delineated training sites, and developed a set of training sites and reference signatures which can be tested. Depending on the algorithm used in the supervised classification a pixel is assigned to a specific class on the basis of the pixel value and the values of its neighbours (variance). Wetland classes are fairly distinct on photography and signatures can be developed by aerial photograph interpreters with extensive field experience.

Possible difficulties which arise involve equating photographs taken by different equipment, at different times of the year, or different years. Photographs are much more variable, than most other images, due to their dependence on light. For an image analysis system to be effective it must be able to equate photographs having a wide degree of variability.

Supervised Classification

Though there are several ways of approaching a supervised classification, we use a standard maximum likelihood supervised classification on our adjusted images with one slight alteration. Supervised classification modules in image analysis software are capable of analyzing across several bands or more than one image of the same scene. For example a colour scan consists of three different images, a red band representing the red frequency, a blue band (blue frequency) and a green band. Our procedure utilizes an adjusted image (produced as described above) and a filtered "adjusted" image to produce two bands. The filtering depends on the level of detail in the scan. Using the 400 dpi example, a mean filter produced a second band. Given that the higher intensity scan is too detailed, the image can be imporoved by filtering the image in conjunction with the adjusted image. Detail is retained and a more accurate classification results. Conversely for scans which lack detail, an edge enhancement filter on the adjusted image can be used to produce the second band. However both the higher and the lower intensity scans produce unsatisfactory results compared to the 400 dpi scan.

Field Tests and Comparisons

An open fen community of Nahma Bog near Cochrane and the surrounding wetland classes was chosen as one of our test sites. We selected this wetland because the vegetation communities have been surveyed in the field in 1959 by H. Sjors, in 1971 by J. Jeglum, in 1984 by S. Taylor and P. Adams, in 1990 by P. Adams and J. Jeglum and in 1993 by P. Adams, J. Jeglum, K. Taylor and H. Wilson. Thus with such a thorough survey and historical record of the vegetation, we are confident that we can accurately interpret both the 1991 and 1961 photography by direct comparisons with field survey information.

We classified both the 1991 and 1961 images using the same reference signatures and compared the results.

Images were adjusted for within and between image variation. Figures 11 and 12 present the supervised classifications of the 1991 and 1961 images based on our set of reference signatures. Each legend category was a training signature applied to each image. The results of the wetland classification were checked in the field in August 1992 by P. Adams and J. Jeglum. The 1961 classification was also checked with the 1959 survey.

In comparing the results of the classifications with the field data, there were some surprising results. The classification picks up the boundaries of the defined classes within a few meters. The main sources of error occur at the class interfaces. Probably the most glaring is at the lower end of the basin fen (labelled "A" in Figure 8). The 1991 image depicts a high density treed bog (HDTB) ringed by a thin layer of swamp. In fact the (HDTB) grades into the low density treed bog (LDTB) without a swamp component at the bottom. These communities are not encountered in the 1961 image. The ring of trees surrounding the basin fen appears to have grown and expanded its area during the intervening 30 years between 1961 and 1991 when the two photographs were taken. In the 1991 image there is considerable vertical structure (large, small and layering trees) at the interface between the HDTB and the LDTB. This structure is not present in 1961. It is reassuring to see the treed signatures in the images match closely the treed bog communities identified in the field.

Further comparison of the 1961 and 1991 classifications reveals an increase in the Sphagnum component of the fen. Sphagnum expansion in the fen would not be unexpected for the 30 year period between photography dates.

Current and Future Work

Ongoing work is aimed at assembling the signatures into a reference collection which can be ran with either IDRISI or ERDAS. Currently the collection consists of 15 signatures which are capable of classifying most kinds of wetland communities for northeastern Ontario. The user would simply enter the signature names at a prompt, and run the classification. Setting an acceptable error level (5%) would ensure that classes not represented in the reference collection were left unclassified. Clearly the prospect of using black and white aerial photographs for classifying boreal wetlands is encouraging. It is an easy, accurate and inexpensive technique which field workers will find to be a good technique to use in their day to day activities. Though more work is required to refine the techniques more fully, these initial results are most encouraging.

List of Figures

Figure 1

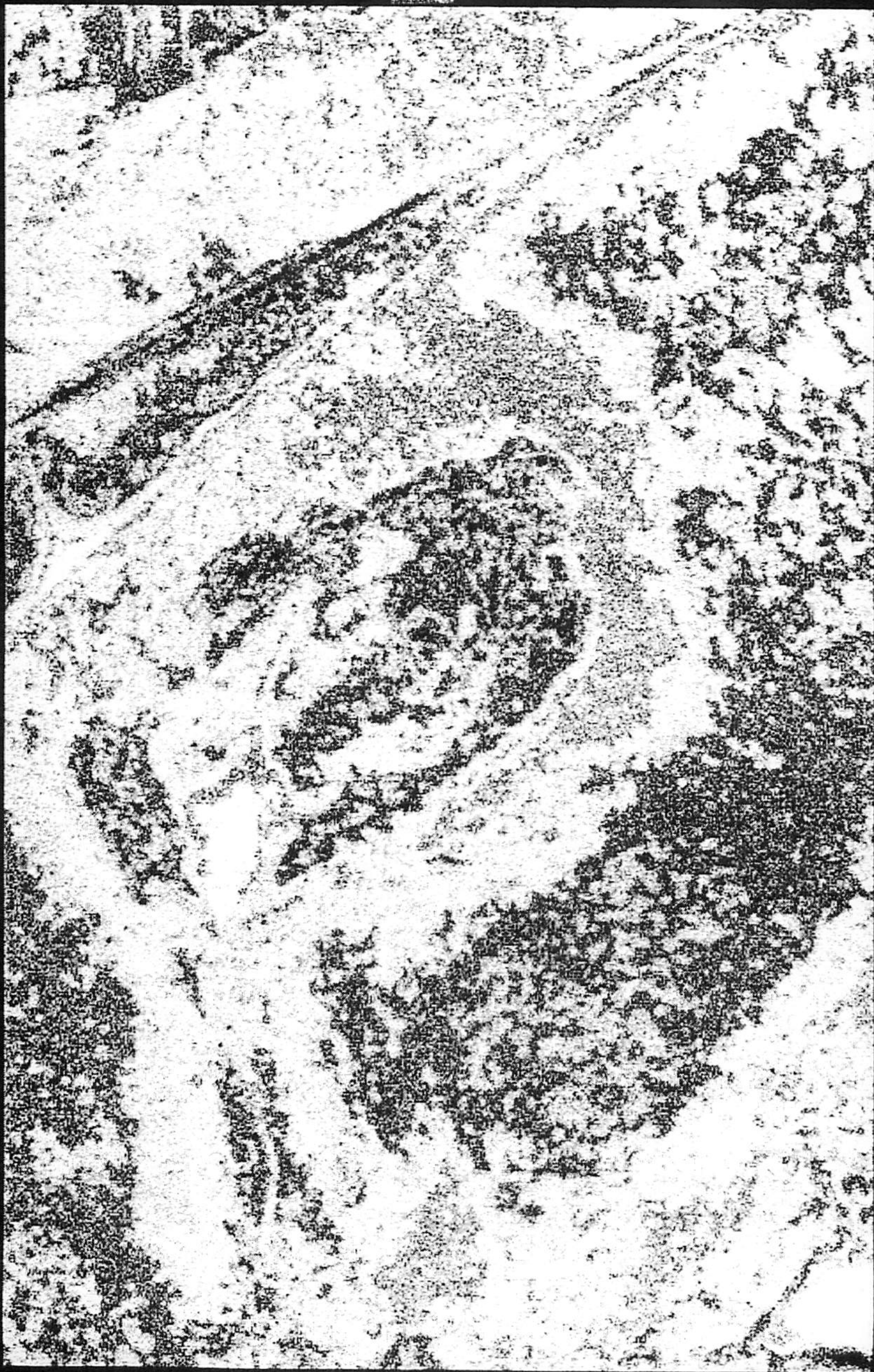

Figure 2

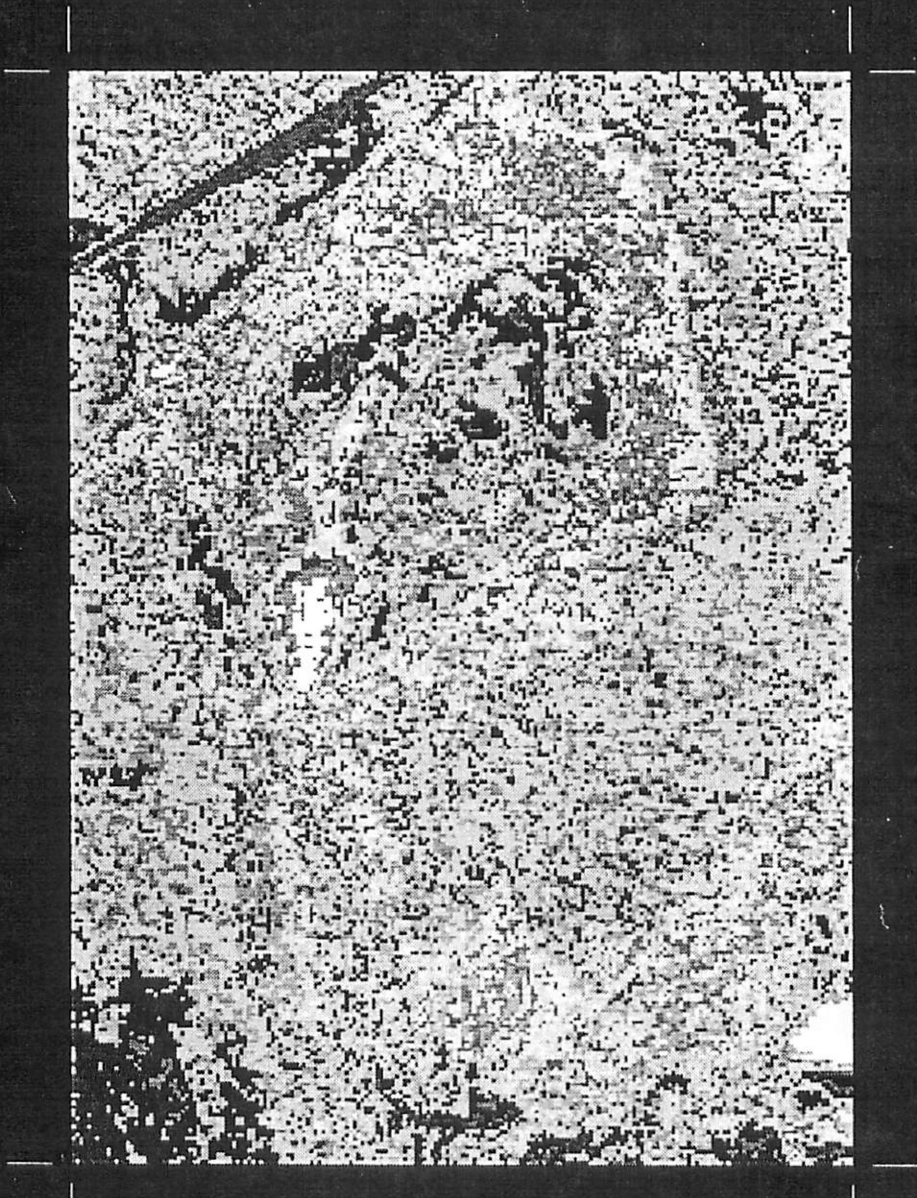

Figure 3

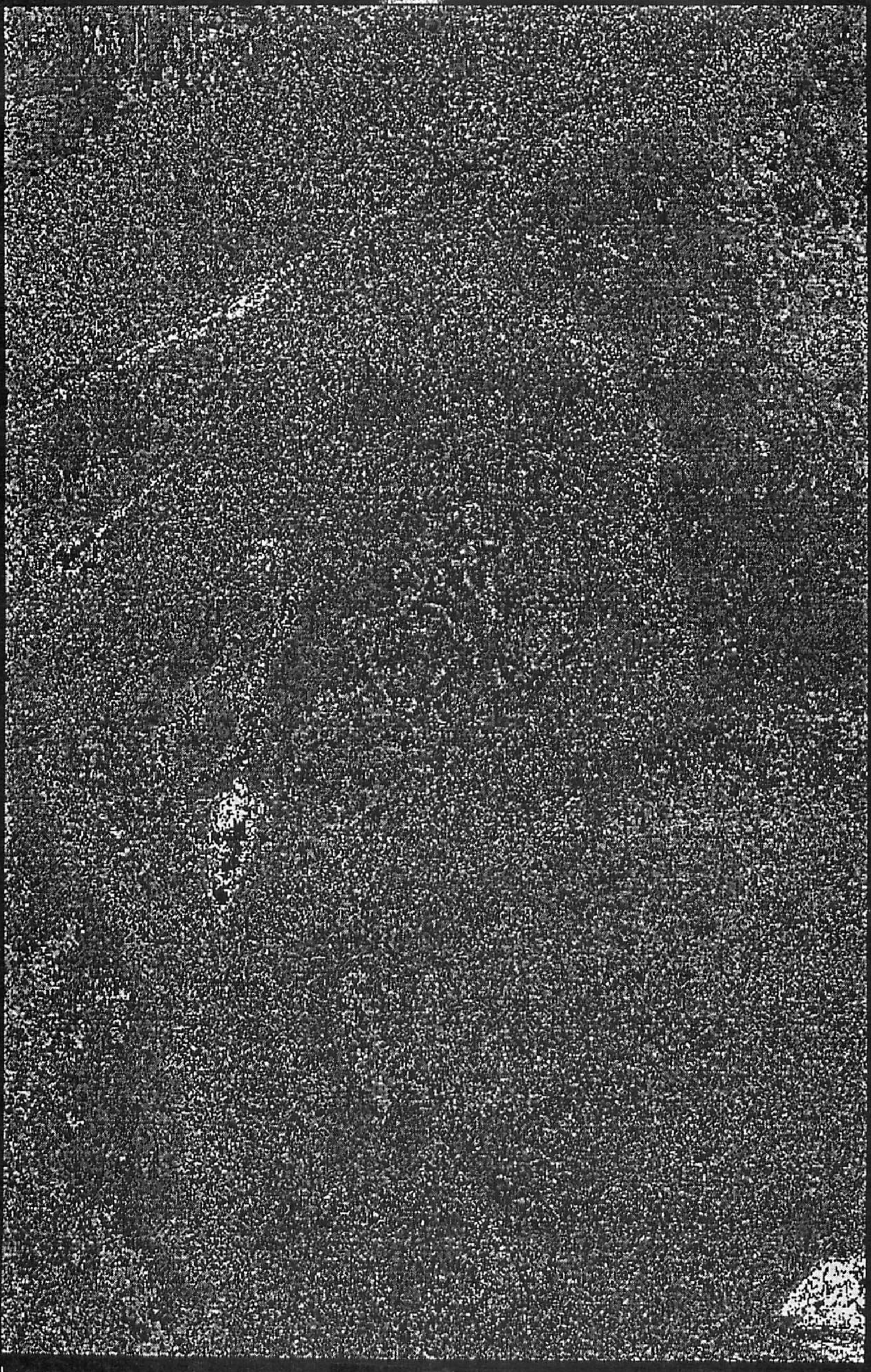

Figure 4

Figure 5

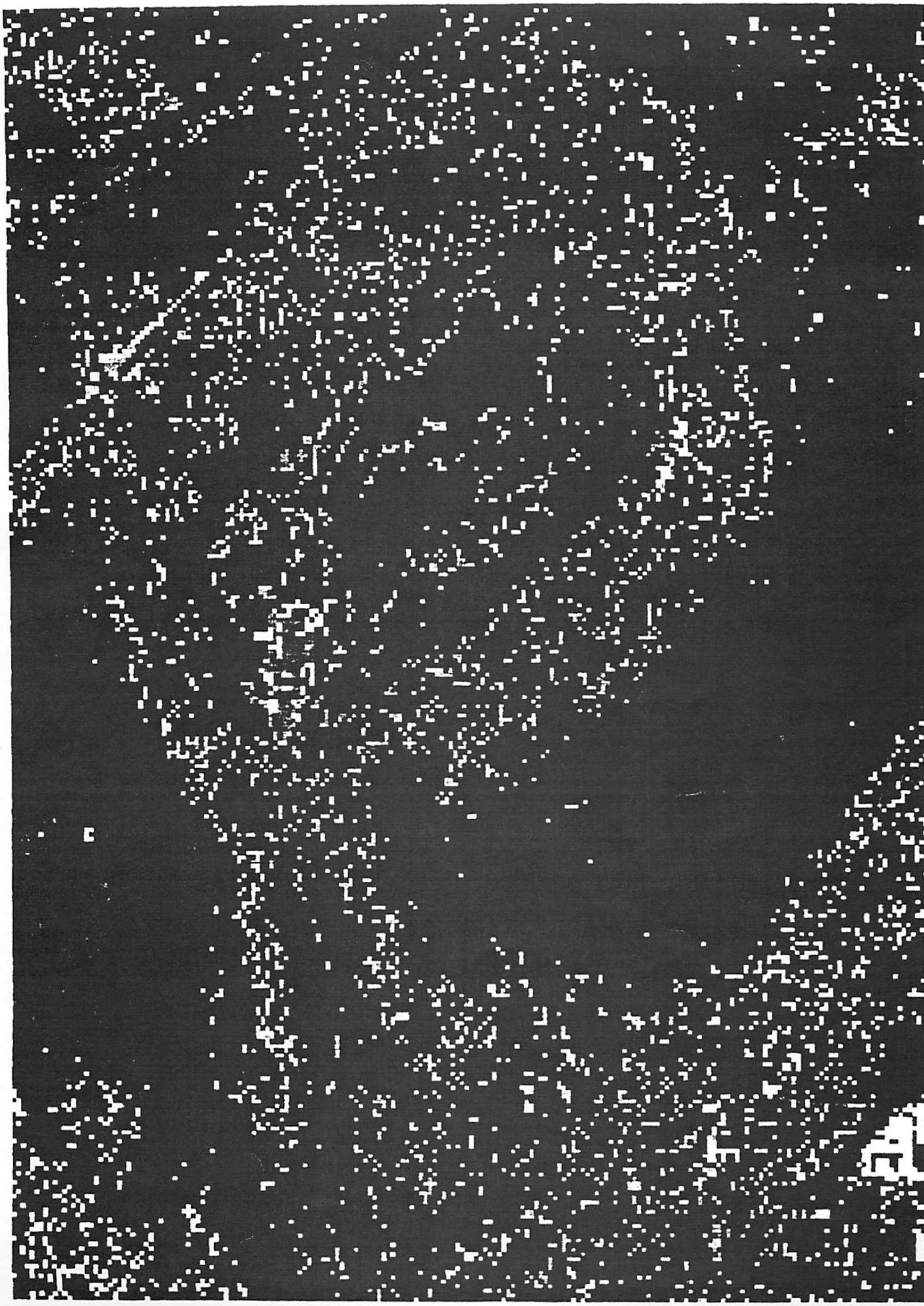

Figure 6

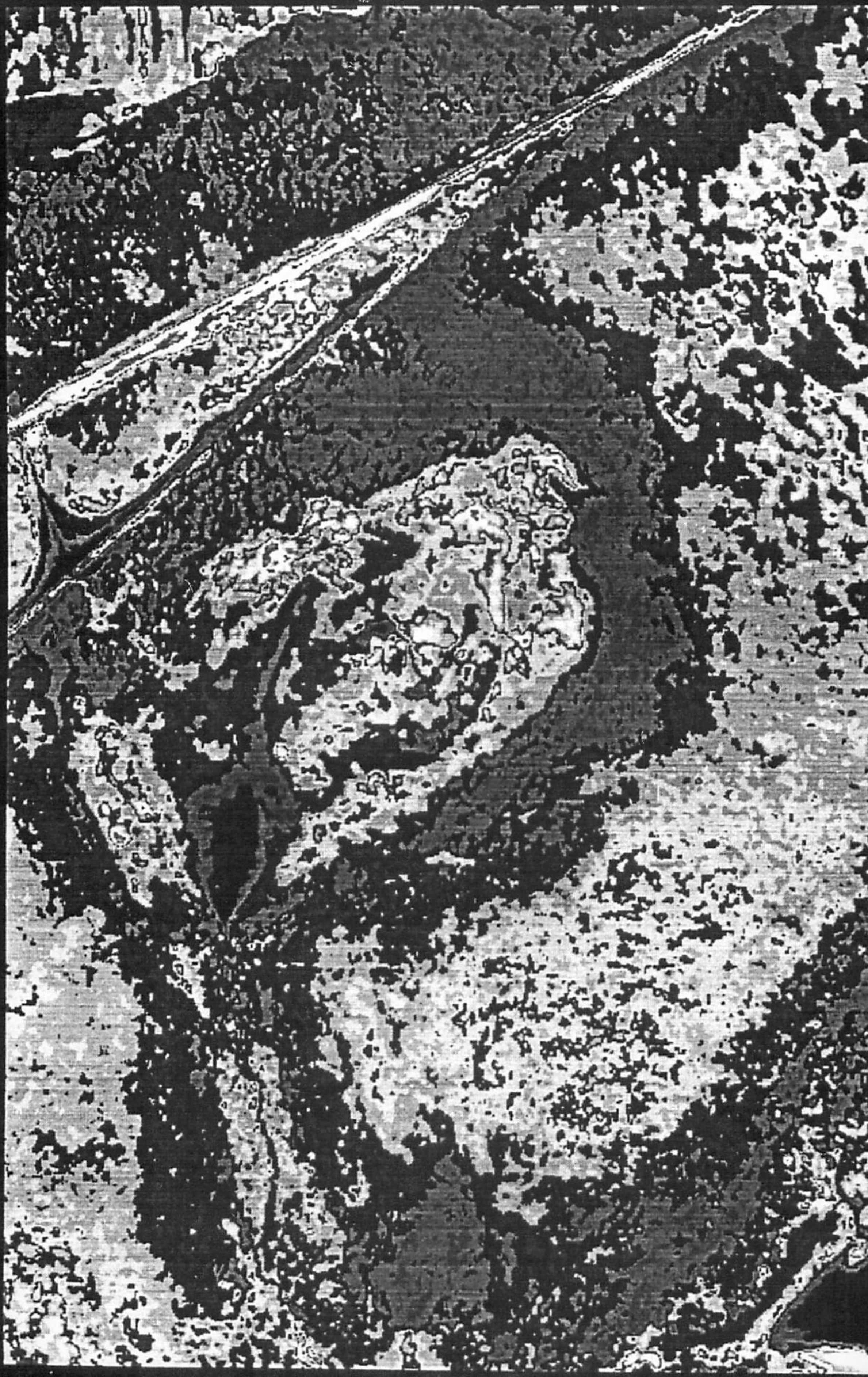

Figure 7

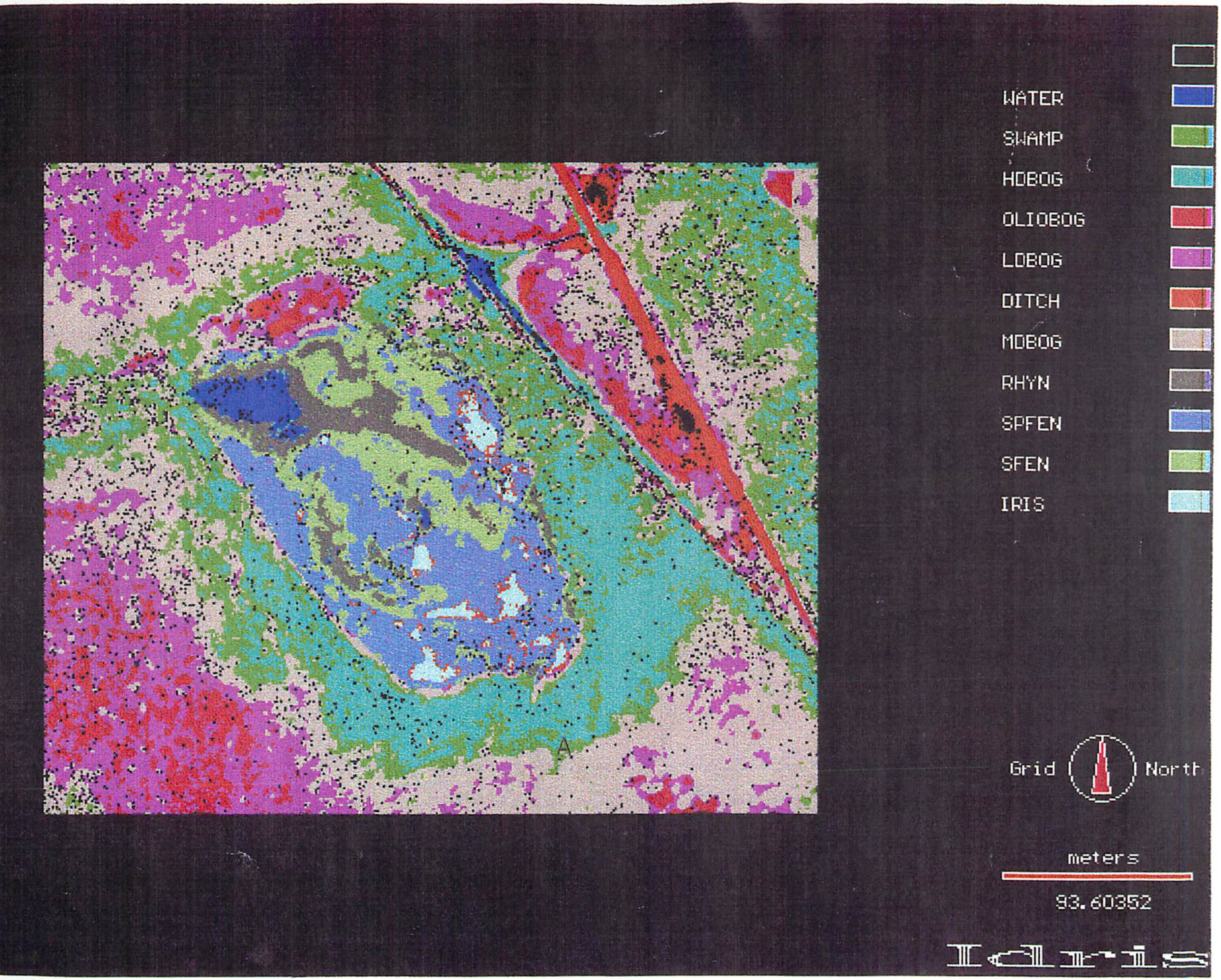
WATER
SWAMP
HDBOG
OLIOBOG
LDBOG
DITCH
MDBOG
RHYN
SPFEN
SFEN
IRIS
A
Grid North
meters
93.60352
Idris

Figure 8

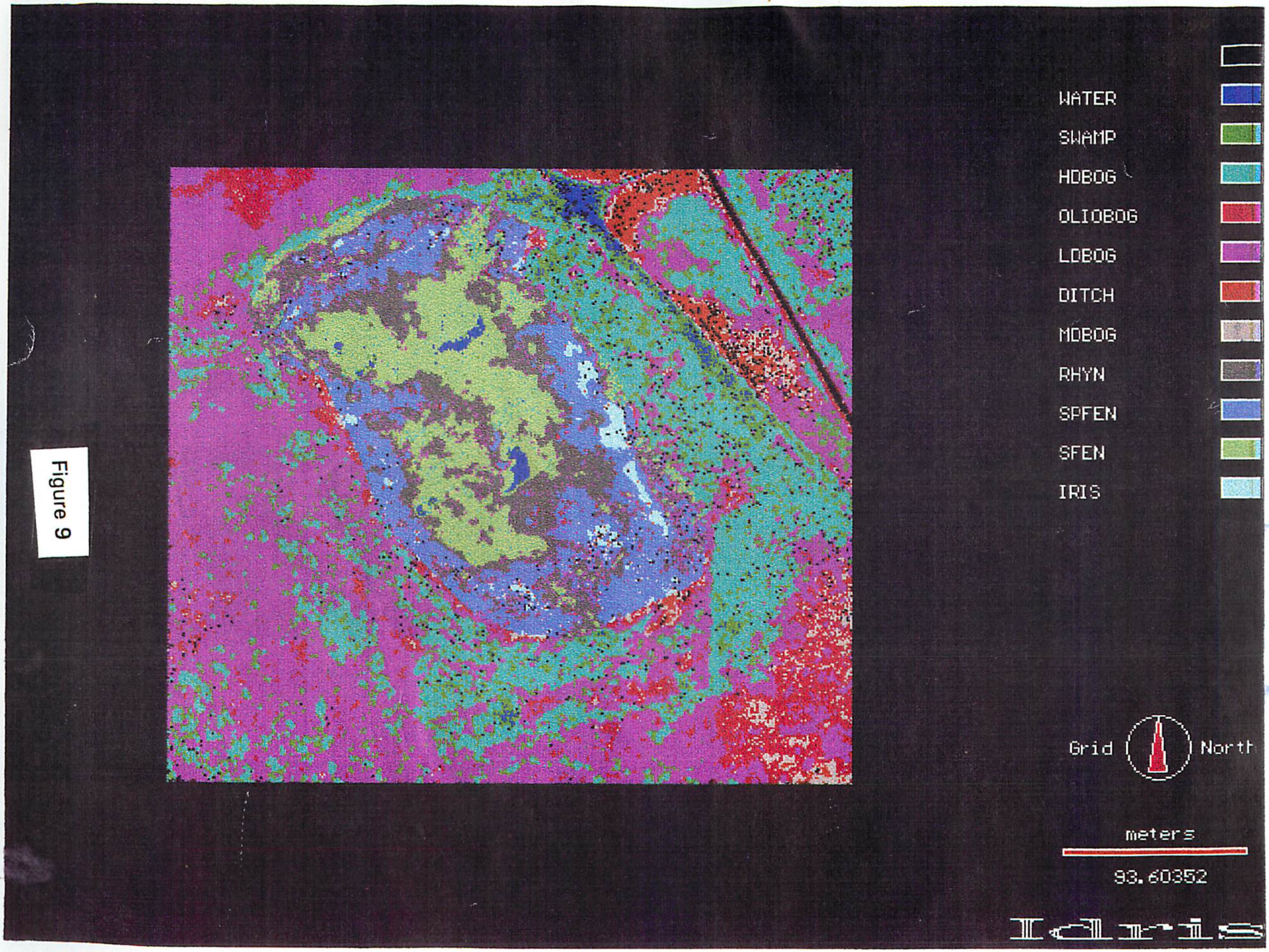
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Figure 9