

Wildland Resource Information System: user's guide

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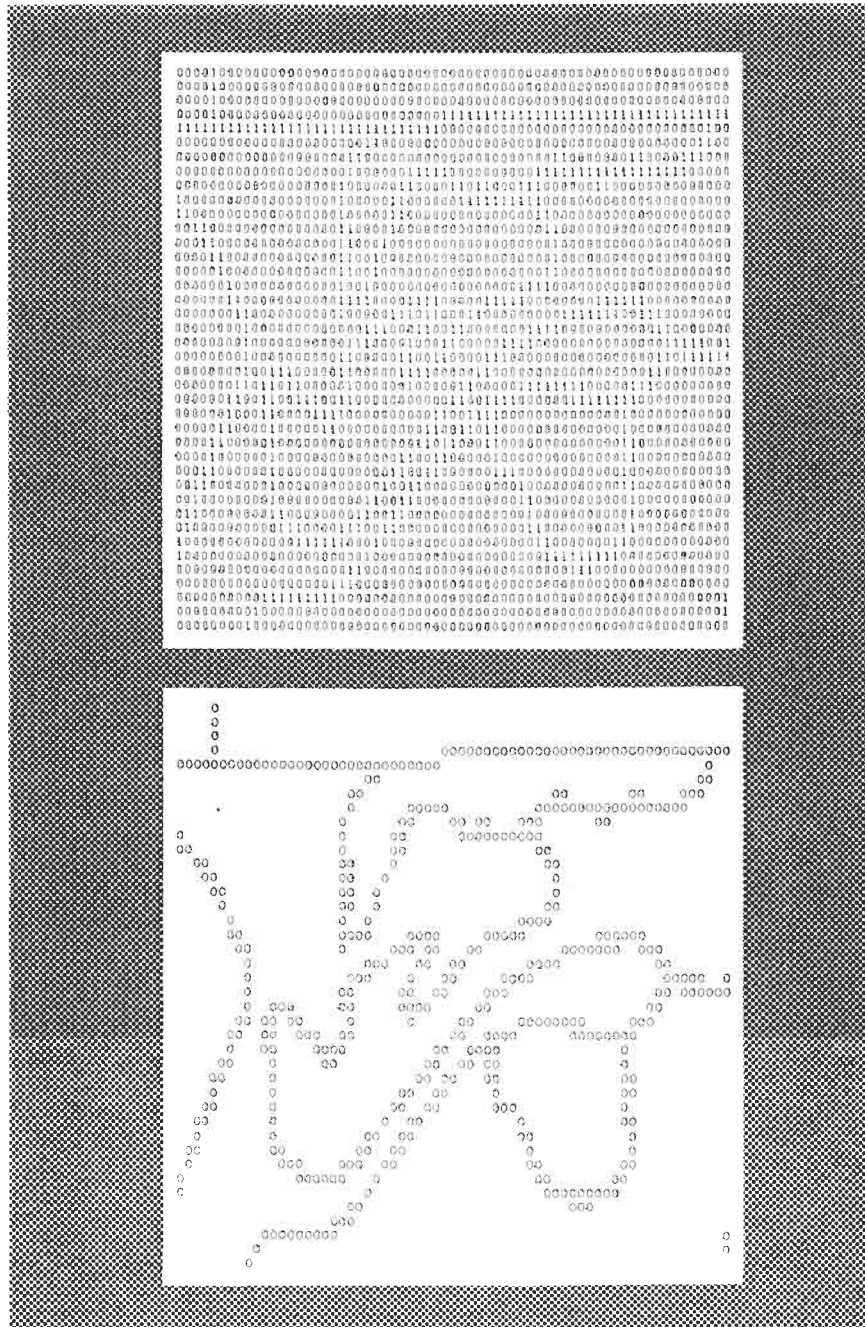
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This user's guide provides detailed information about how to use the computer programs of WRIS, a computer system for storing and manipulating data about land areas. Instructions explain how to prepare maps, digitize by automatic scanners or by hand, produce polygon maps, and combine map layers. Support programs plot maps, store them on tapes, produce summaries, and perform housekeeping tasks.

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PREFACE

The Wildland Resource Information System (WRIS) is a computerized system for storing and manipulating data about land areas. The resource manager defines a geographic area by drawing a boundary around it on a map. In nature, such boundaries are irregular in shape. We retain their shapes within the system by representing them mathematically as multiple-edged polygons. *Polygons* are the fundamental building blocks of WRIS. They can represent timber stands, soil types, alternative treatments, and many other categories. WRIS has so far been used mostly for timber management; therefore examples and terminology in this report are taken from that activity. But the system can be put to work in other fields—even those outside of forestry.

A group of polygons forms a *map*. The mosaic of polygons must exhaust the surface area, but polygons must not overlap each other. All polygons on one map must be from the same *layer* (sometimes called an *overlay* by other workers). The layer can represent one kind of attribute, such as timber type. Other layers may be constructed, defining different attributes of the same ground area. To handle combinations of attributes, WRIS can overlay any two layers.

The attribute of a polygon is expressed as a *label*, consisting of from 1 to 36 characters. Each polygon must have a label attached to it. A label is not unique—it may occur many times on a map, once for every polygon containing the same attribute. The polygons on a map are assigned unique serial numbers, called *item numbers*, for identification purposes.

WRIS can be applied to an entire National Forest by dividing the Forest into townships (quadrangle sheets would be better) and by processing the maps as separate units. Each layer on a township map is drawn separately with inked lines on 24- by 24-inch (610 mm by 610 mm) paper by using a scale of 4 inches per mile. (Other scales and smaller map sheets are possible.) Then we scan it in a microdensitometer with a grid spacing of .024 inch (.61 mm). Our scanner requires transparencies no larger than 9 inches (229 mm) on a side, so the map needs to be reduced photographically.

The scanning operation stores the map in digital form on magnetic tape. This tape is condensed by a computer program (FREQTH) which also prints out the grid so it can be checked for errors. The grid consists of zeroes and ones; zeroes for the areas between lines, and ones for the points falling on polygon boundary lines.

The POLLY program then converts this grid into a file of polygons and attaches a label to each. When this is done for each layer on each township, a complete data base becomes available for a Forest. Other programs are used to combine layers (MOSAIC), accumulate acreage totals (TALLY), and draw the maps on a digital plotter (CHART).

If a map sheet is extremely simple, containing few boundary lines, most of the scanned points are zeroes. It is more efficient to hand digitize this kind of map and to process it through the HANDY program instead of using FREQTH.

WRIS was developed by the Station's research unit investigating measurement and analysis techniques for management planning. This User's Guide provides detailed information about how to use the computer programs of the system. For a fuller description of the development and characteristics of WRIS and for production information, see the companion report *WRIS: A Resource Information System for Wildland Management* (USDA Forest Service Research Paper PSW-107). Copies are available upon request to:

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The WRIS computer programs are also available upon request. They will be copied on a magnetic tape, to be supplied by the requestor. Before sending the tape, the requestor should contact this Station (Attention: Computer Services Librarian), at the above address, and give the tape format desired.

1. PREPARING MAPS

Preparing maps correctly is the single most important step in the digitizing process. Eliminating errors at this step has a greater impact on cost than doing so at any other stage. These two sources of errors can be eliminated: poor ink line quality and logical map errors.

Ink lines should be of uniform width and uniform density. Moving the pen too rapidly along a straight edge when inking straight boundaries produces a thin, weak line. A good quality inking job can completely eliminate the need to make corrections in later stages.

The most common logical errors that can be eliminated at this stage are polygons without labels and two different labels in one polygon. The latter error may occur because the size and shape obscure the fact that it is one polygon. It may also occur because the line separating two polygons was not inked.

Maps to be digitized with a scanner must be specially prepared. Draw in ink the polygons to be digitized. They must be nonoverlapping and completely fill the area to be digitized. Have only one layer of information per map; for example, one map for timber-type, one for management constraints, and one for administrative boundaries. To have polygons fill the area assign a special label to all areas which are not of interest. This step is critical for finding all errors during the editing process. The map must also be free of islands (fig. 1). Remove by connecting them to the "mainland" in two separate places (fig. 2). Eliminating islands creates new polygons. These must be labeled with the same label as the polygon they were split from. The new polygons should be at least large enough for a label to be easily printed inside.

All the maps on the Stanislaus and Eldorado National Forests were drawn with a #2 rapidograph pen. Write all other information on the map, such as polygon labels, control point numbers, or geographic coordinates with a non-photo blue pencil.

No special preparation of maps is needed for the hand digitizing process. However, comments about logical errors still apply.

2. DIGITIZING A MAP WITH A SCANNING DENSITOMETER

2.1 Equipment

In digitizing with scanning densitometer the optical density of a map is measured at every point. For the inventories of the Eldorado and Stanislaus National Forests we used a Photometric Data Systems PDS-1010.¹ Relatively slow but accurate, this flat-bed densitometer uses orthogonal lead screws and stepping motors to provide a raster scan of transparent material. Output is a 10-bit density for each spot in the raster. These densities are written on magnetic tape at 556 bpi. The 10-bit density provides a gray-scale of 1024 levels. The scanner bed has a 9-by 9-inch (229 mm) scan area. To accommodate the bed size and the need for using a transparency, a photographic reduction negative is scanned rather than the original map. Therefore, the user has wide choice of map size and material.

2.2 Aperture and Spacing Alternatives

The scanner can make a density reading at any grid spacing which is a multiple of 2 or 5 micrometers. The scanner can use one of 20 apertures (size of spot measured) ranging from 3.5 to 396.67 micrometers in diameter. In addition, the reduction factor used in making the negative can be varied. Ink line width on the original map can also be varied.

The optimum combination of spacing, aperture, reduction, and line width is influenced by four major interrelated factors: map size, map detail, scanning time, and computer processing time. A loss in efficiency due to a change in one factor can be partially offset by changes in the other three.

1. Map size: The larger the map the longer it takes to scan and process the data for a given level of detail. Spacing, apertures, and line width can be increased to speed up processing if map detail permits.

2. Map detail: Spacing and aperture cannot be larger than the distance between the closest lines which must be recognized as separate, times the reduction factor. Line width times reduction factor must also be equal to or larger than spacing and aperture.

¹/Trade names and commercial enterprises or products are mentioned solely for information. No endorsement by the U.S. Department of Agriculture is implied.

3. Scanning time: Scanning time is a function of the length of a row in micrometers and the number of rows. Typical scanning times for 24- by 24-inch (610 mm by 610 mm) maps run from 10 to 13 hours. Therefore, use the maximum reduction factor possible.

4. Computer processing time: Processing time is almost wholly a function of the total number of density readings. Therefore, use the widest spacing possible consistent with the requirements of map detail. Spacing can be up to 10 percent wider than the aperture.

We found that a spacing of 60 μ m, an aperture of 56 μ m, a 10:1 reduction factor, and #2 rapidograph pen lines provide good results. This combination is for 1:15840-scale and 1:31680-scale maps and for photographic equipment with a maximum reduction of 11X. The capability for greater reduction might have changed the parameters.

Use different weights in assessing optimum combinations if the scanner has different operating characteristics. For example, many high-speed scanners have only three apertures and equivalent spacings. The scanning times, however, run from 2 to 10 minutes, so maximum reduction is not needed. Select a convenient aperture and spacing and vary the reduction factor to suit map detail.

2.3 Photographic Reduction

It is not necessary to obtain an exact reduction factor. Scale control is obtained through control points rather than by calculation of a sequence of enlargement and reduction factors. Almost any high-contrast copy film intended for line drawings can be used for making the reduction negative. A combination of transmitted and reflected light produces the best results. The transmitted light increases the contrast between ink lines and background. The reflected light is needed to wash out the non-photo blue labels.

2.4 Scanning Procedure

Place the negative on the scanner bed so that the scan starts in the upper left-hand corner of the scan area and the first scan line is left to right across the top. In setting up the X and Y scan limits, be sure to include as few extra

readings as possible. The extra readings increase the volume of data and thus the cost of processing.

The machine settings we used for the Stanislaus and Eldorado National Forests maps to get a spacing of 60 μ m and an aperture of 56 μ m were: set upper and lower aperture turret at 11, set upper and lower magnification at 2, set micrometers per step at 0, set steps per reading at 10, X-axis motor at 8, and Y-axis motor at 8. (See also Appendix C.)

2.5 Selection of Density Threshold

To extract polygons from the scanner data, the grid of densities (fig. 3) must be converted to a binary map, which is a grid with ones for lines and zeros for spaces between lines. To convert, all densities below a threshold are set to one and all densities above that threshold to zero. When a scanner tape is read, all or a sample of the densities are used to construct a frequency table. The mode, the most frequent class, represents the density of most of the background of a map. The mode is used to calibrate the densities for differences in exposure and development in making the negative.

The threshold is set by the density adjustment factor read into the program FREQTH (fig. 4). The density adjustment factor is the number of density levels the threshold is below the mode (figs. 5, 6, 7). The larger the density adjustment factor the lower the threshold and thus the fewer ones to represent lines. A particular density adjustment factor should be constant for one batch of maps and negatives. A new batch may require changing the adjustment factor. Tying the threshold to the mode takes care of minor differences within a batch. Edit first FREQTH printout for a batch of maps before making any more runs. (See section 4.1 on editing a binary map.) If the lines have too many gaps, (ADDS) the threshold is too low.

To raise the threshold, lower the density adjustment. If there are too many places which should be gaps and are not (DELETES), the threshold is too high. Lower the threshold by enlarging the adjustment factor. The absolute number of ADDS and DELETES is used to judge the threshold. About twice as many DELETES as ADDS is a good balance to strive for (figs. 8, 9, 10).

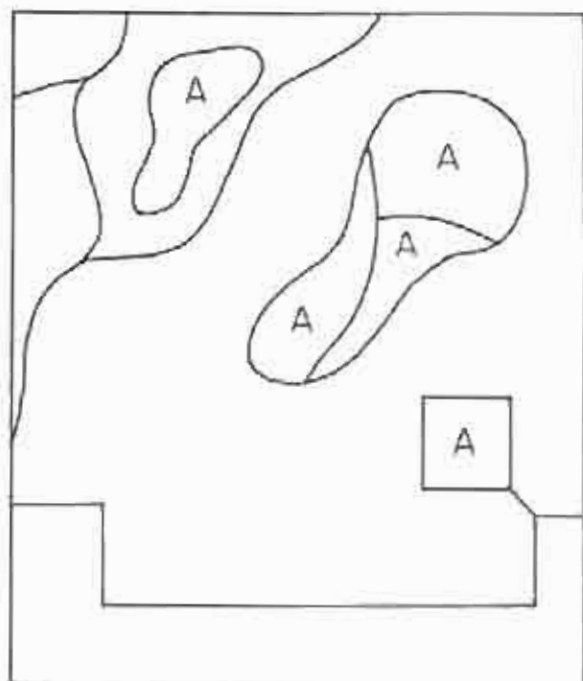


Figure 1-Polygons labeled A are considered islands by WRIS

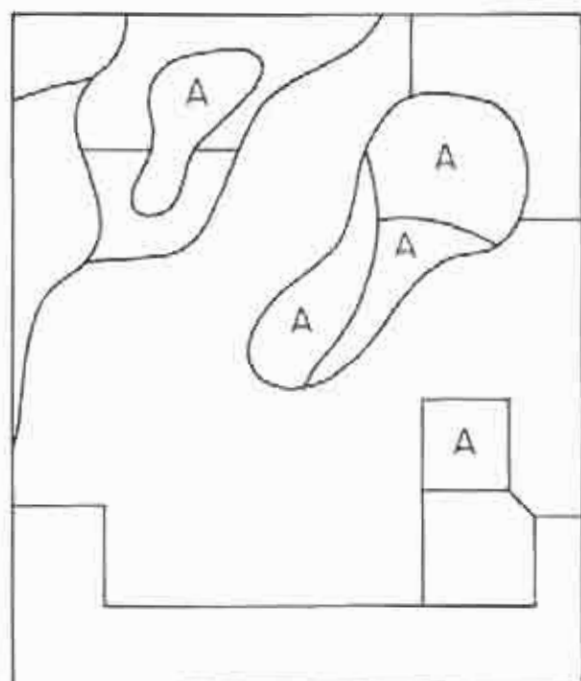


Figure 2-The islands in figure 1 have been removed by adding connecting lines.



Figure 3-Densities of a two-digit scan of a portion of a map.

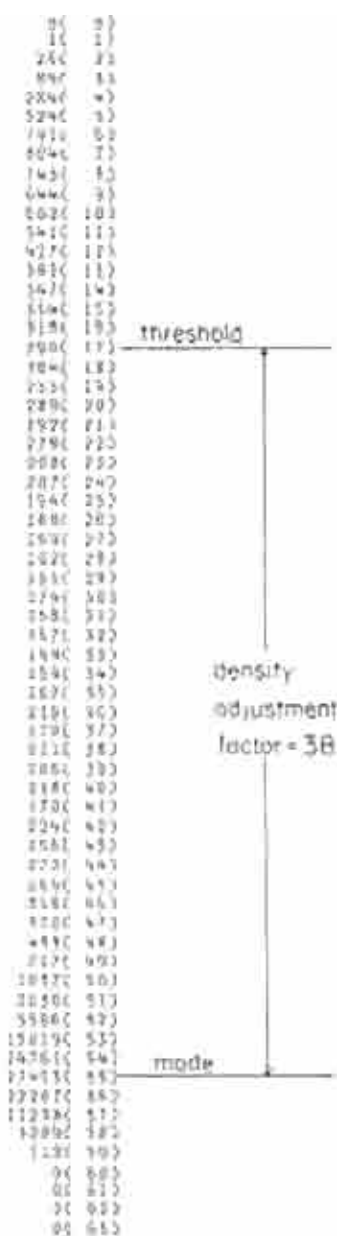


Figure 4-Frequency table shows the relationship between the mode, density adjustment factor, and threshold



Figure 5-A binary map was produced from the densities of Figure 3, but the threshold used was too low

[illegible]

Figure 6-4 binary map was produced from the densitist of Figure 2 with the correct threshold used.

Figure 7. A binary map was produced from the descriptors of Figure 3 with a threshold that was 100 bits.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100
 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300
 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500
 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600
 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700
 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800
 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900
 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000



Figure 8—FREQT8 printout of binary map in figure 5.



Figure 9—FREQT8 printout of binary map in figure 5.



Figure 10-FREQTB printout of binary map in figure 7.

3.2 Converting Binary Map (FREQTB)

FREQTB reads a microdensitometer tape and tabulates the frequency of each density level from 0 to 63, using the six high-order bits of each density reading. Each six-bit value is converted to a one, if below, or a zero, if above an established threshold. FREQTB computes this threshold by subtracting the DENSITY ADJUSTMENT FACTOR from the mode of the density frequency table. The resulting matrix of binary values duplicates the scanned negative, with ones representing lines (low density) and zeros representing the background (high density). The one/zero values are written compactly on tape for use by PBLV. To allow manual editing, the binary values are also printed.

FREQTB will process one or more files (i.e., maps) from one scan tape, with output on one or more tapes as specified by the user.

Input Cards:

1. System card.
2. Input unit description, containing unit designation, number of files (good and bad) on the input tape (FILES=n), and number of files (if any) to be skipped at the beginning (SKIPS=n).
3. DENSITY ADJUSTMENT FACTOR for first map. (See Section 3.3.)
4. Header record (forest, map, and layer) and output unit for first map.

If two or more maps are to be processed from the input tape, items 3 and 4 may be repeated for each map. They must be in the same order as the scanning was done, as FREQTB does not rewind and then search the tape for subsequent maps. Five minutes of Univac 1108 computer time is adequate for a FREQTB job on a map of 1000 scan rows and 1000 readings per row. This size map would produce about 160 pages of output (less if map has large blank areas).

Sample input deck:

```
# RUN FREQTB, 123456,5,100
# CIL CLS=N
#FH ASG A=1234
#W ASG B=5678
# ASG X=9876
# GRR
IN X
IRI X
# AQT FREQTB
```

```
INPUT UNIT=AS
FILES=4;SKIPS=05
DENSITY ADJUSTMENT FACTOR=225
FOREST=ELWOODLAND; LAYER=TIMBER; MAP=17;
OUTPUT UNIT=04
# FIN
```

3. DIGITIZING MAPS BY HAND

The computer time required to process an automatically-scanned map does not depend on its complexity. The same number of density readings must be taken on a simple map as on a "busy" one. But on a simple map, nearly all readings are zeroes. Therefore, such a map is relatively expensive to process by the scanner method, considering the small amount of information collected.

A better method is to digitize only the lines--and do so manually. For this we employ a hand-guided digitizer and a program that processes its output into the same form produced by FREQTB. Because of its limitations, we consider this an alternative rather than primary method. Users should choose the scale and area of their maps in such a way that most of the work can be efficiently processed by the scanning method, leaving only a small part to be hand digitized.

3.1 Equipment

For hand digitizing, we use a Bendix Datagrid digitizer. It has a resolution of 0.01 inch (.25 mm). Move the "cursor" over the map by following the inked lines. The cursor senses its coordinate positions as it moves, and these x-y coordinates are recorded on magnetic tape.

3.2 Digitizing Procedure

Tape the map to the digitizer surface. Move the cursor over all lines to be recorded. All boundaries must be closed. A boundary may be recorded in as many pieces (records) as necessary as long as no gap is left between pieces. A small overlap is desirable. So is a small overrun at T-shaped intersections. A straight line is best done in Point Mode, recording only the end points. (For our purposes, Point and Line Modes are interchangeable.) A straight line done in Point Mode looks better when plotted. Do not digitize the control points.

3.3 Converting to Binary Map (HANDY)

The HANDY program receives as input the tape written by the Bendix digitizer

Output is a tape that appears the same as the output of PREDYB: a map scanned on a grid having a spacing of .02 inch (.5 mm). HANDY constructs a grid of that spacing, presets all of its points to the value 0, and then changes to 1 all points that any digitized line passes over. Thus, overlapped segments are merely redundant. Any spur-like overruns are pared off during later processing.

Two cards are required input. The first is a "header record" containing just the name of the input unit bearing the Bendix tape. The other is also a header record, for our output tape. It must contain the unit name, and Forest, Map, and Layer.

Here is a typical input deck:

```
# RUN RUSS,583301,1,300
# CTL CLS=N
# ASG A=1234
#WI ASG B=5678
#N CON
IN X
TR1 X
#N XQY HANDY
INPUT UNIT=A $
OUTPUT UNIT=B; FOREST=FLDORAD0;
MAP=1; LAYER=TIMBER $
```

4. PRODUCING A POLYGON MAP

Once a map has been digitized and condensed to binary form, it is necessary to generate a file of polygons from it and to attach labels to the polygons. A considerable amount of editing is necessary to correct errors and noise.

4.1 Editing the Binary Map

The general procedure is to flag all errors on the computer printout. Then record all corrections on data forms for keypunching. The printout is a series of vertical strips, commencing with the left-most edge of the map.

4.1.1 Editing Guidelines

Visually scan each strip, comparing it with the map or a photo of the map for errors. Careful editing of the printout at this stage will save considerable time and cost later. Correct each error by circling each "0" to be deleted with a red pencil and circling with a blue or green pencil each space where an "0" is to be added. Put a check in the right margin if one or more corrections occur in a row. These checks will help to avoid

omissions at the data recording stage. Blocks of 10 lines are not printed if they are blank.

Follow these rules for adding or deleting "0's":

1. Fill in gaps in lines with as few points as possible (fig. 11).
2. Open the gaps between close lying lines (fig. 12).

Hints for editing:

1. Construct "rulers" consisting of the column heads for each strip. Insert rulers in the printout at the beginning of each strip. This helps to minimize the error of forgetting to change rulers at the beginning of each strip. Column numbers are printed at the beginning of each strip. Row numbers are printed along the right side of the strip. The strip number is printed in a column to the right of the row number.
2. Visually follow each string of 0's looking for gaps in lines, small polygons, and areas with a high density of 0's. These gaps are potential areas for corrections. Two 0's are considered connected if they are in adjacent spaces either vertically, horizontally, or diagonally. Look particularly for polygons with only a few interior cells. Such polygons are hard to spot when they are formed by diagonal connections. Two kinds of features which can cause extra small polygons are sharp 180° turns of a boundary and two parallel boundaries which are close together on the map but not accurate on the printout.
3. Since each addition and deletion must later be recorded and keypunched, try to keep corrections to a minimum.
4. Two polygons connected by a narrow neck on the map may have two different labels. Therefore, take care when correcting this kind of gap.
5. The first two columns on each strip are repeats of the last two columns of the previous strip. These columns almost eliminate the need to refer to previous strips while making corrections. Any corrections to a repeated column need only be made once.
6. Ignore stray 0's which may occur due to portions of labels or specks of

dirt that were photographed. A computer program will "dissolve" them. It also dissolves any piece of a line that is not part of a loop. This is all right if the line came from a smudge but will be an error if it is due to a gap in an inked line.

7. It is highly desirable that the printout should be edited twice, each time by a different person. Usually omissions will be found and the list will lengthen.

4.1.2 Recording Error Corrections

Record the row and column numbers where the control points appear on the binary map. These are the GRID CONTROL POINTS in the POLLY input deck. Record them in clockwise order starting with the lower left corner.

Next record the "add" and "delete" corrections marked on the FREQU printout. For convenience in handling the card decks later, start the recording with a card which identified the adds and deletes; examples: 'ADDS MAP 30' or 'DELETES MAP NUMBER 26'. It is helpful to start recording deletes at the top of a separate sheet. Each strip has a ruler for recording column numbers. Look for check marks in the right margin opposite rows needing correction. Record adds and deletes by row and column on data forms; examples, 5, 62, 10, 453. For convenience in subsequent editing, start each line with a row entry and end with a column entry followed by a comma. Leave unused columns blank. In this way an item will not be split between lines, and no error will occur if the order of the cards is changed. Long consecutive lists of items in one row or one column may be added or deleted by the following short-cut method: [R,C]AC2], or [R1A82,C]. (See also Section 7.33.)

4.2 Recording Polygon Labels

4.2.1 Setup

To record the x-y position of the labels, establish axes. The length of each axis slightly exceeds the largest map dimension expected. The vertical or "north-south" direction is designated as the y axis. The map is positioned within the right angle formed by the x-y axes so that the control points (and all points) will be positive, non-zero integers. The x and y distances from the origin in hundredths of an inch are recorded as explained in the section on map control points. (7.3.2)

4.2.2 Symbol Transcription

If both upper and lower case letters are used in a map, a translation into a format acceptable as computer input is required. Rules and examples are described in Appendix A.

The Mylar maps supplied by the contractor for the Stanislaus and Eldorado National Forests had standard Region 5 forest-type classifications and therefore require transcription of some symbols.

4.2.3 Label Recording

Start recording labels and their x-y position on a new line of the data form. Select a coordinate position that is roughly centrally located in the polygon. Use a non-photo blue pencil to check off each label as it is recorded. An entity consists of a label followed by its x and y position. Entities are separated by a comma. The last entity is followed by a dollar sign. Within the entity, the three parts are separated by one or more blanks. The x and the y coordinates are in units of 0.01 inch. Thus, 24 inches from the origin is written as 2400.

The data is written as one long "stream;" that is, the end of a line on a data form has no significance. If an entity is not complete when the last column is reached, simply continue on the next line. Just one caution, however. It is easy to forget that a blank is a significant character (separator). There is a tendency to forget recording the blank when it falls just after the last column and thus in column 1 of the next line.

4.2.4 Master Label Accumulation

When complex labels such as the timber labels shown in Appendix A are used, care must be taken to eliminate typographical and logical errors from the label input deck. POLLY, the polygon extracting program, checks each label against a master label list. A message is printed if the label is not on the master list. For some layers an exhaustive list of labels is easy to make. It is not difficult to completely list counties, ranger districts, or even management constraint classes. However, there may be over 1,000 codes used out of a possible million or more codes in the system used for the timber layer on the Stanislaus and Eldorado National Forests. In this situation WHIS uses label decks and

the program SIGNAL described in a following section to construct a complete master label list.

The process is started by using the ADD ITEM control card to put the label input deck of the first map into the master label file. The labels can then be sorted and printed. This sorted list of labels should then be very carefully edited to make sure that the labels follow all the rules of the coding system. Any incorrect labels can be deleted from the list by using the DELETE LABELS control card. The corrected labels are then added to the list. The next deck of labels can then be checked against the master label list by using the CHECK LABELS control card. All labels which were not in the original deck will be flagged in the printout. These should all be checked carefully and any errors corrected in the card deck. This deck can then be added to the master list with the ADD ITEM control card. Duplicates of labels already on the master list will be ignored. Each label input deck is processed in this way; that is, by carefully checking any new labels before adding that deck to the master label list.

When all decks have been processed the master label file will contain a complete list of all labels which occur at least once on a set of maps. Any new or changed labels which are put in the label deck during editing will be flagged by PALLY. This procedure provides an additional chance to check the label against the coding rules. If the label is correctly constructed it can be added to the master label list.

4.3 Extracting Polygons from Binary Map (PALLY)

PALLY corrects a binary map by using the ADDS and DELETES. It then extracts polygons from the binary map by using the label locations as starting points (see Section 4.2.3). All the polygons extracted are written on the output tape. PALLY will run a batch of jobs when there is a series of control cards following the XQT card.

Input Cards

1. System cards.
2. Header record (format, map, layer, geographic control points, map control points, grid control points, location, scale) and input unit for the binary map.

3. Header record containing only the output unit.

4. Correction cards for binary map from editing of FREQTH printout.

5. Master label file name.

6. Label deck.

Example Input Deck

```
* HUB JWC,123456,5,100
* CTL CLS=N
* CTL SYS=A
* ASG A=1234
BK ASG B=5678
* ASG X=3477
BN CDR
IN X
TRI X
ON XQT PALLY
INPUT UNIT=A; FOREST=ELDERWOOD; MAP=255
LAYER=MANAGEMENT; LOCATION=T12N R16E;
SCALE=31680;
GEOGRAPHIC CONTROL POINTS=39:30:0.0,
120:15:0.0,59:37:30.0,120:15:0.0,
59:37:30.0,120:07:30.0,39:30:0.0,
120:07:30.0;
MAP CONTROL POINTS=100,100,102,132,
130,131,131,100;
GRID CONTROL POINTS=474,2,3,3,4,494,
475,475
OUTPUT UNIT=B
*ADDS MAP 255*
10,16 E
*DELETES MAP 255*
588,45, [390,30],45] , 592,44,303,
45, [397,44,45] E
FILE. ALPHA/LABELS)
LS 300 1200, RL 600 7000
```

Limitations

- Maximum number of x-y points in any polygon: 1991
- Maximum number of polygons in one map: 500
- Maximum number of ADDS and DELETES combined: 1000

4.4 Editing PALLY Printout

Printout of a normally terminated PALLY run will consist of these sections:

1. Header record input from cards.
2. Header record resulting from tape header record merged with card input record.
3. Output unit number.

4. List of corrections for binary map.
 - a. Additions input cards
 - b. Sorted list of additions
 - c. Deletions input cards
 - d. Sorted list of deletions
5. List of labels.
 - a. Label input cards
 - b. Sorted list of labels
6. Output header record.
7. Local label list.
8. Detailed list of extracted polygons.
9. Summary record of number and area of polygons.
10. Confirmation of writing of output file.

For the purpose of editing, this output can be considered in two groups: items 1-5 deal with input; items 6-10 deal with output.

The printout is organized for use in editing rather than as a record of data. Errors during input are usually recording, format, or key punch errors. There are two groups of errors: those which stop the program and those that do not. It is best to start looking at the back of the printout to see if any input errors have stopped the program. A list of fatal error messages follows:

INPUT/OUTPUT FILE SPECIFICATION ERROR i

An input or output unit number is given in the wrong place in the input card deck. If $i=0$ no input unit number was given where an output unit number was expected. If $i=1$ an output unit number was given where an input unit number was expected. (See Section 4.3 for proper deck setup.)

INPUT TAPE SHOULD BE NAME 1 BUT IS i

A file with the correct Forest, Map and Layer, but without a binary map was read. Mode of the file is 1. (A binary map is mode 1, a polygon map is mode 2.)

CANNOT RECOGNIZE THE LABEL nnn

The left-hand side of a header record entity (nnn) is misspelled. (See Section 7.3.2.)

INPUT CARD ERROR

The header record card has a format error. (See Section 7.3.2.)

TWO MUCH DATA ON INPUT CARDS

The total amount of data in the header record is more than the program can handle. See the programmer responsible for WRIS maintenance.

READ ERROR WHILE READING ADDITIONS DECK

READ ERROR WHILE READING DELETIONS DECK

Both of these errors result from format errors such as missing or extra commas, extra brackets, or lack of a record terminator. See the sections on Editing the Binary Map and on Card Formats for a complete description of format.

ADDITION OUT OF RANGE ROW i COLUMN j

DELETION OUT OF RANGE ROW i COLUMN j

A row or column exceeds the maximum number of rows or columns in the map. The maximums are found in the header record labelled "SCAN ROWS" and "SCAN COLUMNS."

CARD INPUT ERROR

This message indicates a format error while reading labels. (See Section 4.2 for label format.)

ERROR READING LABEL DECK i

If i equals 1, an end-of-file was encountered while reading the label deck. The usual cause is a missing record terminator. If i is greater than 1 there are more labels than the program can handle. See the programmer responsible for WRIS maintenance.

If the POLLY printout is not terminated by one of the preceding error messages, one of the following messages may appear in the listing of label input cards. (Processing continues after these errors.)

NO MASTER LABEL FOUND nnn

The label nnn is not in the master label list. If nnn is not a valid label it should be corrected, otherwise it should be added to the master label list. The label is used by the program as if it were a correct label.

NO COORDINATES FOUND FOR THIS LABEL mmm

A recording or key-punching error has resulted in no coordinates being associated with the label mmm. This label is ignored for further processing.

The remaining error messages result from logical errors in the data. They are found during the process of extracting polygons. The messages will be interspersed with the detailed list of polygons. To be able to correct logical errors in the data some understanding of the thinning and polygon extracting algorithms is needed.

The thinning algorithm starts with a binary map as output by FREQTB and ends with a binary map with all lines 1 bit thick. It starts at the top of the map and looks at one row at a time. A row is scanned until a string of one bits is found. A one bit is eliminated from the string if it is not essential for maintaining a connection between one-bits in the row above or the row below. The bits in a string are examined in the following order: The bit on the left end of the string is eliminated until a connection would be broken; then the bit on the right end of the string is eliminated until a connection would be broken; finally, the interior bits are examined from left to right. When all strings in a row have been examined the program moves to the row below. The main consequence of the thinning process for the PULLY editor is that a gap in a line causes the line to be etched down and to the right or left but not up. The erasure stops when the line meets or intersects another line.

Figures 13 and 14 show the results of thinning the examples illustrated in Figures 11 and 12. Figures 15 through 18 duplicate Figures 11 through 14, but the ADD and DELETE corrections have been made.

The polygon extractor starts with a label location in the binary map. The label location is found by the program by transforming the x-y label map coordinates into row-column grid coordinates. Starting at the column of the label location, the row is scanned to the right until a line is encountered. The line is followed clockwise around the polygon. At any intersection the closest line in the counter-clockwise direction is taken. The line is followed until the starting point is reached. When a deadend is encountered the last bit in the line is eliminated, and the program attempts to continue following the line.

If the next bit back along the line is now a deadend it is eliminated. This backing up continues until a bit is found which can continue the line or until a fifth bit would be eliminated. When a fifth deadend bit is encountered in a string the program abandons the attempt to extract the polygon. If the program successfully returns to the starting point it creates an artificial deadend by filling in the row of the label location from the starting point to the label location. This artificial deadend is used to detect multiple labels in a single polygon.

With the operation of these two algorithms in mind we can describe the correction of the data errors signaled by the following error messages. Several of the error messages are followed by this label printout:

LABEL NUMBER =n, LABEL=m, X=i,
Y=j MAP LABEL=kkk

n is the position of the label in the input card deck.

m is the position of the label in the local label list

i, j is the label location in map coordinates

kkk is the label

Error messages which begin with 10 asterisks terminate processing of that polygon.

*****LABEL LOCATION OUT OF RANGE*****

When the x-y label location in map coordinates is converted to row-column in grid coordinates one of the coordinates is outside of the range 1 to "SCAN ROWS" or "SCAN COLUMNS." The label printout following this message locates the label in the card deck and on the original map so that it can be corrected.

*****THE FOLLOWING LABEL IS ON OR ADJACENT
TO A LINE*****

The label location given in the label printout that follows this message may be in error. Its location near a line may also keep other errors from being detected.

REACHED EDGE OF MAP n

The scan to the right has gone to column n and has not encountered any line. The label location in the following label printout may have been misread or recorded wrong. If the label is for a small polygon along

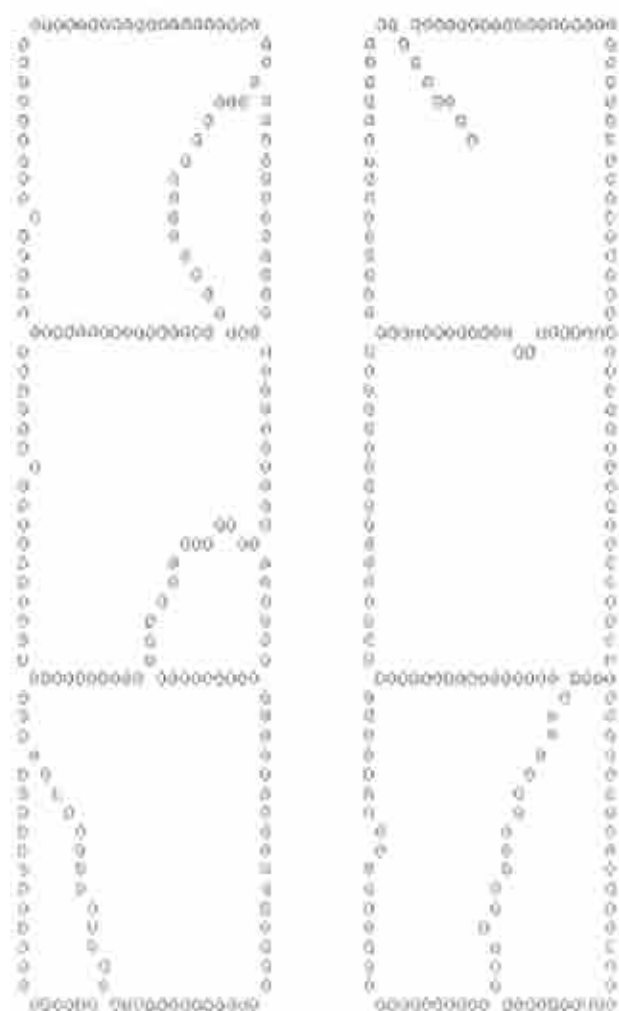


Figure 13-Results of thinning the examples in figure 11 without making ADDS

Figure 14 Results of thinning the examples in figure 12 without making DELETEs





Figure 15-Results of making ADOS in the examples in figure 11.

Figure 16-Results of making DELETES in the examples in figure 12.



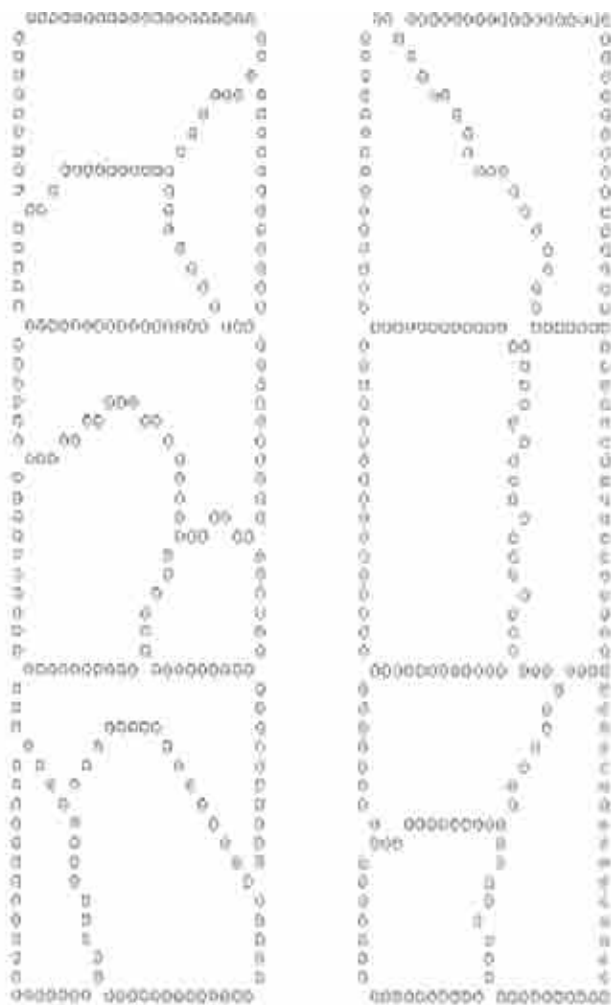


Figure 17-Results of thinning the examples in figure 15.

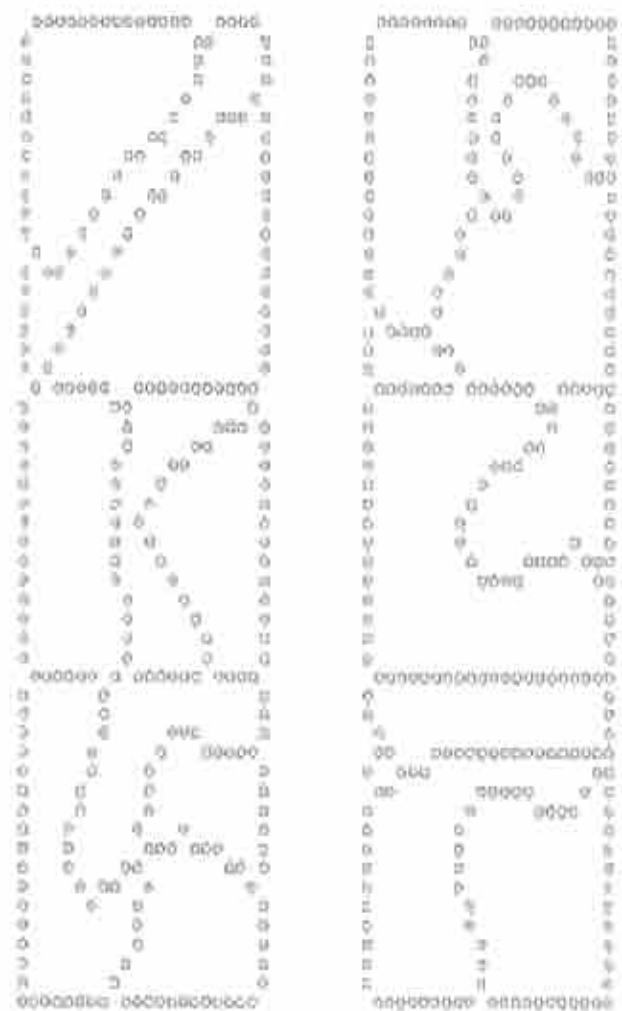


Figure 18-Results of thinning the examples in figure 16.

the top, right, or bottom edge a small error in either map or grid control points could put the label outside of the map perimeter.

POLYGON TOP LONG. STOPPED AT ROW I,
COLUMN J LABEL AT ROW k COLUMN n

The polygon has more than the maximum number of points allowed in its border (see limitations in Section 4.3). The following label printout will locate the polygon on the original map. The polygon must be cut into at least two smaller polygons by adding one bit to the binary map using correction cards. A new label must be added to the label deck for each new polygon created.

*****SCAN INTERRUPTED BY ISLAND*****

LABEL AT ROW i, COLUMN j

The polygon boundary does not enclose the label and is therefore an island inside the polygon for which the label was intended. Find the island using the label printout which follows the error message. Eliminate the island with additions cards (see also Section 1 on preparing maps).

*****DEADEND ENCOUNTERED*****

DEADEND AT ROW I COLUMN J X=x, Y=y.

POLYGON LABEL AT ROW I, COLUMN J

This is followed by a label printout and one of the three following messages. If the deadend is artificial the left end is near a previously used label location. That label is found and this message is printed:

*****THE FOLLOWING LABEL IS WITHIN 2
HANDRUPTHS OF THE DEADEND*****

This is followed by a label printout. The two labels are in the same polygon. They can be found in the sorted label list and on the original map so that the conflict can be resolved. If the two labels appear to be in adjacent polygons on the map and their label locations are correctly recorded, a gap in a line may have caused the thinning algorithm to erase the boundary between the two polygons.

If no label is found within 0.05 inch (1.27 mm) of the deadend it is assumed to be a real, not artificial, deadend. In this case two 20-row by 20-column pieces of the binary map are printed. The first piece is of the original binary map with

the corrections incorporated. The second piece is the thinned map. Both pieces are centered on the deadend. For short deadends these two printouts should be sufficient for correcting the error. For more complex cases, the FREQU printout will have to be consulted. Deadends less than 5 bits long will be eliminated from the boundary by the program and need not be corrected with delete cards.

*****MORE THAN 4 DEADENDS*****

This message is printed when processing of this polygon terminated when the deadend is more than 4 bits long.

*****DEADEND AT BEGINNING AND END OF
POLYGON*****

When a second label in a polygon is on the same row as the first label the artificial deadend is not seen as a deadend in the usual way. This message is followed by a label printout for the current label and a label printout for the label within 0.05 inch (1.27 mm) of the deadend.

At the end of the detailed list of polygons are four numbers which help determine whether all errors have been eliminated. First 'NUMBER OF LABELS READ' should equal 'NUMBER OF POLYGONS WRITTEN'. Any difference comes from not completing some polygon due to an error. The second pair of items 'AREA OF ENCLAVING POLYGON' and 'AREA OF ENCLOSED POLYGONS' should agree within about one part in 3000. While one part in 4000 is usually much greater accuracy than the data warrants, it makes it very unlikely that compensating errors will give the appearance of an error-free map.

Occasionally, due to poor quality input or careless editing, a map will have many interrelated errors. It is sometimes difficult in these cases to trace the cause of all the errors. It is best then to rerun POLLY with as many corrections as can be made. Many of the remaining errors will disappear and the rest will be easier to correct.

4.3 Editing Polygon File With Line Plotter

Editing a polygon file with a line plotter helps detect errors that POLLY cannot find. Five kinds of errors can show up on the line plot. A lack of agreement between the two areas printed at the end of POLLY is an indication that at least one of these errors is present:

1. A line that does not coincide on the plot and the map. This error is usually caused by a mistake in editing the binary map.

2. A line is on the map but not on the plot. If labels are not recorded for two adjacent polygons, their common boundary will not be plotted. If one label is not recorded and an error in editing the binary map causes one side of the polygon to be erased the polygon will be included as part of the adjacent polygon. An unrecorded label for a polygon on the edge of the map will cause part of the map perimeter to be missing from the plot.

3. A straight horizontal line on the plot is not on the map. A label is centered over the left end of the line. Its location fell exactly on a polygon boundary instead of within. PQLLY got lost trying to construct the polygon and accidentally produced this spurious line. Check the label's coordinates or the control points.

4. Small polygons, usually about one-tenth inch on a side are on the plot but not on the map. These are caused by an error in editing the binary map.

5. Polygons are missing from the plot. Since adjacent polygons have some part of their boundary in common with the missing polygon, it will appear to be plotted. The only clue that the polygon is absent is the lack of a label.

To edit the plot, tape it onto the top of the original map with the control points aligned as closely as possible.

Control points on the plot should all be within 0.05 inch of the control points on the original map. If the control points do not agree, re-measure the control points on the original map to help find which coordinate is in error. Usually only one of the eight is wrong. The most common errors are readings that are off by 0.1, 1, or 5 inches. If a corner is off by as much as 1 inch PQLLY should be rerun with the correct corners and a new plot made.

Then, with the plot still on top of the map, systematically scan the plot looking for the five kinds of errors desired earlier. When all of the errors have been found, use the PQLLY printout and the original map to find the cause of all the errors. Then correct the PQLLY input deck and rerun PQLLY.

4.6 Work Flow

Preceding sections have described each step in producing a polygon file from a map sheet. The order of the sections was chosen for expository purposes. The most efficient sequence of steps, in practice, may be somewhat different. The sequence of steps given below was found to work well on maps of the Stanislaus and Eldorado National Forests. Experience with other kinds of map projects may suggest modifications to these steps.

1. Record the labels (See Section 4.2). Recording labels before any other work is done provides an additional close look at the maps and may uncover some remaining logical errors.

2. Make the negative (See Section 2.5).

3. Scan the negative (See Section 2.4).

4. Convert scan tape to binary map with FRQTB (See Section 2.6).

5. Edit the binary map (See Section 4.1).

6. Extract polygons from the binary map with PQLLY (See Section 4.3). PQLLY output should be edited and PQLLY rerun until all error messages are eliminated.

7. Plot the map using CHART (See Section 6.1).

8. Edit the plot (See Section 4.5).

9. Rerun PQLLY making corrections found from plot. Area of enclosing polygon and enclosed polygons should agree to about one part in 4000.

At this point the map is ready for use and can be processed by any WRIS program that operates on a file of polygons.

5. COMBINING LAYERS

5.1 Overlaying Maps from Two Layers (MOSAIC)

MOSAIC combines two maps representing the same area on the ground but from different layers. The result is a polygon map in which each polygon represents the area in common between a pair of polygons, one from each input map. (In mathematical terms, this overlay polygon is the intersection of the sets of points inside the two input polygons.) The label of this new

polygon is a combination of the two constituent labels. All such pairs of overlapping input polygons are processed. If both input maps completely cover a given area of land with polygons, so will the resulting map. But "slivers," or polygons of insignificant size are disregarded. By "insignificant" we mean those whose area is less than 0.0125 square inch or whose area-to-perimeter ratio is less than 1/100 (map coordinates).

The composite map can be written on tape for later use if desired. This is not necessary if all you want is a table of acreages showing the total area for each label pair. This acreage table is printed and also punched. The punched cards are for input to TALLY.

MOSAIC will run a batch of jobs for a series of control card sets following the XQT card. If one of the two input maps is from a layer named "TIMBER" we assume its labels are forest-type descriptions (See Appendix A) and we condense them into major types (Appendix B) before processing.

Input Cards:

1. System cards
2. Header record (forest, map, layer) and input unit of the first input map.
3. Header record (forest, map, layer) and input unit of the second input map.
4. Header record and output unit for output file. Include only those portions of the header record that are different from the input files, namely, Map and Layer. If you do not wish to write the output file, all you punch is "OUTPUT UNIT=NONE."

Example of Input Deck:

```
* RUN JOB,123456,1,50
* CTL CLS=N
* CTL MEM=80M, MAXCARDS=100, SYS=3
* ASG A=1234
* ASG B=5678
* ASG C=4321
* N CUM
IN X
TRI X
* N XQT MOSAIC
INPUT UNIT=A, FOREST=ELDOBRAD0,
MAP=216; LAYER=MANAGEMENTS
INPUT UNIT=B, FOREST=ELDOBRAD0,
MAP=16; LAYER=TIMBER0
OUTPUT UNIT=C; MAP=1616;
LAYER=OVERLAY
```

Limitations:

1. Maximum number of x-y points in any pair of input polygons and their intersection, all combined: 5000
2. Maximum number of items in both input files plus output file: 2000 (effectively, this means a limit of about 500 polygons in each input file).
3. Maximum number of times a polygon pair (one from each input file) can cross each other: 400
4. Timing: MOSAIC requires about 1 minute of Univac 1108 computer time when each input file has 50 polygons, and about 4 minutes for 400 polygons.

5.2 Aggregating Overlay Acreages (TALLY)

Tally adds up the card decks punched by MOSAIC, which contain the acreages of the overlay combination, and prints the total acreages. The totals are also punched, in the same format, so the job can be divided into subtotal steps if desired.

Input Cards:

1. System cards.
2. Forest name, followed by a dollar sign.
3. Location, followed by a dollar sign. This is used for visual identification only.
4. Master label list for each layer. The layers come in alphabetical order. A master label list is a complete list of all labels in the layer, separated by commas and followed by a dollar sign.
5. Packets of cards punched by MOSAIC, in any order. A packet starts with the forest name and ends with a dollar sign. Discard the job I.O. cards that are usually found at top and bottom of the punched deck. The forest name must match the name in Step 2, above. If packets for the same map pair appear more than once, TALLY uses the first and ignores the others.

Example of Input Deck:

```
* RUN JACK,583301,1,50
* CTL CLS=N, MAXCARDS=100
* ASG X=3093
* N CUM
IN X
TRI X
```

```

@ XQT TALLY
MCCLOUD $
T4IN $
PERIMETER,RL,ST,VP,WS$PERIMETER,FB,
WF2(1)*P,WF3(2),WF3(3),P4(1) $
MCCLOUD $ T4IN R2W $ 11 SEP 73 $11,
154,55
PERIMETER,RL,ST,VP$PERIMETER,FB,WF2(1)*P,
WF3(3),P4(1) $44,329,147,69,18,25,
7(0),73,6(0)$
MCCLOUD$ T4IN R3W $ 12 SEP 73 $ 12,252,48
PERIMETER,WS$PERIMETER,FB,WF3(2),P4(1)$
7,1,5(0),13,1,29 $

```

6. SUPPORT PROGRAMS

6.1 Plotting a Map (CHART)

CHART plots the polygons on an automatic digital plotter, allowing a map to be checked visually. The program writes pen movement instructions on a tape, and the tape runs the plotter off-line. CHART comes in two different versions: one for the Cal Comp 1156 plotter and the other for the EAI 430. We will describe the Cal Comp version first and then tell how the EAI version differs from it.

The map is drawn in two colors--the polygons in one color and their labels in another. Also plotted are the control points, the x and y scales in map coordinates, and a title, which is an extract of the header record.

Several options are available, such as plotting only a portion of the map defined by giving a list of item numbers, or blowing up the plot by including a magnification factor. And to identify the polygons there is a choice of plotting labels, label numbers, or item numbers. Numbering is the same as on the printout. If a Cal Comp plotter is used, several maps can be plotted in a single run by repeating input card Sections 2 and 5 (below) for each map to be plotted. The same output tape must be used for all of them.

Input Cards:

1. System cards.
2. Header record of the map to be plotted. The forest, map number, and layer are required. Also include the input unit.
3. Control cards. A semicolon separates control cards. Punch a dollar sign at the end.

a. PLOT TAPE = tape label required). This tape will drive the plotter.

b. MAGNIFICATION = factor. This is the amount of blow-up. Omitting it is equivalent to a factor of 1.0.

c. RECTANGLE = min x, max x, min y, max y. These four numbers define a rectangle in map coordinates within which the plot is to be confined. The numbers are integers, in units of 0.01 inch. Omitting this and "ITEMS" means you want the entire map.

d. ITEMS = list of item numbers. This is another way to specify a subset of the map to be plotted.

e. PLOT ITEM NUMBERS (default)
PLOT LABELS
PLOT LABEL NUMBERS

Choose one. It tells the computer what to plot as identification on each polygon.

Example of Input Deck:

```

@ RUN SMITH,123456,2.50
@ CTL CLE-N
@ ASG A=9701
@W ASG B=4728
@ ASG X=3703
ON CUR
IN X
TRI X
#N XQT CHART
PQRST=ELLYHADD; MAP=33; LAYER=TIMBER;
INPUT UNIT=A;
PLOT TAPE=B;
RECTANGLE=1500,2000,1700,2400;
MAGNIFICATION=2; PLOT LABELS $

```

Plotting on the EAI 430:

The ASG card for the plot tape must have the H option and there is a different program tape. In our example, the ASG cards for B and X become:

```

@H ASG B=4728
@ ASG X=3952

```

6.2 Storing Several Maps on One Tape (FLEET)

The purpose of FLEET is to copy files (maps) from several tapes onto one tape for more compact storage. It can also be used just to copy a tape.

Copying is controlled by a sequence of header records, each containing an IQ unit

name, punched on input cards. As with the other programs, only the minimum identification is required on the header cards, namely Forest, Map Number, and Layer. Any other information is for correction or expansion of the existing header record on tape. With tape input, omission of Forest, Map, and Layer inputs whatever file is next on the tape; specifying Forest, Map, and Layer causes a search through the tape until that file is found.

Example of Input Deck:

This deck copies two files from tape 1000 and one file from tape 2000, writing them onto tape 3000.

```
# RUN MAC,583301,3,50
# CTL CLS=N
# ASG A=1000
# ASG B=2000
# ASG C=3000
# ASG X=3950
ON CUR
IN X
TR1 X
ON XQT FLEET
INPUT UNIT=A; FOREST=ELBORADO; MAP=10;
LAYER=TIMBER$
OUTPUT UNIT=C$
INPUT UNIT=A; FOREST=ELBORADO; MAP=11;
LAYER=TIMBER$
OUTPUT UNIT=C$
INPUT UNIT=B; FOREST=ELBORADO; MAP=55;
LAYER=TIMBER$
OUTPUT UNIT=C$
```

6.3 Printing Diagnostic Summary of a Map (GSSIP)

GSSIP prints a detailed summary of all polygons on a map so that editing can be done and errors detected. The map to be printed and the unit it is on are identified by a header record punched on cards. Any number of maps can be printed by punching a series of header records.

When input is from tape some shortcuts are possible. As with the other programs, the file specified on cards is searched for on the tape. Therefore, any intervening unwanted files can be disregarded. But if more than one file is wanted from a tape each must be processed in order because a tape is not backed up. Another shortcut allows printing all files on a tape by punching just "INPUT UNIT = something \$."

Example- This job prints out one file from tape 7000 and all files on

tape 4000.

```
# RUN JIM,583301,2,150
# CTL CLS=N
# ASG E=7000
# ASG F=4000
# ASG X=3951
ON CUR
IN X
TR1 X
ON XQT GSSIP
INPUT UNIT=E; FOREST=ELBORADO;
MAP=51; LAYER=TIMBER $
INPUT UNIT=F $
```

6.4 Printing General Summary of a Map (RUMOR)

The RUMOR program is similar to GSSIP, but prints less detailed information about the polygons. It is intended more for the worker in the field. In practical usage, such as in keypunching, it is identical to GSSIP in all respects except for two cards: the ASG X card, which is

```
# ASG X=3955
```

and the XQT card, which is

```
ON XQT RUMOR
```

6.5 Housekeeping Program (SIGNAL)

If WRIS is used for a large data base, (for example, 100 maps having 1000 distinct labels), keeping track of the maps as they are processed becomes itself a considerable data handling problem. A record must be kept of what stage of processing each map is in, what tape it is on, and so forth. Each of the thousands of polygons has a label, and it must be checked against a master list of valid labels.

SIGNAL is designed to assist in these housekeeping chores. It enables the user to establish and maintain a file of information about his maps on a drum or disk unit. A "file" consists of a collection of "records," and each record contains a "key" by which it is identified. Two different kinds of files are possible, a "catalogue file" or a "master label file." In a catalogue file there is one record for each map, consisting of a portion of its header record plus a few other pieces of information. All entries in a catalogue file pertain to one forest. In a master label file there is one record for each layer in a forest, and several forests may be intermingled in one file, if desired.

Catalogue file: The permissible items in a record are: MAP, LAYER, LOCATION, DATE

OF ORIGIN, GEOGRAPHIC COORDINATE POINTS, MAP CONTROL POINTS, PROJECTION, ZONE, ENVELOPE, POLYGON REEL, BACKUP REEL, GRID REEL. Most of these can be copied directly from a header record printout, using the same format. As for the others, an example is the best description:

```
DATE OF ORIGIN = 06 JAN 74;
PROJECTION = STATE PLANE;
ZONE = 13; POLYGON REEL = 9117.4;
BACKUP REEL = 5093.0; GRID REEL = 7195.25
```

In the last three items, you have the tape reel number followed by the position on the reel (assuming more than one map per reel). The retrieval key for a record in this kind of file is the map number. For keypunching rules for header records, see Section 4.3.2.

Master label file: A record is a list of all permissible labels for one forest/layer combination. The key is a string of characters composed of the forest name, a slash, and the layer name. Do not have blanks before or after the slash. When entering a list of labels, punch them on cards in the standard format for a label list (See Section 4.2).

Using SIGNAL: Acquire a Fastrend file using any name you want. Also choose a file identification, such as the forest name for a catalogue file. Twenty four characters are the maximum. Operate on a file by a series of SIGNAL control cards. The first card identifies a file by giving its Fastrend name. All further cards operate on this file until another such series is started, if any. Some control cards also refer to a tape, using its external name (A,B,C,etc.) as given on the ASG card. Some other control cards require a key, which is the map number, in the case of a catalogue file or the forest/layer, if it is a master label file. In all cases, this variable portion of a control card (file name, tape name, or key) is enclosed in parentheses. In some cases, though, this is absent and all you have is the control word itself, which is always ended with a period. Thus a control card consists of a control word or phrase specifying an action to be done on the current file, and usually the name of a file, tape, or key. For most control cards, this is enough. But for a few, some data or further control information must follow.

Control Cards: Here is a list of all possible control cards and an explanation of what they do. Lower case indicates a symbol generated by the user.

START FILE. (file name)
FILE. (file name)

Use one of these cards to name the file that subsequent control cards will operate on. This file name remains in effect until another START FILE or FILE card is encountered. The file name must be already known to the operating system. FILE assumes that a previous SIGNAL run has stored something into the file and that you are now updating it. But the first time, use START FILE to initialize. The START FILE card requires an additional control card containing two items. For a catalogue file:

ID = forest; TYPE = CATALOGUE

For a master label file:

ID = anything; TYPE = MASTER LABEL
FILE

On later runs, when the FILE card is used, the above control card is not used because the information is in the file.

CHECKPOINT OFF. (tape name)

Saves the file on tape. At a later date you can restore it by a CHECKPOINT IN. This feature is designed for file security or for simply saving rental on files. The tape name is the same as on the ASG card.

CHECKPOINT IN. (tape name)

This is the reverse of CHECKPOINT OFF. Precede this card by a START FILE card.

PRINT FILE.

Prints the file contents in full, including the index.

PACK FILE.

When the DELETE ITEM control card is used a "gap" is created in the file. If a number of such gaps are present in a file it may be economical to squeeze them out with a PACK FILE card. However, a file is automatically packed whenever it is copied onto any other medium (i.e., with CHECKPOINT OFF or COPY FILE).

COPY FILE. (file name)

This produces a copy of the file which is current (the one named on the most recent

FILE or START FILE card in the run) by writing it onto another file, the one given by "file name" on the control card.

DELETE ITEM. (key).

Deletes an item from the file, the item having the key given.

ADD ITEM. (key).

This adds an entirely new item to the file or augments an existing item, depending on whether the given key exists in the file. The new material must immediately follow the ADD ITEM card. When a catalogue file item is augmented, the new material is favored whenever there are conflicts. When a master label file is augmented, new labels in the punched list are added to the file and duplicates are ignored.

PRINT ITEM. (key)

Prints the given item in full.

PUNCH ITEM. (key)

Punches the given item.

CHECK LABELS. (key)

Used to check a given list of labels against a master list (with the key given) that is in the file. The list to be checked must immediately follow the CHECK LABELS card. And it must, as usual, end with a dollar sign. Any label in this list that does not match a label in the file is flagged in the printout, on the assumption that it is erroneous. No change is made in the file.

DELETE LABELS (key)

With this control card you can delete any of the labels in a master label list (the given key tells which list). Punch the labels to be deleted in label list format and put them after the DELETE LABELS card.

SORT LABELS. (key)

Sorts a master label list (denoted by key) into alphabetical order and writes it back into the file, replacing the old list.

Deck setup

This job establishes a file for master

labels, stores a label list in it. Sorts it, and prints it.

```
@ RUN FREQ.583301,1,20
@ CTR, CDS=N
@ ASG X=5103
@N CUR
IN 1
PR 1
%N XQT FMAPS
AQR SIG/FMPT,1
@N XQT SIGNAL
START FILE. (SIG/FMPT)
ID=SIERRA; TYPE=MASTER LABEL FILE 1
ADD ITEM. (SIERRA/TIMBER)
OP,D,W,F,W,SFS
SORT ITEM. (SIERRA/TIMBER)
PRINT ITEM. (SIERRA/TIMBER)
```

2. PROGRAM NOTES

Miscellaneous information that applies to more than one of the programs is located in this section.

2.1 Computer System

The computer we use is a Univac 1108 computer (Exec 7 operating system). The scanner is a PDS microdensitometer, and the plotter can be either a Cal Comp 1150 or an EAI 430. The programs are written in Fortran and are very close to the ANSI standard.

2.2 Files

The data processed by the WRIS program is kept permanently on magnetic tapes or on FastRAND drums. These two media are interchangeable to the program. For simplicity and to correspond to present practice, we usually refer to a file as being on tape. A "file" in this context is essentially one map. However, several files can be stored on one tape, but only one on FastRAND.

The tape or FastRAND unit onto which a file is to be written has a name. It is a letter (A, B, C, ...) for tapes and two 1-0 character names separated by a slash for FastRAND. Each program requires this unit name to be punched on cards, usually included in the header record. Sometimes you may want to specify no unit, perhaps to indicate that no output file is to be written. In this case use the word "NONE" as unit name. Some examples should illustrate these rules. "INPUT UNIT=A" included in the header record specifying an input file says it is on the tape unit assigned to "A" on the ASG card. If it were an output file you would punch "OUTPUT UNIT=A."

Or, "OUTPUT UNIT=NONE" is possible.

Files have a MODE attribute appearing in header records. It is automatically generated by the computer. MODE=1 indicates a map in scanner (grid) form. MODE=2 indicates a map consisting of a collection of non-overlapping polygons.

7.3 Card Formats

Certain forms recur in the card input to the various WRIS programs. Header records and polygon labels are examples previously described. Others are described in the following sections. Card input to a program is of two kinds: system cards and program input cards.

7.3.1 System Cards

Rules for these cards are determined by the computer installation and are thus out of the programmer's control. These few cards are at the beginning of a job deck. On the Univac 1108, line 2, an "A" character in column 1 identifies most of them. They consist of all cards up to and including the card with "RQT" on it.

In each program writeup, an example shows what should be punched. Observe the placement of spaces carefully. Most of the cards are the same for each run. Mainly what varies are (a) the time and page estimates on the RUN card, and (b) the unit assignments and tape reel numbers on the ASG cards, other than the one naming the program file.

7.3.2 Header Records

Items: A header record is a small collection of information about one map file. This information pertains to the entire map, rather than to specific polygons. Part of it identifies the map. Most programs in WRIS require these identifiers in order to use an existing file. The others are generated and maintained internally. Each time a file is processed, its current header record is printed in full. The user can override an internally generated value, but not the three basic identifiers--FOREST, MAP, LAYER. To override one of the others, punch the desired value along with the required identifiers. The header record is stored on tape along with the file at all times.

Here is a complete list of possible items in a header record. Capital letters give the "official" names, in the only

spelling recognized by WRIS (and only one blank between words please).

FOREST: The name of the forest. (characters)

MAP: Map number. (integer)

LAYER: Layer name. (characters)

LOCATION: Location. (characters)

SCALE: Representative fraction denominator, defined as the number of inches on the ground represented by one inch on the map. A 4-inch-per-mile map has, for example, a representative fraction of 1/15840. (integer)

GEOGRAPHIC CONTROL POINTS: Latitude and longitude of each control point, latitude preceding longitude for each point. Use degrees, minutes and seconds, separated by colons. Do not omit zeroes. In the seconds position, you can record to the nearest hundredth second using a decimal point. An accuracy of at least 0.5 second is essential. The maximum meaningful accuracy is 0.01 second.

MAP CONTROL POINTS: x and y coordinates of the control points, in units of 0.01 inch on the map. (integers)

GRID CONTROL POINTS: Row and column coordinates of the control points. (integers)

SCAN ROWS: Number of rows scanned. (integer)

SCAN COLUMNS: Number of columns scanned. (integer)

MODE: Indicates a scan grid (MODE=1) or a polygon map (MODE=2). (integer)

ENVELOPE: Overall envelope of all polygons on the map, i.e., the smallest x, smallest y, largest x, and largest y. Same units as map control points. (integers).

DATE WRITTEN: The date the file was written. (characters)

TIME WRITTEN: The time the file was written. (characters)

REEL NUMBER: Tells which tape reel the file is on. (characters)

POSITION ON REEL: Indicates one of perhaps several files on the reel. (integer)

Control points: Township corners are usually selected as control points, although any other sharply defined locations will do. These are recorded in a clockwise manner starting in the lower left corner. Four corners are the most desirable but three (or even two) may be sufficient. The corner must be a recognizable point on or within the map boundary, not some arbitrary point on the map sheet. Control points must be identical for all layers of a township as well for all systems of measurement; in other words, they represent the same ground locations on all layers, and are recorded in the same order.

Format of a header record: A free-field format is used. Items do not have to appear in specified card columns. The computer knows what each item is because it is labeled; for example, "MAP=51" means 51 is the map number. The equals sign attaches the name "MAP" to the value 51. The computer program has a list of these names; therefore, names must be spelled correctly. Sometimes a name requires more than one number as its value. Punch commas between the numbers to separate them. Sometimes a value is not a number but a string of characters. In "FOREST=ELBORADO" the value is "ELBORADO."

Thus, we have the basic building block of a header record, namely an item of the form name=value, where the name on the left is from a standard list of names and the value on the right can be a number, several numbers separated by commas, or a string of characters. It is all right to put in extra spaces (blank columns) just so they aren't in the middle of a number or word. Thus, "MAP = 51" and "MAP=51" are both permissible. But blanks in a string value are significant. "ELBORADO" is not the same as "EL DORADO." In key punching, when you reach column 80, continue directly to column 1 of the next card, as if you had one long continuous card.

To form a complete header record, punch one item after another, separated by semicolons, and punch a dollar sign at the end to signal the end of the header record. Again, blanks may be freely inserted before and after these punctuation characters. Here is an example of a complete header record:

```
FOREST=ELBORADO; MAP=51;
LOCATION=TL4N RISE; LAYER=TIMMERS
```

7.3.3 Integer Lists

Many programs will require a list of integers (whole numbers without decimal points) as input from cards at some point, and some header record items are in this form. Rather than require a fixed field size and card location for each number, we use a free format. The integers are punched in as many columns as are needed. Successive integers are separated by commas. The list is terminated by either a semi-colon or a dollar sign, depending on context. When you reach column 80, continue on to the next card as if it were one long card. Blanks (skipped columns) can be inserted anywhere except between the digits of a number.

Three abbreviations are possible: (a) A sequence of increasing or decreasing numbers such as "6, 7, 8, 9" can be shortened to "6-9". (b) A repetition of the same number, such as "4,4,4,4,4" can be abbreviated "5(4)". A combination is possible, such as "2(3,7-9)", which is the same as "3,7,8,9,3,7,8,9". In other words, whatever is inside the parentheses is repeated as many times as the number in front indicates. (c) For ease in recording sequences of coordinate pairs, we allow the special forms (x,abb) and (aab,y). The letters stand for integers. For example, "31,6172653|" is the same as "31,617,31,618,...,31,653".

7.3.4 Comments

Comments can be included anywhere in the program input cards by enclosing the comment material in quote marks. A comment is a note to yourself that you do not want the computer to read. Whenever the computer comes to a quote mark in the input stream, it scans forward until the matching quote mark is found and resumes processing at that point.

7.4 Printout

Some items show up on nearly every printout and may need some explanation. First, every card in the input deck is printed. Those after the XQT card are labelled "INPUT CARD:". This helps you check your work in case an error develops. Every page printed by the program itself (i.e., after XQT) is headed by the program name, the date, and a page number. The date and time of day is printed at beginning and end of the program printout. The message "END OF RUN" is printed at the end. Most of the input information

is printed back at you in a somewhat different form than what was punched on the cards, showing you what the computer thinks it is. This helps you spot errors. Whenever there is an output file, the message "OUTPUT FILE WRITTEN" will be printed after the writing is complete. You need this message to be sure the file can be read as input in a future run.

8. APPENDICES

A--Rules for Transcribing Forest Type Descriptions to Computer-readable Format

Reference: Region 5, U.S. Forest Service, Section 2441 (2441.1 - 2441.5)
Forest Types and Classification System

Encoding Rules:

1. Species symbols (capital letters) are copied unchanged. Species symbols which are lower case letters are discussed later, in Item 4.
2. u, s, and o become capitals; i.e., U, S, and O.
3. Numerals do not change.
4. The asterisk (*) marks the beginning of lower case species letters. If there is no lower case then there is no asterisk.
5. The dash (-) separates two species. It is not needed between a species in upper case and one in lower case because the asterisk serves the same purpose in this instance.
6. (1) replaces - , (2) replaces * , (3) replaces + .
7. Each label is followed by its x and y coordinates (in hundredths of an inch, as integers) by using one or more blanks as separators between them. Then, if another

label follows, insert a comma. If not, use a dollar sign to signal the end of the list of labels.

Keypunch Symbol	Function
/	Replaces the "fraction bar"
*	Precedes lower case letters
-	Separates species
(3)	Replaces + . The numeral is the number of dashes.
:	Replaces colon (:)
UB	Replaces U-Br
WA	Replaces W (water)
B	Replaces Br (brush)
NØ	Indicates NØ LABEL
XF	Experimental forest
XX	Private land inside N.F.
XY	Any land ownership outside N.F.
RL	Reserved land (wilderness)

Examples:

Map Symbol	Characters recorded on data form for keypunching
$\frac{SPwfrf3}{wfrf3_2}$	SP*WF-RF5(2)/WF*RF3(3)
$\frac{SPwfrf3(5)}{wfrf3(0)}$	SP*WF-RF5(5)/WF*RF3(Ø)
PL:PI(u)	PL*PI(U)
U	U
U-Br	UB
$\frac{SP5}{wfrf3_2}$	SP5(2)/*WF-RF3(3)
$\frac{WFpsp5}{WFsp4-WF3}$	WF*P-SP5(1)/WF*SP4(2)/WF3(2)
BA	BA
NC	NC

8--Major Forest Type Assignments

MAJOR FOREST TYPE	VEGETATIVE TYPE
A	A
B	B
BA	BA
G	G
HD	HD
NC	NC
NO	NO
PL	PL+PSP1(S), PL+P1(O), PL+P1(S), PL+P1(U), PL+P2(S), PL+P2(T), PL+P2(3), PL+P2(4), PL+RW1(S), PL+SP*P1(S), PL+SP1(U)
RL	RL
U	U
WA	WA
XX	XX
XY	XY
D.1	D*P5(2)/D*IC3(2), D*P5(2)/D2(2), D*SP5(2), D*SP5(2)/D*IC2(2), D*SP5(2)/D*SP2(2), D*SP5(2)/D*SP3(2), D*SP5(2)/D2(2), D*SP5(2)/D3(2), D*SP5(2)/D4(1)/D*P3(2), D*SP5(2)/D4(1)/D3(2), D*SP5(3), D5(1)/D4(1)/D2(2), D5(1)/D4(1)/D3(2), D5(1)/P4(1)/D*P2(2), D5(2), D5(2)/D2(2), D5(2)/D3(1), D5(2)/D3(2), D5(2)/D4(1)/D*IC3(2), D5(3), D5(3)/D2(2)
D.2	D*IC3(2), D*IC4(2), D*P2(2), D*P3(2), D*P4(2), D*SP3(2), D*SP4(2), D2(1), D2(2), D3(1), D3(2), D4(1), D4(1)/D*SP3(2), D4(2), D5(1), D5(1)/P3(1)
D.3A	D*P-SP4(4), D*SP4(4), D4(4), D5(1)/D*IC3(2), D5(1)/D3(2), D5(1)/IC*O3(2)
D.3B	D*IC4(3), D*P-IC4(3), D*P-SP4(3), D*P4(2)/D*IC2(2), D*P4(2)/D2(2), D*P4(2)/IC*O2(2), D*P4(2)/IC2(3), D*P4(2)/P*O2(2), D*P4(2)/P*IC2(2), D*P4(3), D*SP-P4(3), D*SP4(2)/D*IC2(2), D*SP4(2)/D*SP2(2), D*SP4(2)/D2(2), D*SP4(3), D4(1)/D*IC2(2), D4(1)/D*P2(2), D4(1)/D*SP2(2), D4(1)/D2(2), D4(1)/P*O2(2), D4(2)/D*IC2(2), D4(2)/D2(2), D4(3), D5(1)/D*IC2(2)
D.4A	D5(1)/D*IC4(2)/D2(2), D5(1)/D*P4(2)/D*IC2(2), D5(1)/D*P4(2)/D3(2), D5(1)/D*SP4(2)/D*IC2(2), D5(1)/D*SP4(2)/D2(2), D5(1)/D*SP4(2)/D3(1), D5(1)/D*SP4(2)/D3(2), D5(1)/D4(2)/D2(2), D5(1)/D4(2)/D3(2)
D.4B	D*IC5(2)/D*IC3(3), D*P4(2)/D*IC2(3), D*P4(2)/D*SP2(3), D*P4(2)/D2(3), D*P5(2)/D3(3), D*SP4(2)/D*IC2(3), D*SP4(2)/D*SP2(3), D*SP4(2)/D2(3), D*SP5(2)/D*IC3(3), D*SP5(2)/D*SP3(3), D*SP4(2)/D2(3), D*SP5(2)/D3(3), D4(1)/D*IC2(3), D4(1)/D*P2(3), D4(1)/D2(3), D4(1)/IC*SP2(3), D4(1)/P*O2(3), D4(2)/D*IC2(3), D4(2)/D2(3), D5(1)/D*IC2(3),

MAJOR
FOREST
TYPE

VEGETATIVE TYPE

WF#D4(2), WF#IC3(2), WFHL04(2), WF#P2(2), WF#P3(2), WF#P4(2),
WF#RF2(2), WF#RF3(2), WF#RF4(2), WF#SP2(2), WF#SP3(2), WF#SP4(2),
WF2(1), WF2(2), WF3(1), WF3(2), WF4(1), WF4(2), WF5(1)

MC.3A

D#F-WF4(4), D#WF-IC4(4), D#WF-P4(4), D#WF-SP4(4), D#WF4(4),
D5(1)/D#WF-SP4(3), D5(1)/D#WF3(2), P#D-IC4(3)/P2(2),
P#D-SP4(3)/D#SP2(2), P#D-SP4(4), P#D4(4), P#RF4(4), P#WF-D4(4),
P#WF-SP4(4), P5(1)/D#WF5(2), P5(1)/P#WF3(2), P5(1)/RF#WF3(2),
P5(1)/RF4(3)/WF#RF2(2), P5(1)/WF#D3(2), P5(1)/WF#IC3(2),
P5(1)/WF#LP3(2), P5(1)/WF#P3(2), P5(1)/WF#P4(3), P5(1)/WF#RF3(2),
P5(1)/WF3(2), P5(1)/WF4(2), SP5(1)/D5(2), SP5(1)/RF#SP3(2),
SP5(1)/RF#WF3(2), SP5(1)/WF#P3(2), SP5(1)/WF#RF3(2),
SP5(1)/WF#SP3(2), SP5(1)/WF3(2), WF#D-P4(4), WF#D-SP4(4),
WF#D4(3)/D2(2), WF#D4(4), WF#P-SP4(4), WF#P4(4), WF#RF-SP4(4),
WF#RF4(4), WF#SP-IC4(4), WF4(4), WF5(1)/D#WF3(2),
WF5(1)/IC#WF3(2), WF5(1)/WF#P3(2), WF5(1)/WF#RF3(2),
WF5(1)/WF3(2), WF5(1)/WF4(2)

MC.3B

D#IC-WF4(3), D#P-WF4(3), D#P4(2)/D#WF2(2), D#P4(2)/IC#WF2(2),
D#SP-WF4(3), D#SP4(2)/D#WF2(2), D#W-IC4(3), D#WF-P4(3),
D#WF-SP4(3), D#WF4(2)/D#WF2(2), D#WF4(2)/D2(2),
D#WF4(2)/IC#D2(2), D#WF4(3), D4(1)/D#WF2(2), D5(1)/WF#D2(2),
LP#P-WF4(3), LP#RF-WF4(3), P#D-IC4(3), P#D-SP4(3), P#D-WF4(3),
P#D4(2)/D#IC2(2), P#D4(2)/D#P2(2), P#D4(2)/D2(2),
P#D4(2)/IC#P2(2), P#D4(2)/IC#P2(2), P#D4(2)/P#D2(2),
P#D4(2)/P#IC2(2), P#D4(2)/P#WF2(2), P#D4(2)/WF#P2(2), P#D4(3),
P#IC-WF4(3), P#IC4(2)/P#WF2(2), P#RF-WF4(3), P#RF4(2)/RF#P2(2),
P#RF4(2)/RF2(2), P#RF4(2)/WF#RF2(2), P#RF4(3), P#SP-D4(3),
P#SP-IC4(3), P#SP-RF4(3), P#SP-WF4(3), P#SP4(2)/D#WF2(2),
P#SP4(2)/D2(2), P#SP4(2)/IC#P2(2), P#SP4(2)/P#D2(2),
P#SP4(2)/P#IC2(2), P#SP4(2)/P#SP2(2), P#SP4(2)/P#WF2(2),
P#SP4(2)/P2(2), P#SP4(2)/WF#D2(2), P#SP4(2)/WF#IC2(2),
P#SP4(2)/WF#P2(2), P#SP4(2)/WF#RF2(2), P#SP4(2)/WF2(1),
P#SP4(2)/WF2(2), P#SP4(3), P#WF-D4(3), P#WF-IC4(3), P#WF-RF4(3),
P#WF-SP4(3), P#WF4(2)/D#P2(2), P#WF4(2)/D#WF2(2),
P#WF4(2)/IC#P2(2), P#WF4(2)/IC#WF2(2), P#WF4(2)/P#D2(2),
P#WF4(2)/P#IC2(2), P#WF4(2)/P#WF2(2), P#WF4(2)/P2(2),
P#WF4(2)/WF#D2(2), P#WF4(2)/WF#IC2(2), P#WF4(2)/WF#P2(2),
P#WF4(2)/WF#RF2(2), P#WF4(2)/WF2(2), P#WF4(3), P4(1)/D#WF2(2),
P4(1)/P#WF2(2), P4(1)/WF#IC2(2), P4(1)/WF#P2(2), P4(1)/WF#RF2(2),
P4(1)/WF2(2), P4(2)/P#WF2(2), P5(1)/D#WF2(2), P5(1)/P#WF2(2),
P5(1)/WF#D2(2), P5(1)/WF#IC2(2), P5(1)/WF#P2(2), P5(1)/WF#RF2(2),
P5(1)/WF2(2), SP#P4(2)/P#WF2(2), SP#P4(2)/SP#D2(2),
SP#P4(2)/SP#IC2(2), SP#P4(2)/WF2(2), SP#P4(3), SP#RF-WF4(3),
SP#WF4(3), SP4(2)/SP#P2(2), SP4(2)/WF2(2), SP5(1)/SP#IC2(2),
SP5(1)/WF#D2(2), WF#D-IC4(3), WF#D-P4(3), WF#D-RF4(3),
WF#D-SP4(3), WF#D4(2)/D#WF2(2), WF#D4(2)/D2(2),
WF#D4(2)/IC#P2(2), WF#D4(2)/WF#D2(2), WF#D4(3), WF#IC-P4(3),
WF#IC4(2)/WF#IC2(2), WF#IC4(3), WF#LP4(3), WF#P-D4(3),
WF#P-IC4(3), WF#P-RF4(3), WF#P-SP4(3), WF#P4(2)/IC#WF2(2),
WF#P4(2)/LP2(2), WF#P4(2)/P#IC2(2), WF#P4(2)/P#SP2(2),
WF#P4(2)/WF#D2(2), WF#P4(2)/WF#IC2(2), WF#P4(2)/WF#P2(2),
WF#P4(2)/WF2(2), WF#P4(3), WF#RF-D4(3), WF#RF-LP4(3),
WF#RF-P4(3), WF#RF-SP4(3), WF#RF4(2)/WF#LP2(2),
WF#RF4(2)/WF#RF2(2), WF#RF4(2)/WF2(2), WF#RF4(3), WF#SP-D4(3),
WF#SP-IC4(3), WF#SP-P4(3), WF#SP-RF4(3), WF#SP4(2)/WF#IC2(2),
WF#SP4(2)/WF#P2(2), WF#SP4(2)/WF2(2), WF#SP4(3), WF4(1)/D#WF2(2),
WF4(1)/P#WF2(2), WF4(1)/RF#WF2(2), WF4(1)/WF#IC2(2),
WF4(1)/WF#P2(2), WF4(1)/WF#RF2(2), WF4(1)/WF2(2), WF4(2)/WF2(2),
WF4(3), WF5(1)/P#IC2(2), WF5(1)/WF2(2)

MAJOR
FOREST
TYPE

VEGETATIVE TYPE

MC. 4A

D^WP5(2)/D^WWF4(2)/IC2(1), D^WSP5(2)/D^WWF-SP4(3),
D^WWF5(2)/D^WWF-SP4(3), D^WWF5(2)/D^WWF4(2)/D^WWF2(2),
D^WWF5(2)/D^WWF4(2)/D2(1), D^WWF5(2)/D^WWF4(2)/D3(1),
D5(1)/D^WWF4(2)/D^WWF3(2), D5(1)/D^WSP4(2)/D^WWF3(2),
D5(1)/D^WWF4(2)/D^WSP3(2), D5(1)/D^WWF4(2)/D^WWF2(2),
D5(1)/D^WWF4(2)/D^WWF3(2), D5(1)/D^WWF4(2)/D2(2),
D5(1)/D^WWF4(2)/D3(2), D5(1)/D^WWF4(2)/WF^WD3(2),
D5(1)/D^WWF4(2)/WF^WSP3(2), D5(1)/D^WWF4(2)/WF3(1),
D5(1)/D^WWF4(2)/WF3(2), D5(1)/WF^WD4(2)/D2(2),
D5(1)/WF^WD4(2)/WF^WD3(2), D5(1)/WF4(2)/WF^WD2(2),
P^WSP5(2)/P^WWF4(2)/WF^WSP3(2), P^WSP5(2)/P4(2)/P^WWF2(2),
P5(1)/D^WP4(2)/D^WWF3(2), P5(1)/D^WWF4(2)/D^WWF3(2),
P5(1)/D^WWF4(2)/WF^WD3(2), P5(1)/P^WIC4(2)/P^WWF3(2),
P5(1)/P^WSP4(2)/P^WWF3(2), P5(1)/P^WSP4(2)/WF^WSP3(2),
P5(1)/P^WSP4(2)/WF3(2), P5(1)/P^WWF4(2)/D^WWF2(2),
P5(1)/P^WWF4(2)/LP3(2), P5(1)/P^WWF4(2)/P^WIC2(2),
P5(1)/P^WWF4(2)/P^WWF2(2), P5(1)/P^WWF4(2)/P^WWF3(2),
P5(1)/P^WWF4(2)/WF^WP2(2), P5(1)/P^WWF4(2)/WF^WP3(2),
P5(1)/P^WWF4(2)/WF^WRF2(2), P5(1)/P^WWF4(2)/WF^WRF3(2),
P5(1)/P^WWF4(2)/WF2(2), P5(1)/P^WWF4(2)/WF3(2),
P5(1)/P4(2)/P^WWF3(2), P5(1)/P4(2)/P^WWF3(2),
P5(1)/RF^WWF4(2)/RF3(2), P5(1)/RF^WWF4(2)/WF3(2),
P5(1)/WF^WD4(2)/D^WWF3(2), P5(1)/WF^WD4(2)/WF^WD3(2),
P5(1)/WF^WD4(2)/WF3(2), P5(1)/WF^WP4(2)/WF^WIC2(2),
P5(1)/WF^WP4(2)/WF^WIC3(2), P5(1)/WF^WP4(2)/WF2(2),
P5(1)/WF^WP4(2)/WF3(2), P5(1)/WF^WRF4(2)/RF^WWF2(2),
P5(1)/WF^WRF4(2)/WF^WRF3(2), P5(1)/WF^WSP4(2)/WF^WD2(2),
P5(1)/WF^WSP4(2)/WF^WSP5(2), P5(1)/WF^WSP4(2)/WF3(2),
P5(1)/WF4(2)/P^WIC3(2), P5(1)/WF4(2)/WF^WIC2(2),
P5(1)/WF4(2)/WF^WLP3(2), P5(1)/WF4(2)/WF2(2), P5(1)/WF4(2)/WF3(2),
P5(2)/WF^WRF4(2)/LP3(2), SP^WD5(2)/D^WSP4(2)/D3(1),
SP3(1)/D^WWF4(2)/WF^WD3(2), SP3(1)/P^WWF4(2)/WF^WP2(2),
SP5(1)/P^WWF4(2)/WF^WRF3(2), SP5(1)/SP^WWF4(2)/WF^WP3(2),
SP3(1)/SP^WWF4(2)/WF5(2), SP5(1)/WF^WP4(2)/WF2(2),
SP5(1)/WF^WRF4(2)/RF^WWF3(2), SP5(1)/WF^WSP4(2)/WF^WP3(2),
SP5(1)/WF^WSP4(2)/WF^WSP5(2), SP5(1)/WF^WSP4(2)/WF3(2),
SP5(1)/WF4(2)/WF^WD3(2), SP5(1)/WF4(2)/WF3(2),
WF5(1)/WF^WD4(2)/WF^WD2(2), WF5(1)/WF^WD4(2)/WF^WD3(2),
WF5(1)/WF^WSP4(2)/WF^WP3(2), WF5(1)/WF^WSP4(2)/WF3(2),
WF5(1)/WF4(2)/WF2(2), WF5(1)/WF4(2)/WF3(2)

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D^WP4(2)/WF^WD2(3), D^WP5(2)/D^WWF3(3), D^WSP4(2)/D^WWF2(3),
D^WSP5(2)/D^WWF-SP3(3), D^WSP5(2)/D^WWF3(3), D^WWF4(2)/D^WIC2(3),
D^WWF4(2)/D^WWF-IC2(3), D^WWF4(2)/D^WWF2(3), D^WWF4(2)/D2(3),
D^WWF4(2)/WF^WD-IC2(3), D^WWF4(2)/WF^WD2(3), D^WWF5(2)/D^WWF2(3),
D^WWF5(2)/D^WWF3(3), D^WWF5(2)/D3(3), D^WWF5(2)/WF^WD3(3),
D4(1)/D^WWF-SP2(3), D4(1)/D^WWF2(3), D5(1)/D^WWF-IC3(3),
D5(1)/D^WWF-IC3(3), D5(1)/D^WWF-SP3(3), D5(1)/D^WWF3(3),
D5(1)/D4(1)/D^WWF3(3), D5(1)/WF^WD3(3), D5(1)/WF3(3),
D5(1)/WF4(1)/D^WWF3(3), P^WD4(2)/D^WIC2(3), P^WD4(2)/D^WP2(3),
P^WD4(2)/D2(3), P^WD4(2)/P^WWF-IC2(3), P^WD5(2)/D^WIC3(3),
P^WD5(2)/D^WWF3(3), P^WIC5(2)/WF3(3), P^WRF4(2)/P^WWF-RF2(3),
P^WRF3(2)/RF^WLP3(3), P^WRF5(2)/RF3(3), P^WRF5(2)/WF^WRF2(3),
P^WRF5(2)/WF^WRF3(3), P^WSP4(2)/D^WP-SP2(3), P^WSP4(2)/D^WSP2(3),
P^WSP4(2)/D2(3), P^WSP4(2)/P^WWF-IC2(3), P^WSP4(2)/WF^WIC2(3),
P^WSP4(2)/WF^WP2(3), P^WSP5(2)/D^WIC3(3), P^WSP5(2)/D^WWF2(3),
P^WSP5(2)/D2(3), P^WSP5(2)/D3(3), P^WSP5(2)/P^WSP-WF3(3),
P^WSP5(2)/P^WSP3(3), P^WSP5(2)/P^WWF-IC3(3), P^WSP5(2)/P^WWF-SP3(3),
P^WSP5(2)/P^WWF2(3), P^WSP5(2)/P^WWF3(3), P^WSP5(2)/RF^WP3(3),
P^WSP5(2)/RF^WWF5(3), P^WSP5(2)/RF3(3), P^WSP5(2)/WF^WD-P3(3),
P^WSP5(2)/WF^WD3(3), P^WSP5(2)/WF^WIC3(3), P^WSP5(2)/WF^WP3(3),

MAJOR FOREST TYPE	VEGETATIVE TYPE
MC.5B	D#IC-WF3(3), D#P-WF3(3), D#SP-WF3(3), D#WF-IC3(3), D#WF-P3(3), D#WF-SP3(3), D#WF3(3), D4(1)/WF#D3(2), LP#P-WF3(3), LP#RF-WF3(3), LP#WF-P3(3), LP#WF-WF3(3), LP#WF3(3), P#D-IC3(3), P#D-SP3(3), P#D-WF3(3), P#D3(3), R#IC-WF3(3), P#LP-WF3(3), P#LP3(3), P#RF-IC3(3), P#RF-LP3(3), P#RF-WF3(3), P#RF-SP3(3), P#SP-IC3(3), P#SP-LP3(3), P#SP-WF3(3), P#SP3(3), P#WF-D3(3), P#WF-IC3(3), P#WF-LP3(3), P#WF-RF3(3), P#WF-SP3(3), P#WF3(3), P4(1)/P#WF3(2), P4(1)/W#P3(2), SP#P-WF3(3), SP3(1)/R#P3(2), WF#D-IC3(3), WF#D-P3(3), WF#D-RF3(3), WF#D-SP3(3), WF#D3(3), WF#IC-D3(3), WF#IC-P3(3), WF#IC3(3), WF#LP-P3(3), WF#LP3(3), WF#P-D3(3), WF#P-IC3(3), WF#P-LP3(3), WF#P-RF3(3), WF#P-SP3(3), WF#P3(3), WF#RF-LP3(3), WF#RF-P3(3), WF#RF-SP3(3), WF#RF3(3), WF#SP-P3(3), WF#SP3(3), WF3(3)
MC.6	D#WF2(3), D#WF2(4), P#D2(3), P#SP-IC2(3), P#WF2(3), WF#D-P2(4), WF#D2(3), WF#IC2(3), WF#P-IC2(3), WF#P-RF2(3), WF#P2(3), WF#P2(4), WF#RF-IC2(3), WF2(3), WF2(4)
P.1	R#IC5(2)
P.2	IC#P2(2), IC#P3(2), IC3(1), IC4(1), P#IC2(2), P#IC3(2), P#IC4(2)
P.3B	IC#P4(2)/P2(2), IC4(1)/P2(2), P#IC-D4(3), P#IC-SP4(3), P#IC4(2)/IC#P2(2), P#IC4(2)/P#IC2(2), P#IC4(3)
P.4R	P#IC4(2)/P#SP-IC2(3)
P.5A	P#IC-SP3(4), P#IC3(4)
P.5B	IC#P3(3), P#IC-D3(3), P#IC3(3)
PP.1	P5(1)/P4(1)/P#D2(2), P5(1)/P4(1)/P#D3(2), P5(1)/P4(1)/P#IC2(2), P5(1)/P4(1)/P3(2), P5(2), P5(2)/D#P3(2), P5(2)/D#P4(2)/D#IC3(2), P5(2)/LP2(2), P5(2)/P#D2(2), P5(2)/P#IC2(2), P5(2)/P2(2), P5(2)/P3(1)/P#IC2(2), P5(2)/R#P3(2), P5(3)
PP.2	P2(1), P2(2), P3(1), P3(2), P4(1), P4(1)/D3(3), P4(1)/P#D3(3), P4(1)/P2(1), P4(1)/P3(3), P4(2), P5(1)
PP.3A	P4(4), P5(1)/D#IC3(2), P5(1)/D#P3(2), P5(1)/D3(2), P5(1)/LP3(2), P5(1)/P#D3(2), P5(1)/P#IC3(2), P5(1)/P#SP3(2), P5(1)/P3(2), P5(1)/R#LP3(2), P5(1)/R#P3(2), P5(1)/R#P3(2)
PP.3B	P4(1)/D#IC2(2), P4(1)/D#P2(2), P4(1)/D2(2), P4(1)/IC#D2(2), P4(1)/IC#P2(2), P4(1)/P#D2(2), P4(1)/P#IC2(2), P4(1)/P#RF2(2), P4(1)/P#SP2(2), P4(1)/P2(2), P4(2)/IC#P2(2), P4(2)/P#IC2(2), P4(2)/P#SP2(2), P4(2)/P2(2), P4(2)/SP#IC2(2), P4(3), P5(1)/D#IC2(2), P5(1)/D2(2), P5(1)/IC#D2(2), P5(1)/LP2(2), P5(1)/P#IC2(2), P5(1)/P#RF2(2), P5(1)/P#SP2(2), P5(1)/P2(2), P5(1)/R#LP2(2), P5(1)/R#P2(2), P5(1)/R#P2(2)
PP.4A	P5(1)/D#SP4(2)/D#SP3(2), P5(1)/P#P4(2)/D#IC2(2), P5(1)/P#SP4(2)/D3(1), P5(1)/P#SP4(2)/D3(2), P5(1)/R#P4(2)/P#RF2(2), P5(1)/R#P4(2)/R#P2(2), P5(1)/R#P4(2)/R#LP2(2), P5(1)/R#P4(2)/R#P3(2)
PP.4B	P4(1)/D#IC2(3), P4(1)/D#P-IC2(3), P4(1)/D#P2(3), P4(1)/D#SP2(3), P4(1)/D2(3), P4(1)/IC#P2(3), P4(1)/IC#SP-P2(3), P4(1)/IC2(3), P4(1)/P#D-IC2(3), P4(1)/P#D2(3), P4(1)/P#IC2(3), P4(1)/P#SP-D2(3), P4(1)/P#SP-IC2(3), P4(1)/P2(3), P4(1)/P3(3)

MAJOR FOREST TYPE	VEGETATIVE TYPE
RF.5A	RF::LP3(4), RF::P-WF3(4), RF::P3(4), RF::WF-P3(4), RF::WF3(4), RF3(4)
RF.5B	RF::LP-WF3(3), RF::LP3(3), RF::P-WF3(3), RF::P3(3), RF::SP3(3), RF::WF-LP3(3), RF::WF-P3(3), RF::WF3(3), RF::W3(3), RF3(3)
RF.6	RF::P2(3), RP2(3), RF2(4), RF3(1)/RF::P1(2)
SA.1	LP::WF3(3), MW3(2)
SA.2	LP::P2(2), LP::P3(2), LP::P4(2), LP::RF3(2), LP::RF4(2), LP::SP4(2), LP2(2), LP3(1), LP3(2), LP4(1), LP4(2)
SA.3A	LP4(4)
SA.3B	LP::RF4(3), LP4(3)
SA.4B	W5(1)/LP3(3)
SA.5A	LP3(4)
SA.5B	LP::P-RF3(3), LP::P3(3), LP::RF3(3), LP3(3)
SA.6	LP::RF2(4), LP2(4)

C. Scanning Map Negatives on the PDS-1000 Microdensitometer

Turn on the scanner power, lamp, voltage, x-motor, and y-motor. Make sure the Manual/Automatic switch is in the Manual mode before turning on the data acquisition system (DAS) power and then the tape unit power. Allow a 30-minute warm-up period. During this wait clean the scanner and tape unit.

Position the scanner upper and lower optics to the aperture (slit) and magnification selected for the material to be scanned. Turn scanner x and y stepping motors to proper gearbox positions for desired $\mu\text{m}/\text{step}$. (Do not use 2, 4).

Set the thumbwheel switches for the DAS program location at 499 and the guard length at 999. The x-, y-, and manual-data-include switches must be off. Set the x and y $\mu\text{m}/\text{stop}$ thumbwheel switches to same values as the stepping motor gearbox. Set the x and y steps/reading to obtain the selected spacing of density readings. Preset/Reset toggle switches must be at Reset (down) for both x and y. Set stage travel directions, using right arrow for x and up (row for y). Set the [2th (right hand) thumbwheel manual data switch to one, to correspond with the y stage direction. The first ten manual data switches contain the map number, right justified. The 11th manual data switch is not used for the VHS programs and is best left at zero. The tape-disable switch should be off unless a test is to be made without recording.

When units have warmed up, mount and load a tape. With the Clear/Preslit knob on Clear so that the entire viewing screen is illuminated, focus the upper optics on an empty stage. Then turn the knob (counter-clockwise always) to Preslit and focus the lower optics, making sure the crosshairs are centered in the illuminated circle. Calibrate the densitometer on Preslit as directed on pages 49-50 of the PDS Microdensitometer Technical Manual.

Place the negative on the x-y stage, with the north edge away from the operator and west edge toward his right. Tape film at corners, making sure it is flat and tight. Refocus upper and lower optics on a line in the area to be scanned. Scan the west edge to find zero-x, keeping the map edge to the left of the crosshairs in the viewing screen. Press the "Enter x" button so that zeroes show

in the x-position display. Scan the north edge to find zero-y, keeping the map edge above the crosshairs in the viewing screen. Press the "Enter y" button so zeroes show in the y-position display. To minimize the scan area (thus scan time and processing time also), the stage may be rotated by hand to line up the map edges with the x and y zero-axes. Scan the east edge to find the maximum x value in μm , keeping map edge to the right of the crosshairs. Enter the maximum x value in the "Final x" thumbwheel switches. If this number is not a multiple of the $\mu\text{m}/\text{reading}$ for x, each scan line will be ended at the next such multiple. Scan the south edge to find the maximum y value. Divide this value by the $\mu\text{m}/\text{reading}$ for y. If the number divides evenly, add one to the quotient. Otherwise, add two to the quotient. Enter the resulting value in the "Number of Scans" thumbwheel switches.

Drive the stage back to the origin (NW corner of map). Press the DAS Reset button, located below the "Final x" switches to the value of the function counter above zero. This will also initialize the data acquisition system. The Program Address lights must show 400g and the Contents lights must show 240g. Turn the Clear/Preslit knob to Preslit. Select into on the Manual/Auto button. Press the Program Initiate button to start scanner.

When scan is finished, first select Manual on the Manual/Auto button and Clear on the Clear/Preslit knob. Check for reasonable position of NW map corner in relation to crosshairs on viewer. Check for zero values in present x and y position displays and for the correct number of scans in the function counter display. If this was the last scan for this tape, add two manual file marks before rewinding. Otherwise, do not add any file marks. Change the negative and proceed with the next scan job.