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PROGRESS REPORT 8

Type II

AUTOMATIC PHOTOINTERPRETATION FOR LAND USE MANAGEMENT IN MINNESOTA

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Summary

The Minnesota Iron Range area was selected as one of the land use areas to be evaluated. Six classes were selected namely,

1) hardwood
2) conifer
3) water (including in mines)
4) mines, tailings and wet areas
5) open
6) urban

Initial classification results show a correct classification of 70.1 to 95.4% for the six classes. This is extremely good. It can be further improved since there were some incorrect classifications in the ground truth.

Application of ERTS-1 Imagery to the Evaluation of Land Use in the Minnesota Iron Range:

A Study of the Trout Lake Area

A. Purpose

The purpose of this study was to determine how effectively different types of land use can be distinguished, one from the other by the use of light density levels from the four bands of the ERTS-1 photos.

The photo used for the study was 1075-16312. There were several reasons why this particular photo and the area within were chosen. First, it offered a cloudless view of the Iron Range at a time of the year when vegetation was in full bloom. Second, another area of this photo, Pineville, had already been evaluated by Mike Cheung, a co-investigator. Thus, the density levels of particular features could be compared from one part of the photo to another allowing something to be said about the transferability of evaluations. The Trout Lake area was selected because of the ground truth information available. For all areas such information as aerial photos, county maps, and quadrangle maps are available. But, for this area there was also available a map of land use produced by the Department of Geography of the University of Minnesota from ERTS photos. These were considered good as ground truth because the interpreters had already decided what information could be obtained from the ERTS photos in the Iron Range.

B. Procedure (ad adapted by M. Cheung)

The general procedure for extracting, mapping, and classifying the land use of a particular site explained in the following paragraphs was deviced for our purposes by Mike Cheung. The procedure was as follows:

<u>Step 1</u>

The first step was to pinpoint the proposed study area on the ERTS photo. This was done by overlying 10 by 10 to the centimeter graph paper on the photo. The outline of the photo was then divided into four equal vertical strips, in the same manner as the data of the photo is stored on the magnetic tape. Using the divisions of the graph paper, the area desired was encased. If the area fell within two of the vertical strips, it had to be extracted from two separate digital tapes. This was not the case with Trout Lake. The location of the area on the magnetic tape was determined by the number of columns and rows from the upper left hand corner of its vertical strip times the number of data elements per division in each direction.

Step 2

Next, the data within the study area was transferred from the ERTS tape to a scratch tape. This permitted the convenience of not having to redesignate the area when dealing with the data subsequently. To do this, a simple transfer of data program was used which required the location of the area within the photo and the dimensions of the area.

Step 3

The generation of a density level map of the area from which land use identifications could be made was the next step.

To accomplish this, a histogram program was first run, providing a density level histogram plot from each of the four data bands. This provided, for each band, the total number of data units within the area, the value of the minimum and the maximum data unit, the mean of the data, and the standard deviation. The histogram itself provided the data value on the Y-axis and the percentage of all data units within each value on the X-axis. The total number of data units within each value was also provided. (see figure 1, page 4)

The levels of the histogram for each band were then divided into fourteen intervals, with the fourteenth, over the maximum for that band, being designated as error (E). A symbol or combination of symbols was then assigned to each of the thirteen remaining intervals. These symbols were selected and assigned so that their shading, from white (blank) to black, corresponds with the increasing value of the density intervals.

The density level map was then produced by printing in the place of each data element the symbol of the interval within which its value fell. Hence, instead of merely printing out a sheet of data units, a shaded density level map was obtained. Only the band 7 map was used for interpretive purposes.

Step 4

The map thus produced, provided a convenient base on which to designate the particular land uses of the area. Using water bodies and rivers as orientation points, the density level map was aligned with the various sources of ground truth: in this case an aerial photo from 4/24/69 provided by the Mark Hurd Aerial Surveys, Inc. and a map of land use prepared from ERTS photos by John Harrington and Steve Preston of the Department of Geography of the University of Minnesota. The University's land use map was the principal source of ground truth with the aerial photo being used more as a verification of the uses assigned on that map.

Land use, for this particular Iron Range study, was divided into nine classes:

Class	Name	Number
1	hardwood	11
2	conifer	12
3	water	31
4	water in mines	32
5	wetlands	40
6	mines	61
7	tailings	62
8	open	70
9	urban	80

These classes were thought to represent all the distinct land uses within the area. When a sample was identified on the density level map, it was delineated and labeled.

This procedure was continued until the number of samples within each class was sufficient to establish the class' character. With the character of each class determined, automatic classification could proceed.

In order to extract the numerical data of the four bands for the designated sample so that it could be later manipulated, the next three steps were followed.

Step 5

The information concerning each sample that had been designated was recorded. The column and row number of the upper

```
06OCT72 C N47-25/W092-13 N N47-23/W092-08          SUN EL34 AZ154 192-1045- -1-  D-
 NASA ERTS E-1075-16312-                          D N-      1 3240 1430   67  130  180
T    -         , R    -          TROUT L.
BAND. 7     TOTAL NUMBER OF DATA =  23400
MINIMUM DATA =    0
MAXIMUM DATA =   31
MEAN =  13.154
STANDARD DEVIATION =    4.474

DENSITY LEVEL HISTOGRAM PLOT, (X-AXIS=PERCENTAGE, Y-AXIS=VALUE)

                        0         2         4         6         8         10        12        14
DATA TOTAL PERCENT      +---------+---------+---------+---------+---------+---------+---------+---
  0     6     .03       +
  1   217     .93       I***θ
  2   548    2.34       I**********θ
  3   630    2.69       I************θ
  4   372    1.59       I******θ
  5   259    1.11       I****θ
  6   230     .98       I***θ
  7   290    1.24       I*****θ
  8   610    2.61       I************θ
  9   841    3.59       I****************θ
 10  1010    4.32       +********************θ
 11  1494    6.38       I******************************θ
 12  1878    8.03       I***************************************θ
 13  2357   10.07       I*************************************************θ
 14  2602   11.12       I******************************************************θ
 15  2437   10.41       I***************************************************θ
 16  2947   12.59       I*************************************************************θ
 17  1896    8.10       I***************************************θ
 18  1199    5.12       I************************θ
 19   664    2.84       I*************θ
 20   367    1.57       +******θ
 21   203     .87       I***θ
 22   137     .59       I*θ
 23    58     .25       Iθ
 24    59     .25       Iθ
 25    34     .15       I
 26    32     .14       I
 27    14     .06       I
 28     6     .03       I
 29     0     .00       I
 30     2     .01       +
 31     1     .00       I
DATA TOTAL PERCENT      +---------+---------+---------+---------+---------+---------+---------+---
                        0         2         4         6         8         10        12        14
```

6

figure 1 - histogram of [illegible]

left-hand corner of the sample, the size of the sample (the number of columns and rows), and its land use identification number was punched on a separate computer card.

Step 6

Next, a sorting program was run to determine the order in which the samples were to be extracted from the scratch tape which contained the data of the area. This was necessary due to the fact that data is stored row by row; i.e., if a sample goes from row 1 through row 4, no other data can be taken from those rows without first rewinding the tape. Thus, the data for some samples was extracted, the tape was rewound, and so on. (see figure 3)

Step 7

The data for each band of each sample was now transferred in the order given by the sort program from the scratch tape to a training tape. This is called a training tape because it contains the data with which the K-classification program will "train" in the process of differentiation of classes.

Along with the transfer of the data were printed the values for each band for each element of each sample, as well as the location of the sample and its classification number. (see figure 4) After all of the information had been transfered, the minimum, maximum, mean, and standard deviation for each channel and band of each class were printed out. (see nine page section at end of report). From this it could be determined which channels of which bands were useable for the K-classification. A particular channel is considered of dubious value if its standard deviation is at a level that implies randomness of the data values. In this particular portion of this photo, all channels of all bands seemed to supply valid information.

Step 8

Since each run of the Dispersion K-class peogram can have only six classes, the nine previously designated had to be compressed. This was done by using the minimum, maximum, mean, and standard deviation information as well as information about the land uses themselves. The classes were merged as follows:

1	4
6	3
9	3
13	3
18	4
22	3
26	4
30	5
36	4
40	3
43	5
48	6
54	3
57	5
63	4
67	4
71	4
75	5
81	2
83	4
89	4
94	2
96	5
102	3
105	3
108	6
114	4
118	2
120	3
123	2
125	3
128	3

----- REWIND TAPE HERE -----

1	3
4	3
7	3
11	3
14	5
20	3
24	5
29	4
34	3
38	2
40	3
43	5
50	4
54	4
58	5
63	5
68	6
74	2
76	3
82	3
85	4
89	4
97	2
99	2
102	4
106	4
110	3
113	5
118	4
122	4
126	5

----- REWIND TAPE HERE -----

figure 3

```
O FILE IS SKIPPED FØRWARD ØN TAPE UNIT 10
(UNIT 10 = TAPE DATA, UNIT 20 = TAPE BANK)

RECØRD =   1            ANNØTATIØN
    06ØCT72 C N47-25/W092-13 N N47-23/W092-08          SUN EL34 AZ154 192-1045- -1-  D-   NASA ERTS E
    -1075-16312-                               D N-000100S000FF00130022002U                  TRØUT L-00000000

  ØPTIØN,(FRØM:LINE        BYTE),(AREA:RØW     CØLUMN)    CLASS
       1          1         115         4          4        40

RECØRD =    2          CLASS = 40
 20  15  20  11/  20  14  20  12/  20  14  22  12/  19  14  22  13/   1 115  40

RECØRD =    3          CLASS = 40
 19  14  21  11/  20  14  21  11/  19  14  24  11/  20  13  24  12/   2 115  40

RECØRD =    4          CLASS = 40
 19  14  19  11/  19  14  20  11/  18  14  23  12/  19  15  24  13/   3 115  40

RECØRD =    5          CLASS = 40
 20  15  19  11/  20  14  20  12/  20  16  20  12/  20  16  22  12/   4 115  40

  ØPTIØN,(FRØM:LINE        BYTE),(AREA:RØW     CØLUMN)    CLASS
       1          6          29         3          3        31

RECØRD =    6          CLASS = 31
 17  10   8   2/  17  10   9   2/  17  11  12   5/   6  29  31

RECØRD =    7          CLASS = 31
 17  10   7   2/  16   9   8   3/  17  11  10   5/   7  29  31

RECØRD =    8          CLASS = 31
 19  13  13   5/  17  10   9   2/  17  10   9   2/   8  29  31

  ØPTIØN,(FRØM:LINE        BYTE),(AREA:RØW     CØLUMN)    CLASS
       1          9          21         3          3        12

RECØRD =    9          CLASS = 12
 19  12  18  11/  19  13  19  10/  20  14  23  11/   9  21  12

RECØRD =   10          CLASS = 12
 18  13  19  11/  18  13  19  11/  20  15  20  11/  10  21  12

RECØRD =   11          CLASS = 12
 19  17  21  11/  19  16  21  10/  18  13  20  10/  11  21  12
```

figure 4

feature	new class
hardwood (11)	1
conifer (12)	2
water (31)	3
water in mines (32)	3
wetlands (40)	4
mines (61)	4
tailings (62)	4
open (70)	5
urban (80)	6

Wetlands were put with mines and tailings not only because their numerical values were similar; but, also, because their occurrence in this area seems to be mostly the results of mines and tailings (i.e., part of tailing ponds).

Step 9

Next was generated an annotation of the data listing the channel, line, byte, new classification and ID number, and the data of all four bands for each data element. These were later used in checking the reasons for the various misses in the K-classification. (see figure 5)

Step 10

Finally, the Dispersion K-class program was run on the data of the features contained on the training tape. (For particulars on this program, consult Revised Dispersion K-class-2ddp-24 booklet).

A summary of the population revealed a total of 2855 data elements with 543 in class 1, 381 in class 2, 327 in class 3, 1256 in class 4, 214 in class 5, and 134 in class 6.

Each iteration of the K-class program provided the number of misses along with a confusion matrix by percent and by samples. The first iteration contained 863 misses. By the sixth, this had decreased to 642. (see figure 6)

With the giving of the appropriate signal, the iterations terminate and a list of the misses at that point are printed out. Since the improvements in performance were very slight after the initial ones, it was decided to print out the list of misses after the sixth iteration. In the list were printed the ID number of the element, its assigned class, and the class decided upon by the K-class program. (see figure 7)

ANNOTATION

06OCT72 C N47-25/W092-13 N N47-23/W092-08 SUN EL34 AZ154 192-1045- -1
-1075-16312- D N-000100S000FF00130022002U

CHANNEL= 1,	LINE= 1,	BYTE=115,	CLASS= 5,	ID=1001001	DATE=	20	15	20	11
CHANNEL= 1,	LINE= 1,	BYTE=116,	CLASS= 5,	ID=1001002	DATE=	20	14	20	12
CHANNEL= 1,	LINE= 1,	BYTE=117,	CLASS= 5,	ID=1001003	DATE=	20	14	22	12
CHANNEL= 1,	LINE= 1,	BYTE=118,	CLASS= 5,	ID=1001004	DATE=	19	14	22	13
CHANNEL= 2,	LINE= 2,	BYTE=115,	CLASS= 5,	ID=1001005	DATE=	19	14	21	11
CHANNEL= 2,	LINE= 2,	BYTE=116,	CLASS= 5,	ID=1001006	DATE=	20	14	21	11
CHANNEL= 2,	LINE= 2,	BYTE=117,	CLASS= 5,	ID=1001007	DATE=	19	14	24	11
CHANNEL= 2,	LINE= 2,	BYTE=118,	CLASS= 5,	ID=1001008	DATE=	20	13	24	12
CHANNEL= 3,	LINE= 3,	BYTE=115,	CLASS= 5,	ID=1001009	DATE=	19	14	19	11
CHANNEL= 3,	LINE= 3,	BYTE=116,	CLASS= 5,	ID=1001010	DATE=	19	14	20	11
CHANNEL= 3,	LINE= 3,	BYTE=117,	CLASS= 5,	ID=1001011	DATE=	18	14	23	12
CHANNEL= 3,	LINE= 3,	BYTE=118,	CLASS= 5,	ID=1001012	DATE=	19	15	24	13
CHANNEL= 4,	LINE= 4,	BYTE=115,	CLASS= 5,	ID=1001013	DATE=	20	15	19	11
CHANNEL= 4,	LINE= 4,	BYTE=116,	CLASS= 5,	ID=1001014	DATE=	20	14	20	12
CHANNEL= 4,	LINE= 4,	BYTE=117,	CLASS= 5,	ID=1001015	DATE=	20	16	20	12
CHANNEL= 4,	LINE= 4,	BYTE=118,	CLASS= 5,	ID=1001016	DATE=	20	16	22	12
CHANNEL= 6,	LINE= 6,	BYTE= 29,	CLASS= 3,	ID=1001017	DATE=	17	10	8	2
CHANNEL= 6,	LINE= 6,	BYTE= 30,	CLASS= 3,	ID=1001018	DATE=	17	10	9	2
CHANNEL= 6,	LINE= 6,	BYTE= 31,	CLASS= 3,	ID=1001019	DATE=	17	11	12	5
CHANNEL= 1,	LINE= 7,	BYTE= 29,	CLASS= 3,	ID=1001020	DATE=	17	10	7	2
CHANNEL= 1,	LINE= 7,	BYTE= 30,	CLASS= 3,	ID=1001021	DATE=	16	9	8	3
CHANNEL= 1,	LINE= 7,	BYTE= 31,	CLASS= 3,	ID=1001022	DATE=	17	11	10	5
CHANNEL= 2,	LINE= 8,	BYTE= 29,	CLASS= 3,	ID=1001023	DATE=	19	13	13	5
CHANNEL= 2,	LINE= 8,	BYTE= 30,	CLASS= 3,	ID=1001024	DATE=	17	10	9	2
CHANNEL= 2,	LINE= 8,	BYTE= 31,	CLASS= 3,	ID=1001025	DATE=	17	10	9	2
CHANNEL= 3,	LINE= 9,	BYTE= 21,	CLASS= 2,	ID=1001026	DATE=	19	12	18	11
CHANNEL= 3,	LINE= 9,	BYTE= 22,	CLASS= 2,	ID=1001027	DATE=	19	13	19	10
CHANNEL= 3,	LINE= 9,	BYTE= 23,	CLASS= 2,	ID=1001028	DATE=	20	14	23	11
CHANNEL= 4,	LINE= 10,	BYTE= 21,	CLASS= 2,	ID=1001029	DATE=	18	13	19	11
CHANNEL= 4,	LINE= 10,	BYTE= 22,	CLASS= 2,	ID=1001030	DATE=	18	13	19	11
CHANNEL= 4,	LINE= 10,	BYTE= 23,	CLASS= 2,	ID=1001031	DATE=	20	15	20	11
CHANNEL= 5,	LINE= 11,	BYTE= 21,	CLASS= 2,	ID=1001032	DATE=	19	17	21	11
CHANNEL= 5,	LINE= 11,	BYTE= 22,	CLASS= 2,	ID=1001033	DATE=	19	16	21	10
CHANNEL= 5,	LINE= 11,	BYTE= 23,	CLASS= 2,	ID=1001034	DATE=	18	13	20	10
CHANNEL= 1,	LINE= 13,	BYTE=168,	CLASS= 3,	ID=1001035	DATE=	17	11	10	3
CHANNEL= 1,	LINE= 13,	BYTE=169,	CLASS= 3,	ID=1001036	DATE=	19	11	9	3
CHANNEL= 1,	LINE= 13,	BYTE=170,	CLASS= 3,	ID=1001037	DATE=	17	10	9	3
CHANNEL= 2,	LINE= 14,	BYTE=168,	CLASS= 3,	ID=1001038	DATE=	19	10	10	3
CHANNEL= 2,	LINE= 14,	BYTE=169,	CLASS= 3,	ID=1001039	DATE=	19	11	10	3
CHANNEL= 2,	LINE= 14,	BYTE=170,	CLASS= 3,	ID=1001040	DATE=	19	11	9	2
CHANNEL= 3,	LINE= 15,	BYTE=168,	CLASS= 3,	ID=1001041	DATE=	19	12	7	2
CHANNEL= 3,	LINE= 15,	BYTE=169,	CLASS= 3,	ID=1001042	DATE=	19	10	7	3
CHANNEL= 3,	LINE= 15,	BYTE=170,	CLASS= 3,	ID=1001043	DATE=	19	12	7	2
CHANNEL= 6,	LINE= 18,	BYTE=125,	CLASS= 7,	ID=1001044	DATE=	27	29	28	11
CHANNEL= 6,	LINE= 18,	BYTE=126,	CLASS= 7,	ID=1001045	DATE=	27	26	28	12
CHANNEL= 6,	LINE= 18,	BYTE=127,	CLASS= 7,	ID=1001046	DATE=	25	24	28	14
CHANNEL= 6,	LINE= 18,	BYTE=128,	CLASS= 7,	ID=1001047	DATE=	27	26	29	14
CHANNEL= 1,	LINE= 19,	BYTE=125,	CLASS= 7,	ID=1001048	DATE=	26	27	26	11
CHANNEL= 1,	LINE= 19,	BYTE=126,	CLASS= 7,	ID=1001049	DATE=	26	27	27	13
CHANNEL= 1,	LINE= 19,	BYTE=127,	CLASS= 7,	ID=1001050	DATE=	26	27	29	11
CHANNEL= 1,	LINE= 19,	BYTE=128,	CLASS= 7,	ID=1001051	DATE=	26	27	26	10
CHANNEL= 2,	LINE= 20,	BYTE=125,	CLASS= 7,	ID=1001052	DATE=	25	27	27	11
CHANNEL= 2,	LINE= 20,	BYTE=126,	CLASS= 7,	ID=1001053	DATE=	27	27	29	12
CHANNEL= 2,	LINE= 20,	BYTE=127,	CLASS= 7,	ID=1001054	DATE=	25	23	22	9
CHANNEL= 2,	LINE= 20,	BYTE=128,	CLASS= 7,	ID=1001055	DATE=	25	23	22	8
CHANNEL= 3,	LINE= 21,	BYTE=125,	CLASS= 7,	ID=1001056	DATE=	26	25	26	11

*** PERFORMANCE SUMMARY *** *iteration number 1*

863 MISSES
COST = 863

RUNS CONFUSION MATRIX, BY PERCENTS

	1/	2/	3/	4/	5/	6/
CLASS 1/	77.0	.2	.0	2.9	10.1	9.8
CLASS 2/	13.1	55.9	22.6	3.7	3.1	1.6
CLASS 3/	.0	.0	100.0	.0	.0	.0
CLASS 4/	10.6	6.3	12.0	57.7	.9	12.5
CLASS 5/	6.1	.0	.0	.0	89.3	4.7
CLASS 6/	5.2	.0	.0	3.0	3.7	88.1

RUNS CONFUSION MATRIX, BY SAMPLES

418	1	0	16	55	53
50	213	86	14	12	6
0	0	327	0	0	0
133	79	151	725	11	157
13	0	0	0	191	10
7	0	0	4	5	118

*** PERFORMANCE SUMMARY *** *iteration number 6*

642 MISSES
COST = 642

RUNS CONFUSION MATRIX, BY PERCENTS

	1/	2/	3/	4/	5/	6/
CLASS 1/	77.3	.4	.0	4.6	9.6	8.1
CLASS 2/	10.0	80.3	2.1	5.8	.3	1.6
CLASS 3/	.0	3.1	95.4	1.5	.0	.0
CLASS 4/	8.6	9.6	4.2	70.1	.3	7.2
CLASS 5/	7.5	.5	.0	.0	87.9	4.2
CLASS 6/	5.2	.0	.0	11.9	3.0	79.9

RUNS CONFUSION MATRIX, BY SAMPLES

420	2	0	25	52	44
38	306	8	22	1	6
0	10	312	5	0	0
108	121	53	880	4	90
16	1	0	0	188	9
7	0	0	16	4	107

ID 1002923	1 - TT 5,	CLASS 4,	DEC'N 2
ID 1002931	1 - TT 6,	CLASS 4,	DEC'N 3
ID 1002936	1 - TT 5,	CLASS 4,	DEC'N 1
ID 1002937	1 - TT 5,	CLASS 4,	DEC'N 1
ID 1002938	1 - TT 5,	CLASS 4,	DEC'N 1
ID 1002939	1 - TT 5,	CLASS 4,	DEC'N 6
ID 1002940	1 - TT 5,	CLASS 4,	DEC'N 6
ID 1002941	1 - TT 5,	CLASS 4,	DEC'N 6
ID 1002945	1 - TT 4,	CLASS 3,	DEC'N 4
ID 1002953	1 - TT 6,	CLASS 4,	DEC'N 6
ID 1002957	1 - TT 6,	CLASS 4,	DEC'N 6
ID 1002958	1 - TT 6,	CLASS 4,	DEC'N 6
ID 1002959	1 - TT 6,	CLASS 4,	DEC'N 6
ID 1002960	1 - TT 6,	CLASS 4,	DEC'N 6
ID 1002961	1 - TT 6,	CLASS 4,	DEC'N 6
ID 1002965	1 - TT 5,	CLASS 4,	DEC'N 1
ID 1002967	1 - TT 5,	CLASS 4,	DEC'N 1
ID 1002968	1 - TT 5,	CLASS 4,	DEC'N 6
ID 1002973	1 - TT 2,	CLASS 2,	DEC'N 4
ID 1002977	1 - TT 2,	CLASS 2,	DEC'N 1
ID 1002980	1 - TT 6,	CLASS 4,	DEC'N 6
ID 1002998	1 - TT 4,	CLASS 3,	DEC'N 4
ID 1002999	1 - TT 4,	CLASS 3,	DEC'N 4
ID 1003000	1 - TT 4,	CLASS 3,	DEC'N 4
ID 1003009	1 - TT 7,	CLASS 4,	DEC'N 2
ID 1003010	1 - TT 7,	CLASS 4,	DEC'N 1
ID 1003011	1 - TT 7,	CLASS 4,	DEC'N 1
ID 1003012	1 - TT 7,	CLASS 4,	DEC'N 6
ID 1003013	1 - TT 7,	CLASS 4,	DEC'N 2
ID 1003014	1 - TT 7,	CLASS 4,	DEC'N 1
ID 1003015	1 - TT 7,	CLASS 4,	DEC'N 6
ID 1003017	1 - TT 7,	CLASS 4,	DEC'N 6
ID 1003021	1 - TT 7,	CLASS 4,	DEC'N 6
ID 1003022	1 - TT 7,	CLASS 4,	DEC'N 6
ID 1003027	1 - TT 7,	CLASS 4,	DEC'N 6
ID 1003034	1 - TT 2,	CLASS 2,	DEC'N 4
ID 1003037	1 - TT 2,	CLASS 2,	DEC'N 4
ID 1003039	1 - TT 2,	CLASS 2,	DEC'N 1
ID 1003040	1 - TT 2,	CLASS 2,	DEC'N 4
ID 1003075	1 - TT 2,	CLASS 2,	DEC'N 4
ID 1003076	1 - TT 2,	CLASS 2,	DEC'N 1
ID 1003080	1 - TT 2,	CLASS 2,	DEC'N 6
ID 1003082	1 - TT 2,	CLASS 2,	DEC'N 1
ID 1003084	1 - TT 2,	CLASS 2,	DEC'N 4
ID 1003086	1 - TT 2,	CLASS 2,	DEC'N 1
ID 1003087	1 - TT 2,	CLASS 2,	DEC'N 4
ID 1003088	1 - TT 2,	CLASS 2,	DEC'N 1
ID 1003089	1 - TT 2,	CLASS 2,	DEC'N 1
ID 1003090	1 - TT 2,	CLASS 2,	DEC'N 1
ID 1003091	1 - TT 2,	CLASS 2,	DEC'N 1
ID 1003093	1 - TT 2,	CLASS 2,	DEC'N 1
ID 1003094	1 - TT 2,	CLASS 2,	DEC'N 1
ID 1003095	1 - TT 2,	CLASS 2,	DEC'N 6
ID 1003096	1 - TT 2,	CLASS 2,	DEC'N 6
ID 1003097	1 - TT 2,	CLASS 2,	DEC'N 1
ID 1003098	1 - TT 7,	CLASS 4,	DEC'N 2
ID 1003099	1 - TT 7,	CLASS 4,	DEC'N 2
ID 1003100	1 - TT 7,	CLASS 4,	DEC'N 2
ID 1003101	1 - TT 7,	CLASS 4,	DEC'N 2
ID 1003102	1 - TT 7,	CLASS 4,	DEC'N 1
ID 1003103	1 - TT 7,	CLASS 4,	DEC'N 2

figure 7

A comparison of this information with the annotation of step 9 and the minimum-maximum data of step 7 aided in the explanation of why particular misses occurred.

C. Discussion of Results

In discussing the success of the automatic evaluation of land use in the Trout Lake area, emphasis must be put on the reasons for the misses. There are several reasons which can be easily corrected and increase the performance of the routine.

Some misses arise from the misdesignation of features. A comparison of the print out of feature location, designation, and data of each band and the maximum-minimum information, both mentioned in step 7, with the density level map reveals many of these misdesignations. It many times occurred that values within a feature would be very uniform, except for one or two points on the periphery. These peripheral points usually fell on or very near the minimum or maximum value for that feature as expressed on the minimum-maximum sheets. Upon checking the location of these points on the density level map, it was, in most cases, found that they were not actually part of the feature with which they had been grouped, but were part of a neighboring feature.

The inclusion of these peripheral points in the wrong class caused an alteration of the minimum-maximum values of that class. The inclusion of some hardwoods with open would cause the distinctions between the two classes, expressed by the minimum-maximum values for each class to be blurred. Thus, numerous occasions would arise when an element could be classified one of two ways. A correction of these erroneous inclusions would eliminate some of the extremes in classes (i.e., lower the maximum and raise the minimum); therefore, further separating the classes and allowing the K-class program to operate more effectively.

In two instances, the wrong column or row number was punched onto the computer cards in step 5. Thus a whole sample was erroneously classed. Correction of this error would have the same effect as the correction of the previous type: elimination of extreme values in classes.

The misses thus far discussed have been human errors: ones that occurred as a result of the researcher. Others occurred because of the nature of the K-classification program.

The K-class program uses all four bands of the ERTS photo simultaneously in distinguishing one class from another (except those bands or channels of bands which were designated as faculty). Hence, for two classes to be distinguished, one from the other, 100 percent of the time, none of their values on any of the four bands may overlap; i.e., the maximum of one must be less than the minimum of the other. This is generally not the case.

(For the following discussion, the minimum-maximum sheets mentioned in step 7 are used.)

For example, the values for open and conifer overlap in bands 4 and 5 but not in 6 and 7. Conifer and urban overlap in bands 5 and 7, but not in 4 and 6. The two classes of water and conifer overlap in bands 4 and 5, but not in 6 and 7. Natural water can be distinguished from water in mines by band 4 only. This is an important distinction; because, natural waters (lakes, rivers, reservoirs) can be used for recreational purposes, while water in mines can not. Hence, when taking a total of all usable waters in an area, water in mines should not be included. Hardwoods can be distinguished from tailings, mines, & wetlands by band 7 only. Whereas hardwoods and conifers can be distinguished by 6 and 7, they cannot by 4 and 5. Hence, it should be obvious that a technique using all four bands together would result in much misclassification. Indeed, in over half of the misses that occurred, the value of at least one of the bands did not fit within the minimum-maximum values for the class decision.

Some classes, however, overlap at least to some degree in all of the four bands. Mines and tailings overlap, but this is not of extreme importance because they are both in the class extractive. Hardwood and open completely overlap, as do hardwood and urban. In the case of the former, however, their means are different enough to suggest that the elimination of the erroneous peripheral data elements mentioned earlier may cause their values to separate. This seems much less likely in the case of the latter. Open and urban also overlap on all four bands. Their overlaps are slight enough, especially in band four, that they could at least be lessened by eliminating erroneous data.

In conclusion, more care must be taken in the initial designating and a classification technique should be used which compares and evaluates all four bands separately rather than together. These changes would better the already encouraging results.

The comparison of the data of the Trout Lake area with that of Pineville, located northwest on the same photo, was not very encouraging. A comparison of the various classes was made from the minimum-maximum sheets of the two areas.

Values for hardwoods in the two areas matched in bands 6 and 7 with the mean for Pineville being slightly higher, but not in bands 4 and 5, where the Trout Lake means are higher. Conifers matched except for band 5 with, again, Trout Lake's mean being higher. Urban matched well in all four bands. Open matched in band 6, but only overlaps in bands 4, 5, and 7 with Trout Lake's mean consistently higher. No comparison could be made of extractive due to the differences in the extractive classes used (extractive 1, 2, 3, and 4 in the Pineville study verses mines, tailings, and water in mines in the Trout Lake study.).

The question is whether these differences occurred due to the relative locations of the areas on the photo used or due to differences in ground truth interpretation. This researcher believes it may be the latter since the two studies match in easily identified classes such as urban. Hardwood and conifer, on the other hand, could be easily confused by the researcher untrained in photo interpretation or lacking adequate ground truth. Also, Pineville was evaluated with high altitude and regular aerial photos, while Trout Lake was evaluated using land use interpretations from ERTS photos. In the latter case, qualified land use interpreters had already decided what could or could not be designated from satellite photos.

In conclusion it must be stressed that valid results and meaningful comparisons begin with adequate ground truth, reasonable classes, and reliable feature designations.

D. Further Studies to Pursue

Since the two areas studied from photo 1075-16312 were not conducted by the same researcher, it is questionable if the comparison of the results of the two areas can be considered conclusive. Likely, a second comparison should be done of two areas on the same photo interpreted by the same researcher. Then something could really be said about the transferability of class interval designations from one part of a photo to another.

A possible and worthwhile extension of this study would be the evaluation of the same area, Trout Lake, on another photo. There is an appropriate photo taken within a few days of the 1075-16312 shot. The physical situation (plant growth, waterbodies, and human manifestations) should be nearly the same for both shots. Thus, the results of the two studies of the same area on different photos could be compared to determine the transferability of class interval designations from one photo to another.

----- CLASS = 11 ----- I Hardwood

CHANNEL = 1
BAND. = 4, MIN.= 21, MAX.= 31, MEAN = 25.236, ST.DV. = 1.7739
BAND. = 5, MIN.= 17, MAX.= 28, MEAN = 24.371, ST.DV. = 2.7371
BAND. = 6, MIN.= 27, MAX.= 38, MEAN = 31.787, ST.DV. = 2.2609

BAND. = 7, MIN.= 15, MAX.= 23, MEAN = 18.281, ST.DV. = 1.6421

CHANNEL = 2
BAND. = 4, MIN.= 20, MAX.= 28, MEAN = 24.812, ST.DV. = 1.5337
BAND. = 5, MIN.= 17, MAX.= 28, MEAN = 24.150, ST.DV. = 2.7391
BAND. = 6, MIN.= 27, MAX.= 39, MEAN = 32.750, ST.DV. = 2.4213
BAND. = 7, MIN.= 16, MAX.= 23, MEAN = 18.337, ST.DV. = 1.5325

CHANNEL = 3
BAND. = 4, MIN.= 22, MAX.= 28, MEAN = 24.551, ST.DV. = 1.9488
BAND. = 5, MIN.= 16, MAX.= 27, MEAN = 23.955, ST.DV. = 2.5743
BAND. = 6, MIN.= 26, MAX.= 39, MEAN = 32.135, ST.DV. = 2.3490
BAND. = 7, MIN.= 14, MAX.= 24, MEAN = 18.225, ST.DV. = 1.7848

CHANNEL = 4
BAND. = 4, MIN.= 21, MAX.= 28, MEAN = 24.615, ST.DV. = 1.8219
BAND. = 5, MIN.= 17, MAX.= 30, MEAN = 24.239, ST.DV. = 2.3653
BAND. = 6, MIN.= 25, MAX.= 40, MEAN = 31.725, ST.DV. = 2.9358
BAND. = 7, MIN.= 15, MAX.= 25, MEAN = 18.550, ST.DV. = 1.7995

CHANNEL = 5
BAND. = 4, MIN.= 21, MAX.= 27, MEAN = 23.776, ST.DV. = 1.3630
BAND. = 5, MIN.= 16, MAX.= 27, MEAN = 23.855, ST.DV. = 2.6985
BAND. = 6, MIN.= 26, MAX.= 40, MEAN = 33.395, ST.DV. = 2.27[illegible]
BAND. = 7, MIN.= 16, MAX.= 24, MEAN = 18.395, ST.DV. = 1.6629

CHANNEL = 6
BAND. = 4, MIN.= 21, MAX.= 28, MEAN = 24.720, ST.DV. = 1.8925
BAND. = 5, MIN.= 20, MAX.= 32, MEAN = 24.820, ST.DV. = 2.3511
BAND. = 6, MIN.= 22, MAX.= 41, MEAN = 32.370, ST.DV. = 2.84[illegible]8
BAND. = 7, MIN.= 15, MAX.= 23, MEAN = 18.450, ST.DV. = 1.74[illegible]

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----- CLASS = 12 -----
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2 Conifer

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CHANNEL = 1
    BAND* = 4, MIN.= 17, MAX.= 24, MEAN = 20.800, ST.DV. = 1.7310
    BAND* = 5, MIN.= 11, MAX.= 22, MEAN = 16.491, ST.DV. = 2.7953
    BAND* = 6, MIN.= 17, MAX.= 27, MEAN = 23.200, ST.DV. = 2.3618
    BAND* = 7, MIN.=  9, MAX.= 15, MEAN = 12.964, ST.DV. = 1.1113

CHANNEL = 2
    BAND* = 4, MIN.= 17, MAX.= 25, MEAN = 21.038, ST.DV. = 1.7863
    BAND* = 5, MIN.= 13, MAX.= 22, MEAN = 16.718, ST.DV. = 2.5110
    BAND* = 6, MIN.= 17, MAX.= 29, MEAN = 22.974, ST.DV. = 2.4754
    BAND* = 7, MIN.=  9, MAX.= 15, MEAN = 12.179, ST.DV. = 1.4566

CHANNEL = 3
    BAND* = 4, MIN.= 18, MAX.= 23, MEAN = 20.302, ST.DV. = 1.3474
    BAND* = 5, MIN.= 12, MAX.= 21, MEAN = 15.442, ST.DV. = 2.4993
    BAND* = 6, MIN.= 17, MAX.= 27, MEAN = 21.895, ST.DV. = 2.7578
    BAND* = 7, MIN.=  9, MAX.= 16, MEAN = 11.942, ST.DV. = 1.4089

CHANNEL = 4
    BAND* = 4, MIN.= 17, MAX.= 23, MEAN = 19.764, ST.DV. = 1.3341
    BAND* = 5, MIN.= 11, MAX.= 22, MEAN = 15.217, ST.DV. = 2.4369
    BAND* = 6, MIN.= 17, MAX.= 26, MEAN = 21.623, ST.DV. = 2.1810
    BAND* = 7, MIN.=  9, MAX.= 14, MEAN = 12.232, ST.DV. = 1.2982

CHANNEL = 5
    BAND* = 4, MIN.= 17, MAX.= 23, MEAN = 19.367, ST.DV. = 1.5869
    BAND* = 5, MIN.= 11, MAX.= 21, MEAN = 15.184, ST.DV. = 2.7156


    BAND* = 6, MIN.= 15, MAX.= 25, MEAN = 22.041, ST.DV. = 2.5149
    BAND* = 7, MIN.=  8, MAX.= 14, MEAN = 11.306, ST.DV. = 1.2810

CHANNEL = 6
    BAND* = 4, MIN.= 18, MAX.= 25, MEAN = 20.727, ST.DV. = 1.8136
    BAND* = 5, MIN.= 11, MAX.= 26, MEAN = 16.341, ST.DV. = 3.5223
    BAND* = 6, MIN.= 17, MAX.= 29, MEAN = 22.773, ST.DV. = 2.5661
    BAND* = 7, MIN.=  8, MAX.= 16, MEAN = 12.295, ST.DV. = 1.6178
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lower top

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----- CLASS = 31 ----- 3 Water
CHANNEL = 1
    BAND* = 4, MIN.= 16, MAX.= 20, MEAN = 18.471, ST.DV. = 1.2184
    BAND* = 5, MIN.=  9, MAX.= 15, MEAN = 10.794, ST.DV. = 1.3456
    BAND* = 6, MIN.=  6, MAX.= 14, MEAN =  8.882, ST.DV. = 1.6227
    BAND* = 7, MIN.=  1, MAX.=  6, MEAN =  2.853, ST.DV. = 1.1149
CHANNEL = 2
    BAND* = 4, MIN.= 16, MAX.= 20, MEAN = 18.682, ST.DV. = 1.1633
    BAND* = 5, MIN.=  9, MAX.= 13, MEAN = 10.932, ST.DV. = 1.2685
    BAND* = 6, MIN.=  6, MAX.= 13, MEAN =  9.136, ST.DV. = 1.6038
    BAND* = 7, MIN.=  1, MAX.=  5, MEAN =  2.182, ST.DV. =  .9599
CHANNEL = 3
    BAND* = 4, MIN.= 16, MAX.= 20, MEAN = 18.268, ST.DV. =  .9113
    BAND* = 5, MIN.=  9, MAX.= 13, MEAN = 10.561, ST.DV. = 1.3261
    BAND* = 6, MIN.=  4, MAX.= 11, MEAN =  7.049, ST.DV. = 1.7384
    BAND* = 7, MIN.=  1, MAX.=  5, MEAN =  2.073, ST.DV. =  .8665
CHANNEL = 4
    BAND* = 4, MIN.= 17, MAX.= 21, MEAN = 18.091, ST.DV. = 1.1642
    BAND* = 5, MIN.=  8, MAX.= 15, MEAN = 10.485, ST.DV. = 1.7429
    BAND* = 6, MIN.=  4, MAX.= 12, MEAN =  7.212, ST.DV. = 2.0999
    BAND* = 7, MIN.=  1, MAX.=  5, MEAN =  2.424, ST.DV. = 1.1018
CHANNEL = 5
    BAND* = 4, MIN.= 15, MAX.= 21, MEAN = 17.400, ST.DV. = 2.1541
    BAND* = 5, MIN.=  9, MAX.= 14, MEAN = 11.100, ST.DV. = 1.9723
    BAND* = 6, MIN.=  6, MAX.= 13, MEAN =  8.400, ST.DV. = 2.6533
    BAND* = 7, MIN.=  1, MAX.=  5, MEAN =  2.500, ST.DV. = 1.2845
CHANNEL = 6
    BAND* = 4, MIN.= 17, MAX.= 22, MEAN = 18.864, ST.DV. = 1.6038
    BAND* = 5, MIN.=  9, MAX.= 15, MEAN = 11.091, ST.DV. = 1.4431
    BAND* = 6, MIN.=  7, MAX.= 13, MEAN =  9.227, ST.DV. = 1.8570
    BAND* = 7, MIN.=  2, MAX.=  5, MEAN =  3.091, ST.DV. = 1.1245
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----- CLASS = 32 -----4 Water in Mines

```
CHANNEL =  1
     BAND* = 4, MIN.= 19, MAX.= 24, MEAN = 21.241, ST.DV. = 1.8318
     BAND* = 5, MIN.= 10, MAX.= 17, MEAN = 14.276, ST.DV. = 1.9982
     BAND* = 6, MIN.=  7, MAX.= 14, MEAN = 10.759, ST.DV. = 1.6745
     BAND* = 7, MIN.=  2, MAX.=  6, MEAN =  3.621, ST.DV. =  .9970

CHANNEL =  2
     BAND* = 4, MIN.= 20, MAX.= 25, MEAN = 21.958, ST.DV. = 1.9035
     BAND* = 5, MIN.= 11, MAX.= 20, MEAN = 14.792, ST.DV. = 2.1981
     BAND* = 6, MIN.=  7, MAX.= 16, MEAN = 11.292, ST.DV. = 2.2818
     BAND* = 7, MIN.=  1, MAX.=  6, MEAN =  3.292, ST.DV. = 1.4855

CHANNEL =  3
     BAND* = 4, MIN.= 19, MAX.= 26, MEAN = 21.409, ST.DV. = 1.7751
     BAND* = 5, MIN.= 10, MAX.= 19, MEAN = 14.727, ST.DV. = 2.2600
     BAND* = 6, MIN.=  6, MAX.= 15, MEAN = 10.409, ST.DV. = 2.1247
     BAND* = 7, MIN.=  1, MAX.=  6, MEAN =  3.409, ST.DV. = 1.1544

CHANNEL =  4
     BAND* = 4, MIN.= 20, MAX.= 25, MEAN = 21.417, ST.DV. = 1.3202
     BAND* = 5, MIN.= 11, MAX.= 17, MEAN = 14.917, ST.DV. = 1.3202
     BAND* = 6, MIN.=  7, MAX.= 12, MEAN =  9.917, ST.DV. = 1.3202
     BAND* = 7, MIN.=  2, MAX.=  5, MEAN =  3.750, ST.DV. =  .8292

CHANNEL =  5
     BAND* = 4, MIN.= 18, MAX.= 23, MEAN = 20.947, ST.DV. = 1.7614
     BAND* = 5, MIN.= 11, MAX.= 16, MEAN = 14.105, ST.DV. = 1.4103
     BAND* = 6, MIN.=  8, MAX.= 12, MEAN =  9.526, ST.DV. = 1.0939
     BAND* = 7, MIN.=  2, MAX.=  3, MEAN =  2.684, ST.DV. =  .4648

CHANNEL =  6
     BAND* = 4, MIN.= 16, MAX.= 25, MEAN = 21.040, ST.DV. = 1.3705
     BAND* = 5, MIN.= 11, MAX.= 18, MEAN = 14.520, ST.DV. = 2.0024
     BAND* = 6, MIN.=  8, MAX.= 15, MEAN = 10.760, ST.DV. = 1.5819
     BAND* = 7, MIN.=  2, MAX.=  6, MEAN =  3.360, ST.DV. =  .9749
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------ CLASS = 40 ------ 5 Wetlands → w/-tailing & [illegible]
                     noise bottom
CHANNEL =  1
     BAND* = 4, MIN.= 19, MAX.= 27, MEAN = 23.214, ST.DV. = 2.4836
     BAND* = 5, MIN.= 14, MAX.= 27, MEAN = 19.333, ST.DV. = 3.1522
     BAND* = 6, MIN.= 17, MAX.= 29, MEAN = 23.524, ST.DV. = 3.1866
     BAND* = 7, MIN.=  6, MAX.= 15, MEAN = 12.310, ST.DV. = 1.8960

CHANNEL =  2
     BAND* = 4, MIN.= 19, MAX.= 25, MEAN = 22.846, ST.DV. = 2.1428
     BAND* = 5, MIN.= 13, MAX.= 23, MEAN = 18.949, ST.DV. = 3.0963
     BAND* = 6, MIN.= 12, MAX.= 29, MEAN = 23.103, ST.DV. = 3.3034
     BAND* = 7, MIN.=  4, MAX.= 16, MEAN = 11.538, ST.DV. = 2.2854

CHANNEL =  3
     BAND* = 4, MIN.= 18, MAX.= 33, MEAN = 22.632, ST.DV. = 2.7855
     BAND* = 5, MIN.= 14, MAX.= 30, MEAN = 19.395, ST.DV. = 3.3837
     BAND* = 6, MIN.= 18, MAX.= 29, MEAN = 23.105, ST.DV. = 2.9539
     BAND* = 7, MIN.=  8, MAX.= 15, MEAN = 12.105, ST.DV. = 1.7739

CHANNEL =  4
     BAND* = 4, MIN.= 20, MAX.= 25, MEAN = 23.024, ST.DV. = 1.6303
     BAND* = 5, MIN.= 14, MAX.= 23, MEAN = 19.244, ST.DV. = 2.2172
     BAND* = 6, MIN.= 17, MAX.= 28, MEAN = 23.317, ST.DV. = 2.8149
     BAND* = 7, MIN.=  5, MAX.= 16, MEAN = 12.634, ST.DV. = 2.0572

CHANNEL =  5
     BAND* = 4, MIN.= 18, MAX.= 27, MEAN = 22.882, ST.DV. = 1.7784
     BAND* = 5, MIN.= 15, MAX.= 25, MEAN = 19.353, ST.DV. = 1.9385
     BAND* = 6, MIN.= 14, MAX.= 30, MEAN = 24.176, ST.DV. = 4.1761
     BAND* = 7, MIN.=  4, MAX.= 16, MEAN = 11.676, ST.DV. = 2.6977

CHANNEL =  6
     BAND* = 4, MIN.= 20, MAX.= 27, MEAN = 23.730, ST.DV. = 1.9952
     BAND* = 5, MIN.= 15, MAX.= 29, MEAN = 21.027, ST.DV. = 2.9727
     BAND* = 6, MIN.= 13, MAX.= 29, MEAN = 23.568, ST.DV. = 3.7166
     BAND* = 7, MIN.=  6, MAX.= 15, MEAN = 11.784, ST.DV. = 2.2317
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------ CLASS : 61 -----6 Mines

CHANNEL = 1
                    raise bottom
    BAND* = 4, MIN.= 21, MAX.= 28, MEAN = 24.807, ST.DV. = 1.7037
    BAND* = 5, MIN.= 15, MAX.= 30, MEAN = 23.048, ST.DV. = 2.9285
    BAND* = 6, MIN.= 12, MAX.= 29, MEAN = 23.000, ST.DV. = 3.7352
    BAND* = 7, MIN.=  5, MAX.= 16, MEAN = 10.157, ST.DV. = 2.1368

CHANNEL = 2
    BAND* = 4, MIN.= 20, MAX.= 28, MEAN = 24.922, ST.DV. = 1.4924
    BAND* = 5, MIN.= 14, MAX.= 28, MEAN = 23.189, ST.DV. = 2.9511
    BAND* = 6, MIN.= 11, MAX.= 32, MEAN = 24.156, ST.DV. = 3.8899
    BAND* = 7, MIN.=  4, MAX.= 16, MEAN =  9.344, ST.DV. = 2.5029

CHANNEL = 3
    BAND* = 4, MIN.= 20, MAX.= 29, MEAN = 24.530, ST.DV. = 1.9096
    BAND* = 5, MIN.= 19, MAX.= 30, MEAN = 23.361, ST.DV. = 2.4768
    BAND* = 6, MIN.= 15, MAX.= 31, MEAN = 23.169, ST.DV. = 3.2032
    BAND* = 7, MIN.=  6, MAX.= 16, MEAN =  9.482, ST.DV. = 1.8971

CHANNEL = 4
    BAND* = 4, MIN.= 21, MAX.= 28, MEAN = 24.212, ST.DV. = 1.5305
    BAND* = 5, MIN.= 14, MAX.= 27, MEAN = 22.787, ST.DV. = 2.5870
    BAND* = 6, MIN.= 14, MAX.= 30, MEAN = 23.200, ST.DV. = 3.3667
    BAND* = 7, MIN.=  5, MAX.= 16, MEAN = 10.000, ST.DV. = 2.3611

CHANNEL = 5
    BAND* = 4, MIN.= 21, MAX.= 32, MEAN = 23.772, ST.DV. = 1.4073
    BAND* = 5, MIN.= 16, MAX.= 33, MEAN = 22.174, ST.DV. = 2.8876
    BAND* = 6, MIN.= 13, MAX.= 34, MEAN = 23.674, ST.DV. = 3.4801
    BAND* = 7, MIN.=  4, MAX.= 15, MEAN =  9.620, ST.DV. = 2.0999

CHANNEL = 6
    BAND* = 4, MIN.= 22, MAX.= 32, MEAN = 24.851, ST.DV. = 1.8725
    BAND* = 5, MIN.= 18, MAX.= 32, MEAN = 23.103, ST.DV. = 2.5910
    BAND* = 6, MIN.= 13, MAX.= 36, MEAN = 23.713, ST.DV. = 3.7475
    BAND* = 7, MIN.=  5, MAX.= 17, MEAN = 10.368, ST.DV. = 2.3445
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----- CLASS = 62 ----- 7-tailings

noise bottom

```
CHANNEL =  1
     BAND* = 4, MIN.= 20, MAX.= 32, MEAN = 24.830, ST.DV. = 2.5832
     BAND* = 5, MIN.= 16, MAX.= 35, MEAN = 23.651, ST.DV. = 4.8664
     BAND* = 6, MIN.= 18, MAX.= 34, MEAN = 25.096, ST.DV. = 3.8039
     BAND* = 7, MIN.=  7, MAX.= 15, MEAN = 11.394, ST.DV. = 1.9198

CHANNEL =  2
     BAND* = 4, MIN.= 20, MAX.= 31, MEAN = 24.539, ST.DV. = 2.3178
     BAND* = 5, MIN.= 16, MAX.= 34, MEAN = 22.551, ST.DV. = 4.3005
     BAND* = 6, MIN.= 17, MAX.= 35, MEAN = 24.640, ST.DV. = 3.5450
     BAND* = 7, MIN.=  6, MAX.= 14, MEAN = 10.787, ST.DV. = 2.1799

CHANNEL =  3
     BAND* = 4, MIN.= 20, MAX.= 39, MEAN = 23.845, ST.DV. = 3.2385
     BAND* = 5, MIN.= 15, MAX.= 34, MEAN = 21.976, ST.DV. = 3.7606
     BAND* = 6, MIN.= 17, MAX.= 31, MEAN = 23.869, ST.DV. = 2.9672
     BAND* = 7, MIN.=  6, MAX.= 16, MEAN = 10.905, ST.DV. = 2.3331

CHANNEL =  4
     BAND* = 4, MIN.= 20, MAX.= 37, MEAN = 24.465, ST.DV. = 3.0220
     BAND* = 5, MIN.= 15, MAX.= 38, MEAN = 23.209, ST.DV. = 5.2697
     BAND* = 6, MIN.= 17, MAX.= 38, MEAN = 25.035, ST.DV. = 4.1469
     BAND* = 7, MIN.=  5, MAX.= 16, MEAN = 11.453, ST.DV. = 2.2447

CHANNEL =  5
     BAND* = 4, MIN.= 19, MAX.= 29, MEAN = 23.207, ST.DV. = 1.8329
     BAND* = 5, MIN.= 16, MAX.= 33, MEAN = 21.793, ST.DV. = 4.0004
     BAND* = 6, MIN.= 14, MAX.= 34, MEAN = 24.770, ST.DV. = 4.0278
     BAND* = 7, MIN.=  5, MAX.= 15, MEAN = 10.770, ST.DV. = 2.0550

CHANNEL =  6
     BAND* = 4, MIN.= 20, MAX.= 32, MEAN = 24.900, ST.DV. = 2.6140
     BAND* = 5, MIN.= 15, MAX.= 35, MEAN = 23.971, ST.DV. = 4.8843
     BAND* = 6, MIN.= 15, MAX.= 35, MEAN = 25.336, ST.DV. = 3.9939
     BAND* = 7, MIN.=  6, MAX.= 16, MEAN = 11.429, ST.DV. = 2.0603
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------ CLASS = 70 ----- 8 Open

CHANNEL = 1
BAND* = 4, MIN.= 20, MAX.= 27, MEAN = 24.237, ST.DV. = 1.8272
BAND* = 5, MIN.= 14, MAX.= 27, MEAN = 18.158, ST.DV. = 2.6904
BAND* = 6, MIN.= 29, MAX.= 45, MEAN = 37.605, ST.DV. = 3.9439
BAND* = 7, MIN.= 16, MAX.= 31, MEAN = 23.526, ST.DV. = 3.0927

CHANNEL = 2
BAND* = 4, MIN.= 20, MAX.= 28, MEAN = 24.367, ST.DV. = 1.7693
BAND* = 5, MIN.= 14, MAX.= 26, MEAN = 18.959, ST.DV. = 3.0968
BAND* = 6, MIN.= 29, MAX.= 46, MEAN = 37.633, ST.DV. = 4.6585
BAND* = 7, MIN.= 17, MAX.= 30, MEAN = 22.755, ST.DV. = 3.0741

CHANNEL = 3
BAND* = 4, MIN.= 22, MAX.= 28, MEAN = 23.680, ST.DV. = 1.7826
BAND* = 5, MIN.= 14, MAX.= 23, MEAN = 18.100, ST.DV. = 2.2204
BAND* = 6, MIN.= 31, MAX.= 46, MEAN = 38.080, ST.DV. = 4.0440
BAND* = 7, MIN.= 17, MAX.= 28, MEAN = 22.840, ST.DV. = 2.7376

CHANNEL = 4
BAND* = 4, MIN.= 21, MAX.= 27, MEAN = 23.839, ST.DV. = 1.8854
BAND* = 5, MIN.= 15, MAX.= 26, MEAN = 18.548, ST.DV. = 3.3199
BAND* = 6, MIN.= 28, MAX.= 44, MEAN = 37.645, ST.DV. = 4.6458
BAND* = 7, MIN.= 14, MAX.= 27, MEAN = 22.871, ST.DV. = 3.2897

CHANNEL = 5
BAND* = 4, MIN.= 19, MAX.= 25, MEAN = 23.267, ST.DV. = 1.5261
BAND* = 5, MIN.= 16, MAX.= 26, MEAN = 18.933, ST.DV. = 2.5421
BAND* = 6, MIN.= 30, MAX.= 50, MEAN = 38.467, ST.DV. = 4.9648
BAND* = 7, MIN.= 19, MAX.= 26, MEAN = 22.533, ST.DV. = 2.1250

CHANNEL = 6
BAND* = 4, MIN.= 21, MAX.= 27, MEAN = 23.645, ST.DV. = 2.0407
BAND* = 5, MIN.= 13, MAX.= 26, MEAN = 18.065, ST.DV. = 2.8163
BAND* = 6, MIN.= 28, MAX.= 49, MEAN = 38.806, ST.DV. = 4.8952
BAND* = 7, MIN.= 17, MAX.= 30, MEAN = 22.290, ST.DV. = 3.1335

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------ CLASS = 80 ------ 9 Urban
CHANNEL =  1
     BAND* = 4, MIN.= 24, MAX.= 31, MEAN = 26.970, ST.DV. = 1.3814
     BAND* = 5, MIN.= 18, MAX.= 27, MEAN = 22.727, ST.DV. = 1.5230
     BAND* = 6, MIN.= 29, MAX.= 34, MEAN = 31.091, ST.DV. = 1.5048
     BAND* = 7, MIN.= 13, MAX.= 19, MEAN = 16.515, ST.DV. = 1.4590

CHANNEL =  2
     BAND* = 4, MIN.= 24, MAX.= 28, MEAN = 26.320, ST.DV. = 1.2238
     BAND* = 5, MIN.= 20, MAX.= 26, MEAN = 22.080, ST.DV. = 1.5728
     BAND* = 6, MIN.= 27, MAX.= 39, MEAN = 31.080, ST.DV. = 2.7701
     BAND* = 7, MIN.= 14, MAX.= 22, MEAN = 16.320, ST.DV. = 1.7600

CHANNEL =  3
     BAND* = 4, MIN.= 26, MAX.= 33, MEAN = 28.000, ST.DV. = 1.9149
     BAND* = 5, MIN.= 20, MAX.= 27, MEAN = 23.333, ST.DV. = 2.4944
     BAND* = 6, MIN.= 26, MAX.= 35, MEAN = 31.750, ST.DV. = 2.9190
     BAND* = 7, MIN.= 13, MAX.= 20, MEAN = 16.583, ST.DV. = 2.2898

CHANNEL =  4
     BAND* = 4, MIN.= 27, MAX.= 32, MEAN = 28.000, ST.DV. = 1.4606
     BAND* = 5, MIN.= 22, MAX.= 30, MEAN = 24.400, ST.DV. = 1.9933
     BAND* = 6, MIN.= 26, MAX.= 38, MEAN = 33.133, ST.DV. = 3.5565
     BAND* = 7, MIN.= 13, MAX.= 20, MEAN = 17.600, ST.DV. = 2.0591

CHANNEL =  5
     BAND* = 4, MIN.= 25, MAX.= 29, MEAN = 27.000, ST.DV. = 1.2978
     BAND* = 5, MIN.= 21, MAX.= 26, MEAN = 23.632, ST.DV. = 1.9252
     BAND* = 6, MIN.= 27, MAX.= 38, MEAN = 33.316, ST.DV. = 3.2453
     BAND* = 7, MIN.= 11, MAX.= 20, MEAN = 16.421, ST.DV. = 2.3241

CHANNEL =  6
     BAND* = 4, MIN.= 25, MAX.= 32, MEAN = 27.700, ST.DV. = 1.3204
     BAND* = 5, MIN.= 22, MAX.= 29, MEAN = 24.533, ST.DV. = 2.0450
     BAND* = 6, MIN.= 26, MAX.= 36, MEAN = 31.533, ST.DV. = 3.4325
     BAND* = 7, MIN.= 11, MAX.= 21, MEAN = 16.167, ST.DV. = 2.5959

*STOP* 00000000
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