USING LAND RESOURCE MAPS TO DEFINE HABITAT FOR FOREST BIRDS

by

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ABSTRACT

Forest birds located by their calls were related to mapping units of different land resource maps using a new method. The method involved computer programs which use mathematical descriptions of landform, forest canopy heights, and the nature of the bird's call to predict the area censused for each bird species from each listening station. Computer programs were also used to display locations made from each station, and to associate the locations and areas censused with different mapping units. Yellow-bellied Sapsucker (Sphyrapicus varius), Chestnut-backed Chickadee (Parus rufescens), Steller's Jay (Cyanocitta stelleri), Winter Wren (Troglodytes troglodytes), Varied Thrush (Ixoreus naevius), and Swainson's Thrush (hylocichla ustulata) were each related to both seral stages and vegetation taxonomic units; while Hairy Woodpecker (Dendrocopus villosus), Common Flicker (Colaptes cafer), Red-breasted Nuthatch (Sitta canadensis), and Olive-sided Flycatcher (Nuttallornis borealis) were each related only to seral stages.

Most species showed a consistent pattern of selection for mapping types with repeated census. Results for the Steller's Jay indicated some change in the use of seral stages between census periods. However, there was no clear trend in use over time, and the observed changes may include effects of flocking which would violate the statistical

assumption that locations were independent. Each species had a unique pattern of selection of seral stages and of vegetation types. Species with similar patterns of selection were grouped to form five groups for seral stages and three groups for vegetation types (groups not mutually exclusive). Only Chestnut-backed Chickadee with Yellow-bellied Sapsucker, Swainson's Thrush with Winter Wren, and Varied Thrush with Winter Wren were grouped together both for seral stages and for vegetation types.

A more definite preference among seral stages than vegetation types was detected for most of the species studied. However, the Steller's Jay preferred only two of the vegetation types, while it used all seral stages somewhat equally. Most of the species studied preferred older seral stages. Common Flicker, Steller's Jay, and Olive-sided Flycatcher also used younger stages; while Swainson's Thrush selected for stages of medium age. Of the species related to vegetation types, only Chestnut-backed Chickadee did not show some preference for taxonomic units associated with high soil moisture. The preference was most pronounced for Steller's Jay, which concentrated its use on the two wettest types. The preference by Yellow-bellied Sapsucker may be explained by the older trees and snags that survived logging and fire in wet areas. All of the species also used many of the drier types.

The data support the hypothesis that land resource maps can be used to predict the occurrence of wildlife. The results suggest that habitat for a wildlife species can be predicted over vast areas if the areas have been mapped, and if significant differences in the habitat value of different mapping units have been documented. The results indicate that the prediction can be improved by combining the predictions from two or more maps. The predicted area and spatial distribution of high-quality habitat can be compared with management policy objectives for the wildlife species. The predicted change in available habitat with planned forest management activities can provide criteria for habitat management. The same land resource maps may be used for many wildlife species, thereby facilitating multi-species habitat management.

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OBJECTIVES

This study was inspired by a desire to provide criteria for managing forested land to simultaneously provide habitat for many species of wildlife. Forested land may be managed for wildlife by modifying projected plans for timber management and harvest. Foresters use land resource maps as a base for management decisions and as a medium for recording management activities. The objective of this study was to demonstrate that such maps also could be used for mapping wildlife habitat. That can be restated as the hypothesis: land resource maps can be used to predict the occurrence of wildlife.

Before attempting to evaluate the hypothesis, a method for quantifying the occurrence of wildlife must be selected or developed. Birds were chosen as the subject wildlife group because their calls are readily detected and identified. Available methods of evaluating relative densities of birds located by sound have proved to be unsatisfactory. A first and major step in addressing the broad objective was to develope a technique that would permit comparison of the occurrence of birds in different parts of a land resource map. Specific sub-objectives thus were:

1. To develope a rigorous technique for using the calls of birds to determine relative densities of birds in different areas.
2. To write computer programs to implement the technique employing computer-based mapping systems.

3. To test the method by demonstrating repeatable results for a number of bird species.
4. To use the results to document and explore habitat relationships for selected bird species.

INTRODUCTION

Much of the land in British Columbia is forested and has been allocated to forest companies for timber production. Many investigators have associated changes in wildlife populations with changes in vegetative structure that occur when forests are managed for timber production (e.g. Odum 1950; Johnston and Odum 1956; Hager 1960; Martin 1960; Hooven 1969; Bock and Lynch 1970; Conner 1973; Wight 1973; Conner and Adkisson 1975; Meslow and Wight 1975; Bunnell and Eastman 1976; Thomas *et al.* 1976; Franzreb 1977). Forest companies record timber harvest and other land management activities on maps. If the occurrence of a wildlife species has been shown to depend on the type and extent of land management that has occurred, then a map of these activities will be useful for predicting the abundance of that species in a particular area.

Other investigators have reported a variation in vegetative structure that occurs within forest stands (e.g. Kuchler 1951; Major 1951; Jenny 1958; Krajina 1960; Rowe 1960; Klinka 1976). Plant species do not grow everywhere with equal vigor. Areas of abundant growth for one plant species tend to be associated with areas of abundant growth for certain other plant species. These naturally-occurring groups have prompted the investigators to define plant communities as components of ecosystems. An area is designated as a certain community if the species composition falls within selected limits. Maps of plant communities have been made using species composition limits as criteria for drawing boundaries (e.g. Klinka 1976). Man has always been aware of selective use of plant species by herbivores and omnivores, so it is expected that a map based on the distribution of plant species would be useful for predicting the occurrence of plant-eating wildlife. A map of plant communities might also be useful for predicting the distribution of carnivore species, if the carnivores were attracted to areas of high density of prey or if they were relating to the structure of the vegetation.

Relationships between the areas used by a wildlife species and the types of a plant community map could result from a common response to abiotic factors. If this were the case then the spatial occurrence of a wildlife species might be correlated with that of certain soil types of a soils map or with certain landform classes of a landform map. Maps of soil moisture, air temperature or snow depth might produce significant correlations for some wildlife species.

If two or more of the maps were useful for predicting the occurrence of a wildlife species, then overlaying the maps should improve the prediction. For example, a species might be most abundant on a certain soil type or in a vegetation type only if the area was in a certain seral stage or had been subjected to (or protected from) certain land management practices. The size of the population using the habitat should fluctuate in response to such factors as weather, predators and parasites. Use of the habitat should also vary seasonally with such processes as reproduction and dispersal. Land maps alone would not be sufficient for predicting such short term fluctuations, but they might provide information on the distribution and relative quality of habitat available to maintain a fluctuating population.

The hypothesis that land maps can predict the occurrence of wildlife habitat, can be tested by demonstrating a significant difference in the use of two different mapping types by a wildlife species. To explore more completely the potential for using existing forest land maps in decisions on managing wildlife habitat, it is preferable to have sampled many of the classification types of each of a number of different land maps for each of a number of species. The different maps could then be compared for their ability to predict habitat for each of the species, and differences between species could be assessed.

Many species of forest wildlife are difficult to detect. Relating one such species to one map type is a sizeable project. Success in relating several species to more than one map will depend on choosing species that can be detected easily. Birds which can be seen or heard, and small mammals which can be can be trapped or heard (e.g. squirrels, pika) are likely candidates. Birds located by sound were chosen because there are many species of birds common to forested land that can be readily identified by their calls. An observer listening for bird calls does not interfere with subject species as much as when trapping, and he does not have to deal with the problem of extremely limited visibility within a forest canopy. Very few of the birds heard in forested habitat are ever seen.

Most methods for censusing birds rely on sight for making point locations, although sound may be important in attracting the observers attention to a bird (e.g. Breckenridge 1935; Kendeigh 1944; Williamson 1964; Williamson and Homes 1964; Emlen 1971; Best 1975). Some methods have allowed locations made by sound to supplement visual records when the sound allowed a point location. Amman and Baldwin (1960: 701) used sound to determine "...the tree in which a bird was located..." when censusing woodpeckers in spruce-fir forests. Colquhoun (1940a: 55) recorded a bird that was heard but not seen only "...when it could be localized in any one tree or group of shrubs...". In his method, "...all distant songs and calls were ignored, but there was no distance limit when identification was visual." Colquhoun (1940b: 131) later restated that "...counts were restricted to individuals close at hand..." when identification was vocal.

Previous methods which recorded all birds identified by sound have been used to show population trends between years. The methods require the same listening route or stations to be used each year, and they incorporate records made over a large area into a single density estimate or relative density index. Howell (1951) employed both sound and sight during a roadside census to detect changes in bird populations over years. His density index, made from a moving automobile, represents an average over the distance driven. Petraborg _et al._ (1953) used drumming counts to estimate densities of Ruffed Grouse (_Bonasa umbellus_) by determining the average frequency of drumming by a bird. They assumed a circular plot with a radius equal to the mean distance that drumming could be heard, but averaged the results from ten different listening stations when calculating densities.

Thomas et al. (1977: 3) stated that they were unable to use the records of birds heard but not seen when censusing plots in suburban areas: " We found that the data for birds censused solely by sound were not useful. Some species could be heard at great distances. Since all vegetational variables and many other variables were measured on an 83-foot radius plot, the plot may not have been representative of habitat of distant birds". They concluded that "...only in a very homogenous habitat could birds be censused by sound alone". They recognized that the size of the plot censused by sound would differ among species, but suggested a circular plot with a radius dependent on the average distance that a song could be heard (following Petraborg et al. 1953).

Three major problems must be overcome before records of birds censused by sound can provide a comparative index of abundance between different mapping types. Determining the size and shape of the area being censused is the first problem. The plot censused for any species will not be circular unless in a level area with homogenous vegetative cover. An irregular shape will result from the attenuation of sound by heterogenous vegetative cover and the blocking of sound by physical obstructions such as hills and buildings. In directions where sound is unobstructed, the plot radius is the average maximum distance that a song can heard through still air. Other factors such as high background noise reduce this distance, while some obstructions can be avoided if the bird or the observer seeks an elevated position.

The method developed for this study determines the size and shape of the area censused using a mathematical representation of the physical situation of a person listening for birds in a mountain forest. The landform around the listener is represented by a grid of points in a three-dimensional, rectangular coordinate system. The elevation of each point is determined from the contour lines of a topographical map. The grid is used to produce cross-sections of the landform surface in many directions from the listener. The cross-sections are then used to determine if sound will be blocked by landform features. The cross-sections are expanded to include forest canopy on top of the landform surface using information from a map of canopy heights. The forest canopy cross-sections are then used to determine if sound will be absorbed by trees. The maximum distance a bird could be heard in any direction is determined by testing successive distances in that direction. Each direction and maximum distance defines one point of a polygon which predicts the size and shape of the area censused by sound. This pclygon, which describes the area covered by census, is henceforth called a "coverage polygon".

The second problem is that a single plot may sample two or more land class types. The plot or area censused tends to be large, reflecting the efficiency of using sound to detect and identify calling birds. If an area classified as a single type is also large, the observer may be able to position himself such that the plot is contained entirely within the type even for bird species with loud calls. Interpretation of the results are then straightforward. For many maps of land classification, the area of most types will be smaller than the area covered from a single spot when censusing birds by sound. A single plot may contain examples of more than one classification type, although it is differences between types that are to be demonstrated.

The method developed recognizes that areas classified as being different may be censused simultaneously. Each area that is mapped as a single type is represented by a polygon defined by points located along its perimeter. An area classified as a single type is henceforth called a "type island" as the area will be an "island" of that type surrounded by islands of different types. Polygons representing the type islands of a land classification map are henceforth referred to as "classification polygons". The area of a type island that is censused from a given point is determined by intersecting the coverage polygon for that point with the classification polygon for the type island. The areas censused are summed for each classification type to give the total area censused of each type.

The third problem concerns the nature of locating a calling bird. An observer cannot plot the exact postion of a calling bird unless the bird can be seen. The observer can give a direction, an estimate of his confidence in the direction, and limits on the distance to the bird. Because the location is described as an area which may cover more than one land type, it will not always be possible to say which type the bird was in.

The method developed for this study calculates the coordinates of the points which delineate the area that a bird was in, using the direction and distance estimates recorded in the field. The polygon defined by these points is henceforth referred to as a "location polygon". The method assumes equal probability of the bird actually being located anywhere within a location polygon. The area of intersection between a location polygon and a classification polygon, divided by the area of the location polygon gives the probability that the bird was actually located in that type island. For example, if only ten percent of the area of a location polygon overlaps with a given classification polygon, then the probability is ten percent that the bird was really situated in that type island when it called.

The probabilities determined this way are summed over classification types to provide the probable number of birds that were located in each type. The total, probable number of birds divided by the total area censused of each classification type is the index of abundance which is used in comparisons between types. The same coverage and location polygons are intersected with classification polygons from two different maps, and comparisons are made between maps. Different coverage and location polygons for different bird species are used with the same maps, and to make comparisons in the use of classification types between species.

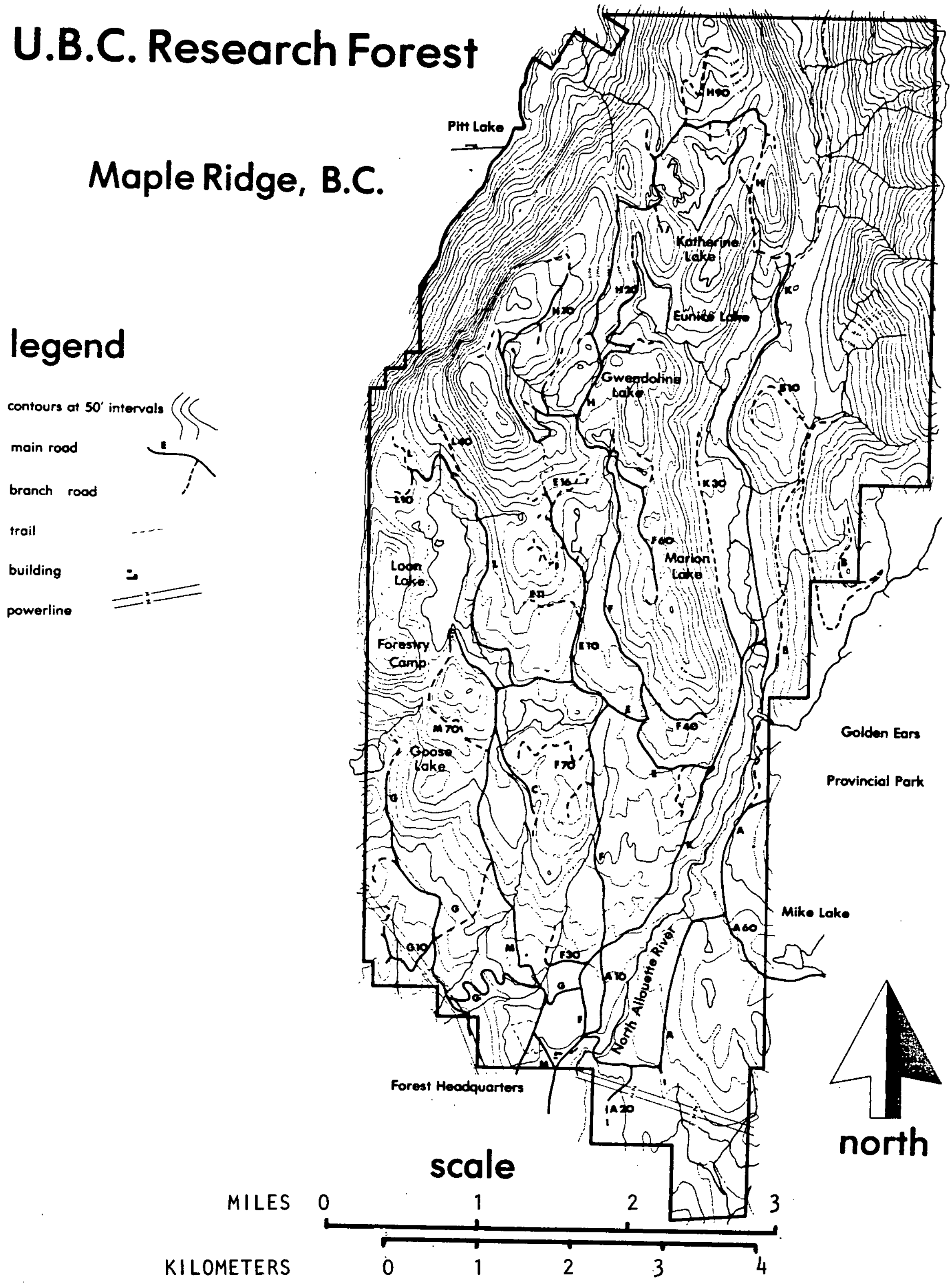
STUDY AREA AND ANIMALS

The University of British Columbia Research Forest is located in the mountains adjacent to the lower Fraser River Valley about ten km north of Haney, British Columbia (Figure 1). Measuring about 4 by 13 km, its 5,151 ha contain 12 lakes plus a variety of landforms, soil types and vegetation communities. Many seral stages are represented on the Research Forest as a result of its long history of fires and timber harvest. A dense network of roads and trails allows easy access to all but the most remote parts of the forest.

The climate of the area reflects the strong marine influence of the Pacific Ocean. Winters are cool and extremely wet with the precipitation building up as snow only during cold spells. Summers are drier and warm but frequently cloudy. The portion of the forest covered in census by this study ranged in elevation from about 200 to 800 m above sea level. It is an area of high relief with lower elevations occurring to the South. The most common species of trees are Douglas-fir (Pseudotsuga menziesii), western hemlock (Tsuga heterophylla), western red cedar (Thuja plicata), red alder (Alnus rubra), and amabilis fir (Abies amabilis). For a more complete description of the U.B.C. Research Forest see Klinka (1976).

Birds were selected in this study of wildlife habitat because they provide potential for documenting habitat relations for many species. Of the species of birds known to occur in the study area, ten were selected according to the

FIGURE 1. MAP OF THE STUDY AREA



following criteria:

1. Each species should frequently produce sounds that are readily identified.
2. Each species should be abundant in at least some parts of the study area.
3. Species chosen should represent a variety of lifestyles.
4. Each species should have been studied previously so that comparative data would be available.
5. Some of the species should be cavity nesters.

Based on these criteria, the following ten bird species were selected:

1. Common Flicker (*Colaptes cafer*)
2. Yellow-bellied Sapsucker (*Sphyrapicus varius*)
3. Hairy Woodpecker (*Dendrocopus villosus*)
4. Olive-sided Flycatcher (*Nuttallornis borealis*)
5. Steller's Jay (*Cyanocitta stelleri*)
6. Chestnut-backed Chickadee (*Parus rufescens*)
7. Red-breasted Nuthatch (*Sitta canadensis*)
8. Winter Wren (*Troglodytes troglodytes*)
9. Varied Thrush (*Ixoreus naevius*)
10. Swainson's Thrush (*Hylocichla ustulata*)

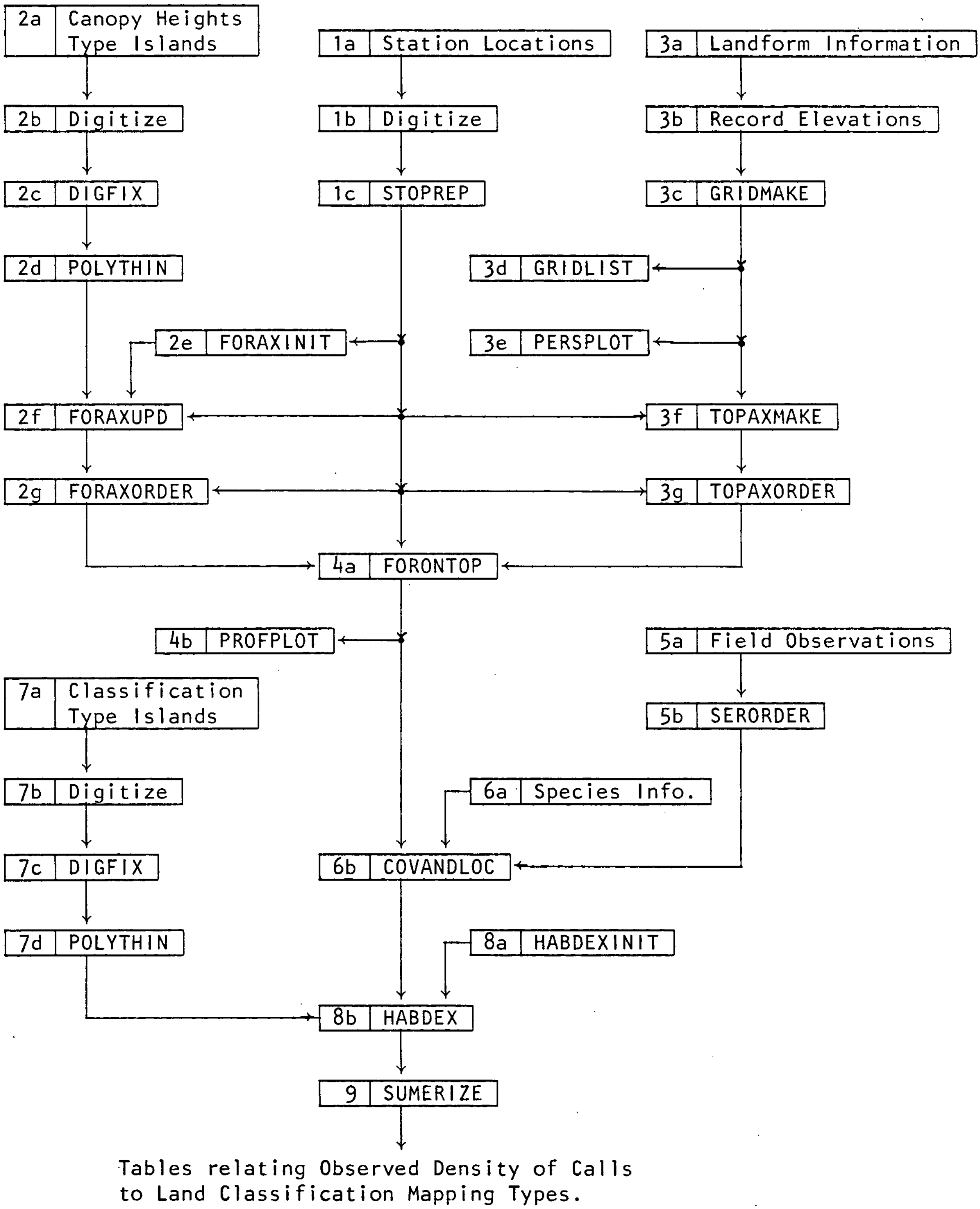
METHOD

The method requires data from six different sources to be prepared and eighteen different computer programs to be run to produce a table relating one bird species to the types of one map for one study area. The required steps are represented as a flowchart in Figure 2.

Steps #1a to #1c involve locating listening stations in the field, determining the coordinates of each station, and storing the information in a computer file. Steps #2a to #2d require preparing a map of tree canopy heights, determining the coordinates of points which define polygons representing the canopy-height type islands, storing the coordinates in a computer file, and running a computer program which removes points from each polygon which are not important to its shape. Steps #2e to #2g involve running programs which use the locations of listening stations and the canopy-height polygons to produce a cross-sectional description of the forest canopy around each station.

Steps #3a to #3c involve superimposing a regular grid on a topography map, recording the elevation at each grid point, and storing the information in a computer file. The information is listed and plotted in steps #3d and #3e so that errors may be found and corrected. In steps #3b and #3g computer programs use the locations of listening stations and the grid of elevations to produce a cross- sectional description of the landform around each station. The cross-sectional description of the forest canopy is combined with the landform description in step #4a. The resulting canopy

FIGURE 2. FLOWCHART OF STEPS REQUIRED TO PRODUCE TABLES RELATING ONE BIRD SPECIES TO THE TYPES OF ONE MAP FOR ONE AREA.



and landform profiles for any station may be plotted for checking in step #4b.

Listening stations are visited, locations of birds recorded and the data stored in computer files in steps #5a and #5b. Information on the call and calling position of the bird species is prepared and stored in step #6a. That information, the field data from step #5, and the canopy and landform profiles from step #4 are used in the program of step #6b to produce polygons defining the area censused and the areas of locations made at each station.

Steps #7a to #7d require preparing or obtaining a land classification map, determining the coordinates of points which define polygons representing type islands on the map, storing the coordinates in a computer file, and running a program which removes points which are not important to the shape of each polygon. These classification polygons are used in step #8, along with the coverage and location polygons prepared in step #6b, to calculate an index of bird abundance for each mapped type island. The results are combined over islands classed as the same type to calculate an index of bird abundance for each mapping type by running the computer program in step #9. The tables produced by this program are discussed under "Results".

Steps #1 to #4 need to be repeated only if a new study area is selected or if there are changes in the landform, vegetative cover or location of listening stations on the original study area. Tables relating different species to the same map are produced by repeating steps #5, #6, #8 and #9;

while tables relating the same species to different maps are produced by repeating steps #7, #8 and #9.

In the following sections the purpose and nature of each step is described as they are numbered on the flowchart. For example, the details of locating birds in the field is described in step #5 along with a description of the computer program which checks and orders the data.

The computer programs used in the method were written specifically for this study. Four of the subroutines used by the programs were adapted from other sources as noted in the text. All programs are in FORTRAN, and each program is self-sufficient so as to be machine-independent. Programs are listed in Appendix A.

#1a. Determine the Locations of Listening Stations.

Listening stations may be located anywhere and by any method, including random placement, without violating the assumptions of the statistical analysis employed. However, more representative results will be obtained if some rules for systematic placement are followed:

1. Stations should be placed so that a variety of examples of each classification type will be censused. The final relationship between one bird species and one classification type is derived from the examples of that type which are within hearing distance of the stations. Species that call more softly require a type island to be closer to a station if the type is to be censused. The most representative results are expected when a variety

of examples of the type have been censused. For example, consider relating use by a bird species to seral stages in a harvested forest. If much of the forest has been harvested, then available examples of old growth might be restricted to poor quality growth that was bypassed by loggers. Locating some stations near good quality old growth stands tends to offset the problem. If good quality examples were not available then the results must be viewed as a relationship of the species with poor quality old growth. As a second example, consider relating use by a species within different vegetation types. If one vegetation type occurs in valley bottoms, but most of the valley bottoms have been logged recently, then most examples of that vegetation type will also be in an early seral stage. The problem can be offset by locating some listening stations in unlogged valley bottoms or by recognising the restriction in the results.

2. Stations should be placed a variety of distances from the examples of any one classification type. There are a number of problems associated with locations made by sound. These are discussed in conjunction with step #5. For now it is neccessary only to consider that an area close to a listening station and an area far from the same station (yet still within hearing distance for the species) may not accumulate observed use by the species with the same ease. More representative results are obtained when a given type is censused from a variety of positions. For example, consider again relating use by a

species to seral stages in a harvested forest. Logging roads are common in the younger stages and relatively rare in old growth areas. If stations are located only on logging roads then old growth examples tend to be censused from a distance. More representative results are expected if some of the stations are located within or at least close to old growth examples.

3. Once the approximate location for all stations has been selected using maps, each station should be visited and the location modified if necessary to maximize the area censused per hour in the field. The census period is restricted to a few hours on spring mornings during good weather, thus the observer should minimize time traveling between stations. This can be accomplished by locating stations on or near established roads but taking care not to violate the first two rules for systematic placement just discussed. The stations should also be located to allow the observer to cover a large area from each one. For example, it would be inefficient to locate a listening station beside a loud river (background noise is discussed in step #5) or in an area where sound is blocked from most directions by nearby topographic features (discussed in step #3g).

A total of 163 listening stations were established. Their positions in the field were marked with flagging tape. Most of the stations were situated on or near logging roads. An attempt was made to distribute the stations such that most spots within an area of about 2000 ha were covered from one or more stations for a species calling at moderate volume. This area includes a variety of examples of most seral stages and vegetation types present on the Research Forest.

#1b. Digitize Locations of Listening Stations.

The locations of the listening stations were marked on a topographic map (scale 1 cm represents 100 m) and digitized. The map was aligned on the digitizer table and the lower left corner of the map was initialized as the origin. The digitizer gives an (X,Y) coordinate defining the position of its cursor relative to the origin. By taking coordinates with the cursor positioned a known map distance from the origin, a factor for converting digitizer units to map units was determined. The factor was used in step #1c to convert the (X,Y) coordinates of each listening station to real distances. As the coordinates of each station were taken, a third coordinate - the Z coordinate or elevation - was recorded manually by interpreting the contour lines of the map.

The map needed to be repositioned as it was too large for the digitizer table. The origin was no longer at the lower left corner of the map, so the map location of the relocated origin was recorded for use in step #1c.

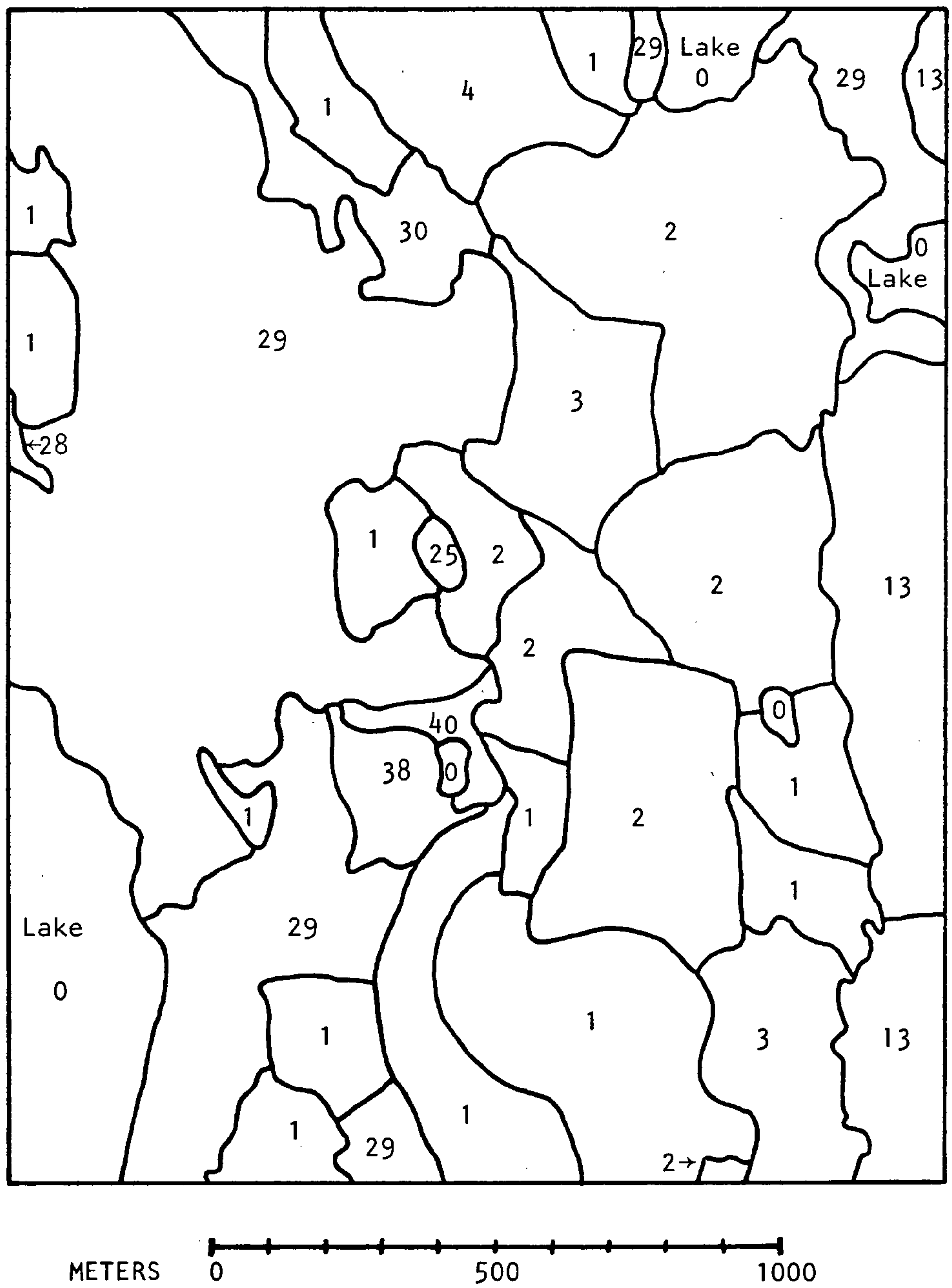
#1c. Prepare the Listening-Station Computer File.

The program STOPREP (48 lines) prepared listening-station locations for use by other computer programs. The (X,Y) coordinate of listening stations or "stops" recorded in digitizer units measured from the origin were converted to meters east and north of the origin using the conversion factor from step #1b. If the digitizer origin was set other than at the lower left corner of the map, then the amount that the origin was moved in each direction was added. The Z coordinate values entered manually were associated with the X and Y coordinates for the same station. STOPPREP then stored the information in a form easily handled by the computer. The information was used in steps #2e, #2f, #2g, #3f #3g, and #4a.

#2a. Prepare Map of Canopy Heights.

A map of canopy heights was prepared for the study area. A small portion of this map is reproduced in Figure 3. The existing logging history and forest inventory map for the Research Forest was the base. The type islands of the inventory map were modified where neccessary to provide units of approximately uniform canopy height. The resulting type islands were numbered and a canopy height was associated with each number. Effective canopy heights for absorbing sound, defined as the height at which the canopy was half closed, were estimated visually as being 80 percent of the average tree height given on the inventory map for older stands. The effective canopy heights of younger stands for which average

FIGURE 3. EXAMPLE OF CANOPY HEIGHT MAP WITH CANOPY HEIGHTS IN METERS.



tree heights were not given were measured in the field. Resulting canopy heights were keypunched and stored in a file for use in step #2g.

#2b. Digitize Canopy-Height Map.

The map of canopy heights was prepared at the same scale as the map of listening station locations. The map of canopy heights was attached to the digitizer table as described in step #1b. The same conversion factor was determined and the same procedure for moving the map and relocating the origin was followed. The boundaries of each canopy-height type-island were traced with the cursor. As the cursor was moved along the boundaries, the digitizer recorded (X,Y) coordinate pairs that defined the positions of points. When joined, the points defined a polygon with the same shape and relative position as the type-island that was traced. The map contained about 250 polygons.

#2c. Prepare Computer Files of Canopy-Height Polygons.

The program DIGFIX (127 lines) prepared polygon files for use by other computer programs. The (X,Y) coordinates of each point in each polygon were converted from digitizer units to real distances. If the origin was positioned other than at the lower left corner of the map, then the amount of displacement was added to each point.

#2d. Thin the Canopy-Height Polygons.

Programs which use polygons run more quickly when the polygons have fewer points. Polygons with fewer points can also be stored in a smaller file. The program POLYTHIN (220 lines) retained only those points important to defining the shape of each polygon. The digitizer recorded points at regular intervals. It included many points that were in line and thus not important to the shape of the polygon. The point thinning algorithm used in POLYTHIN was suggested by D. Williams[1] (pers. comm.). A thinning tolerance parameter was set to adjust how much out of line three points must be in order for the center point to be retained. Some examples of polygon shapes before and after thinning are shown in Figure 4.

#2e. Prepare Computer File to Receive Canopy Descriptions.

The program FORAXUPD described in step #2f was designed to work with one file of polygons at a time, although the polygons for one classification map may be stored in two or more files. FORAXUPD added the information gained from each polygon file to the information already recorded from previous polygon files. When FORAXUPD was run on the first of the files it needed an empty information file on which to build. This empty file was created by the program FORAXINIT (30 lines).

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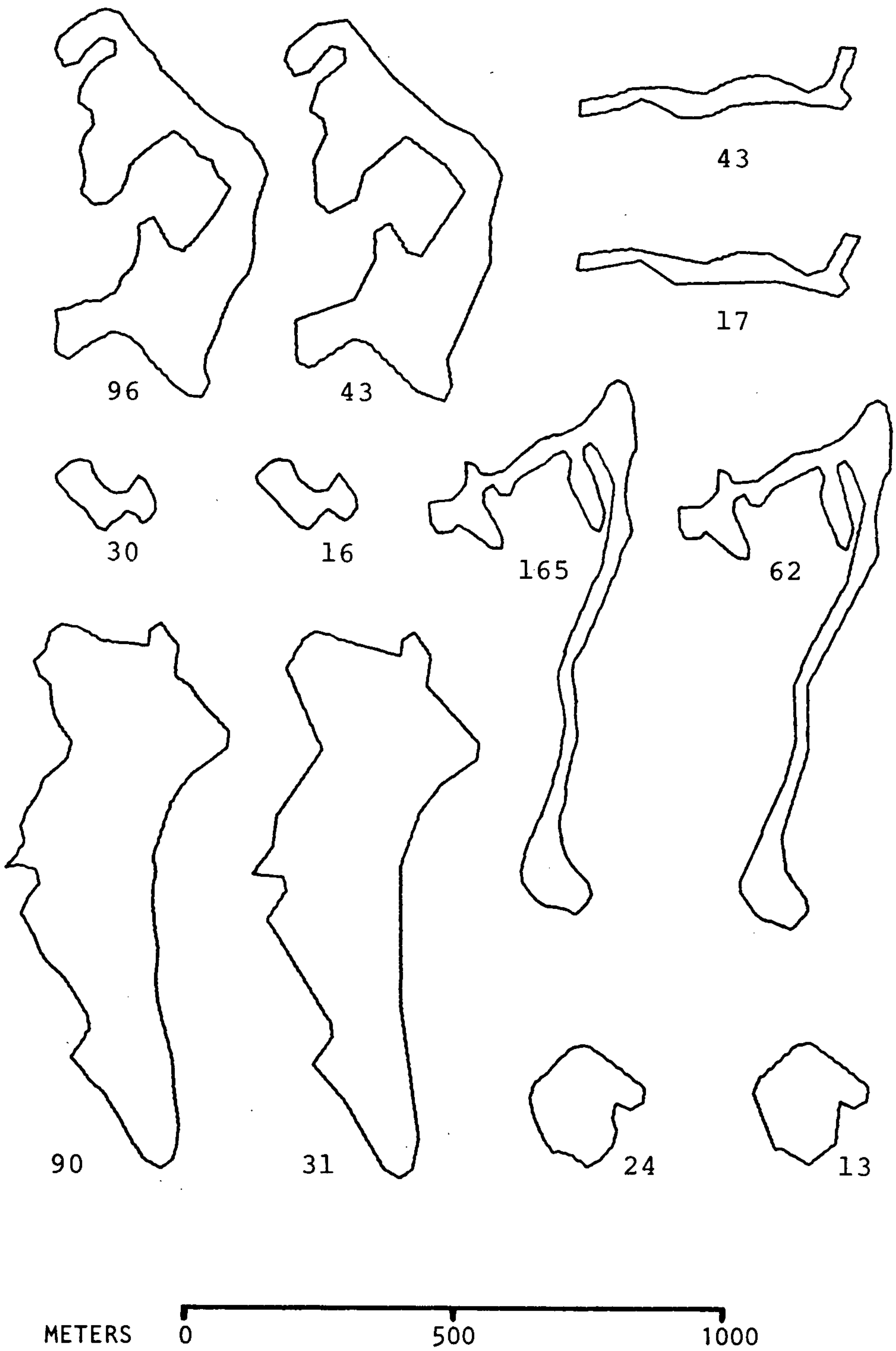
[1] Assistant Professor, Faculty of Forestry, University of British Columbia.

FIGURE 4. SOME EXAMPLES OF POLYGONS DIGITIZED FROM LAND MAPS WITH NUMBER OF POINTS BEFORE AND AFTER THINNING.



#2f. Get Information for Canopy Descriptions.

The program FORAXUPD (495 lines) used the canopy-height polygons and listening-station locations to produce a description of the vegetative canopy height around each station. The method relied on a routine which determined the intersections of a line segment with a polygon. The routine was a modified version of subroutine PIP, a vector and polygon intersection subroutine written by D. Troyer[1] (pers. comm.). FORAXUPD treated the intersection of the line segment defined by the listening station point and a point 1200 m away (farther than the maximum auditory distance for the bird species with the loudest call) with each of the canopy-height polygons within range (Figure 5). It calculated and stored the distances (D1 and D2 of Figure 5) within which the canopy height of each polygon was operative. The process was repeated for each of the 16 points of the compass (1=N, 2=NNE, 3=NE, 4=ENE, 5=E etc.) at each listening station (e.g. Figure 6). The program handled one file of about 50 polygons at a time. The information gained on any run was added to that from previous runs.

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[1] Systems Programmer, British Columbia Systems Corporation, Victoria.

FIGURE 5. AN EXAMPLE INTERSECTION OF ONE LINE SEGMENT WITH ONE CANOPY-HEIGHT POLYGON.

The canopy-height of this polygon will be used in the canopy profile for distance D1 and D2 from the listening station.

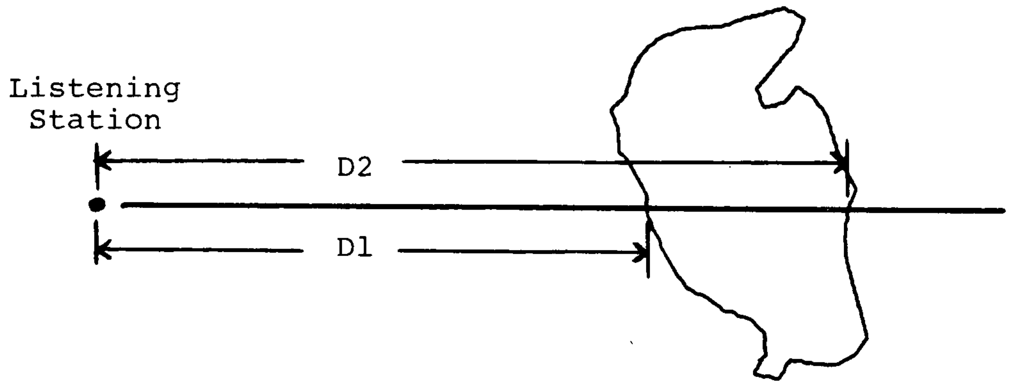
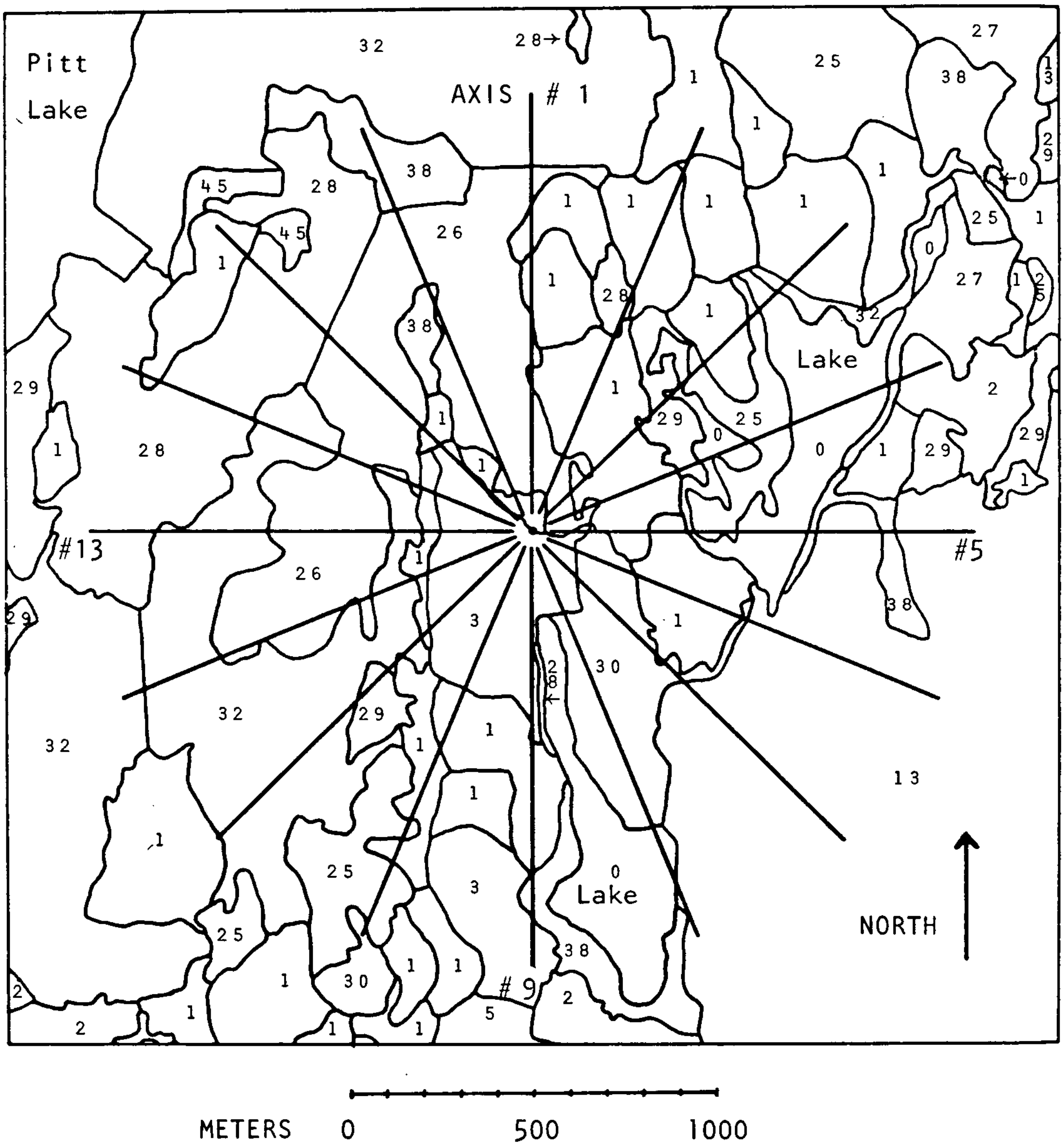


FIGURE 6. ILLUSTRATION OF THE LINE SEGMENTS AND CANOPY-HEIGHT POLYGONS USED TO MAKE THE SIXTEEN CANOPY PROFILES FOR LISTENING STATION NUMBER 103.

Canopy heights are given in meters.



#2g. Order the Canopy Descriptions.

In step #2f the polygons were intersected with each line segment in the order that they were originally digitized. The program FORAXORDER (88 lines) ordered the intersection results by increasing distance from the listening station. Each of the 16 canopy cross-sections at each station was ordered separately with a single run. The canopy height for each polygon was associated with the calculated distances (#2f) using the canopy-height information file from step #2a.

#3a. Prepare Information for the Digital Terrain Model.

Topographical maps can be derived from air photographs using an ortho-photo machine. The information needed to make an elevation grid is available as part of the process. Neither the equipment nor the proper air photographs were available for this study, so the digital terrain model needed for step #3f was produced by hand from a topographical map of the scale 1 cm represents 50 m.

#3b. Record Elevations at Grid Points.

A grid with 1 cm spacing was drawn on a plastic sheet and placed over the map. Elevations were interpolated from map contours at each point of the grid line intersection. The values were keypunched and checked.

#3c. Make the Digital Terrain Model.

The program GRIDMAKE (47 lines) used the elevation information recorded in step #3b to produce a regular grid of elevations, or digital terrain model. The grid was stored in an internal format computer file.

#3d. List the Digital Terrain Model.

The grid was listed for checking using the program GRIDLIST (23 lines).

#3e. Plot the Digital Terrain Model.

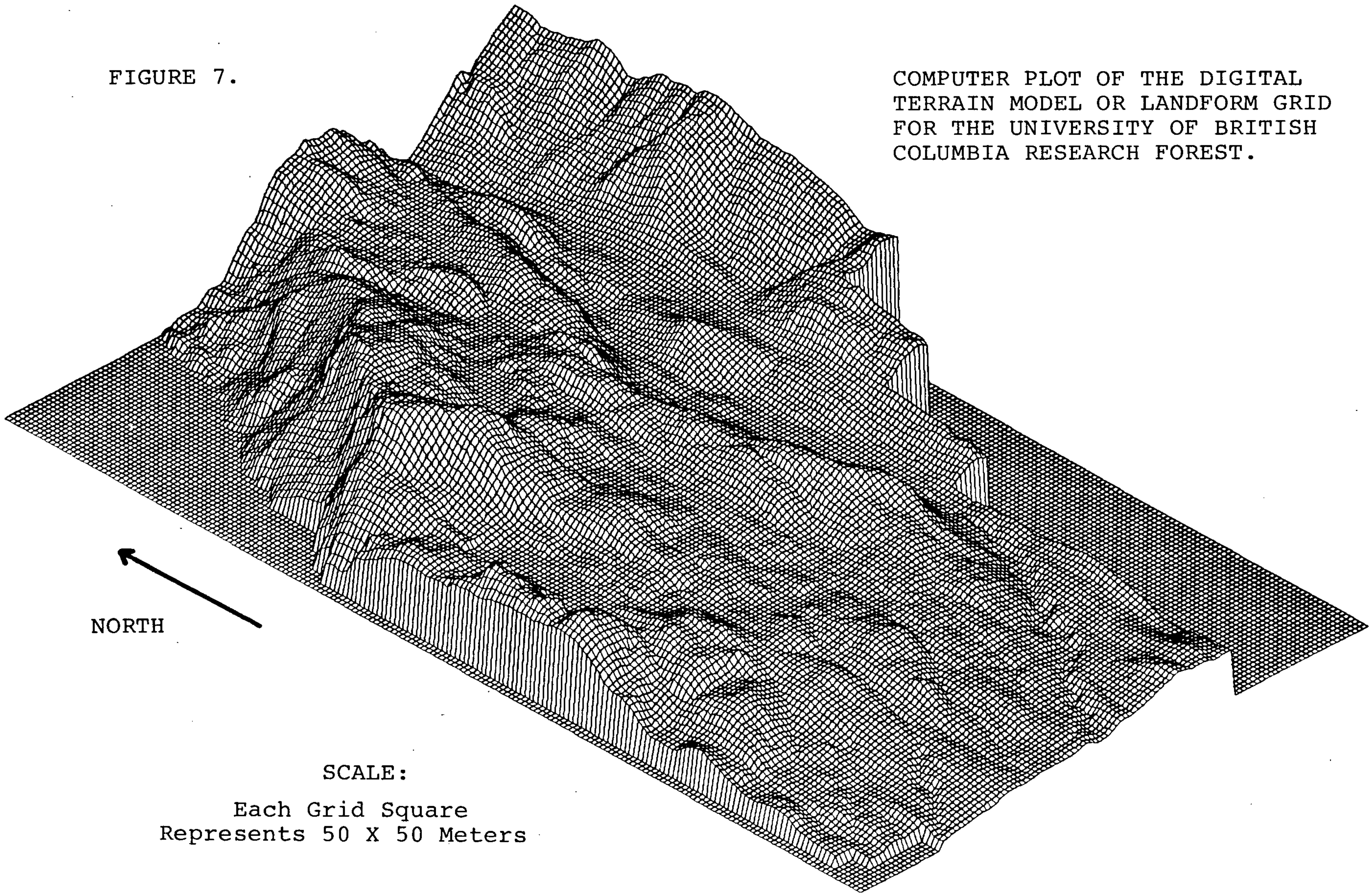
The digital terrain model made for the Research Forest was plotted using PERS, a hidden line perspective plot routine resident in the U.B.C. Computing Centre Library. The plot is shown in Figure 7, reduced to about one-fifth the original plotting size. Vertical scale is approximately in proportion to horizontal scale. The plot can be compared with the map of Figure 1 as viewed from the southwest corner.

#3f. Prepare Landform Descriptions.

The program TOPAXMAKE (264 lines) used the digital terrain model to provide a description of the landform around each listening station. The procedure was analagous to that described in step #2f in that the same 16 line segments were considered. Here the segments were intersected with the line segments defined by adjacent points of the elevation grid (Figure 8). The distance from the listening station at which the intersection occurred was recorded, along with the

FIGURE 7.

COMPUTER PLOT OF THE DIGITAL TERRAIN MODEL OR LANDFORM GRID FOR THE UNIVERSITY OF BRITISH COLUMBIA RESEARCH FOREST.



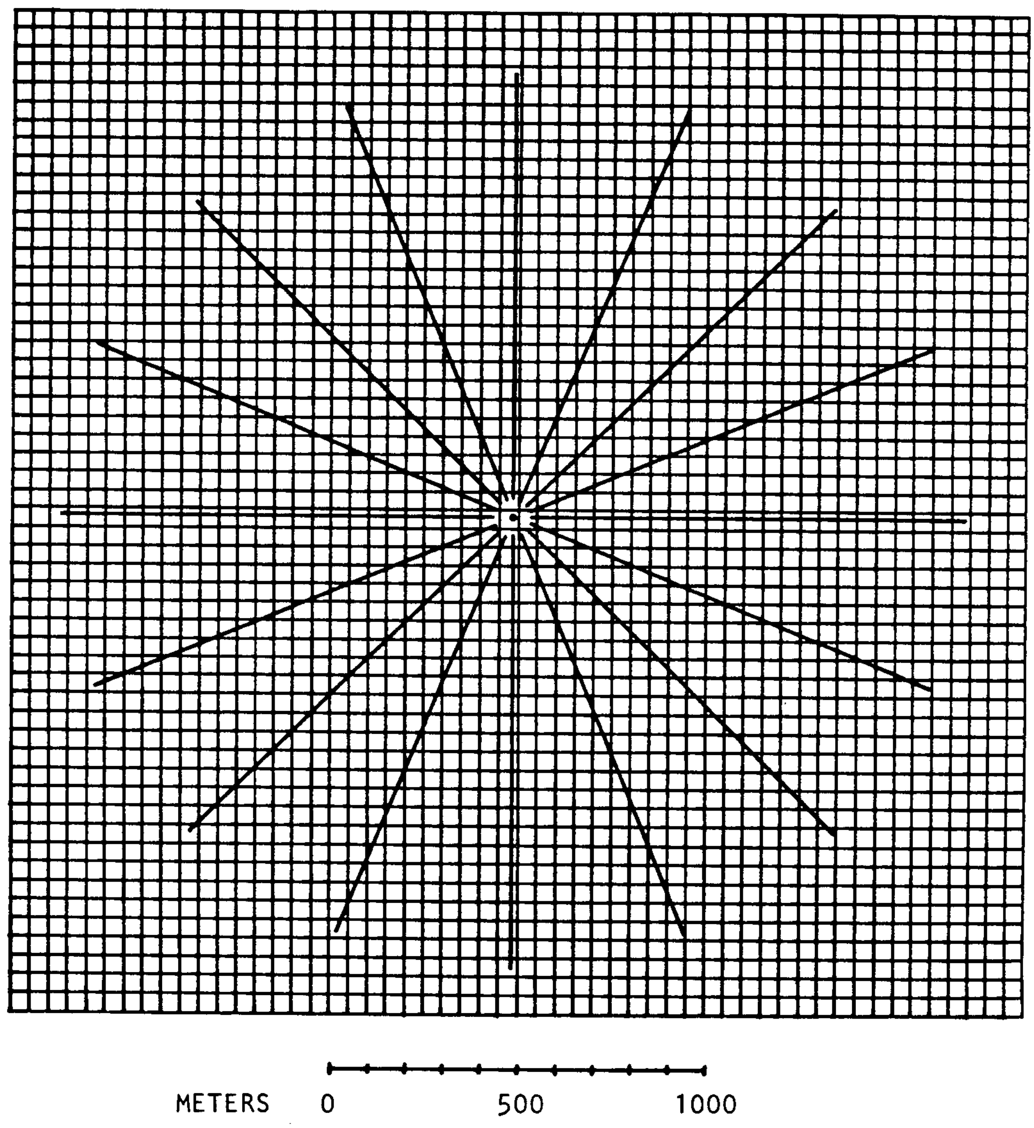
NORTH

SCALE:

Each Grid Square
Represents 50 X 50 Meters

FIGURE 8. ILLUSTRATION OF THE LINE SEGMENTS AND LANDFORM GRID USED TO MAKE THE SIXTEEN LANDFORM PROFILES FOR ANY LISTENING STATION.

The station point has been arbitrarily located within one grid cell.



elevation as determined by linearly interpolating between the elevations of the two grid points (Figure 9a). A single run of TOPAXMAKE prepared landform descriptions for each of the 16 directions from each listening station.

#3g. Order the Landform Descriptions and Add Close Features.

The intersections with the grid prepared in step #3f were ordered according to increasing distance from the listening station by the program TOPAXORDER (99 lines). At the same time, raised observer position and close topographic features were added to the landform description. Stations had been located whenever possible to avoid close topographic features that would obstruct sound, some obstacles were avoided by standing on a rock or vehicle. Remaining obstructions were represented by the digital terrain model unless they were smaller than the spacing of grid points. Small irregularities in landform were important only when close to the observer. To establish the presence of any close topographic features that blocked sound but were not represented by the grid, it was neccessary to check each direction from each listening station. If the observer sought a raised position, the increase in height was the recorded and the position of close topographic features was measured from the raised position.

A Silva Ranger compass was used to determine each of the 16 directions in which landform was being described. Only features closer than 75 m (1.5 times the grid spacing distance of 50 m) were noted. The slope distance to each

FIGURE 9a. AN EXAMPLE OF USING LINEAR INTERPOLATION BETWEEN POINTS OF THE LANDFORM GRID TO DETERMINE THE ELEVATION OF THE POINT OF INTERSECTION WITH ONE LINE SEGMENT.

The elevation E will be used in the landform profile for this direction at distance D from the listening station.

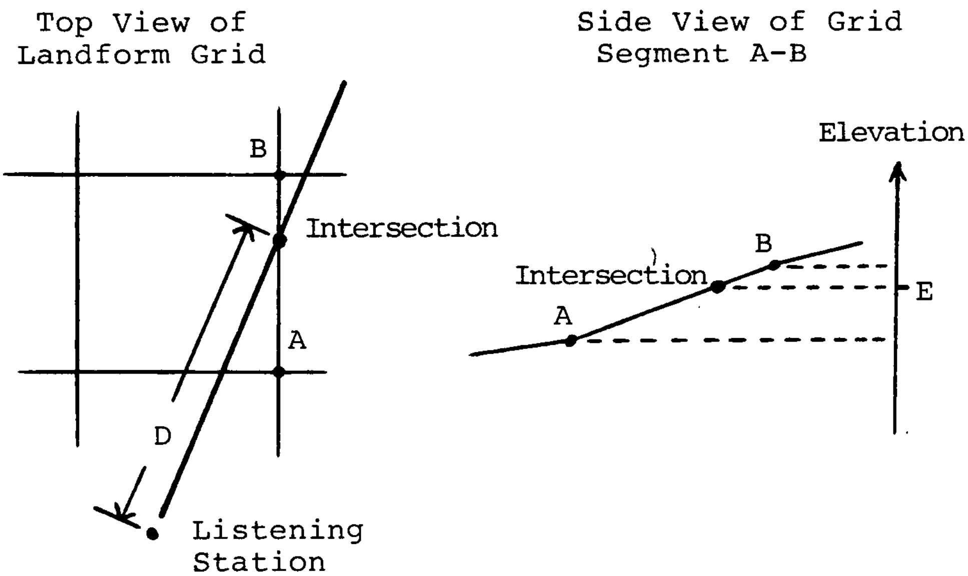
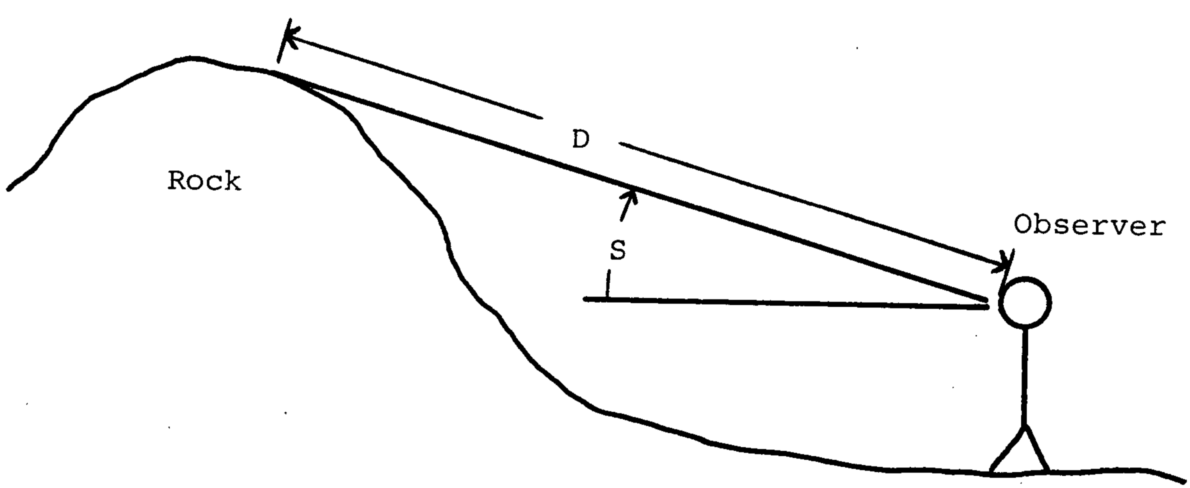


FIGURE 9b. RECORDING THE POSITION OF CLOSE TOPOGRAPHIC FEATURES AT A LISTENING STATION.

Distance D and slope S are recorded in any of the sixteen directions for which sound is blocked by landform irregularities too small to be represented accurately by the landform grid.



obstruction was measured with a long-base rangefinder as it did not require the observer to move from the station. A Sunto slope gauge was used to determine the angle in degrees from horizontal to the top of the feature (Figure 9b).

#4a. Complete the Canopy-Landform Profiles.

The program FORONTOP (280 lines) completed the vegetative canopy and landform cross-section profiles. The landform in each direction from each station was described in a two-dimensional rectangular coordinate system. The listening station point was (0,STOPZ), where STOPZ was the elevation of the station. The second point was derived from close topographic data if any such features had been recorded. The remainder of the landform profile was derived from the distance-elevation pairs prepared in steps #3f and #3g. Two additional points were added to complete the polygon representing the landform profile so that a vector-polygon intersection routine could be used in step #6b. The first was located at sea level, 1300 m horizontal distance from the station; and the second was at sea level, directly below the station.

The distance-canopy height pairs prepared in steps #2f and #2g were used in conjunction with the corresponding landform profile to produce a two-dimensional profile of the vegetative canopy top in each direction from each station. The canopy height operative at the distance was added to the elevation coordinate of each point defining the landform profile. Additional points were added when a change in canopy height occured. The polygons representing the canopy-height profiles were also completed by adding the two points at sea level.

#4b. Plot Profile Polygons for Checking.

The 16 pairs of profile polygons were plotted for a number of stations for checking using the program PROFPLOT (42 lines). The landform and canopy profiles for one direction are plotted on top of each other. In the example for station #103 presented in Figure 10, the lower part of most of the polygons has been deleted for illustrative purposes.

#5a. Collect Field Observations.

Six visits to each of the 163 listening stations were conducted from March 1 to June 8 of 1977. Each round of visits represented 40.75 hours of listening for the calls of birds for a total of 244.5 hours (dates for dach round are included in Table 3). Stations were visited only between 6:00 and 10:30 am in March, changing to between 4:30 and 9:30 am in June. Visits were cancelled or curtailed during frequent spells of bad weather. Otherwise the census continued uninterrupted over the spring period. Stations were visited in scrambled order to average trends over time within a single round.

Each visit to one station was 15 minutes long. The station number and date were recorded together with a subjective evaluation of the level of background noise. The

FIGURE 10. LANDFORM AND FOREST CANOPY PROFILES IN SIXTEEN DIRECTIONS FROM STOP NUMBER 103.

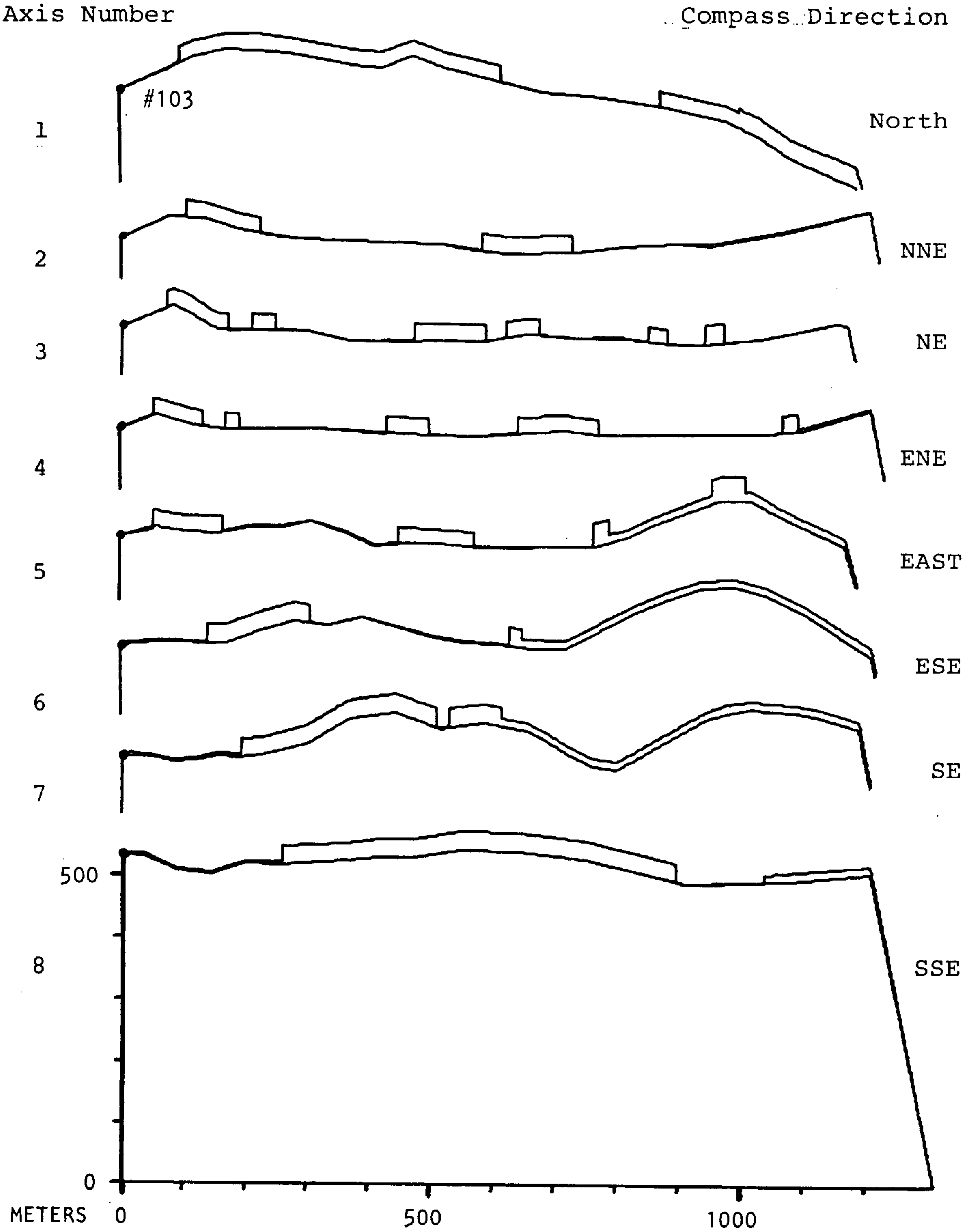
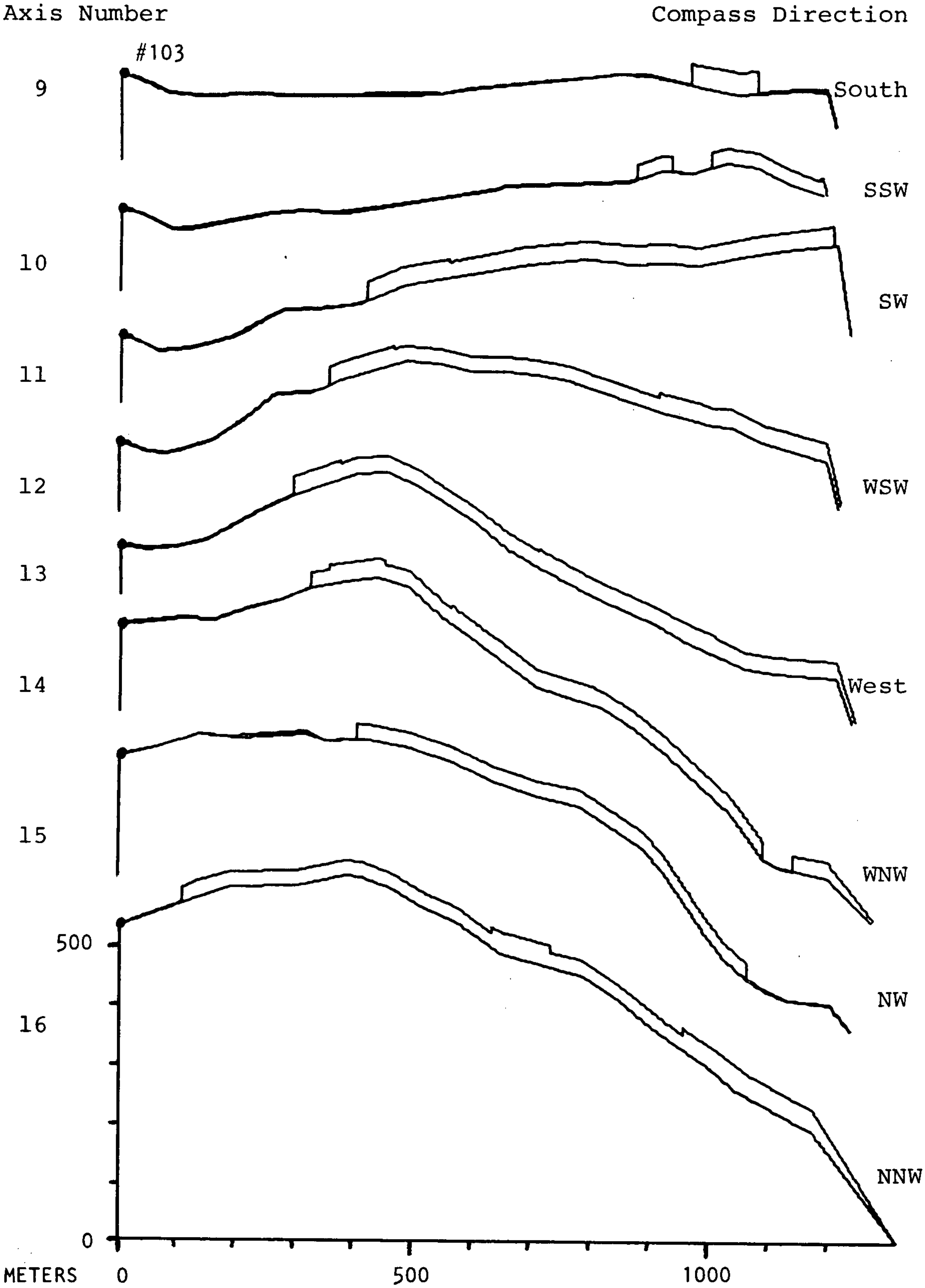


FIGURE 10. (continued)



calls, songs and/or raps of 10 different species were monitored. Upon hearing a call, the observer estimated the direction of the calling bird to the nearest degree, using a Silva Ranger compass. The observer also estimated the degree of error involved in determining the direction. "Crisp" sounds repeated three times or more could be located more exactly than sounds that echoed or were not repeated sufficiently often to allow the observer to obtain a bearing. Lower frequency sounds with sharp bursts could be located more accurately than high-pitched notes that faded gradually. Three arbitrary error classes were established. A rating of 1, 2 or 3 was used to indicate directional errors of plus or minus 5, 10 and 20 degrees, respectively. Two observers listening to the same bird from the same station at the same time recorded directions within 2 or 3 degrees of each other when the error had been judged by each as being Class 1. Birds that were seen as well as heard were assigned a 2 degree measuring error. Birds that were seen but not heard were not recorded.

Limits on the distance to birds that were heard but not seen were estimated in meters. The minimum distance was estimated as the maximum distance to which visual scrutiny was possible. This estimate might have been increased if the bird sounded particularly faint and thus far away. The maximum distance was always limited by the maximum distance that a bird of that species could be heard, as determined in step #6a. This distance may have been reduced if the bird sounded particularly loud or was heard to be calling from the tops of adjacent trees. The distance to birds that were seen as well as heard was measured using a long-base rangefinder or was estimated using a map and recognizable landmarks.

The distance limits and directional error were estimated conservatively such that the observer always felt confident that the bird was actually located within the area that they defined. Care was also taken not to record the same bird twice in the same position. If a bird was heard calling from the same general direction in which a location for that species had already been recorded, then it was recorded only if the areas of location did not overlap. The second location was recorded if its direction differed from that of the first location by at least the sum of the directional errors estimated for the two locations, or if the maximum distance for one location was less than the minimum for the other.

#5b. Prepare the Recorded Observations.

The data from each round of visits to the 163 stations was keypunched and checked. The program SERORDER (104 lines) checked for any illogical values and ordered the stations by number as was required by COVANDLOC in step #6b.

#6a. Prepare File of Information for each Species.

The estimates required by the program COVANDLOC (step #6b) were placed in an information file which was prepared for each species (summarized in Table 1). COVANDLOC required an estimate of the maximum distance at which a bird of the species could be heard through still air; an estimate of the average position of the bird in the canopy or above the ground when calling; an estimate of the ability of sound to travel through a forest canopy relative to its ability to travel through air; and an estimate of the extent to which the maximum distance at which a bird can be heard is reduced by background noise.

Each species of bird was identified by an arbitrarily assigned number in the information file. Dates marking the onset and cessation of calling were given for migratory species and for species that showed seasonal differences in calling activities. The maximum distance at which a bird of each species could be heard was estimated as the maximum known distance of birds located by both sight and sound. An attempt was made to increase the maximum distance by using two observers in radio contact. In some cases one observer stayed close to a calling bird to confirm its location while the other observer moved away from the bird until it could no longer be heard. In other cases a bird heard by observers separated by about 200 m was located by triangulation.

An experiment was performed to determine the ability of sound to travel through a forest canopy relative to its ability to travel through air. A tape recorder was fitted

TABLE 1. INFORMATION NEEDED TO PREDICT THE AREA COVERED IN CENSUS FOR EACH BIRD SPECIES.

Species Name	Active Period[1] (1977)	Typical Calling[2] Position	Maximum Distance[3] Heard in Open Air
Common Flicker	March 1 to July 30	60% up in canopy	650 meters
Yellow-bellied Sapsucker	March 1 to July 30	70% up in canopy	700
Hairy Woodpecker	March 1 to July 30	70% up in canopy	700
Olive-sided Flycatcher	May 22 to July 30	5 meters above canopy	550
Steller's Jay	March 1 to July 30	60% up in canopy	500
Chestnut-backed Chickadee	March 1 to July 30	60% up in canopy	150
Red-breasted Nuthatch	March 1 to July 30	50% up in canopy	400
Winter Wren	March 1 to July 30	2 meters above ground	250
Varied Thrush	March 1 to July 30	2 meters above canopy	550
Swainson's Thrush	May 15 to July 30	30% up in canopy	450

1. Period within census period (March 1 to July 30) during which calls were commonly heard.
2. Canopy height defined as height at which canopy is half closed (see Step #2a).
3. Maximum auditory distance in meters recorded for a calling bird of known position.

with a scale allowing the position of the volume knob to be recorded and reset. The recorder and speaker were located at one side of a large, flat area covered with a well-developed canopy of trees and underbrush. One person remained with the recorder in radio contact with the second person who positioned himself at 50, 100, 150, 200, and 250 m from the playback speaker. At each distance the call of each of 12 bird species was played repeatedly until the volume control had been adjusted so that the remote observer could just hear the call. The recorder and speaker were then moved to an open field. The volume was set to the levels recorded in the forest, and the observer moved away from the speaker until the call could just be heard.

The resulting distances are displayed in Table 2. Note that at 50 and 100 m there is little difference between forest canopy and air. Matthews (1971) found no significant differences at distances up to 46 m. Unfortunately he did not try distances greater than 46 m, for at 150 m and greater this study demonstrated that the forest canopy was important in absorbing sound.

Consider the hypothesis that a sound wave will not be significantly absorbed by a forest canopy if there are many passageways through the canopy along which sound may travel unobstructed in a straight line. The average visual distance in the canopy was about 50 m, such that two observers separated by 100 m could each see an object placed halfway between them. The hypothesis suggests then that a sound wave should travel 50 m from its source without much absorbtion by

TABLE 2. COMPARISON OF SOUND ATTENUATION IN FOREST CANOPY AND IN AIR.

Playback of recorded calls with volume adjusted to be just heard at distance in forest. All distances in meters.

SPECIES	DISTANCE IN FOREST: 50	100	150	200	250
	DISTANCE IN AIR (D):				
Winter Wren	59	112	---	---	---
Chestnut-backed Chickadee	66	120	---	---	---
Black-capped Chickadee	65	113	261	506	---
Olive-sided Flycatcher	65	112	253	417	963
Varied Thrush	66	108	246	493	950
Swainson's Thrush	59	102	279	482	957
Red-breasted Nuthatch	66	81	257	424	995
Common Flicker	56	89	293	489	1091
Pileated Woodpecker	59	98	286	473	1109
Hairy Woodpecker	51	104	273	520	1081
Steller's Jay	45	149	272	546	1065
Yellow-bellied Sapsucker	51	121	245	512	1176
ΣD =	708	1309	2665	4862	9387
ΣD^2 =	42324	146069	712719	2378584	9841667
S^2 =	50.2	298.1	277.4	1631.1	6378.3
n =	12	12	10	10	9
	AVERAGE DISTANCE IN AIR ($\overline{D}$):				
	59.0	109.1	266.5	486.2	1043.0
	95% CONFIDENCE INTERVAL				
Lower =	54.50	98.13	254.58	457.25	981.61
Upper =	63.50	120.07	278.42	515.15	1104.39

"---" indicates insufficient playback volume to be heard in the forest.

forest canopy. It also suggests that once a sound wave was within 50 m of an observer it should travel the remaining distance without a significant increase in absorption. However, for distances greater than 100 m there should be significant absorption by forest canopy that is more than 50 m from the source and the observer.

This hypothesis explains the observed results and could form the basis for further experimentation. It has been adopted in this study as the simplest alternative. Any forest canopy within 50 m of observer or the source was assumed to conduct sound at the same rate as open air. Any additional forest canopy between the observer and the source was assummed to conduct sound at a fixed, reduced rate relative to open air.

The fixed rate is definitely not correct. The addition of another 50 m at the 150 m stop was equivalent to about an additional 150 m in open air (ratio 1:3). At 200 m the additional 50 m was equivalent to adding about 200 m to the distance in open air (ratio 1:4), and at 250 m the addition of 50 m of forest was equivalent to an extra 550 m in air (ratio 1:11). For this study an average fixed ratio of 1:4 was used in step #6b. It was considered to be sufficient because few species can be heard at distances over 800 m in open air, the variation in forest canopy densities was not considered, and the effect of canopy edges was not studied.

Noise from flowing water or internal combustion engines was sufficiently loud at some listening stations to impair the observer's ability to hear calling birds. Only birds that were close could be heard over a high level of background noise. The observer subjectively rated the background noise at any station. A scale of 0 to 3 was used, with 0 indicating no appreciable noise and 3 indicating that the observer was standing next to a roaring river.

A simple, unreplicated experiment was performed in which the distance at which a noise of constant volume could just be heard was determined for each level of background noise. The resulting distances were divided by the distance with no background noise and rounded to a single digit. The results are 1.0, 0.8, 0.6, and 0.2 for noise ratings 0, 1, 2 and 3, respectively.

#6b. Produce Coverage and Location Polygons for each Species for each Round of Visits to the Listening Stations.

The program COVANDLOC (1347 lines) used the canopy and landform profiles from step #4 to predict the area covered from each station when listening for the calls of one bird species. The predicted area, or coverage polygon, was defined by 16 points. The location of each point was defined as the maximum distance that a bird could be heard in one of the 16 directions. This distance was determined by testing successively shorter distances starting at the maximum distance a bird could be heard through open air (step #6a) reduced for the effect of any background noise. The test consisted of intersecting the line segment defined by the position of the observer's head and the position of a calling bird at the test distance, with the canopy and landform profile polygons.

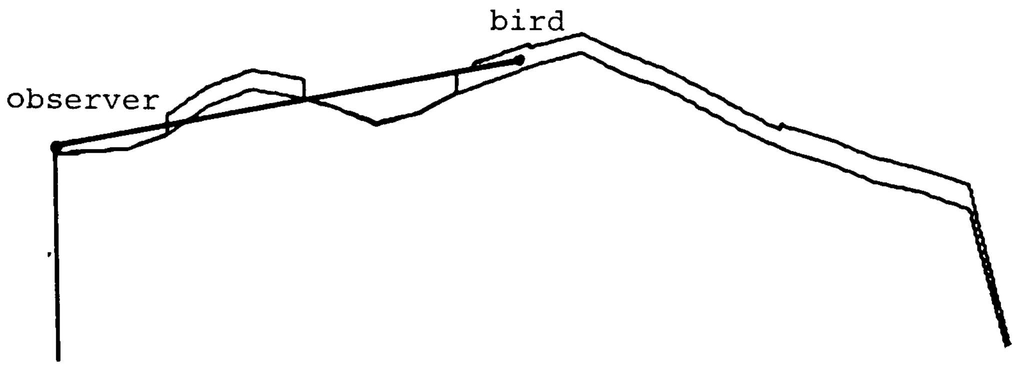
The observer point was located 2 m above the listening station point. If a raised observer had been specified, the elevation of the point was increased accordingly. The point representing the bird was located at the test distance. The elevation of the bird point was defined relative to the ground surface and/or the canopy top as given in the species information file (step #6a).

If the line intersected the landform profile polygon, the observer would not have been able to hear the bird at that distance (Figure 11a). The bird point was then moved one step closer, positioned appropriately relative to the ground and/or canopy top at the new distance, and the intersection performed again. Steps of 50 m were used to match the resolution of the landform grid.

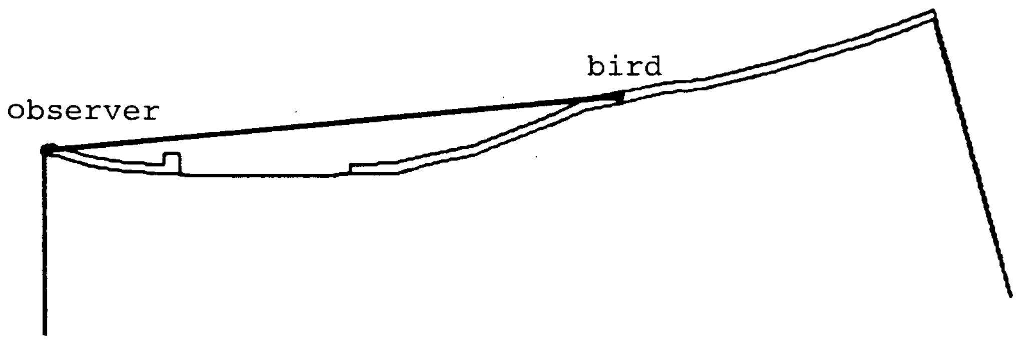
If the line segment did not hit the ground it was next intersected with the canopy profile polygon for that direction from that stop. If the segment did not hit the canopy profile either, then the test distance was accepted as the maximum at which a bird of that species could be heard (Figure 11b). If the segment did hit the canopy profile, then the total distance that the line was inside the canopy was calculated (Figure 11c). The distance through the canopy was converted to an air-equivalent distance using the conversion factor calculated in step #6a. The total effective distance was then computed by adding the air-equivalent distance inside the canopy plus the distance through air outside the canopy. The test distance was accepted if the effective

FIGURE 11. EXAMPLES OF USING LANDFORM AND CANOPY PROFILES TO DETERMINE IF A BIRD COULD BE HEARD AT A GIVEN DISTANCE.

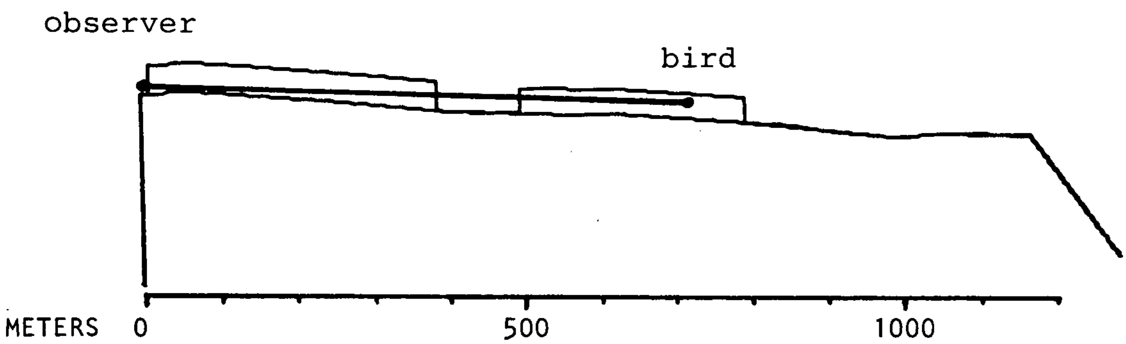
a. Line intersects landform profile polygon. Sound will be blocked by the hill, so the bird could not be heard.



b. Line does not intersect landform polygon. Line intersects forest canopy polygon only within 50 meters of observer and bird. The observer will hear the bird.



c. Line segment is inside the forest canopy polygon for much of its length. Bird will not be heard because its sound will be absorbed by the forest canopy.



distance was less than the maximum for the species reduced by any background noise effect. Otherwise the test distance was reduced by one step and the process repeated again.

The maximum successful test distance and the test direction were used with the coordinate location of the listening station (from step #1) to calculate the coordinates of the point estimating the limit of census for the bird species in that direction. The process was repeated for each of the 16 directions in which canopy and landform descriptions had been prepared. The resulting 16 coordinate pairs defined the perimeter of a coverage polygon which estimated the boundries of the area censused.

COVANDLOC also projected any locations noted for the bird species at each station. The polygon representing the area within which a bird was located was initially defined by four points. The position of each point was determined using the direction and distance estimates for the location with the coordinates of the listening station. Two points were positioned in the recorded direction plus directional error; one at the minimum distance and one at the maximum distance limit. The other two points were positioned at these distances in the direction minus directional error. The resulting wedge-shaped polygon was intersected with the coverage polygon to contain the location within the area covered.

COVANDLOC provided a computer file containing the coordinates and area of each coverage polygon, and the coordinates and areas of any location polygons, for use in step #8b. It also provided a record of the coverage and location polygons and the area (ha) of each (for example see Figure 12). Finally, it provided a file which could be sent to the plotter. Each area covered and its associated locations could be plotted (for examples see Figure 13).

There are four attributes of the areas of locations made by sound that could bias the results. First, the minimum distance was likely to be estimated more accurately than the maximum distance. The distance limits were estimated conservatively, so the maximum distance was probably placed far beyond the actual location of the bird in most instances. The wedge-shape of the areas of location meant that an increase in maximum distance caused a disproportionate increase in the area of location. The part of the location that was near the observer tended to become a smaller proportion of the total area of the location, which caused the area close-by to be under-rated relative to the area around the perimeter. The second attribute, that the presence of an observer may inhibit birds that are close from calling, also caused areas close-by to be under-rated.

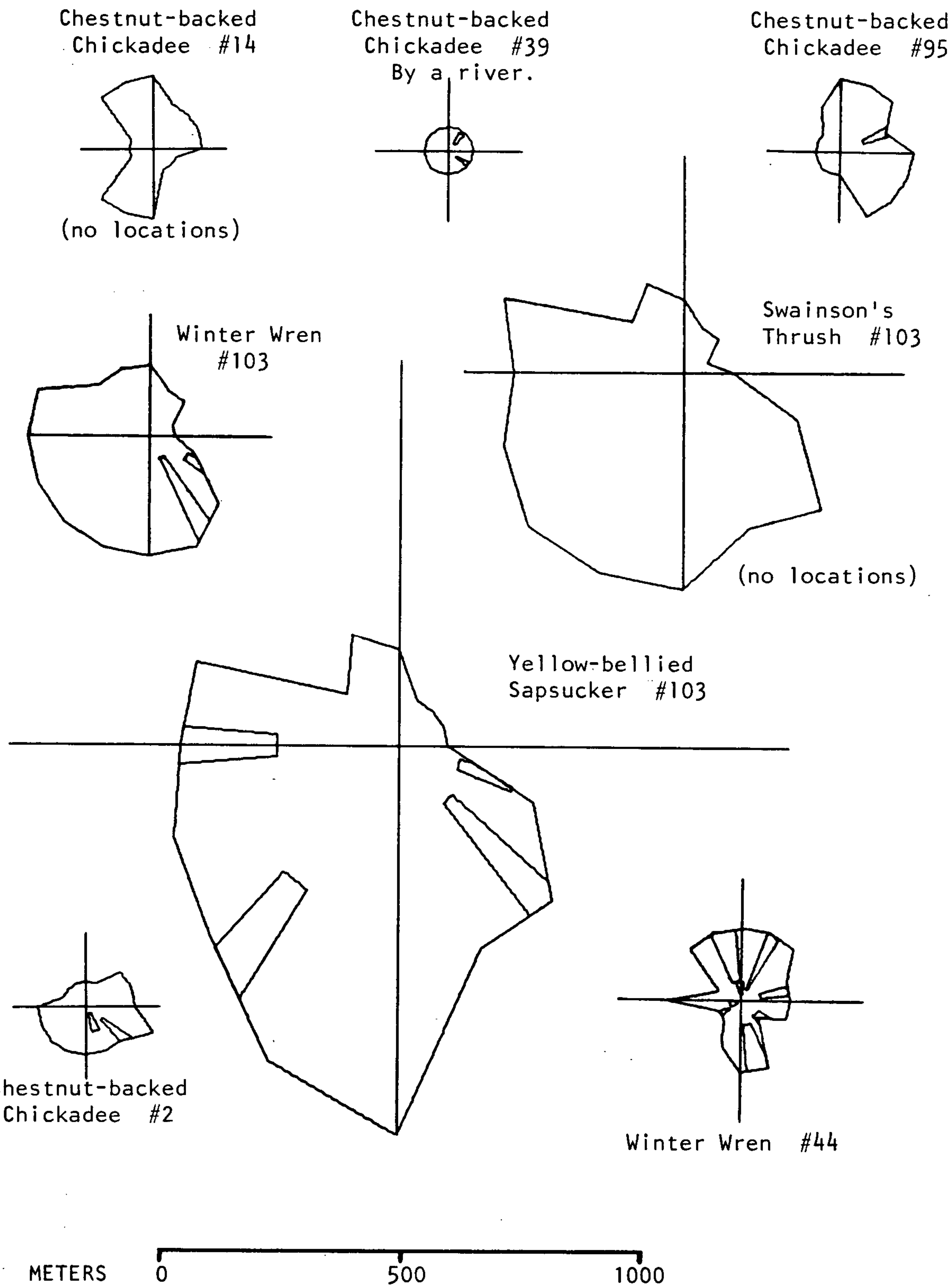
The third attribute is that a calling bird was more likely to be detected when it was close. Areas that were close-by tended to be over-rated because a bird that was closer did not need to call as loudly to be heard. Areas close-by also tended to be over-rated because of the fourth

FIGURE 12. AN EXAMPLE OF THE RECORD OF COVERAGE AND LOCATION POLYGONS MADE BY PROGRAM COVANDLOC. Stop=listening station. Species 1 is Winter Wren.

COVERAGE COMPLETED FOR STOP	1	SPECIES	1	AREA COVERED	6.89
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.08	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.19	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.05	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.04	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.08	
COVERAGE COMPLETED FOR STOP	2	SPECIES	1	AREA COVERED	4.97
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.03	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.19	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.12	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.19	
COVERAGE COMPLETED FOR STOP	3	SPECIES	1	AREA COVERED	3.64
COVERAGE COMPLETED FOR STOP	4	SPECIES	1	AREA COVERED	6.55
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.20	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.32	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.01	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.18	
COVERAGE COMPLETED FOR STOP	5	SPECIES	1	AREA COVERED	9.42
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.34	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.14	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.37	
COVERAGE COMPLETED FOR STOP	6	SPECIES	1	AREA COVERED	4.02
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.09	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.29	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.17	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.01	
COVERAGE COMPLETED FOR STOP	7	SPECIES	1	AREA COVERED	4.45
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.25	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.06	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.19	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.08	
COVERAGE COMPLETED FOR STOP	8	SPECIES	1	AREA COVERED	8.37
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.33	
LOCATION PROJECTED FOR SPECIES		1	WITH AREA	0.32	

FIGURE 13. SOME EXAMPLES OF COVERAGE AND LOCATION POLYGONS PRODUCED BY THE PROGRAM COVANDLOC.

Plots are labeled with species name and listening station number.



attribute. A bird that was nearby would not need to move as far to become a candidate for a second location. For example, a bird moving in a circle around an observer would need to move only half as far if it were at half the distance in order for the observer to perceive the same change in direction to the bird.

The latter two effects probably more than make up for the former two, such that overall the method tends to be center-weighted. An attempt was made to reduce center-weighting by recording birds known to be close only when they called loudly, and by being more demanding of separation when recording two locations in a similar direction when both birds were known to be relatively close. The impact of any consistent biases on the results was reduced by censusing each classification type from a variety of distances as discussed in step #1a.

#7a, #7b, and #7c. Digitize, Prepare and Thin Polygon Files for each Map to which Use by Birds is to be Related.

The procedure described in steps #2b, #2c, and #2d was used to produce polygons representing the types of a land classification map. Two maps of the Research Forest were digitized. The first was a map of seral stages containing 248 polygons (Figure 14). The second was a synecological map (Klinka, 1976) using plant associations and sub-associations as mapping units (Figure 15). It contained over 2000 polygons of which time and resources allowed only 499 to be digitized. All but a few of the vegetation type islands that were

FIGURE 14. EXAMPLE OF MAP OF SERAL STAGES.

Seral stages are numbered as in the computer output and text. For ages see Table 15.

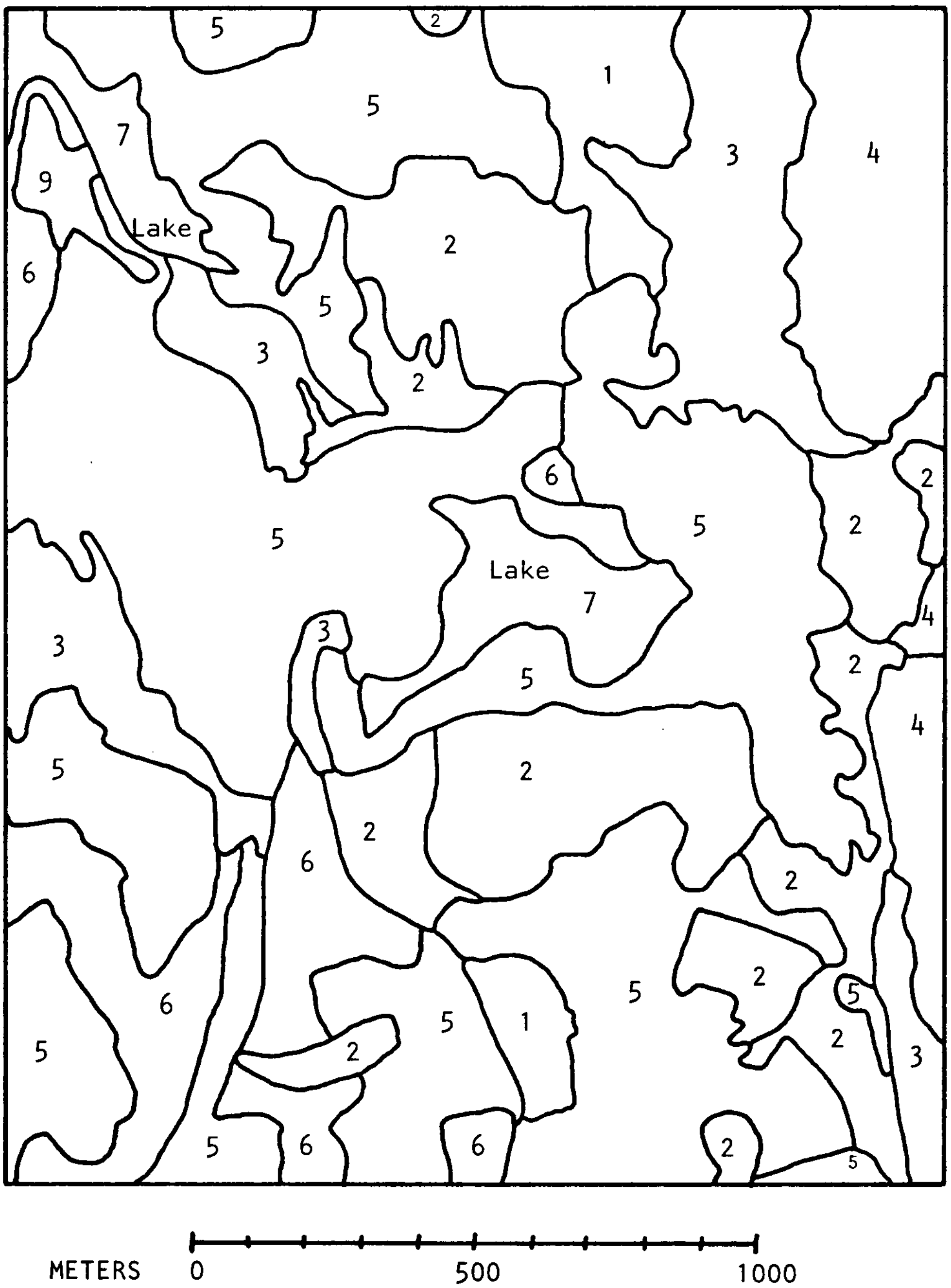
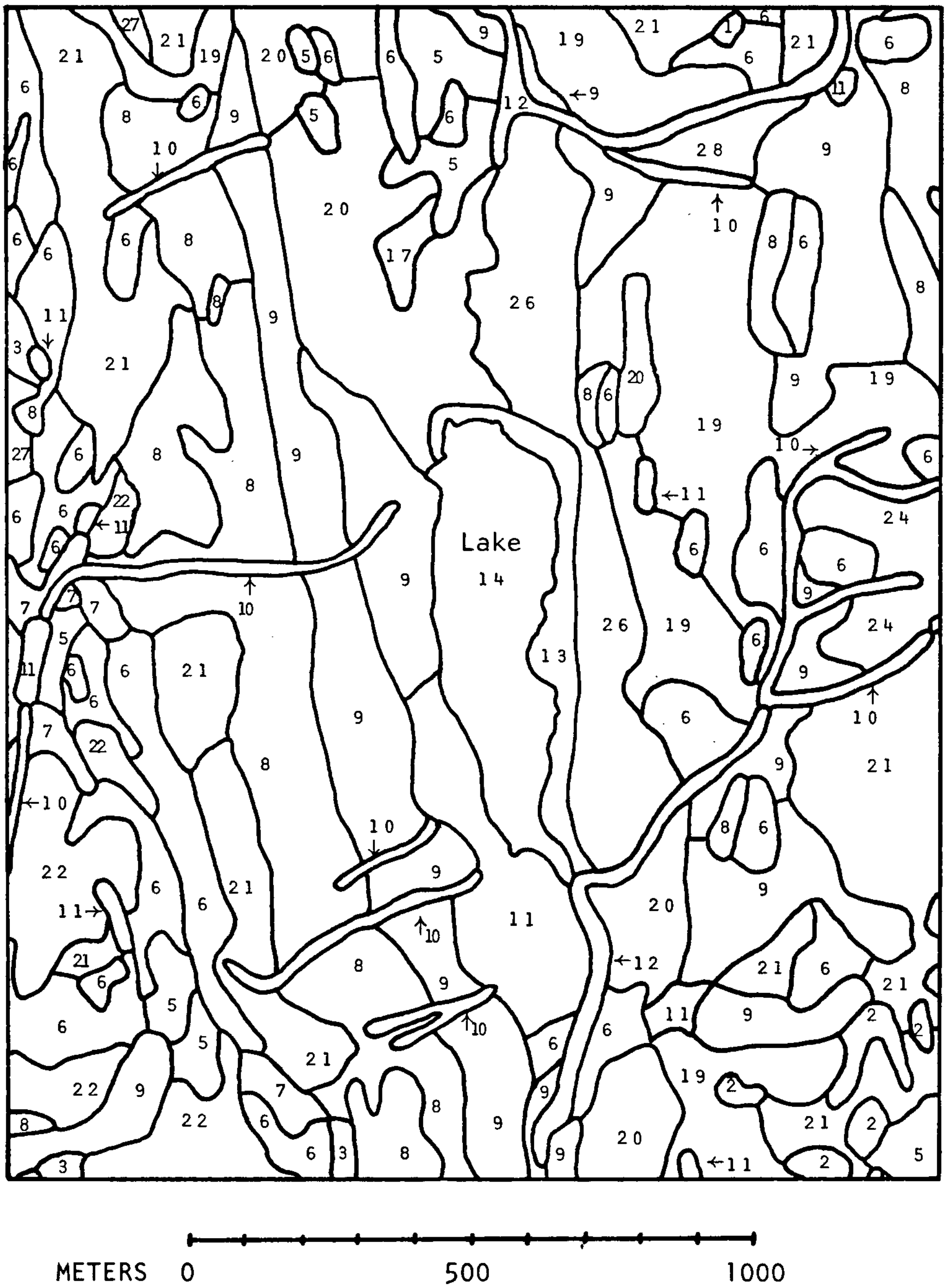


FIGURE 15. EXAMPLE OF VEGETATION TYPES MAPPED AT THE LEVEL OF PLANT SUB-ASSOCIATIONS (AFTER KLINKA, 1976.)

Vegetation types are numbered as in the computer output and the text. For names see Table 16.



digitized were at the same seral stage (about 42 years since logging and fire) to reduce confounding. For each map a file was prepared relating the polygon numbers to the appropriate classification type.

#8a. Prepare an Empty Computer File.

The computer program used in step #8b was designed to work with one file of land classification polygons at a time. It added the information gained during any run to information gained in previous runs. When being run for the first time with a new map or species, it required an empty information file produced by HABDEXINIT (22 lines).

#8b. Relate Use by one Bird Species to the Types of one Map.

The program HABDEX (973 lines) intersected the coverage and location polygons produced in step #6b with the polygons that represent the types of a land classification map produced in step #7. HABDEX intersected the coverage polygon for one station with any classification type polygons that were within range, to determine the extent to which each was censused from the station. It intersected any location polygons made from the station with each classification polygon that was censused, to determine the probability that any of the birds located were in the classification polygon. The logic and mathematics of the intersections are described in detail under "Statistical Analysis of Results". HABDEX also provided a list of all the classification polygons covered or partially covered from each station, complete with areas and areas of intersection (Figure 16).

#9. Summarize the Results and Complete the Statistical Analysis.

The program SUMERIZE (898 lines) brought together the results of all the rounds of visits for one species with one map. As such it used the output from many series of runs of HABDEX, where one series represented the repeated updating of the information file for one round of visits with each of the land classification polygon files. SUMERIZE completed the statistical analysis of results begun in program HABDEX and described in the following section. It provided tables relating one species to one map type. A discussion of the tables is included in the "Results" section. SUMERIZE included the subroutines PROBINVR (Greig ,1977), FPROB (Dempster and Halm, 1974) and CADRE (Madderom, 1972); all from the U.B.C. Computing Centre Library.

FIGURE 16. EXAMPLE OF THE LIST OF POLYGON INTERSECTIONS DONE BY PROGRAM HABDEX. Stop=listening station; Polygon=land classification polygon; Birds=proportion of location that was in polygon.

```
STOP   1     AREA COVERED      6.89
       POLYGON NUMBER      6     AREA OF POLYGON    92.07    AREA COVERED     4.69    PERCENT COVERED    5.10
             BIRDS  0.20     AREA OF LOCATION   0.08    AREA IN POLYGON   0.02
             BIRDS  1.00     AREA OF LOCATION   0.19    AREA IN POLYGON   0.19
             BIRDS  1.00     AREA OF LOCATION   0.05    AREA IN POLYGON   0.05
             BIRDS  1.00     AREA OF LOCATION   0.04    AREA IN POLYGON   0.04
             BIRDS  0.15     AREA OF LOCATION   0.08    AREA IN POLYGON   0.01
             TOTAL BIRDS   3.35      BIRDS PER HECTARE  0.714
       POLYGON NUMBER     30     AREA OF POLYGON     9.91    AREA COVERED     0.16    PERCENT COVERED    1.59
             TOTAL BIRDS   0.0       BIRDS PER HECTARE  0.0
       POLYGON NUMBER     37     AREA OF POLYGON   101.92    AREA COVERED     1.98    PERCENT COVERED    1.55
             BIRDS  0.64     AREA OF LOCATION   0.08    AREA IN POLYGON   0.05
             BIRDS  0.85     AREA OF LOCATION   0.08    AREA IN POLYGON   0.07
             TOTAL BIRDS   1.49      BIRDS PER HECTARE  0.751
STOP   2     AREA COVERED      4.97
       POLYGON NUMBER      6     AREA OF POLYGON    92.07    AREA COVERED     4.90    PERCENT COVERED    5.32
             BIRDS  1.00     AREA OF LOCATION   0.03    AREA IN POLYGON   0.03
             BIRDS  1.00     AREA OF LOCATION   0.19    AREA IN POLYGON   0.19
             BIRDS  0.94     AREA OF LOCATION   0.12    AREA IN POLYGON   0.11
             BIRDS  1.00     AREA OF LOCATION   0.19    AREA IN POLYGON   0.19
             TOTAL BIRDS   3.94      BIRDS PER HECTARE  0.804
       POLYGON NUMBER     37     AREA OF POLYGON   101.92    AREA COVERED     0.07    PERCENT COVERED    0.07
             BIRDS  0.05     AREA OF LOCATION   0.12    AREA IN POLYGON   0.01
             TOTAL BIRDS   0.05      BIRDS PER HECTARE  0.792
STOP   3     AREA COVERED      3.64
       POLYGON NUMBER      6     AREA OF POLYGON    92.07    AREA COVERED     2.44    PERCENT COVERED    2.66
             TOTAL BIRDS   0.0       BIRDS PER HECTARE  0.0
       POLYGON NUMBER     43     AREA OF POLYGON    13.98    AREA COVERED     1.07    PERCENT COVERED    7.69
             TOTAL BIRDS   0.0       BIRDS PER HECTARE  0.0
STOP   4     AREA COVERED      6.55
       POLYGON NUMBER      6     AREA OF POLYGON    92.07    AREA COVERED     0.53    PERCENT COVERED    0.57
             BIRDS  0.91     AREA OF LOCATION   0.20    AREA IN POLYGON   0.18
             BIRDS  0.95     AREA OF LOCATION   0.18    AREA IN POLYGON   0.18
             TOTAL BIRDS   1.86      BIRDS PER HECTARE  3.514
       POLYGON NUMBER     37     AREA OF POLYGON   101.92    AREA COVERED     0.41    PERCENT COVERED    0.41
             TOTAL BIRDS   0.0       BIRDS PER HECTARE  0.0
       POLYGON NUMBER     43     AREA OF POLYGON    13.98    AREA COVERED     5.56    PERCENT COVERED   39.80
             BIRDS  1.00     AREA OF LOCATION   0.32    AREA IN POLYGON   0.32
             BIRDS  1.00     AREA OF LOCATION   0.01    AREA IN POLYGON   0.01
             BIRDS  0.01     AREA OF LOCATION   0.18    AREA IN POLYGON   0.00
             TOTAL BIRDS   2.01      BIRDS PER HECTARE  0.361
STOP   5     AREA COVERED      9.42
       POLYGON NUMBER      6     AREA OF POLYGON    92.07    AREA COVERED     4.07    PERCENT COVERED    4.42
             BIRDS  0.16     AREA OF LOCATION   0.34    AREA IN POLYGON   0.05
```

STATISTICAL ANALYSIS OF RESULTS

METHOD OF ANALYSIS

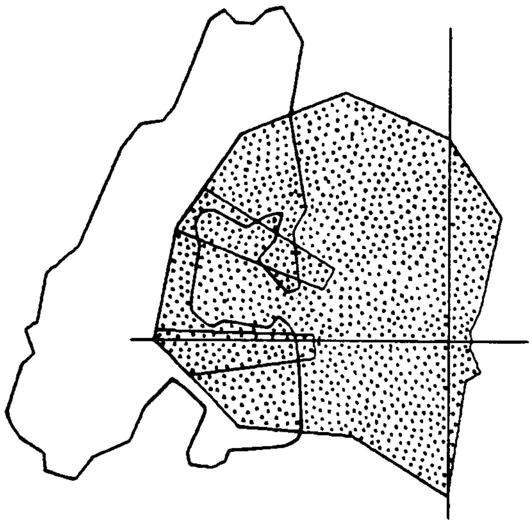
Consider first the observation pertaining to a single classification type island for one bird species from one listening station during a single round of visits. The intersection of the polygon defining the area censused from the station, and the polygon defining the land class type, is a polygon defining the area of the type that was censused. This area has been labeled C_i for the i^{th} listening station as illustrated in the example of Figure 17. The location of a bird that was heard is described as the area L_{ik} for the k^{th} location at the i^{th} station. If the area of location intersected the area of the class type that was censused (C_i), then the bird may have been in that classification type. The ratio of the area of intersection (B_{ik}) to the total area of the location (L_{ik}) is the probability that the bird located by sound was in the classification type. The ratio B_{ik} to L_{ik} is also the proportion of one bird located by sound (Y_{ik}) that was assigned to the type, giving Y_{ik} the units cf number of observed calls:

$$Y_{ik} = \frac{B_{ik}}{L_{ik}} \qquad \begin{array}{l} i = 1 \text{ to } m \text{ stations} \\ k = 1 \text{ to } n_i \text{ locations per station} \end{array}$$

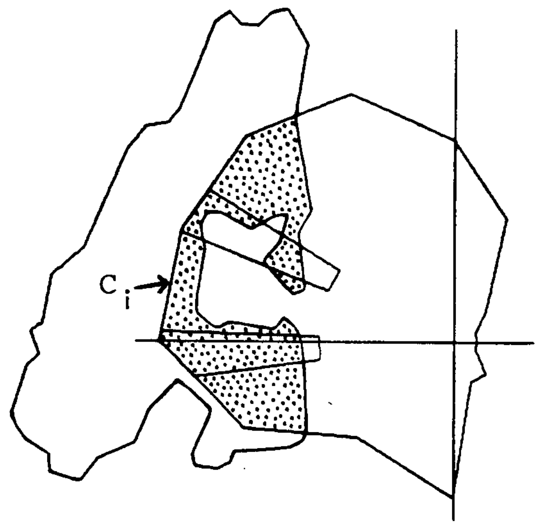
But $Y_{ik} = 0.0$ and $n_i = 1$ if no locations were made.

The observed density of calls (D_i) from the classification

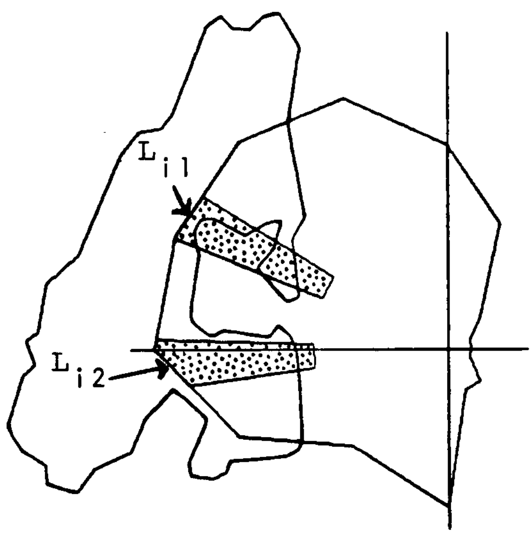
FIGURE 17. EXAMPLE OF INTERSECTING COVERAGE AND LOCATION POLYGONS WITH A LAND CLASSIFICATION POLYGON.



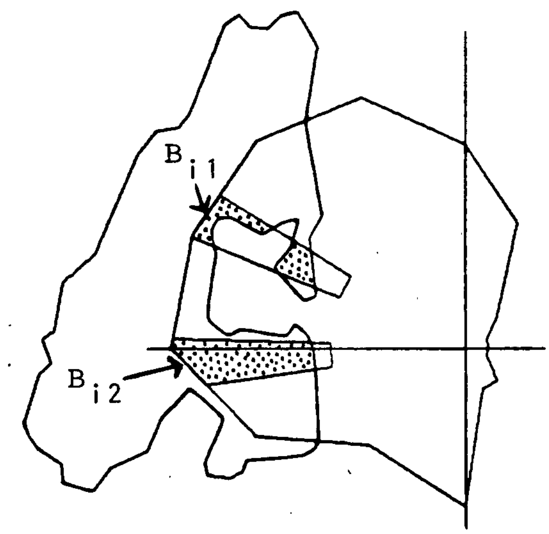
a. Area censused from the i^{th} station.



b. Area of the land polygon that was censused.



c. Area of locations made from this station.



d. Area of locations that hit the land polygon.

type (C_i) being censused from the i^{th} station is defined as:

$$D_i = \frac{\sum_{k=1}^{n_i} Y_{ik}}{C_i}$$

with units of total observed calls per hectare (calls/ha). The average density of calls for a classification type for all stations is given as:

$$D = \frac{\sum_{i=1}^{m} C_i \ D_i}{\sum_{i=1}^{m} C_i} = \frac{\sum_{i=1}^{m} \sum_{k=1}^{n_i} Y_{ik}}{\sum_{i=1}^{m} C_i}$$

Observations based on plots of equal area should have a common variance of σ_Y^2. An estimate of this variance (S_Y^2) could be used to calculate an estimate of the variance (S_D^2) of the observed average density (D). However, each observed density of calls (D_i) and associated proportions Y_{ik} (k=1 to n_i) were based on a different area (C_i). A typical set of data was divided into three parts, corresponding to small, medium and large values of C_i. The estimated variance (S_Y^2) of Y_{ik} increased approximately in proportion to the average value of C_i for each group. Since the square of observations is used in calculating variance, Nash (pers. comm.) suggested a transformation (Z_{ik}) of Y_{ik} involving the square root of the area for each observation:

$$Z_{ik} = \frac{Y_{ik}}{\sqrt{C_i}}$$

The variance of Z_{ik} is estimated by S_Z^2:

$$S_z^2 = \frac{1}{(N-1)} \sum_{i=1}^{m} \sum_{k=1}^{n_i} (Z_{ik}-\overline{Z})^2 = \frac{1}{(N-1)} \left[\sum_{i=1}^{m} \sum_{k=1}^{n_i} Z_{ik}^2 - \frac{\left(\sum_{i=1}^{m} \sum_{k=1}^{n_i} Z_{ik} \right)^2}{N} \right]$$

with $(N-1)$ degrees of freedom, where $N = \sum_{i=1}^{m} n_i$.

The estimated variance of Z_{ik} was calculated for each of the three groups corresponding to size classes of C_i . The variance (S_Z^2) was approximately constant over the groups. The calculation was accepted as a test confirming homogeneity of variances. The variance of the average density (D) can then be calculated.

Since
$$D = \frac{\sum_{i=1}^{m} \sum_{k=1}^{n_i} Y_{ik}}{\sum_{i=1}^{m} C_i} = \frac{\sum_{i=1}^{m} \sqrt{C_i} \sum_{k=1}^{n_i} Z_{ik}}{\sum_{i=1}^{m} C_i}$$

and since the Z_{ik} are based on independent locations:

$$VAR(D) = \frac{\sum_{i=1}^{m} C_i \ VAR\left(\sum_{k=1}^{n_i} Z_{ik} \right)}{\left(\sum_{i=1}^{m} C_i \right)^2} = \frac{\sum_{i=1}^{m} C_i \left(n_i \ \sigma_z^2 \right)}{\left(\sum_{i=1}^{m} C_i \right)^2}$$

$$= \frac{\sigma_z^2 \sum_{i=1}^{m} n_i \ C_i}{\left(\sum_{i=1}^{m} C_i \right)^2} = \frac{\sigma_z^2}{W} \quad \text{where} \quad W = \frac{\left(\sum_{i=1}^{m} C_i \right)^2}{\sum_{i=1}^{m} n_i \ C_i}$$

The VAR(D) is estimated by:

$$S_D^2 = \frac{S_Z^2 \sum_{i=1}^{m} n_i \; C_i}{\left(\sum_{i=1}^{m} C_i\right)^2} = \frac{S_Z^2}{W}$$ with (N-1) degrees of freedom.

$S_D = \sqrt{S_D^2}$ is the standard error of the average density in one classification type for one round of visits to the stations. It is presented in the tables for each round of visits.

Now consider several classification types (h=1 to p) and several rounds of visits (r=1 to q). We then have $Y_{hr,ik}$, $C_{hr,i}$, D_{hr}, $Z_{hr,ik}$, N_{hr}, $n_{hr,i}$, W_{hr} and $S^2_{Z,hr}$. Each $S^2_{Z,hr}$ is an estimate of the same σ_Z^2, so an improved estimate is obtained by pooling the independent estimates:

$$S_Z^2 = \frac{\sum_{h=1}^{p} \sum_{r=1}^{q} \left(N_{hr}-1\right) S^2_{Z,hr}}{\sum_{h=1}^{p} \sum_{r=1}^{q} \left(N_{hr}-1\right)}$$ with $\sum_{h=1}^{p} \sum_{r=1}^{q} (N_{hr}-1)$ degrees of freedom is the variance within types.

S_Z^2 is an estimate of the variance within one classification type for one round of visits. The variance among classification types for each of the rounds of visits can be calculated independently using the densities for each type.

Dot notation is used to denote summing over types (h=1 to p):

$$\bar{D}_{\cdot r} = \frac{\sum_{h=1}^{p} W_{hr} D_{hr}}{\sum_{h=1}^{p} W_{hr}}$$

is the average density for all types for one round of visits.

$$S_C^2 = \frac{\sum_{h=1}^{p} \sum_{r=1}^{q} W_{hr} \left(D_{hr} - \bar{D}_{\cdot r} \right)^2}{q(p-1)}$$

with q(p-1) degrees of freedom is the variance between types including interaction between types and time.

The ratio $F = S_C^2 \, / \, S_Z^2$ is a proper F statistic to test whether all classification types have the same mean. The probability of exceeding F by chance has been calculated using subroutine FPROB (Dempster and Halm,1974) obtained from the U.B.C. Computer Library and incorporated into the coding of the statistical analysis program. The F value can be used to compare the predictive abilities of two or more maps for a single species if the maps show significant differences and if all of the variances are associated with a relatively high number of degrees of freedom. The map with the larger ratio will then account for the observed distribution of birds more completely.

The average density for each type (D_{hr}) has been combined over rounds of visits (r) to give an overall weighted mean density ($\bar{D}_{h\cdot}$) for the type:

$$\bar{D}_{h\cdot} = \frac{\sum_{r=1}^{q} \sum_{i=1}^{m} C_{hr,i} \, D_{hr}}{\sum_{r=1}^{q} \sum_{i=1}^{m} C_{hr,i}} = \frac{\sum_{r=1}^{q} \sum_{i=1}^{m} \sum_{k=1}^{n_{hr,i}} Y_{hr,ik}}{\sum_{r=1}^{q} \sum_{i=1}^{m} C_{hr,i}}$$

$$= \frac{\sum_{r=1}^{q} \sum_{i=1}^{m} \sqrt{C_{hr,i}} \sum_{k=1}^{n_{hr,i}} Z_{hr,ik}}{\sum_{r=1}^{q} \sum_{i=1}^{m} C_{hr,i}}$$

The

$$\mathrm{VAR}\left(\sum_{k=1}^{n_{hr,i}} Z_{hr,ik} \right) = n_{hr,i} \, \sigma_Z^2$$

and the coefficient of

$$\left(\sum_{k=1}^{n_{hr,i}} Z_{hr,ik} \right) \quad \text{is} \quad \frac{\sqrt{C_{hr,i}}}{\sum_{r=1}^{q} \sum_{i=1}^{m} C_{hr,i}}$$

so the

$$\mathrm{VAR}(\bar{D}_{h\cdot}) = \sum_{r=1}^{q} \sum_{i=1}^{m} \left(\frac{\sqrt{C_{hr,i}}}{\sum_{r=1}^{q} \sum_{i=1}^{m} C_{hr,i}} \right)^2 \left(n_{hr,i} \, \sigma_Z^2 \right)$$

$$= \frac{\sigma_Z^2 \sum_{r=1}^{q} \sum_{i=1}^{m} n_{hr,i} \, C_{hr,i}}{\left(\sum_{r=1}^{q} \sum_{i=1}^{m} C_{hr,i} \right)^2}$$

$$= \frac{\sigma_Z^2}{W_{h\cdot}} \quad \text{where} \quad W_{h\cdot} = \frac{\left(\sum_{r=1}^{q} \sum_{i=1}^{m} C_{hr,i} \right)^2}{\sum_{r=1}^{q} \sum_{i=1}^{m} n_{hr,i} \, C_{hr,i}}$$

Consider now the question as to whether two classification types differ significantly in their observed density of calls. The variance of the difference between two types is the weighted sum of the variance of each:

$$VAR(D_{1}.- D_{2}.) = \sigma_Z^2 \left(\frac{1}{W_{1}.} + \frac{1}{W_{2}.} \right)$$

so the confidence interval on the true difference between two types is:

$$(D_{1}.- D_{2}.) - t_{\frac{\alpha}{2}} S_Z \sqrt{\frac{1}{W_{1}.} + \frac{1}{W_{2}.}}$$

$$\leq (\Delta_{1}.- \Delta_{2}.) \leq$$

$$(D_{1}.- D_{2}.) + t_{\frac{\alpha}{2}} S_Z \sqrt{\frac{1}{W_{1}.} + \frac{1}{W_{2}.}}$$

where Δ_{hr} is the true value which D_{hr} estimates,
S_Z is the standard error of Z,
and $t_{\frac{\alpha}{2}}$ is the students t statistic the value of which has been obtained for 95% confidence level using subroutine FPROB (Dempster and Halm,1974).

The ability to reject the null hypothesis that two types are used equally ($D_{1}.=D_{2}.$) has been tested using the t statistic:

$$t = \frac{D_{1}. - D_{2}.}{S_Z \sqrt{\frac{1}{W_{1}.} \quad \frac{1}{W_{2}.}}}$$

The probability (α) of exceeding the t value by chance is calculated using subroutine TINVR (Greig,1977) obtained from the U.B.C. Computer Library and incorporated into the coding. TINVR returns the correct probability for the two-tailed test with the alternate hypothesis that the types are used differently ($D_1. \neq D_2.$). Nash (pers. comm.) recommended that the t value and its associated probability be used to evaluate each of the one-tailed alternate hypothesis ($D_1. > D_2.$ and $D_1. < D_2.$). The probability (P) for the two-tailed test must be changed accordingly:

Alternate hypothesis $D_1. > D_2.$ right tail (PRT)

if t is positive, $PRT = \frac{1}{2} P$

if t is negative, $PRT = 1 - \frac{1}{2} P$

Alternate hypothesis $D_1. < D_2.$ left tail (PLT)

if t is positive, $PLT = 1 - \frac{1}{2} P$

if t is negative, $PLT = \frac{1}{2} P$

The probabilities of being correct in rejecting the null hypothesis in favour of each alternative will always add to unity ($PRT + PLT = 1$).

STATISTICAL ASSUMPTIONS

The method developed for this study uses the relative density of observed calls per unit time as a measure of the use by a bird species that an area receives. It assumes that birds spend more time and/or call more frequently in areas that are more valuable to their survival. This assumption has been evaluated by looking for consistent patterns of call densities with repeated censusing, and by comparing the patterns with habitat relationships noted in the literature. The calculation of the variance about Z assumes that the locations of birds assigned to one type are made independently. This assumption would be violated if birds located by their calls tended to occur in groups for reasons other than habitat selection. Such a contagious distribution of calls would occur if a bird species moved in flocks and different members of the flock were each located while the flock remained within a single type. Grouping would also occur if one bird calling prompted others to call from the same area, or if a single bird were located repeatedly as it moved about within a single type. A tape recorder playback was used during the first two rounds of visits to prompt birds to call. The practice was discontinued because it could encourage contagious distributions. However, the results show no obvious differences between rounds.

The violation of assumptions caused by contagious distribution would be reduced by following the rules of never locating members of a flock within the same type, and of recording each bird only once from any station.

Unfortunately, these rules cannot be applied in the field. First, few of the birds located were actually seen. Unless the movements of a bird could be followed visually, it was not possible to know if a second bird heard calling was really a second bird or the same bird calling a second time. Secondly, the observer was not always be aware of the location of boundaries between classification types. Even if the boundaries were easy to recognize as with seral stages, the observer was seldom able to see as far as he could hear. Thirdly, it is intended that the same census for birds be used with many different maps. The data may be used with a mapping system not yet conceived at the time of census. Finally, all locations were described as areas. A single location may overlap with more than one classification type, further confusing any attempt to make observations independent.

A set of rules that could be readily applied in the field were established to avoid blatant violations of the requirement for independent observations. At each listening station, the observer kept track of locations made for each species during that visit. The first call of a species was always located and recorded. Subsequent calls of that species were recorded only if the areas of location would not overlap (as discussed in Methods section #5a). A bird that could be followed visually was recorded only once, and then only if (and where) it called loudly. Flocks located by sound were subject to the same requirement for separation between individual locations. Flocks seen were located as a single bird while in sight. While this caused the absolute density of flocking birds to be under-estimated, the relative density remained unbiased because the large number of listening stations allowed each classification type to be censused from a variety of positions.

The observations are independent if the separation of locations is sufficient to require a bird to move to a different type in order to be counted again. This is more likely to be true for small type islands such as those of the vegetation map, than for the larger type islands of the seral stages map.

Any violation of the statistical assumptions should appear as conflicts in the significant differences in the use of types between rounds for a single species. As is discussed in the Results section, only Steller's Jay with seral stages and Chestnut-backed Chickadee with seral stages show many conflicts between rounds of visits. These are the only species studied that were commonly seen in flocks. The combination of flocking plus the larger type islands of the seral stage map likely constituted a violation of the need for independent locations. However, the summary over rounds of visits takes the variation between rounds into account. Comparisons between rounds and the summary of rounds do not show many conflicts for any species.

RESULTS

The broad objective was to demonstrate that land management maps can be used with wildlife inventory data to provide criteria for managing the occurrence of habitat for wildlife species. The null hypothesis - that wildlife habitat cannot be predicted using land management maps - would be rejected if the bird species showed significant differences in their use of mapping types.

The method of producing tables which relate one bird species to the types of one map has been described. Each time the program SUMERIZE was used it produced three tables. The first table (or set of tables) lists the results of all the polygon intersections completed by the program HABDEX for the rounds of visits being analysed. If the information from two or more rounds was combined, then a separate table was printed for each round. The results of the many polygon intersections are grouped by classification type. For the example of Common Flicker with seral stages see Table 3. Nine columns of information are given:

1. Classification types identified and ordered by number.
2. The number of times that the area covered from a station intersected a polygon of the type.
3. The number of times an area of location intersected a polygon of the type.

TABLE 3. SUMMARY OF RESULTS OF INTERSECTIONS BY ROUNDS AS PRINTED BY PROGRAM SUMERIZE.

a. COMMON FLICKER WITH SERAL STAGES ROUND ONE March 1, 1977 to April 16, 1977

POLYGON TYPE	NUMBER OF VISITS THAT HIT	NUMBER OF LOCATIONS THAT HIT	TOTAL BIRDS	SAMPLING INTENSITY (HEC-HRS)	BIRD DENSITY INDEX (BIRDS/HEC-HR)	DENSITY STANDARD ERROR	DEGREES OF FREEDOM	VARIANCE ABOUT Z
1	28	1	0.0	17.3	0.003	0.0233	27	0.0023
2	279	38	15.5	173.5	0.089	0.0144	288	0.0083
3	74	6	2.8	79.2	0.036	0.0157	73	0.0049
4	178	9	4.8	387.0	0.012	0.0087	178	0.0073
5	116	6	2.9	84.3	0.034	0.0138	116	0.0040
6	183	27	10.6	86.0	0.123	0.0340	189	0.0227
7	72	9	1.0	63.9	0.016	0.0067	73	0.0007
8	15	1	0.0	2.2	0.014	0.0112	14	0.0001

b. COMMON FLICKER WITH SERAL STAGES ROUND TWO April 17, 1977 to May 30, 1977

POLYGON TYPE	NUMBER OF VISITS THAT HIT	NUMBER OF LOCATIONS THAT HIT	TOTAL BIRDS	SAMPLING INTENSITY (HEC-HRS)	BIRD DENSITY INDEX (BIRDS/HEC-HR)	DENSITY STANDARD ERROR	DEGREES OF FREEDOM	VARIANCE ABOUT Z
1	30	4	2.8	19.0	0.146	0.0659	29	0.0206
2	303	56	26.5	199.5	0.133	0.0176	316	0.0138
3	80	15	5.6	97.0	0.057	0.0286	84	0.0166
4	192	28	21.6	451.5	0.048	0.0149	195	0.0240
5	130	17	7.6	95.4	0.080	0.0171	133	0.0065
6	194	29	12.3	99.9	0.123	0.0211	198	0.0105
7	75	13	1.5	70.3	0.021	0.0139	75	0.0034
8	20	1	0.0	2.5	0.002	0.0129	19	0.0001

c. COMMON FLICKER WITH SERAL STAGES ROUND THREE April 2, 1977 to May 1, 1977

POLYGON TYPE	NUMBER OF VISITS THAT HIT	NUMBER OF LOCATIONS THAT HIT	TOTAL BIRDS	SAMPLING INTENSITY (HEC-HRS)	BIRD DENSITY INDEX (BIRDS/HEC-HR)	DENSITY STANDARD ERROR	DEGREES OF FREEDOM	VARIANCE ABOUT Z
1	30	0	0.0	18.0	0.0	0.0	29	-0.0
2	307	18	7.0	204.6	0.034	0.0096	306	0.0047
3	82	0	0.0	101.3	0.0	0.0	81	-0.0
4	197	1	0.3	478.8	0.001	0.0006	196	0.0000
5	132	1	0.8	97.2	0.008	0.0079	131	0.0015
6	198	7	1.4	100.8	0.014	0.0055	197	0.0008
7	76	4	1.4	70.9	0.020	0.0140	75	0.0035
8	20	0	0.0	2.5	0.0	0.0	19	-0.0

TABLE 3. (continued)

d. COMMON FLICKER WITH SERAL STAGES ROUND FOUR April 18, 1977 to May 27, 1977

POLYGON TYPE	NUMBER OF VISITS THAT HIT	NUMBER OF LOCATIONS THAT HIT	TOTAL BIRDS	SAMPLING INTENSITY (HEC-HRS)	BIRD DENSITY INDEX (BIRDS/HEC-HR)	DENSITY STANDARD ERROR	DEGREES OF FREEDOM	VARIANCE ABOUT Z
1	30	2	1.4	18.9	0.075	0.0364	30	0.0058
2	284	19	9.3	184.1	0.051	0.0111	286	0.0056
3	77	4	2.0	84.3	0.023	0.0090	77	0.0017
4	185	10	7.6	421.1	0.018	0.0043	185	0.0019
5	125	0	0.0	89.4	0.0	0.0	124	-0.0
6	189	15	7.9	92.5	0.086	0.0201	192	0.0089
7	73	5	0.4	67.4	0.007	0.0036	74	0.0002
8	18	1	0.1	2.1	0.027	0.0248	17	0.0003

e. COMMON FLICKER WITH SERAL STAGES ROUND FIVE May 25, 1977 to June 8, 1977

POLYGON TYPE	NUMBER OF VISITS THAT HIT	NUMBER OF LOCATIONS THAT HIT	TOTAL BIRDS	SAMPLING INTENSITY (HEC-HRS)	BIRD DENSITY INDEX (BIRDS/HEC-HR)	DENSITY STANDARD ERROR	DEGREES OF FREEDOM	VARIANCE ABOUT Z
1	27	1	0.6	17.2	0.035	0.0254	26	0.0028
2	288	36	20.7	190.8	0.109	0.0202	299	0.0179
3	75	7	1.9	93.6	0.021	0.0177	75	0.0072
4	179	11	8.9	380.3	0.023	0.0069	180	0.0043
5	126	4	2.2	96.1	0.023	0.0112	126	0.0030
6	186	18	10.5	84.4	0.124	0.0285	189	0.0166
7	70	1	0.2	65.4	0.003	0.0019	69	0.0001
8	15	1	0.2	1.6	0.141	0.1193	14	0.0057

f. COMMON FLICKER WITH SERAL STAGES ROUND SIX June 9, 1977 to June 15, 1977

POLYGON TYPE	NUMBER OF VISITS THAT HIT	NUMBER OF LOCATIONS THAT HIT	TOTAL BIRDS	SAMPLING INTENSITY (HEC-HRS)	BIRD DENSITY INDEX (BIRDS/HEC-HR)	DENSITY STANDARD ERROR	DEGREES OF FREEDOM	VARIANCE ABOUT Z
1	29	5	4.2	17.2	0.244	0.1090	30	0.0454
2	296	21	9.6	192.6	0.050	0.0125	299	0.0072
3	80	7	3.9	92.2	0.042	0.0123	81	0.0032
4	188	17	10.7	434.0	0.025	0.0053	191	0.0029
5	126	5	3.0	88.2	0.034	0.0244	126	0.0130
6	192	14	7.6	93.6	0.081	0.0226	195	0.0113
7	74	3	0.6	67.7	0.009	0.0174	73	0.0051
8	19	0	0.0	2.4	0.0	0.0	18	-0.0

4. The cumulative probability that a bird was in the type, determined by summing the probabilities from each of the locations that intersected the type.
5. The sampling intensity in hectare-hours, determined by summing the areas of intersection of coverage polygons with the type.
6. The observed density of calls in calls per hectare-hour, calculated by dividing the cumulative probability by sampling intensity.
7. The standard error about the observed density.
8. The degrees of freedom associated with the standard error.
9. The variance about Z on which the standard error was based.

The second table contains a summary over rounds. For the example of Common Flicker with seral stages see Table 4. Three columns of information are given:

1. The classification types identified by number and ordered by level of use.
2. The observed density of calls per hectare-hour of listening. If only one round was analysed, then the densities are the same as those in the first table (eg. Table 3a); otherwise they are the weighted average of those in the first tables (eg. Table 3a to 3f).

TABLE 4. COMMON FLICKER WITH SERAL STAGES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
6	0.107	1.000
1	0.101	0.939
2	0.087	0.810
3	0.036	0.338
5	0.035	0.323
8	0.030	0.276
4	0.026	0.241
7	0.011	0.104

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.01003 (VAR Z)
WITH 4575. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.04215
WITH 35. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 4.2011 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0 OF EXCEEDING BY CHANCE

DEFINITION OF SERAL STAGES

STAGE	DEFINITION
1	AGE 1 TO 5 YEARS
2	AGE 6 TO 15 YEARS
3	AGE 16 TO 35 YEARS
4	AGE 36 TO 75 YEARS
5	AGE 76 TO 155 YEARS
6	AGE 156 AND OVER
7	LAKES
8	MARSH

3. A relative index of habitat value for each type. It was obtained by dividing the observed density for the type into the observed density of the type which rated highest.

The rating ranges from 0.0 to 1.0, with 1.0 being ascribed to the type with the greatest density. For the birds sampled, lakes should rate 0.0; but lakes tend to accumulate use because all locations of birds are described as areas. The area locating a bird that was near a lake may overlap with the lake. Any area that is really not used will tend to accumulate use, while adjacent areas of high habitat value are robbed of the full value of birds that actually were located there.

The F-ratio given in the table is used to determine the probability that the observed differences in densities between types could have occurred by chance. A probability of 0.0 in the table indicates a probability of less than 0.0000001.

A third table examines all possible comparisons between the densities listed in the second table. For the example of Common Flicker with seral stages see Table 5. Eight columns of information are given:

1&2. The classification types ("A" and "B") being compared.

TABLE 5. COMMON FLICKER WITH SERAL STAGES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE	TYPE	T	ALTERNATE_HYPOTHYSIS		CONFIDENCE_LIMITS_FOR		
A	B	VALUE	A_GT_B	A_LT_B	LOWER	A_MINUS_B	UPPER
1	2	0.613	0.2698	0.7302	-0.030	0.014	0.058
1	3	2.713	0.0033	0.9967	0.018	0.064	0.111
1	4	3.390	0.0004	0.9996	0.032	0.075	0.118
1	5	2.797	0.0026	0.9974	0.020	0.066	0.112
1	6	-0.275	0.6084	0.3916	-0.053	-0.007	0.040
1	7	3.687	0.0001	0.9999	0.042	0.089	0.
1	8	1.097	0.1363	0.8637	-0.056	0.071	0.198
2	3	4.237	0.0000	1.0000	0.027	0.050	0.074
2	4	7.503	0.0000	1.0000	0.045	0.061	0.077
2	5	4.467	0.0000	1.0000	0.029	0.052	0.075
2	6	-1.729	0.9581	0.0419	-0.043	-0.020	0.003
2	7	5.833	0.0000	1.0000	0.050	0.076	0.101
2	8	0.930	0.1761	0.8239	-0.063	0.057	0.
3	4	0.966	0.1670	0.8330	-0.011	0.010	0.032
3	5	0.121	0.4520	0.5480	-0.025	0.002	0.028
3	6	-5.150	1.0000	0.0000	-0.098	-0.071	-0.044
3	7	1.698	0.0447	0.9553	-0.004	0.025	0.054
3	8	0.108	0.4572	0.5428	-0.114	0.007	0.128
4	5	-0.835	0.7980	0.2020	-0.029	-0.009	0.012
4	6	-7.636	1.0000	0.0000	-0.102	-0.081	-0.060
4	7	1.231	0.1092	0.8908	-0.009	0.015	0.038
4	8	-0.062	0.5246	0.4754	-0.124	-0.004	0.116
5	6	-5.352	1.0000	0.0000	-0.099	-0.072	-0.
5	7	1.608	0.0539	0.9461	-0.005	0.023	0.052
5	8	0.081	0.4678	0.5322	-0.116	0.005	0.126
6	7	6.540	0.0000	1.0000	0.067	0.096	0.125
6	8	1.255	0.1048	0.8952	-0.044	0.077	0.198
7	8	-0.297	0.6169	0.3831	-0.140	-0.018	0.103

3. The t-value for evaluating the null hypothesis that the two types are used equally.
4. The probability of being wrong in rejecting the null hypothesis in favour of the alternate hypothesis that type A is used more than type B.
5. The probability of being wrong in rejecting the null hypothesis in favour of the alternate hypothesis that type B is used more than type A.
6. The lower limit of the 95% confidence interval for the difference.
7. The observed difference in use (calls/ha-hr) of the two types.
8. The upper limit of the 95% confidence interval for the difference.

Tables of the second and third type just described for the Flicker (Tables 4 and 5) are presented in Appendix B for ten different species with seral stages and for six of these species with vegetation types in Appendix C. Only those species recorded regularly in the 42-year seral stage can be related to vegetation types because the vegetation map for the rest of the study area was not digitized.

The tables in Appendices B and C provide the evidence needed to reject the null hypothysis that land management maps cannot be used to predict use by wildlife species. Regardless of which species and which map choosen, each pair of tables gives an extremely low probability that the results could have occurred by chance. In every case there are many differences in the use of two types that are significant at

95% or 99% confidence. The map of seral stages or the map of plant associations could be used with the appropriate observed densities or habitat index ratings for a species to predict the spatial pattern of use by the species over the area mapped.

Each of the 14 computer programs used has been tested using an example set of data that was also analysed by hand. The statistics have been carefully checked and statistical assumptions have been considered. The determination of plot shape and the representation of the position of calling birds rely on a three dimensional model of the real situation. All the input has been double checked. There is no reason to expect that the programs are not functioning as anticipated. However, it is possible that an error has gone undetected and that the output is misleading. It can be demonstrated that this possibility is unlikely by comparing the results for each species with information from the literature. First we must deal with the fact that the tables produced by SUMERIZE contain so much information as to make interpretation difficult.

The program COMPARE presents some of the information from the tables in graphic form. The relative habitat value of each mapping type is presented in the form of a bar graph with the types ordered by decreasing level of use (e.g. Table 6). Note that the bar graph does not indicate the error associated with the measurement of the use of each stage. This information is displayed in the accompanying table of significant differences in use (e.g. Table 7).

TABLE 6. COMMON FLICKER WITH SERAL STAGES

RELATIVE LEVEL OF USE OF TYPES

```
1.0|  6---------------------|
   | XX  1                  |
   | XX XX                  |
   | XX XX  2               |
   | XX XX XX               |
.75|-XX-XX-XX---------------|
   | XX XX XX               |
   | XX XX XX               |
   | XX XX XX               |
   | XX XX XX               |
0.5|-XX-XX-XX---------------|
   | XX XX XX               |
   | XX XX XX               |
   | XX XX XX  3  5         |
   | XX XX XX XX XX  8      |
.25|-XX-XX-XX-XX-XX-XX  4---|
   | XX XX XX XX XX XX XX   |
   | XX XX XX XX XX XX XX  7|
   | XX XX XX XX XX XX XX XX|
   | XX XX XX XX XX XX XX XX|
0.0|-XX-XX-XX-XX-XX-XX-XX-XX|
```

TABLE 7. COMMON FLICKER WITH SERAL STAGES

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	6	1	2	3	5	8	4	7
6								
1								
2	X							
3	X	X	X					
5	X	X	X					
8								
4	X	X	X					
7	X	X	X	X				
	6	1	2	3	5	8	4	7

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

Both the columns and the rows of Table 7 are labelled with mapping-type numbers which are ordered by decreasing level of use. If the type represented by a given column was used significantly more ($p \leq 0.05$) than the type represented by a given row, then the position of intersection of the column with the row will be marked with an "X". For example the Flicker (Table 7) was not observed to use stage 6 (age 156 years and over) significantly more than stage 1 (age 1 to 5 years); but it was observed to use stage 6 significantly more than stage 2 (age 6 to 15 years), stage 3 (16 to 35 years), stage 5 (76 to 155 years), stage 4 (36 to 75 years), and stage 7 (lakes). Note that use of stage 8 (marsh) did not differ significantly from other stages because the available examples of stage 8 were small. Observers were within hearing distance of flickers in marshy areas for only 13.3 hectare-hours during all rounds (calculated from Table 3). That value compares to 107.6 ha-hr for stage 1, and 2552.7 ha-hr for stage 4. Even though stage 8 was observed to be used at a low level, it may in fact be used more than stage 6 (probability 0.1048 of being wrong in rejecting the null hypothesis in favour of the alternate hypothesis that stage 6 is used more than stage 8; Table 5). A bar graph and associated significance table are presented for each of ten species with seral stages and for each of six species with vegetation types in the "Discussion" section.

COMPARE was designed to use the output from two different runs of SUMERIZE at a time. A graph of relative use and a table of significant differences was produced with each run. For example, Tables 8 and 9 for Winter Wren with seral stage were produced at the same time as Tables 6 and 7 for Common Flicker with seral stage.

The tables of significant differences were compared to test the premise that the two species show the same pattern of use. When a comparison between the use of two types is significant for both species, COMPARE checks to see if the direction is the same. The program first sums those instances for which the direction is different, here termed a "contrast". For example, Common Flicker uses stage 1 (age 1 to 5 years) significantly more than it uses stage 4 (age 36 to 75 years); while Winter Wren uses stage 4 significantly more than stage 1. That observation represents one contrast. COMPARE next sums significant comparisons for which the direction is the same, here termed a "reinforcement". For example, both Common Flicker and Winter Wren use stage 6 (age 156 years and older) significantly more than they use stage 3 (age 16 to 35 years). That observation represents one reinforcement. Finally, the ratio of the number of contrasts to the number of reinforcements is calculated. For the present example see Table 10. This ratio equals 0.0 when use is identical; is less than 1.0 if two species have similar patterns of use; but greater than 1.0 if the species are selecting very differently. Significant differences were decided at the 95% confidence level, so about one in twenty of the differences should be incorrectly recorded (i.e. contrast-to-reinforcement ratio 0.05 by chance when use

TABLE 8. WINTER WREN WITH SERAL STAGES

RELATIVE LEVEL OF USE OF TYPES

```
1.0|   5-------------------|
   |  XX                   |
   |  XX                   |
   |  XX                   |
   |  XX                   |
.75|-XX--------------------|
   |  XX  4                |
   |  XX XX                |
   |  XX XX                |
   |  XX XX  6             |
0.5|-XX-XX-XX--------------|
   |  XX XX XX             |
   |  XX XX XX  3          |
   |  XX XX XX XX  1       |
   |  XX XX XX XX XX       |
.25|-XX-XX-XX-XX-XX--------|
   |  XX XX XX XX XX  2    |
   |  XX XX XX XX XX XX   7|
   |  XX XX XX XX XX XX  XX|
   |  XX XX XX XX XX XX  XX|
0.0|-XX-XX-XX-XX-XX-XX-XX--|
```

TABLE 9. WINTER WREN WITH SERAL STAGES

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	5	4	6	3	1	2	7
5							
4	X						
6	X	X					
3	X	X	X				
1	X	X	X				
2	X	X	X	X	X		
7	X	X	X	X	X	X	
	5	4	6	3	1	2	7

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

TABLE 10. COMPARISON BETWEEN COMMON FLICKER AND WINTER WREN.

CONTRASTS IN USE OF SERAL STAGES

1	4
1	5
2	3
2	4
2	5
6	4
6	5

REINFORCEMENTS IN USE OF SERAL STAGES

1	7
2	7
3	7
6	2
6	3
6	7

NUMBER OF CONTRASTS 7.
NUMBER OF REINFORCEMENTS 6.
TOTAL COMPARISONS IN COMMON 13.
CONTRAST TO REINFORCEMENT RATIO 1.167

DEFINITION OF SERAL STAGES

STAGE	DEFINITION
1	AGE 1 TO 5 YEARS
2	AGE 6 TO 15 YEARS
3	AGE 16 TO 35 YEARS
4	AGE 36 TO 75 YEARS
5	AGE 76 TO 155 YEARS
6	AGE 156 AND OVER
7	LAKES
8	MARSH

was really identical). In fact the number of these types of errors should be much less because the confidence level is often greater than 95%.

The contrast-to-reinforcement ratio for Common Flicker with Winter Wren presented for seral stages in Table 10 (1.167) includes significant comparisons involving lakes (type 7), although "lakes" is not a seral stage. The species appear to be more alike when lakes are included as neither species is able to use lakes. Four of the six reinforcements are the result of both species using stages 1, 2, 3 and 6 significantly more than lakes. The ratio calculated without lakes (3.500) more accurately represents the observed difference in use of seral stages. The remaining two reinforcements result from a common preference for oldgrowth stage 6 over younger stages 2 and 3. However, the reason for this preference is different for each species. The Flicker is using oldgrowth snags for nesting, while the Wren lives in the dense underbrush.

Six of the seven contrasts in use of seral stages involve stages 4 and 5 versus stages 1, 2 and 6. Stage 5 did not provide nesting snags as did stage 6 for the Flicker, while the dense growth of stage 4 did not provide open areas for feeding as did stages 1 and 2. By contrast, the Wren was most abundant in the dense shrub growth of stages 4 and 5, less abundant in stage 6, and least abundant in the sparse growth of stages 1 and 2. The remaining contrast concerns a strong preference by the Flicker for the open feeding areas of stage 2 over the regenerating growth of stage 3; while the

Wren prefers the dense growth of stage 3 to the more sparse vegetative cover of stage 2.

The method just described for comparing the use of mapping types by two species was also used to compare use of types by one species between two rounds of visits. For each species, the program SUMERIZE was run separately for each round as well as for all rounds together. The program COMPARE was then used to make all possible comparisons between rounds to test the premise that the species was consistent in its pattern of use. The number of comparisons in contrast to and in reinforcement of the premise were each summed to give a single contrast-to-reinforcement ratio representing the amount of change in the use of types between rounds.

Tables 11 and 12 demonstrate that most species were very consistent in their pattern of choice over the census period. Only one of the ten species related to seral stages, and none of the six species related to vegetation types, has a contrast-to-reinforcement ratio greater than 0.3 for comparisons between rounds. Steller's Jay, a flocking species, has a ratio of 0.718 for comparisons between rounds with seral stages (Table 11). The congregation of birds in flocks would violate the statistical assumption that locations of birds are always independent. The observed contradictions could then reflect flocking and not changes in the use of stages over time. The Chestnut-backed Chickadee occurred in flocks less frequently and has ratio of 0.267. The remaining species were not observed in flocks and have ratios less than 0.07 for comparisons with seral stages. The

TABLE 11. THE NUMBER OF CONTRASTS AND REINFORCEMENTS FOR ALL COMPARISONS BETWEEN ROUNDS FOR EACH SPECIES WITH SERAL STAGES.

Does not include comparisons involving lakes.

SPECIES	NUMBER OF CONTRASTS	NUMBER OF REINFORC.	TOTAL COMPAR.	RATIO CONT/REIN
Common Flicker	2	50	52	0.040
Yellow-bellied Sapsucker	1	152	153	0.007
Hairy Woodpecker	3	53	56	0.057
Olive-sided Flycatcher	0	4	4	0.000
Steller's Jay	23	32	55	0.718
Chestnut-backed Chickadee	8	30	38	0.267
Red-breasted Nuthatch	2	51	53	0.039
Winter Wren	0	152	152	0.000
Varied Thrush	1	74	75	0.013
Swainson's Thrush	0	6	6	0.000

TABLE 12. THE NUMBER OF CONTRASTS AND REINFORCEMENTS FOR ALL COMPARISONS BETWEEN ROUNDS FOR EACH SPECIES WITH VEGETATION TYPES.

Does not include lakes or types not in forty year seral stage.

SPECIES	NUMBER OF CONTRASTS	NUMBER OF REINFORC.	TOTAL COMPAR.	RATIO CONT/REIN
Yellow-bellied Sapsucker	6	51	57	0.118
Steller's Jay	11	86	97	0.128
Chestnut-backed Chickadee	2	36	38	0.056
Winter Wren	24	192	216	0.125
Varied Thursh	10	91	101	0.110
Swainson's Thrush	5	18	23	0.278

flocking species do not show higher ratios for comparisons with vegetation types (Table 12). The smaller size of the type islands means that the locations are more likely to be independent.

A second ratio was calculated by comparing each round with all rounds together. This ratio gives an indication of how well the summary over all rounds together has represented any differences between individual rounds. The second ratio has not been presented in tabular form because in every case the ratio is very small (less than 0.07). As expected, the summary over all rounds is representative of the rounds from which it was made.

All possible comparisons between species were made for each map. The table of significant differences based on the summary of all rounds was used for each species as was described for Common Flicker and Winter Wren (e.g. Tables 7 and 9 compared to produce Table 10). The results for seral stages (Table 13) do not include contrasts or reinforcements involving stage 7 (lakes). None of the species use lakes, so the inclusion of this type, which is not a seral stage, confuses the results of comparisons between species by consistantly boosting the number of reinforcements. Likewise, the results for vegetation types (Table 14) do not include type 14 (lakes) or type 39 (vegetation types which were digitized but which were not of the 36- to 75-year seral stage).

TABLE 13. THE NUMBER OF CONTRASTS AND REINFORCEMENTS FOR ALL COMPARISONS BETWEEN SPECIES WITH SERAL STAGES.

Does not include comparisons involving lakes.

SPECIES COMPARED	NUMBER OF CONTRASTS	NUMBER OF REINFORC.	TOTAL COMPAR.	RATIO CONT/REIN
Common Flicker with:				
Yellow-bellied Sapsucker	2	6	8	0.333
Hairy Woodpecker	2	6	8	0.333
Olive-sided Flycatcher	0	4	4	0.000
Steller's Jay	2	2	4	1.000
Chestnut-backed Chickadee	4	4	8	1.000
Red-breasted Nuthatch	3	3	6	1.000
Winter Wren	7	2	9	3.500
Varied Thrush	4	3	7	1.333
Swainson's Thrush	6	0	6	∞
Yellow-bellied Sapsucker with:				
Hairy Woodpecker	0	11	11	0.000
Olive-sided Flycatcher	0	4	4	0.000
Steller's Jay	5	2	7	2.500
Chestnut-backed Chickadee	1	8	9	0.125
Reb-breasted Nuthatch	1	8	9	0.125
Winter Wren	5	7	12	0.714
Varied Thrush	1	8	9	0.125
Swainson's Thrush	6	1	7	6.000
Hairy Woodpecker with:				
Olive-sided Flycatcher	0	4	4	0.000
Steller's Jay	4	2	6	2.000
Chestnut-backed Chickadee	1	8	9	0.125
Red-breasted Nuthatch	1	8	9	0.125
Winter Wren	4	7	11	0.571
Varied Thrush	1	8	9	0.125
Swainson's Thrush	6	1	7	6.000

Continued...

TABLE 13 Continued...

SPECIES COMPARED	NUMBER OF CONTRASTS	NUMBER OF REINFORC.	TOTAL COMPAR.	RATIO CONT/REIN
Olive-sided Flycatcher with:				
Steller's Jay	1	4	5	0.250
Chestnut-backed Chickadee	3	1	3	3.000
Red-breasted Nuthatch	0	2	2	0.000
Winter Wren	5	1	6	5.000
Varied Thrush	3	2	5	1.500
Swainson's Thrush	6	0	6	∞
Steller's Jay with:				
Chestnut-backed Chickadee	6	0	6	∞
Red-breasted Nuthatch	3	1	4	3.000
Winter Wren	6	3	9	2.000
Varied Thrush	6	1	7	6.000
Swainson's Thrush	5	3	8	1.667
Chestnut-backed Chickadee with:				
Red-breasted Nuthatch	1	7	8	0.143
Winter Wren	2	9	11	0.222
Varied Thrush	0	10	10	0.000
Swainson's Thrush	3	4	7	0.750
Red-breased Nuthatch with:				
Winter Wren	1	8	9	0.125
Varied Thrush	0	8	8	0.000
Swainson's Thrush	4	1	5	4.000
Winter Wren with:				
Varied Thrush	1	10	11	0.100
Swainson's Thrush	3	7	10	0.429
Varied Thrush with:				
Swainson's Thrush	4	4	8	1.000

TABLE 14. THE NUMBER OF CONTRASTS AND REINFORCEMENTS FOR ALL COMPARISONS BETWEEN SPECIES WITH VEGETATION TYPES.

Does not include lakes or types not in forty year seral stage.

SPECIES COMPARED	NUMBER OF CONTRASTS	NUMBER OF REINFORC.	TOTAL COMPAR.	RATIO CONT/REIN
Yellow-bellied Sapsucker with:				
Steller's Jay	3	10	13	0.300
Chestnut-backed Chickadee	2	11	13	0.182
Winter Wren	12	12	24	1.000
Varied Thrush	9	11	20	0.818
Swainson's Thrush	7	10	17	0.700
Steller's Jay with:				
Chestnut-backed Chickadee	10	3	13	3.333
Winter Wren	10	23	33	0.435
Varied Thrush	2	24	26	0.083
Swainson's Thrush	1	35	36	0.029
Chestnut-backed Chickadee with:				
Winter Wren	6	12	18	0.500
Varied Thrush	11	7	18	1.571
Swainson's Thrush	5	4	9	0.800
Winter Wren with:				
Varied Thrush	7	29	36	0.241
Swainson's Thrush	8	35	43	0.229
Varied Thrush with:				
Swainson's Thrush	2	30	32	0.067

DISCUSSION

The results are organized in three different ways in the following discussion. First, the use of mapping types is discussed for one bird species at a time. The observed level of use by each species is compared with any information from the literature. The second part examines the pattern of use by different species for each map. Species that show similar patterns of use are identified. The third part considers the types of each map; looking for types that are used commonly by many species as opposed to types that are avoided by most species. Before entering any of these discussions it is important to appreciate that the results reflect the examples available in the study area. The nature of examples available for each map will first be reviewed.

Seral Stages Map

When the Fraser Valley was first settled, the area now known as the University of British Columbia Research Forest had escaped fire for at least 150 years. The area would have supported old-growth forest. In 1840 and again in 1868 fires escaped from early settlements in the valley below. Much of the western half of the forest was burned. Most of the old growth was completely destroyed, but some patches of trees and snags survived in wet areas. When large, the patches were mapped as old growth (map stage 6; age 156 years and older).

Some of these areas contained many trees about 100 years of age growing around large, often fire-damaged survivors. Otherwise the areas were mapped as stage 5 (age 76 to 155 years) even though they contained occasional lone snags and trees of a much older age. Part of the stage 5 forest was logged, providing some examples of stage 1 (age 1 to 5) and stage 2 (age 6 to 15).

Most of the eastern half of the old growth was logged by railroad. In 1931 the logged area burned severely. In some places old growth along the edge was burned leaving small areas of hard snags. The area regenerated naturally but with low stocking density in many places. A few old trees and snags survived around a small marsh, but this area was mapped as being stage 4 (age 36 to 75 years) along with the surrounding area just discussed.

After the logging and fire of 1931, only the central and north-central portion of the forest remained as an expanse of old growth. Most of this has since been logged. A major portion of it which was clearcut in the 1950's was mapped as stage 3 (age 16 to 35 years). The logging continued until the time of this study, providing areas which were mapped as stage 2 (age 6 to 15 years) and stage 1 (age 1 to 5 years). The remaining old growth (type 6) was restricted to a few reserve patches, some thin strips around lake edges, and some poor quality growth on dry ridges.

The age range for each seral stage number is listed in Table 15 for reference.

TABLE 15. DEFINITION OF SERAL STAGE NUMBERS

SERAL STAGE	YEARS SINCE CUTTING OR BURNING	AGE OF EXAMPLES CENSUSED
1	1 TO 5	2, 3, 4, 5
2	6 TO 15	6,7,8,9,10,11,12,13,14,15
3	16 TO 35	16,17,19,20,24
4	36 TO 75	46, 51
5	76 TO 155	109, 137
6	156 AND OVER	APPROX 250
7	LAKE	
8	MARSH	

Vegetation Types Map

The map of vegetation types, or synecological map, for the Research Forest contained about 2500 type islands (Klinka, 1976). Only about 500 of these were digitized and used in this study. All were located in the area that was heavily burned in 1931 to remove the effect of seral stages. Consequently only those species that are relatively abundant in stage 4 of the seral stages map (age 36 to 75 years) can be related to vegetation types.

It is not uncommon for one vegetation type, or taxonomic unit, to be mapped as small patches within an expanse of a second taxonomic unit. Klinka did not represent the patches individually when they were very small relative to the mapping scale. If the combined areas of the very small patches was less than 15 percent of the total area, the patches were ignored. Otherwise the two types were mapped using a composite mapping unit. The first type named in the composite unit covered more than half of the area, while the second type named covered 16 to 49 percent of the area.

The taxonomic units were mapped as types 2 through 12 (Table 16). Types 15 through 32 are composites of these. Exposed rock was mapped as type 1, but it is insufficiently common to show significant differences in use for any bird species. Areas of marsh were mapped as type 13, and lakes as type 14. Type 13 included marshy areas containing some old trees and snags which survived both logging and fire. A few of the vegetation type islands digitized were wholly or

TABLE 16. DEFINITION OF VEGETATION TYPE NUMBERS

VEGETATION TYPES GROUPED AT PLANT ALLIANCE LEVEL.
TYPES NAMED AT ASSOCIATION OR SUB-ASSOCIATION LEVEL.

TYPE	ECOSYSTEM UNITS
1	EXPOSED ROCK
2	(LICHEN)-GAULTHERIA-DOUGLAS FIR
	LICHEN-GAULTHERIA-LODGEPOLE PINE-DOUGLAS FIR
3	GAULTHERIA-WESTERN HEMLOCK-DOUGLAS FIR
	MAHONIA-GAULTHERIA-WESTERN HEMLOCK-DOUGLAS FIR
4	MOSS-WESTERN HEMLOCK
	MAHONIA-MOSS-WESTERN REDCEDAR-WESTERN HEMLOCK
5	MOSS-(POLYSTICHUM)-WESTERN REDCEDAR-WESTERN HEMLOCK
6	VACCINIUM-GAULTHERIA-DOUGLAS FIR-WESTERN HEMLOCK
	VACCINIUM-MOSS-WESTERN HEMLOCK
7	BLECHNUM-AMABILIS FIR-WESTERN HEMLOCK
	STREPTOPUS-BLECHNUM-AMABILIS FIR-WESTERN HEMLOCK
	BLECHNUM-WESTERN HEMLOCK-WESTERN REDCEDAR
8	RIBES-VINE MAPLE
	POLYPODIUM-GAULTHERIA-DOUGLAS FIR-WESTERN REDCEDAR
	POLYPODIUM-POLYSTICHUM-DOUGLAS FIR-WESTERN REDCEDAR
	MAHONIA-POLYSTICHUM-DOUGLAS FIR-WESTER REDCEDAR
9	TIARELLA-POLYSTICHUM-WESTERN REDCEDAR
	RUBUS-POLYSTICHUM-WESTERN REDCEDAR
	ADIANTUM-POLYSTICHUM-WESTERN REDCEDAR
10	POLYSTICHUM-OPLOPANAX-WESTERN REDCEDAR
	RIBES-OPLOPANAX-WESTERN REDCEDAR
11	VACCINIUM-LYSICHITUM-WESTERN REDCEDAR
	VACCINIUM-LYSICHITUM-YELLOW CEDAR-WESTERN REDCEDAR
12	ATHYRIUM-ARUNCUS-RED ALDER-SITKA ALDER
13	MARSH
14	LAKE

THE FOLLOWING TYPES ARE COMPOSITES OF ABOVE TYPES
THE FIRST REPRESENTS 50% OR MORE OF THE TOTAL AREA

15	2-3	26	7-11
16	3-4	27	8-6
17	MARSH-11	28	6-9
18	11-9	29	8-9
19	9-8	30	11-7
20	9-11	31	7-8
21	6-8	32	2-8
22	2-6	33-38	NOT USED
23	1-2	39	OTHER SERAL STAGES
24	8-5	40	NUMBER NOT USED
25	5-6		

partially in seral stages other than age 36 to 75 years. These were grouped as type 39.

THE USE OF MAPPING TYPES BY EACH BIRD SPECIES

This section discusses the use of seral stages by each of the 10 bird species, and the use of plant alliances by 6 of those species. A brief summary of the life history of each species is first presented. It includes only that information found which provides insight on habitat selection by the species.

The main question to be answered for any bird species is whether either of the maps provide information useful for managing the availability of their habitat. One bar graph - significance table pair has been presented for each map for each species. The bar graphs can be used to find species restricted to a few mapping types as opposed to those which use many types indiscriminately. The matching significance table can be used to determine if the observed differences are statistically significant.

For each bird species the mapping types are discussed in decreasing order of use. The relative level of use, or "rating", of each type (expressed as a percent of the type used most) has been taken directly from the tables in Appendices B and C. Also appearing in these tables is an F-ratio for the variation between types, including any interaction between types and time. The F-ratio is sensitive to the number and size of the classification types used and does not provide a simple measure for comparing the predictive value of two different maps. In every case this ratio is greater with seral stages. Nonetheless, the probability of achieving the observed F-ratio by chance is always less than 0.01 for both maps and for all species.

Lakes and marsh (seral stages 7 and 8; vegetation types 14 and 13) are not forest habitat types, and they are not included in the discussion where numbers of types have been counted. This is true also for vegetation type 39 (vegetation types not in 40 year seral stage). However, the relative level of use of lakes provides some information about edge effects. Because all locations of birds are described as areas, the location of a bird that was sitting near a boundary between two mapping types will likely overlap with both types. Consequently a type that is never used will tend to accumulate a low level of use. This phenomenon has been termed "overlap" in the discussion.

The amount of overlap will be greater for bird species which select for edges between mapping types. However, overlap will also increase with loudness of call, as the average area of locations will be greater. Maps with many small mapping polygons, or with much irregularity of mapping polygon shapes, will tend to have more overlap as well. "Overlap" acts to dilute real differences in the use of mapping types such that observed differences will always be conservative estimates. "Overlap" may affect the order of ranking of two mapping types which were used nearly equally.

Of the species studied, only the Olive-sided Flycatcher was expected to use the areas mapped as lakes. The Flycatcher might catch insects in the air over the water. However, it was never observed to call while flying. It is unlikely that this or any of the bird species were actually on or over a lake when located by sound. All of the use attributed to lakes is the result of "overlap".

The observed level of use of lakes by a species should be small unless the species was attracted to lake edges. The attraction might be a characteristic habitat preference for lake edge, or the result of a coincidence as in the case of loggers leaving thin strips of old growth along the edge of lakes. Use of lakes rated from 0.102 to 0.349 for seral stages, and 0.006 to 0.233 for vegetation types. The digitized part of the map of vegetation types contained a single lake which was large and regular in shape; while the map of seral stages also contained many small, irregularly-shaped lakes.

Mapping types are identified by arbitrarily assigned numbers in all computer produced tables and graphs. Names are associated with the numbers for seral stages in Table 15, and for vegetation types in Table 16. Typical soil moisture regime and topographic position are listed for each vegetation type in Table 17.

It is easy to remember seral stages as they are numbered by increasing age. It is not so easy to become familiar with the vegetation types. Klinka (1976) mapped vegetation types at the level of plant associations and sub-associations. The types are grouped in this study at the plant alliance level. This means that a single vegetation type referred to in this study may include two or more association and/or sub-association names. For example, vegetation type 8 may be

Table 17. Soil Moisture and Topographic Position Typical of Each Vegetation Type.

Vegetation types are named in Table 16.

Type	Soil Moisture	Topographic Position
2	very dry	hill tops and shoulders; ridge tops.
5	medium	mid-slope on hillsides.
6	dry to medium-dry	hill shoulders and upper slopes.
7	wet	patches on hillsides that accumulate soil seepage.
8	medium to medium-wet	mid-slope hillsides receiving soil seepage but well drained.
9	wet	lower slopes, receiving soil seepage and poorly drained.
10	wet to very wet	along banks of small creeks and streams.
11	very wet	flat valley bottoms.
12	wet	along banks of larger streams and rivers.
13	marsh	
14	lakes	

Composite types (The first type named represents more than 50% of area.)

19	9 wet and 8 medium to medium-wet.
20	9 wet and 11 very wet.
21	6 dry to medium-dry and 8 medium to medium-wet.
22	2 very dry and 6 dry to medium-dry.
26	7 wet and 11 very wet.
27	8 medium to medium-wet and 6 dry to medium-dry.
29	8 medium-wet and 9 wet.
39	types in seral stages other than stage 4.

Ribes - vine maple or Polypodium - Gaultheria - Douglas fir - western red cedar or Polypodium - Polystichum - Douglas fir - western red cedar or Mahonia - Polystichum - Douglas fir - western red cedar. The problem is compounded with types that are composites of two plant alliances. The reader must refer to Table 16 for names.

Common Flicker (*Colaptes cafer*)

Life History

The Flicker was reported to use open woodlands, burns and slash rather than heavy coniferous forest (Guiguet, 1970). Conner and Adkisson (1975) found it common in recent clearcuts and older clearcuts but not in regeneration advanced to the pole stage or older. Jackman and Scott (1974) described it to feed mainly on the ground, taking mostly ants. Flickers nest in tree cavities which they may excavate themselves in dead snags or even in live wood. Conner (1973) found that nests were always near clearings. Jackman (1974) reported that they use large posts or even holes in dirt banks in the absence of nesting snags.

Seral Stages

The Flicker used 3 of the 6 seral stages (50%) at a relative rating of 0.50 or more (Table 18.). Stages 6, 1 and 2 were used significantly more than stages 3, 5 and 4. The former group rated no less than 0.81, while the latter rated no more than 0.34. Lakes (stage 7) rated 0.10 from overlap, indicating little or no edge effect.

Stage 6, oldgrowth, provides nesting snags large enough for the Flicker. Stages 1 and 2 were commonly found adjacent to old growth on the Research Forest at the time of this study. They provide open areas in which the Flicker feeds on the ground. Apparently, stages 3, 4 and 5 were too young to provide snags for nesting and yet too old in terms of canopy development to provide open areas for feeding. For Common Flickers, the map of seral stages would be a useful management tool.

Vegetation Types

Common Flicker was not observed regularly in seral stage 4, so a relationship with vegetation types could not be established.

TABLE 18. COMMON FLICKER WITH SERAL STAGES

RELATIVE LEVEL OF USE OF TYPES

```
1.0|  6--------------------|
   | XX  1                 |
   | XX XX                 |
   | XX XX  2              |
   | XX XX XX              |
.75|-XX-XX-XX--------------|
   | XX XX XX              |
   | XX XX XX              |
   | XX XX XX              |
   | XX XX XX              |
0.5|-XX-XX-XX--------------|
   | XX XX XX              |
   | XX XX XX              |
   | XX XX XX  3  5        |
   | XX XX XX XX XX  8     |
.25|-XX-XX-XX-XX-XX-XX  4---|
   | XX XX XX XX XX XX XX   |
   | XX XX XX XX XX XX XX  7|
   | XX XX XX XX XX XX XX XX|
   | XX XX XX XX XX XX XX XX|
0.0|-XX-XX-XX-XX-XX-XX-XX-XX|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	6	1	2	3	5	8	4	7
6								
1								
2	X							
3	X	X	X					
5	X	X	X					
8								
4	X	X	X					
7	X	X	X	X				
	6	1	2	3	5	8	4	7

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

Yellow-bellied Sapsucker (Sphyrapicus varius)

Life History

Tree sap forms a large part of the diet of the Sapsucker when the sap is flowing heavily in the summer. In the fall they take large amounts of small fruits, while in winter they eat mostly insects. In spring, when this study was conducted, they feed mostly on insects found on tree trunks and large branches. They also make sapwells and eat bast from conifers (Tate, 1973). During the study period, they were probably benefiting from spring sap flow (Jackman, 1974). Trees used include hemlock, birch, aspen (Tate, 1973), alder, willow, cedar (Jackman, 1974), fir and pine (Guiguet, 1970). The Sapsucker excavates a nest cavity in standing wood.

Seral Stages

The Yellow-bellied Sapsucker used 2 of the 6 seral stages (33%) at a relative rating of 0.50 or more (Table 19). Stages 6 and 5 were used significantly more than stages 2, 3, 4 and 1. The former group rated 0.77 or more, while the latter group rated 0.27 or less. Lakes rated 0.28, indicating a strong edge effect. Marsh (stage 8), which rated 0.90, was also used significantly more than of stages 2, 3, 4 and 1.

Seral stage 6 would provide nesting snags as well as feeding trees for the sapsucker. Marsh likely rated high because it provided protection for trees from logging and fire. Many of the marshy areas on the forest contained old trees and snags, often in contrast to the younger stages

TABLE 19. YELLOW-BELLIED SAPSUCKER WITH SERAL STAGES

RELATIVE LEVEL OF USE OF TYPES

```
1.0|  6----------------------|
   | XX                      |
   | XX  8                   |
   | XX XX                   |
   | XX XX  5                |
.75|-XX-XX-XX----------------|
   | XX XX XX                |
   | XX XX XX                |
   | XX XX XX                |
   | XX XX XX                |
0.5|-XX-XX-XX----------------|
   | XX XX XX                |
   | XX XX XX                |
   | XX XX XX                |
   | XX XX XX  7  2          |
.25|-XX-XX-XX-XX-XX----------|
   | XX XX XX XX XX          |
   | XX XX XX XX XX  3  4   1|
   | XX XX XX XX XX XX XX XX|
   | XX XX XX XX XX XX XX XX|
0.0|-XX-XX-XX-XX-XX-XX-XX-XX|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	6	8	5	7	2	3	4	1
6								
8								
5	X							
7	X	X	X					
2	X	X	X					
3	X	X	X	X	X			
4	X	X	X	X	X			
1	X	X	X	X	X			
	6	8	5	7	2	3	4	1

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

which they frequently bordered. Stage 5 would provide feeding trees and small snags in addition to the occasional large nesting snag which survived the fires of the 1800's. Three nests were found in stage 5 forest, all in old snags.

A number of the areas of old growth (stage 6) form strips along the edges of lakes. Use of these strips by the Yellow-bellied Sapsucker caused the high edge effect for lakes. Stage 2 has probably benefitted from much edge effect also, although Sapsuckers were occasionally seen using young alder trees in this stage. Deciduous tree species were used occasionally in stage 3. Deciduous and coniferous trees (mostly hemlock) were used for sap feeding in stage 4. However, the smaller trees contained relatively few and unproductive sapwells in contrast to the high density of sapwells on the clder trees of stages 5 and 6 from which sap poured profusely. A map of seral stages would be a valuable aid in managing an area for Yellow-bellied Sapsuckers.

Vegetation Types

Vegetation type 2 rated highest for the Sapsucker (Table 20), but the rating is not significant in most comparisons because the available examples of type 2 in the area digitized were few and small. Type 2 occurs with type 6 in composite type 22. The fact that type 22 rated significantly low supports the suspicion that type 2 rated high by chance. Type 39, which rates next, is vegetation types in seral stages other than stage 4. Seral stage 4 rated low for the Sapsucker, while type 39 includes seral stages 5

TABLE 20. YELLOW-BELLIED SAPSUCKER WITH VEGETATION TYPES

RELATIVE LEVEL OF USE OF TYPES

```
1.0| 2---------------------------------------------------------------|
   | XX 39 13                                                         |
   | XX XX XX                                                         |
   | XX XX XX  5 20                                                   |
   | XX XX XX XX XX                                                   |
.75|-XX-XX-XX-XX-XX-----------------------------------------------------|
   | XX XX XX XX XX  6                                                |
   | XX XX XX XX XX XX                                                |
   | XX XX XX XX XX XX 11                                             |
   | XX XX XX XX XX XX XX 12                                          |
0.5|-XX-XX-XX-XX-XX-XX-XX-XX 19-------------------------------------------|
   | XX XX XX XX XX XX XX XX XX 21                                    |
   | XX XX XX XX XX XX XX XX XX XX                                    |
   | XX XX XX XX XX XX XX XX XX XX 10                                 |
   | XX XX XX XX XX XX XX XX XX XX XX  9 29  7                        |
.25|-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX 14 27------------|
   | XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX                  |
   | XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX 26 22  8         |
   | XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX         |
   | XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX         |
0.0|-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX  3|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	2	39	13	5	20	6	11	12	19	21	10	9	29	7	14	27	26	22	8	3
2																				
39																				
13																				
5																				
20																				
6																				
11																				
12																				
19		X	X	X	X															
21		X	X	X	X	X														
10		X	X	X	X	X														
9	X	X	X	X	X	X	X													
29		X	X	X	X	X														
7		X	X	X	X															
14	X	X	X	X	X	X	X													
27	X	X	X	X	X	X														
26		X	X	X	X															
22	X	X	X	X	X	X														
8	X	X	X	X	X	X	X		X	X										
3																				
	2	39	13	5	20	6	11	12	19	21	10	9	29	7	14	27	26	22	8	3

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

and 6. Marsh (type 13) probably rated high again because of the snags and older trees that survived logging and fire in wet areas. This protective ability is an important attribute of marsh.

Type 5 is then the vegetation type most heavily used. The Yellow-bellied Sapsucker used 8 of the 17 vegetation types (47%) at a rate of 0.50 or more relative to that of type 5. Types 5, 20, and 6 each rated significantly higher than eleven of the remaining types. Type 2 was used significantly over five types, while type 11 was used significantly over three types. Although the remaining vegetation types are ordered in a gradually decreasing fashion, the only significant differences in use are those of types 19 and 21 over type 8.

The relatively low level of abundance of the Yellow-bellied Sapsucker in seral stage 4 means that there were fewer locations to work with in attempting to show significant differences in use. The most striking results of relating use by the sapsucker to the vegetation types map are concerned with the occurrence of older seral stages in type 39 and in marsh. Perhaps a relationship with vegetation types could be established more readily in older seral stages. The evidence from this study suggests that a map of vegetation types would be useful in managing Yellow-bellied Sapsuckers only as a supplement to a map of seral stages.

Hairy Woodpecker (<u>Dendrocopus villosus</u>)

Life History

Insects form 90 percent of the diet of the Hairy Woodpecker (Guiguet, 1970). It forages for arthropods on the bark of the trunk and large branches of living trees; and more extensively from within the decaying wood of dead trees, stumps and logs (Stallcup, 1968). The species is generally associated with coniferous trees and with open rather than dense timber (Jackman, 1974). This woodpecker prefers stands of dead trees such as are produced by fire, insects and disease (Jackman, 1974). Conner (1973) and Conner and Adkisson (1975) found it to use recent logging slash. Johnston and Odum (1956) found it to occur in forests of age 60 years and over, with abundance increasing with forest age. Odum (1950) and Conner and Adkisson (1975) found it to be most abundant in mature forest. It nests in a cavity which it excavates in standing dead wood (Conner, 1973).

Seral Stages

The Hairy used 2 of the 6 seral stages (33%) at a relative rate of 0.50 or more (Table 21). Stages 6 and 5 were used significantly more than every other stage. Stage 6 was used significantly more than stage 5. The rating of marsh (stage 8) is not significant. Stage 2 rated only slightly better than lakes (stage 7). Lakes show a strong edge effect, rating 0.26 from overlap. The Research Forest has a number of examples of old growth which are strips along lake edges.

TABLE 21. HAIRY WOODPECKER WITH SERAL STAGES

RELATIVE LEVEL OF USE OF TYPES

```
1.0|  6--------------------|
   | XX                    |
   | XX                    |
   | XX                    |
   | XX                    |
.75|-XX  5-----------------|
   | XX XX                 |
   | XX XX                 |
   | XX XX                 |
   | XX XX                 |
0.5|-XX-XX-----------------|
   | XX XX                 |
   | XX XX  8              |
   | XX XX XX  2           |
   | XX XX XX XX  7        |
.25|-XX-XX-XX-XX-XX--------|
   | XX XX XX XX XX  4     |
   | XX XX XX XX XX XX     |
   | XX XX XX XX XX XX  1 3|
   | XX XX XX XX XX XX XX XX|
0.0|-XX-XX-XX-XX-XX-XX-XX-XX|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	6	5	8	2	7	4	1	3
6								
5	X							
8								
2	X	X						
7	X	X						
4	X	X		X				
1	X	X						
3	X	X		X				
	6	5	8	2	7	4	1	3

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

Stage 2 also commonly bordered on old growth. Much of its rating may be attributed to overlap. Stages 4, 1 and 3 rated less than 0.17.

Stage 6 provides the Hairy Woodpecker with much standing dead wood for feeding and nesting. Stage 5 provides these resources for the Hairy to a lesser extent. The remaining stages are too young. The Hairy was seen on occasion using logging slash in clearcuts, but this could be expected only for the first rotation after cutting old growth or very advanced regeneration. For management purposes, the map of seral stages can be used to predict areas of habitat for the Hairy Woodpecker.

Vegetation Types

The Hairy woodpecker was observed only occasionally in seral stage 4. Consequently a relationship with vegetation types could not be established.

Olive-sided Flycatcher (Nuttallornis borealis)

Life History

The Olive-sided Flycatcher feeds mainly on flying insects. The bird makes brief sorties from a high perch to catch passing insects. Martin (1960) found they used tree tops over 40 feet in height. Hagar (1960) found them most common around brushy clearcuts. The nest is an open cup usually placed well out on a conifer branch, and usually at a considerable height (Godfrey, 1966).

Seral Stages

The Olive-sided Flycatcher used 5 of the 6 seral stages (83%) at a relative level of 0.50 or more (Table 22). Stages 2, 6, 5, 1 and 3 were used significantly more than stage 4. The only significant difference in use within the former group of stages is that of stage 2 over stage 3. Stage 4 rated lower than lakes (stage 7) which rated 0.30 from strong edge effect.

Stages 5 and 6 provide the high trees needed for perching while feeding. Stages 2, 1 and to a lesser extent stage 3 provide open areas over which to feed. Lakes also appear to provide open areas for feeding. The tree canopy is likely too well developed in stage 4 to provide open areas, and insufficiently developed to provide tall perching trees.

The map of seral stages provides some information for managing an area for Olive-sided Flycatchers, but more information on the use of edges between old and young stages is needed.

Vegetation Types

The Olive-sided Flycatcher was observed only rarely in seral stage 4, so a relationship with vegetation types could not be established.

TABLE 22. OLIVE-SIDED FLYCATCHER WITH SERAL STAGES

RELATIVE LEVEL OF USE OF TYPES

```
1.0 |  2  6-------------------|
    | XX XX  5                |
    | XX XX XX                |
    | XX XX XX  1             |
    | XX XX XX XX             |
.75 |-XX-XX-XX-XX-------------|
    | XX XX XX XX  3          |
    | XX XX XX XX XX          |
    | XX XX XX XX XX          |
    | XX XX XX XX XX          |
0.5 |-XX-XX-XX-XX-XX----------|
    | XX XX XX XX XX          |
    | XX XX XX XX XX          |
    | XX XX XX XX XX          |
    | XX XX XX XX XX  7  4    |
.25 |-XX-XX-XX-XX-XX-XX-XX----|
    | XX XX XX XX XX XX XX    |
    | XX XX XX XX XX XX XX    |
    | XX XX XX XX XX XX XX    |
    | XX XX XX XX XX XX XX    |
0.0 |-XX-XX-XX-XX-XX-XX-XX   8|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	2	6	5	1	3	7	4	8
2								
6								
5								
1								
3	X							
7	X	X	X	X	X			
4	X	X	X	X	X			
8								
	2	6	5	1	3	7	4	8

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

Steller's Jay (*Cyanocitta stelleri*)

Life History

Guiguet (1970) reported the Steller's Jay to be abundant at the coniferous forest edge; around slashes, rivers and shore-lines. It eats "everything going" according to Guiguet, including fruits, seeds, insects and carrion. The nest is an open cup usually in a group of small conifer trees and about 8 to 40 feet above the ground (Guiguet, 1970).

Seral Stages

The Steller's Jay used 6 of the 6 seral stages (100%) at a relative rate of 0.50 or more (Table 23). Stages 3 and 1 were used significantly more than most other stages. Stage 4 rated 0.52, which was significantly less than most other stages. Lakes (stage 7) rated 0.27, indicating a strong edge effect.

Stage 3 provides nesting trees for the Jay. Steller's Jays were often seen feeding on the ground amongst the logging slash of stages 1 and 2, or moving among the trees of stages 5 and 6. The map of seral stages would be of limited use for predicting the occurrence of Steller's Jays because they use all of the stages frequently.

TABLE 23. STELLER'S JAY WITH SERAL STAGES

RELATIVE LEVEL OF USE OF TYPES

```
1.0|  3   1---------------|
   | XX  XX               |
   | XX  XX               |
   | XX  XX               |
   | XX  XX               |
.75|-XX-XX   5   2--------|
   | XX  XX  XX  XX       |
   | XX  XX  XX  XX  6    |
   | XX  XX  XX  XX  XX   |
   | XX  XX  XX  XX  XX  4|
0.5|-XX-XX-XX-XX-XX-XX---|
   | XX  XX  XX  XX  XX  XX   |
   | XX  XX  XX  XX  XX  XX   |
   | XX  XX  XX  XX  XX  XX   |
   | XX  XX  XX  XX  XX  XX  7|
.25|-XX-XX-XX-XX-XX-XX-XX|
   | XX  XX  XX  XX  XX  XX  XX|
   | XX  XX  XX  XX  XX  XX  XX|
   | XX  XX  XX  XX  XX  XX  XX|
   | XX  XX  XX  XX  XX  XX  XX|
0.0|-XX-XX-XX-XX-XX-XX-XX|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	3	1	5	2	6	4	7
3							
1							
5	X						
2	X	X					
6	X	X					
4	X	X	X	X			
7	X	X	X	X	X	X	
	3	1	5	2	6	4	7

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

Vegetation Types

The Steller's Jay used 5 of the 15 vegetation types (33%) at a relative rate of 0.50 or more (Table 24). However, only 2 of the 15 types (13%) were used at a rate of 0.55 or more. Types 11 and 12 rated significantly higher than all other types, at nearly twice the rating of the next highest type. Types 20, 6, 8 and 9 were used from 0.54 to 0.46. They were used significantly more than most remaining types. Types 27, 10, 19, 22 and 5 were used at 0.39 to 0.34. Their use is significant over remaining types in only a few instances.

The Steller's Jay showed strong preference for two vegetation types associated with wet sites. Type 11 is a very wet type occurring in valley bottoms (Table 17). It is commonly found near lakes, marshes and in areas which receive runoff but are themselves poorly drained. Type 12 is a wet type found along the banks of larger streams and rivers. This agrees with the life history information that the Jays are common around rivers and shore-lines. Type 9 is a wet type occurring on lower slopes; and type 20 is a combination of types 9 and 11. However, type 8 is only medium to medium-wet and is found mid-slope on hillsides; while type 6 is a dry to medium dry type associated with hill shoulders and upper slopes. Moisture may be a factor in habitat selection by Steller's Jays, but the observed pattern of use of vegetation types cannot be explained by soil moisture alone.

The map of vegetation types could be useful in managing the habitat of Steller's Jays. The Jay shows marked preference for _Vaccinium_-_Lysichitum_-(yellow cedar)-western

TABLE 24. STELLER'S JAY WITH VEGETATION TYPES

RELATIVE LEVEL OF USE OF TYPES

```
1.0| 12 11--------------------------------------------------------|
   | XX XX                                                        |
   | XX XX                                                        |
   | XX XX                                                        |
   | XX XX                                                        |
.75|-XX-XX--------------------------------------------------------|
   | XX XX                                                        |
   | XX XX                                                        |
   | XX XX                                                        |
   | XX XX 20  6  8                                               |
0.5|-XX-XX-XX-XX-XX  9--------------------------------------------|
   | XX XX XX XX XX XX                                            |
   | XX XX XX XX XX XX 27 10                                      |
   | XX XX XX XX XX XX XX XX 19 22  5                             |
   | XX XX XX XX XX XX XX XX XX XX XX                             |
.25|-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX 39  7-----------------------|
   | XX XX XX XX XX XX XX XX XX XX XX XX XX                       |
   | XX XX XX XX XX XX XX XX XX XX XX XX XX 21 14 13              |
   | XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX 29           |
   | XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX 26        |
0.0|-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX        |
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	12	11	20	6	8	9	27	10	19	22	5	39	7	21	14	13	29	26
12																		
11																		
20	X	X																
6	X	X																
8	X	X																
9	X	X																
27	X	X																
10	X	X																
19	X	X	X	X														
22	X	X																
5	X	X	X															
39	X	X	X	X	X	X												
7	X	X	X															
21	X	X	X	X	X	X			X									
14	X	X	X	X	X	X			X		X							
13	X	X	X	X	X	X												
29	X	X	X	X	X	X	X	X	X		X							
26	X	X	X	X	X	X												
	12	11	20	6	8	9	27	10	19	22	5	39	7	21	14	13	29	26

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

red cedar and for *Athyrium-Aruncus*-red alder-sitka alder vegetation types. They also showed many significant differences in the use of the other types. The map of seral stages could act to supplement the map of vegetation types.

Chestnut-backed Chickadee (*Parus rufescens*)

Life History

The Chestnut-backed Chickadee gleans insects and insect larvae from foliage and twigs. They feed mainly from coniferous trees but also use deciduous trees. They feed more commonly towards the tops of trees (Sturman, 1968a and 1968b) but also use foliage of understory brush (Root, 1964). For nesting they require a small tree cavity which they may excavate themselves in soft, rotting wood.

Seral Stages

The Chickadee used 3 of the 6 seral stages (50%) at a relative rate of 0.50 or more (Table 25). Stage 6 was used significantly more than all others. Stages 4 and 5 rated 0.60, significantly higher than the use of the remaining stages. Lakes (stage 7) rated 0.35 from strong edge effect, probably as a result of the many strips of old growth left along lake edges.

The map of seral stages is useful for predicting the areas used by Chestnut-backed Chickadees. Stage 6 provides

TABLE 25. CHESTNUT-BACKED CHICKADEE WITH SERAL STAGES

RELATIVE LEVEL OF USE OF TYPES

```
1.0|  6------------------|
   | XX                  |
   | XX                  |
   | XX                  |
   | XX                  |
.75|-XX------------------|
   | XX                  |
   | XX  4               |
   | XX XX  5            |
   | XX XX XX            |
0.5|-XX-XX-XX------------|
   | XX XX XX            |
   | XX XX XX            |
   | XX XX XX  7  3  2   |
   | XX XX XX XX XX XX   |
.25|-XX-XX-XX-XX-XX-XX---|
   | XX XX XX XX XX XX   |
   | XX XX XX XX XX XX   |
   | XX XX XX XX XX XX  1|
   | XX XX XX XX XX XX XX|
0.0|-XX-XX-XX-XX-XX-XX-XX|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	6	4	5	7	3	2	1
6							
4	X						
5	X						
7	X						
3	X	X	X				
2	X	X	X				
1	X	X	X				
	6	4	5	7	3	2	1

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

many snags for nesting and good feeding opportunities. Stage 4 has abundant coniferous tree foliage for feeding, but nesting is restricted to fast growing deciduous species. Stage 5 provides both high densities of coniferous tree foliage for feeding and coniferous snags large enough for small nest cavities. Seral stages 3 and 2 provide much less foliage and no nesting opportunity. Stage 1 has neither foliage nor snags to attract the Chickadee.

Vegetation Types

The Chestnut-backed Chickadee used only 3 of the 12 vegetation types (25%) at a rate of 0.50 or more (Table 26). Types 21 and 5 were used significantly more than of all other types. Type 20 rated 0.57, which was significantly higher than the four types used least.

The Chestnut-backed Chickadee has strong preference for two vegetation types associated with hillsides (Table 17). Vegetation type 21 is a composite of types 6 (found on dry to medium-dry hill shoulders and upper slopes) and 8 (occurring on medium to medium-wet hillsides). Type 5 is also typically found on mesic hillsides. By contrast, type 20 is a combination of wet type 9 (lower slopes) and very wet type 11 (valley bottoms). Rating next is wet type 9 and then dry type 6. While the Chickadee showed definite preferences among vegetation types, the pattern of selection cannot be explained by moisture gradient or topographic position alone. The foliage of trees growing on dry sites must provide insects for feeding as well as that of trees growing on wet

TABLE 26. CHESTNUT-BACKED CHICKADEE WITH VEGETATION TYPES

RELATIVE LEVEL OF USE OF TYPES

```
1.0| 21---------------------------------|
   | XX  5                              |
   | XX XX                              |
   | XX XX                              |
   | XX XX                              |
.75|-XX-XX------------------------------|
   | XX XX                              |
   | XX XX                              |
   | XX XX 20                           |
   | XX XX XX                           |
0.5|-XX-XX-XX  9------------------------|
   | XX XX XX XX                        |
   | XX XX XX XX  6                     |
   | XX XX XX XX XX 10 11               |
   | XX XX XX XX XX XX XX               |
.25|-XX-XX-XX-XX-XX-XX-XX 12  8---------|
   | XX XX XX XX XX XX XX XX XX         |
   | XX XX XX XX XX XX XX XX XX 19  7   |
   | XX XX XX XX XX XX XX XX XX XX XX 22|
   | XX XX XX XX XX XX XX XX XX XX XX XX|
0.0|-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	21	5	20	9	6	10	11	12	8	19	7	22
21												
5												
20	X	X										
9	X	X										
6	X	X										
10	X	X										
11	X	X										
12	X	X										
8	X	X	X									
19	X	X	X	X	X							
7	X	X	X	X								
22	X	X	X	X								
	21	5	20	9	6	10	11	12	8	19	7	22

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

sites. The map of vegetation types appears to provide information for habitat management, but the reasons for the preferences are not obvious.

Red-breasted Nuthatch (*Sitta canadensis*)

Life History

The Nuthatch is a bird of mature forest (Odum, 1950; Hagar, 1960) and particularly of mature coniferous forest (Bent, 1948). It feeds mainly on insects gleaned from the bark of tree trunks and larger branches, though it will also use smaller branches (Bent, 1948). Coniferous tree seeds are also consumed, especially in winter (Kilham, 1975). The Nuthatch typically nests in a tree cavity which it can excavate itself in rotting wood.

Seral Stages

The Red-breasted Nuthatch used 2 of the 6 seral stages (33%) at a relative rate of 0.50 or more (Table 27). Stage 5 was used significantly more than all other stages. Stage 6 rated only 0.57, while the remaining stages rated less than 0.12. Lakes (stage 7) rated 0.11 indicating only moderate edge effect. The Nuthatch was never observed to be anywhere but within a well-developed forest canopy, while the oldgrowth left along lake edges consisted only of thin strips.

TABLE 27. RED-BREASTED NUTHATCH WITH SERAL STAGES

RELATIVE LEVEL OF USE OF TYPES

```
1.0|  5--------------------|
   | XX                    |
   | XX                    |
   | XX                    |
   | XX                    |
.75|-XX--------------------|
   | XX                    |
   | XX                    |
   | XX  6                 |
   | XX XX                 |
0.5|-XX-XX-----------------|
   | XX XX                 |
   | XX XX                 |
   | XX XX                 |
   | XX XX                 |
.25|-XX-XX-----------------|
   | XX XX                 |
   | XX XX  2  7           |
   | XX XX XX XX           |
   | XX XX XX XX  4  1  3  |
0.0|-XX-XX-XX-XX-XX-XX-XX  |
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	5	6	2	7	4	1	3
5							
6	X						
2	X	X					
7	X	X					
4	X	X					
1	X	X					
3	X	X					
	5	6	2	7	4	1	3

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

Stage 5 provides a high density of trees which have large stems and many large branches from which the nuthatch could glean insects. It also contains snags large enough for the Nuthatch to nest in. Stage 6 provides larger snags and trees, but these are more widely spaced and support fewer branches. The younger stages offer neither of these resources. The map of seral stages is useful for predicting the occurrence of habitat for the Red-breasted Nuthatch because the Nuthatch is restricted to the older seral stages.

Vegetation Types

The Nuthatch could not be related to vegetation types as it was not observed in seral stage 4.

Winter Wren (*Troglodytes troglodytes*)

Life History

The Winter Wren nests in dense forest underbrush where it feeds on insects. Bent (1948) described it to use the thick tangle of shrubs, roots and fallen logs in the shade of large trees.

Seral Stages

The Winter Wren used 3 of the 6 seral stages (50%) at a relative level of 0.50 or more (Table 28). Every comparison between stages has produced a significant difference, except the comparison between stages 3 and 1. Stage 5 was used the most while stage 4 rated 0.70 and stage 6 rated 0.53. The younger stages rated 0.37 or less. Lakes show little edge effect with a rating of 0.11.

The more open tree canopy of stages 4 and 6 was often associated with a denser layer of shrubs than stage 5. In spite of this, the Wren shows marked preference for stage 5. This preference, plus the low use of younger stages which frequently supported abundant shrub growth but had no tree canopy, suggests that the Wren is selecting not solely for shrubs, but for shrubs when they form an understory.

The preference shown by the Winter Wren for the older seral stages can be used with the map of seral stages to predict the occurrence of habitat for the Wren over the area mapped.

Vegetation Types

The Winter Wren used 10 of the 14 vegetation types (71%) at a relative level of 0.50 or more (Table 29). Type 5, found on mesic hillsides, was used the most; while type 12, occurring on the wet banks of rivers and large streams, rated 0.90. Dividing the 14 types into two groups of 7, and using Table 17 to determine the moisture status of each type, reveals a preference for vegetation types found in moist

TABLE 28. WINTER WREN WITH SERAL STAGES

RELATIVE LEVEL OF USE OF TYPES

```
1.0|  5--------------------|
   | XX                    |
   | XX                    |
   | XX                    |
   | XX                    |
.75|-XX--------------------|
   | XX  4                 |
   | XX XX                 |
   | XX XX                 |
   | XX XX  6              |
0.5|-XX-XX-XX--------------|
   | XX XX XX              |
   | XX XX XX  3           |
   | XX XX XX XX  1        |
   | XX XX XX XX XX        |
.25|-XX-XX-XX-XX-XX--------|
   | XX XX XX XX XX  2     |
   | XX XX XX XX XX XX   7|
   | XX XX XX XX XX XX  XX|
   | XX XX XX XX XX XX  XX|
0.0|-XX-XX-XX-XX-XX-XX-XX|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	5	4	6	3	1	2	7
5							
4	X						
6	X	X					
3	X	X	X				
1	X	X	X				
2	X	X	X	X	X		
7	X	X	X	X	X	X	
	5	4	6	3	1	2	7

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

TABLE 29. WINTER WREN WITH VEGETATION TYPES

RELATIVE LEVEL OF USE OF TYPES

```
1.0|  5---------------------------------------------------|
   | XX                                                   |
   | XX  12                                               |
   | XX  XX   7                                           |
   | XX  XX  XX                                           |
.75|-XX-XX-XX-----------------------------------------|
   | XX  XX  XX  19  10  20   9   8                       |
   | XX  XX  XX  XX  XX  XX  XX  XX                       |
   | XX  XX  XX  XX  XX  XX  XX  XX  21                   |
   | XX  XX  XX  XX  XX  XX  XX  XX  XX   6               |
0.5|-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX----------------|
   | XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  29           |
   | XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  11  22  27     |
   | XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX     |
   | XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX     |
.25|-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX 13 39|
   | XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX|
   | XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX|
   | XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX|
   | XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX|
0.0|-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	5	12	7	19	10	20	9	8	21	6	29	11	22	27	13	39
5																
12																
7																
19	X	X														
10	X	X														
20	X	X														
9	X	X	X													
8	X	X														
21	X	X	X	X			X									
6	X	X	X	X	X	X	X	X								
29	X	X	X	X	X	X	X	X								
11	X	X	X	X	X	X	X	X	X							
22	X	X	X	X	X	X	X	X	X							
27	X	X	X	X	X	X	X	X	X	X						
13	X	X	X	X	X	X	X	X	X	X	X					
39	X	X	X	X	X	X	X	X	X	X	X	X				
	5	12	7	19	10	20	9	8	21	6	29	11	22	27	13	39

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

places. The 7 types used most include five wet, one medium-wet and one medium type; while the 7 types used least include one wet, one medium-wet, one medium, two medium-dry and two dry types. The differences in use are significant in most cases and may reflect the increased abundance of underbrush on many wet sites. However, the Wren is by no means restricted to moist types. Dry type 6 rated 0.50, wet type 11 rated only 0.40, and the type used least still rated 0.35.

The map of vegetation types reveals areas which show significant differences in use. However, the Winter Wren was very abundant in those seral stages which it used, including stage 4. Because of this abundance, rather subtle differences in use of vegetation types have become significant differences. The Wren used most vegetation types at somewhat similar levels. While it does prefer moist types, it does not depend on any one type or small group of types, nor is it totally excluded from any types. When used with a map of seral stages, the map of vegetation types does provide a refined definition of habitat for the Winter Wren.

Varied Thrush (*Ixoreus naevius*)

Life History

According to Guiguet (1964), the Varied Thrush is commonly found in mature coniferous forest, alder bottoms and in older second growth stands. It feeds mostly on the ground, taking insects, seeds and small fruits. Its nest is an open cup placed at moderate height in a tree (Godfrey, 1966).

Seral Stages

The Varied Thrush used 3 of the 6 seral stages (50%) at a relative level of 0.50 or more (Table 30). Of all the species censused, this Thrush has the distinction of having the seral stages ordered by age. However, many of the differences are not significant. Stages 6 and 5 rate nearly equally at the top. Their observed level of use is significantly higher than that of all other stages. Stage 4 rated 0.65 and was also used significantly more than the younger stages. The remaining stages rated 0.29 or less. Lakes rate 0.20, indicating moderate edge effect.

The high rating of stages 6 and 5 agrees with the life history information that the Varied Thrush is found commonly in mature coniferous forests. The older stage 6 does not appear to provide better habitat than does stage 5. Even stage 4 satisfied the habitat requirements, though the Thrush occurred there at lower levels. The younger stages did not provide good habitat for this species. Using these relationships with the map of seral stages provides criteria

TABLE 30. VARIED THRUSH WITH SERAL STAGES

RELATIVE LEVEL OF USE OF TYPES

```
1.0|  6  5------------------|
   | XX XX                  |
   | XX XX                  |
   | XX XX                  |
   | XX XX                  |
.75|-XX-XX------------------|
   | XX XX                  |
   | XX XX  4               |
   | XX XX XX               |
   | XX XX XX               |
0.5|-XX-XX-XX  8------------|
   | XX XX XX XX            |
   | XX XX XX XX            |
   | XX XX XX XX            |
   | XX XX XX XX  3  2      |
.25|-XX-XX-XX-XX-XX-XX------|
   | XX XX XX XX XX XX  7   |
   | XX XX XX XX XX XX XX   |
   | XX XX XX XX XX XX XX  1|
   | XX XX XX XX XX XX XX XX|
0.0|-XX-XX-XX-XX-XX-XX-XX-XX|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	6	5	4	8	3	2	7	1
6								
5								
4	X	X						
8								
3	X	X	X					
2	X	X	X					
7	X	X	X					
1	X	X	X					
	6	5	4	8	3	2	7	1

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

for predicting areas of habitat for Varied Thrush.

Vegetation Types

The Varied Thrush used 8 of the 16 vegetation types (50%) at a relative level of 0.50 or more (Table 31). Type 12 was used significantly more than the 10 types which rated lowest. Type 5 rated 0.86, significantly higher than 9 of the lower rating types. Types 7, 10, 11, 9, and 6 rated 0.80 to 0.61, significantly higher than the 6 lowest rating types in most instances. Type 22 rated with this group at 0.67, but its use is significantly greater than the lowest rating type only. The top 8 types include five wet types, one medium and two dry types. The 8 types used least include two wet types, five medium-wet to medium-dry, and one type that is typically dry.

The Varied Thrush has shown a definite preference in its use of vegetation types, although it uses many types at moderate levels. There is no clear trend over soil moisture or topographic position. The map of vegetation types could be used to improve the prediction made using the map of seral stages.

TABLE 31. VARIED THRUSH WITH VEGETATION TYPES

RELATIVE LEVEL OF USE OF TYPES

```
1.0| 12------------------------------------------------------|
   | XX                                                      |
   | XX  5                                                   |
   | XX XX                                                   |
   | XX XX  7                                                |
.75|-XX-XX-XX 10---------------------------------------------|
   | XX XX XX XX 22 11  9                                    |
   | XX XX XX XX XX XX XX  6                                 |
   | XX XX XX XX XX XX XX XX                                 |
   | XX XX XX XX XX XX XX XX                                 |
0.5|-XX-XX-XX-XX-XX-XX-XX-XX 26------------------------------|
   | XX XX XX XX XX XX XX XX XX 29 19 39 20                  |
   | XX XX XX XX XX XX XX XX XX XX XX XX XX  8               |
   | XX XX XX XX XX XX XX XX XX XX XX XX XX XX               |
   | XX XX XX XX XX XX XX XX XX XX XX XX XX XX 27            |
.25|-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX------------|
   | XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX 13         |
   | XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX  2      |
   | XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX 21 14|
   | XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX|
0.0|-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	12	5	7	10	22	11	9	6	26	29	19	39	20	8	27	13	2	21	14
12																			
5																			
7																			
10																			
22																			
11																			
9	X	X																	
6	X	X																	
26	X																		
29	X	X																	
19	X	X	X	X			X	X											
39	X	X	X				X												
20	X	X	X	X		X	X	X											
8	X	X	X	X		X	X	X											
27	X	X	X	X		X	X	X											
13	X	X	X	X	X	X	X	X											
2	X	X	X	X			X												
21	X	X	X	X	X	X	X	X		X	X	X	X	X					
14	X	X	X	X	X	X	X	X		X	X	X	X	X					
	12	5	7	10	22	11	9	6	26	29	19	39	20	8	27	13	2	21	14

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

Swainson's Thrush (*Hylocichla ustulata*)

Life History

The Swainson's Thrush occupies dense forest growth. It prefers forest interior rather than edge. It forages more in trees than does the Varied Thrush (Morse, 1972; Sealy, 1974). It eats mostly insects but takes much small fruit such as twinberries and salmonberries when in season (Guiguet, 1964). The nest is an open cup typically built low in an evergreen tree or bush (Godfrey, 1966).

Seral Stages

The Swainson's Thrush used 2 of the 6 seral stages (33%) at a relative level of 0.50 or more (Table 32). However, only 1 of the 6 seral stages (17%) rated 0.53 or more. Stage 4 was used significantly more than all other stages, at nearly twice the rating of the next highest stage. Stage 3 rated 0.52, significant over the remaining stages. Stages 6, 2 , 5, and 1 rated less than 0.33. Lakes (stage 7) rated 0.10, indicating little or no edge effect.

The map of seral stages provides criteria for managing the habitat of the Swainson's Thrush. High densities of the Thrush can be expected only in stage 4. Moderate densities can be expected in stage 3. This Thrush should benefit from logging activities once regeneration has advanced to these stages.

TABLE 32. SWAINSON'S THRUSH WITH SERAL STAGES

RELATIVE LEVEL OF USE OF TYPES

```
1.0|  4------------------|
   | XX                  |
   | XX                  |
   | XX                  |
   | XX                  |
.75|-XX------------------|
   | XX                  |
   | XX                  |
   | XX                  |
   | XX  3               |
0.5|-XX-XX---------------|
   | XX XX               |
   | XX XX               |
   | XX XX  6            |
   | XX XX XX  2         |
.25|-XX-XX-XX-XX  5------|
   | XX XX XX XX XX      |
   | XX XX XX XX XX  7   |
   | XX XX XX XX XX XX  1|
   | XX XX XX XX XX XX XX|
0.0|-XX-XX-XX-XX-XX-XX-XX|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	4	3	6	2	5	7	1
4							
3	X						
6	X	X					
2	X	X					
5	X	X					
7	X	X	X	X			
1	X	X	X				
	4	3	6	2	5	7	1

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

Vegetation Types

The Swainson's Thrush used 10 of the 14 vegetation types (71%) at a relative rate of 0.50 or more (Table 33). Types 12 and 11 stand out significantly higher in observed use than most of the remaining types. Types 7, 10, 9, 20, 5, 8, 21 and 6 have rated 0.68 to 0.50. All members of the group were used significantly more than the three lowest-rating types. Lakes (type 14) show no edge effect.

Associating soil moisture (Table 17) with types ordered by use reveals that the top six types are all wet to very wet types; while the eight types rating lowest are all medium-wet to dry types. Not all differences are significant, so the perfect grouping of wet types at the top is to some extent the result of chance. Nonetheless, many significant differences support the generalization that the Swainson's Thrush uses wet areas in preferences to dry areas.

The map of vegetation types should be a useful supplement to the map of seral stages for managing the habitat of Swainson's Thrush. Within medium-age seral stages the Thrush is selecting for vegetation types associated with high soil moisture. A map of soil moisture would likely be of similar value in managing this Thrush species.

TABLE 33. SWAINSON'S THRUSH WITH VEGETATION TYPES

RELATIVE LEVEL OF USE OF TYPES

```
1.0| 12-------------------------------------------------|
   | XX                                                 |
   | XX  11                                             |
   | XX  XX                                             |
   | XX  XX                                             |
.75|-XX-XX----------------------------------------------|
   | XX  XX   7                                         |
   | XX  XX XX  10   9                                  |
   | XX  XX XX  XX  XX  20   5                          |
   | XX  XX XX  XX  XX  XX  XX   8  21   6              |
0.5|-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX----------------------|
   | XX  XX XX  XX  XX  XX  XX  XX  XX  XX              |
   | XX  XX XX  XX  XX  XX  XX  XX  XX  XX  22          |
   | XX  XX XX  XX  XX  XX  XX  XX  XX  XX  XX  19      |
   | XX  XX XX  XX  XX  XX  XX  XX  XX  XX  XX  XX      |
.25|-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX 29-------------|
   | XX  XX XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX 27  |
   | XX  XX XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX XX 39  |
   | XX  XX XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX XX XX 13 |
   | XX  XX XX  XX  XX  XX  XX  XX  XX  XX  XX  XX  XX XX XX XX 14|
0.0|-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX-XX|
```

SIGNIFICANT DIFFERENCES IN USE OF TYPES (P=0.05)

	12	11	7	10	9	20	5	8	21	6	22	19	29	27	39	13	14
12																	
11																	
7																	
10	X																
9	X	X															
20	X	X															
5	X	X															
8	X	X															
21	X	X															
6	X	X															
22	X	X															
19	X	X	X	X	X	X	X	X	X	X							
29	X	X	X	X	X	X	X	X	X	X							
27	X	X	X	X	X	X	X	X	X	X							
39	X	X	X	X	X	X	X	X	X	X							
13	X	X	X	X	X	X	X	X	X	X		X					
14	X	X	X	X	X	X	X	X	X	X	X	X					
	12	11	7	10	9	20	5	8	21	6	22	19	29	27	39	13	14

"X" DENOTES COLUMN SIGNIFICANTLY GREATER THAN ROW

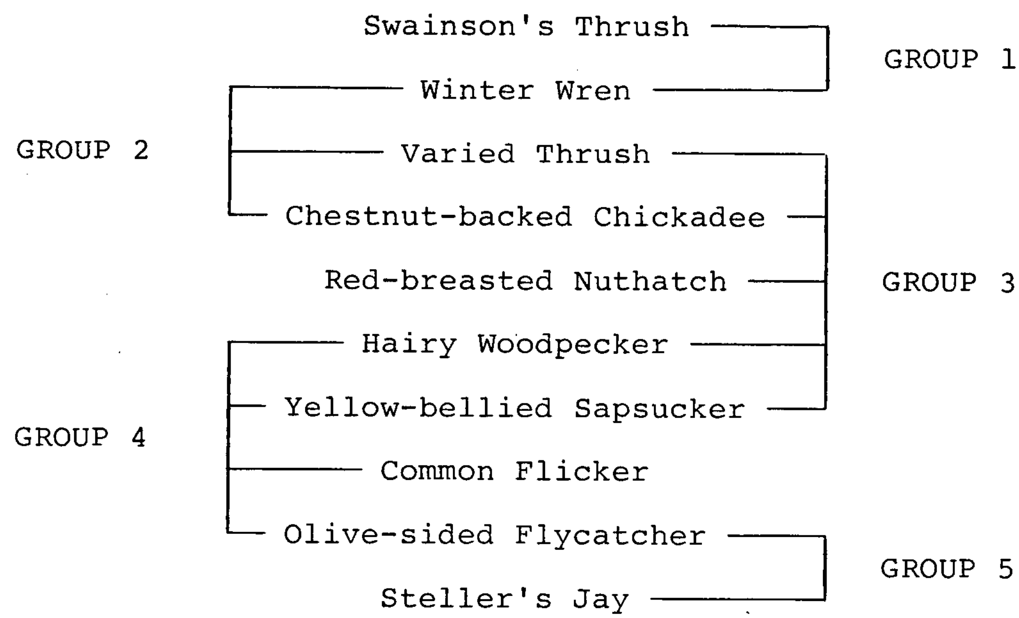
COMPARISONS BETWEEN BIRD SPECIES

The first section of this discussion presented the pattern of observed use of mapping types by each bird species. The patterns of use of seral stages by different bird species were compared in Table 13. Species with similar patterns of use are identified in Figure 18. Species are grouped in the figure if the ratio of contrasts to reinforcements for all comparisons between members of the group is less than or equal to 0.50. A species may be a member of more than one group. Five groups of species which use seral stages similarly were identified. The groups are discussed in order from top to bottom of Figure 18. The predicted abundance of each species will be valid only for those areas allowed to regenerate naturally or subjected to low-intensity forest management.

GROUP 1: The Swainson's Thrush and Winter Wren are similar in that they use medium age stage 4 heavily, and medium-young stage 3 and oldgrowth stage 6 moderately. They differ mainly in that the Wren also prefers mature stage 5, while the Thrush concentrates its use in middle age stages 4 and 3. Both species should prosper within their range in the Pacific Northwest as naturally regenerating clearcuts age to stages 3, 4 and 5. Both species should initially decline with logging, and begin to prosper as regeneration advances to stage 3.

FIGURE 18. Species with Similar Patterns of Use of Seral Stages

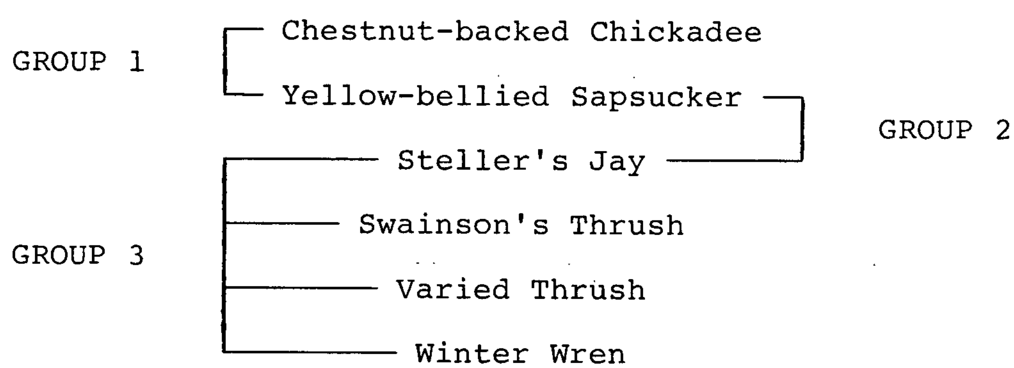
Grouping based on comparisons in Table 10.



Species joined by bar have a contrast to reinforcement ratio less than or equal to 0.50.

FIGURE 19. Species with Similar Patterns of Use Of Vegetation Types

Grouping based on comparisons in Table 11.



Species joined by bar have a contrast to reinforcement ratio less than or equal to 0.50.

GROUP 2: The Winter Wren, Varied Thrush and Chestnut-backed Chickadee show heavy use of stages 4, 5 and 6. The Thrush prefers older stages 5 and 6 equally over medium age stage 4; the Wren uses mature stage 5 the most with stage 4 second; while the Chickadee prefers oldgrowth stage 6 with stage 4 second. The species of GROUP 2 will not be abundant in areas recently logged. The Thrush and Chickadee should become abundant in their range as clearcuts age to stages 4 and 5, and in younger stages when older growth is nearby. The Wren should become abundant as clearcuts age to stage 3.

GROUP 3: The Chestnut-backed Chickadee, Varied Thrush, Red-breasted Nuthatch, Hairy Woodpecker and Yellow-bellied Sapsucker share a preference for mature stage 5 and oldgrowth stage 6. The Chickadee and Thrush also use stage 4 as discussed with GROUP 2. The Nuthatch prefers mature stage 5, while the Woodpecker and Sapsucker prefer oldgrowth stage 6. Reliance on the two oldest seral stages by the Nuthatch, Woodpecker and Sapsucker means that these species will suffer great declines in the Pacific Northwest as oldgrowth timber becomes increasingly rare. Regenerating forests will be of value to these species only if they are allowed to mature to stage 5 before harvest. Reserve areas of oldgrowth will help to preserve remnant populations.

GROUP 4: The Hairy Woodpecker and Yellow-bellied Sapsucker are grouped with Common Flicker and Olive-sided Flycatcher because of a common selection for older stages. However, the Woodpecker and Sapsucker are more restricted to older stages as discussed with GROUP 3, while the Flicker and Flycatcher also show heavy use of the youngest stages. The Flicker should be abundant in areas recently logged (stages 1 and 2) if it can find nesting snags within "commuting" distance. It will become less abundant as regenerating clearcuts age to stages 3, 4 and 5. The Flycatcher should abound in the three youngest stages if it can find a sufficient number of tall trees or snags on which to perch while feeding. It will become less abundant as regeneration advances to stage 4. The Flycatcher should be most abundant in logged areas containing many small patches of mature growth.

GROUP 5: The Olive-sided Flycatcher and Steller's Jay used most stages somewhat equally. The Flycatcher uses the older stages for perching, the younger stages for feeding, but is mostly excluded from medium age stage 4. The Jay nests in medium age stages and uses all stages for feeding. The Jay should remain abundant through logging of the old growth, perhaps increasing in abundance as clearcuts regenerate to stages 3 and 4.

The patterns of use of vegetation types were compared for different bird species in Table 14. Species with similar patterns are identified in Figure 19. Species are grouped if the ratios for all comparisons are less than 0.50. Three groups of species which use vegetation types similarly were identified. Groups are discussed in order from top to bottom of the figure:

GROUP 1: The Chestnut-backed Chickadee and Yellow-bellied Sapsucker are similar in their heavy use of types 5 and 20. They differ in the use of type 21, preferred by the Chickadee but used only moderately by the Sapsucker. However, the use of vegetation types by the Chickadee is well established for only a few types. The call of the Chickadee is not loud, so the area censused by sound from any station was relatively small. Fewer types were censused sufficiently often to be used in the analysis, and fewer significant differences were found between these. Both species use the trees in seral stage 4 for feeding. The Chickadee gleans insects from their foliage, while the Sapsucker taps the sap produced by the foliage. The preference for vegetation types 5 and 20 may be related to the selection of feeding trees.

GROUP 2: The Yellow-bellied Sapsucker and Steller's Jay show a common preference for types 6, 11 and 20. The reason for the preference, and the reasons for the similarity, are not apparent.

GROUP 3: The Steller's Jay, Swainson's Thrush, Varied Thrush and Winter Wren show a common preference for types 12, 9 and 6. The Jay differs in that it does not also show heavy use of types 5, 7 and 10; the Varied Thrush does not use types 8 and 20 heavily; while the Wren does not use type 11 as heavily as do the other three species of GROUP 3. Insects caught on the ground or in the underbrush form the major portion of the diet of each species during the spring census period. The nine vegetation types used heavily by three or all of the species may provide higher densities of insect food, but information is not available to evaluate this hypothesis. Six of the nine types used in common are associated with high soil moisture.

The grouping of species can be compared between maps by considering the six species for which patterns of selection were established for both seral stages and vegetation types. In three cases, two species were grouped together for both maps (Chestnut-backed Chickadee with Yellow-bellied Sapsucker, Swainson's Thrush with Winter Wren, and Varied Thrush with Winter Wren). In five cases, two species were not grouped together for either map (Chestnut-backed Chickadee with Steller's Jay, Chestnut-backed Chickadee with Swainson's Thrush, Yellow-bellied Sapsucker with Swainson's Thrush, Yellow-bellied Sapsucker with Varied Thrush, and Yellow-bellied Sapsucker with Winter Wren). There were two instances of two species grouped together for seral stages but not for vegetation types (Chestnut-backed Chickadee with Varied

Thrush and Chestnut-backed Chickadee with Winter Wren), and five instances of two species grouped for vegetation types but not for seral stages (Yellow-bellied Sapsucker with Steller's Jay, Steller's Jay with Swainson's Thrush, Steller's Jay with Varied Thrush, Steller's Jay with Winter Wren, and Swainson's Thrush with Varied Thrush).

COMPARISONS BETWEEN MAPPING TYPES

This section considers the use of mapping types by all bird species, looking for types that are used by many species and for types that are avoided by most species. The possibility that the bird species are selecting seral stages by age and vegetation types by soil moisture is evaluated. Seral stages are listed and defined in order of average use by all species in Table 34. Vegetation types are similarly listed and defined in Table 35.

Seral Stages

For each seral stage, Table 36 shows the bird species that used the type at a rate of 0.50 or more, and lists the average level of use of the type by all species calculated from tables in Appendix B. Bird species are ordered as they were grouped in Figure 18. Seral stages are ordered by decreasing age since logging or fire.

The average level of use could be used to rate seral stages for their value as wildlife habitat if a more representative sample of wildlife species had been included in the study. Instead, the results represent the value of each stage to a select group of forest bird species. Of the ten species related to seral stages, only the Swainson's Thrush and Steller's Jay do not show strong preference for the older stages. The census did not include species such as the White-crowned Sparrow and Rufus Hummingbird which were most abundant in the early seral stages.

Table 36 also summarizes the stages and number of stages

TABLE 34. Seral Stages Ordered by Average Use By All Species

Stage Number		Age	Age Examples Censused
used most	6	156 plus	approx. 250
	5	76 to 155	109, 137
	4	36 to 75	46, 51
	2	6 to 15	6, 7, ... 14, 15
	3	16 to 35	16, 17, 19, 20, 24
used least	1	1 to 5	2, 3, 4, 5

TABLE 35. Vegetation Types Ordered by Average Use By All Species

Vegetation Type		Soil Moisture and Topographic Position
used most	12	wet / along banks of larger streams and rivers
	5	medium / mid-slope on hillsides
	11	very wet / flat valley bottoms
	20	composite 9 and 11 / wet lower slopes and very wet valley bottoms
	6	dry to medium dry / hill shoulders and upper slopes
	9	wet / lower slopes receiving soil seepage and poorly drained
	10	wet to very wet / along banks of small creeks and fast flowing streams
	7	wet / patches on hillsides that accumulate soil seepage
	21	composite 6 and 8 / dry slopes and medium mid-slopes
	8	medium to medium wet / mid-slope hillsides receiving soil seepage but well drained
	19	composite 9 and 8 / wet lower slopes and medium mid-slopes
	22	composite 2 and 6 / very dry hill tops and dry upper slopes
	27	composite 8 and 6 / medium hillsides and dry upper slopes
used least	29	composite 8 and 9 / medium hillsides and wet lower slopes

Table 36. Use of Seral Stages by All Bird Species.

Bird species grouped by similarity
Seral stages ordered by decreasing age

Seral Stages		*STR	*WWR	*VTR	*CBC	RBN	HRY	*YBS	FLK	OSF	*SJY	Number of species using stage	Average level of use
		Species											
old	6		X	X	X	X	X	X	X	X	X	9	0.80
	5		X	X	X	X	X	X		X	X	8	0.73
	4	X	X	X							X	4	0.43
	3	X								X	X	3	0.43
	2								X	X	X	3	0.37
young	1								X	X	X	3	0.36
lakes	7											0	0.21
Number of stages used by species		2	3	3	2	2	2	2	3	5	6		

"*" Denotes species also related to vegetation types
"X" Indicates relative rating of 0.50 or more

Abbreviation of bird species names:

FLK Common Flicker
YBS Yellow-bellied Sapsucker
HRY Hairy Woodpecker
OSF Olived-sided Flycatcher
SJY Steller's Jay

CBC Chestnut-backed Chickadee
RBN Red-breasted Nuthatch
WWR Winter Wren
VTR Varied Thrush
STR Swainson's Thrush

used heavily by each species. The table shows how species with similar patterns of use were grouped using the contrast-to-reinforcement ratio as criteria for grouping. Scanning across the table from left to right, the preference of species shifts from medium age stages towards mature stages, then towards use of old and young stages, and finally to the use of all stages equally.

Vegetation Types

Many of the vegetation types were not sufficiently abundant in the area censused to provide a good sample. Types which received less than one hectare-hour of listening per round were not included in the analysis.

For each vegetation type, Table 37 shows the bird species that used the type at a rate of 0.50 or more, and lists the average level of use of the type by all species calculated from tables in Appendix C. Bird species are ordered as they were grouped in Figure 19. Vegetation types are ordered by decreasing level of typical soil moisture.

The average level of use could be used to rate vegetation types for their value as habitat to the six species studied. However, it is unlikely that these bird species provide a representative sample of the use by all wildlife species. Information on the relative use of vegetation types by a broader group of species is needed before a generalized index of wildlife use could be calculated.

Table 37 also summarizes the types and number of types

Table 37. Use of Vegetation Types by All Bird Species.

Vegetation types ordered by decreasing soil moisture.

Vegetation Types	Species: CBC	YBS	SJY	STR	VTR	WWR	Total Species	Average level of use
wet 11		X	X	X	X		4	0.63
20	X	X	X	X		X	5	0.60
10				X	X	X	3	0.51
9				X	X	X	3	0.53
12		X	X	X	X	X	5	0.78
7				X	X	X	3	0.49
19						X	1	0.40
29	-						0	0.29
8			X	X		X	3	0.41
5	X	X		X	X	X	5	0.76
27	-						0	0.29
21	X			X		X	3	0.46
6		X	X	X	X	X	5	0.53
dry 22					X		1	0.32
Number of types used 0.50 or more by species	3	5	5	10	8	10		

"X" Indicates a relative rating of 0.50 or more.

"-" Means type not censused sufficiently often.

Abbreviation of bird species names as in Table 36.

used heavily by each species. The table illustrates graphically the result of using the contrast-to-reinforcement ratios as criteria for grouping species that show similar patterns of use. Consider dividing the vegetation types into two equal groups according to soil moisture. At the left side of the table, the Chestnut-backed Chickadee used more dry types than wet types, while the species to the right used more wet types than dry types. The preference for sites associated with high levels of soil moisture may be common to many wildlife species, but it is not a general rule for all species. Even species that do appear to favour wet types also use many of the drier types. Drier types 5 and 6 were each used frequently by five of the six species. Also, the group selected as test species may be biased towards species that select for wet sites.

MANAGEMENT IMPLICATIONS

A map of seral stages is also a map of forest management activities if the only form of forest management is clearcut logging starting with an unbroken expanse of oldgrowth forest. This was true for the map of seral stages for the University of British Columbia Research Forest, with a few exceptions. Some areas of mature growth were originally burned by fires which escaped from early settlements in the valley below, regenerating vegetation was advanced in some areas by replanting coniferous trees, and retarded in others through soil destruction by large machinery used for log removal, or by slash burning. Most of the forest bird species studied were restricted to using certain seral stages. Thus the abundance of habitat for these species on the Research Forest depended mainly on the history of clearcut timber harvest in the area. The fate of these species depends mainly on plans for timber harvest in the future.

Consider dividing the land of the Research Forest into two classes: harvested areas committed to timber production which will be repeatedly harvested before reaching maturity; and areas which have not yet been clearcut and which support mature growth. The species of forest birds studied can similarly be divided into species that are found in young, timber-producing forests; and species that are restricted to using mature or oldgrowth forests. This study did not include a representative of the many species of migratory birds which return to regenerating clearcuts each year after the snow has melted. Habitat for these species has expanded greatly in the past twenty years. The Swainson's Thrush alone represents species which use only medium-age seral stages. Habitat for these species will become increasingly abundant over the next fifty years. The Winter Wren, Varied Thrush, Chestnut-backed Chickadee, and Yellow-bellied Sapsucker use medium-age seral stages although they prefer mature and oldgrowth stages. They have experienced a drastic decline in available habitat that will be only partially offset by advanced regeneration. Management for these species should include preserving mature or oldgrowth stands, and extending rotation lengths. Common Flicker and Olive-sided Flycatcher need elements of mature growth near areas recently clearcut. Preserving patches of oldgrowth forest spaced throughout areas harvested for timber should assure the abundance of both species. The Red-breasted Nuthatch and Hairy Woodpecker were excluded from areas managed for timber production. The only way to preserve these species is to preserve the mature and oldgrowth forest they require as habitat. The Steller's Jay is apparantly unaffected by clearcut timber harvest. The Jay did not show appreciable differences in use of seral stages and therefore cannot be managed by modifying plans for timber harvest.

The map of vegetation taxonomic units reflected the natural variation inherent to the study area by using plant species composition as an integrator over all factors which affect plant growth. All bird species related to vegetation types had definite preferences among the types as expressed by variation in observed density of calls from different mapping units. Thus two areas of equal size and of the same seral stage may not be of equal habitat value to a wildlife species if the areas contain examples of different vegetation units. For example, if an area of mature forest is to be preserved to provide habitat for a given wildlife species, then a map of vegetation types could provide criteria for selecting the best area of mature forest to preserve if use of vegetation mapping units has been documented for the species.

Forest managers choose vegetation types associated with rapid tree growth when they select areas of mature forest for harvest. These types are subsequently maintained in young and medium-age seral stages, while vegetation types associated with scrubby timber at higher elevations on rocky hillsides remain as oldgrowth. Strips of trees protecting lake edges and streamsides provide mature seral stage examples of vegetation types associated with wet valley bottoms, while small timber preserves and leave-strips provide mature examples of other types. Forest managers also alter the naturally-occurring pattern of vegetation types by their management activities. Soil destruction during road building, tree removal and slash burning may render an area unable to support the original community of plants; or plant species composition may be altered directly by planting crop tree species or by controlling the growth of competing herbs, shrubs and trees. With the change in vegetation there will be a change in the habitat value of the area for most species.

The results of this study suggest that managing habitat for groups of species might be a useful approach if groups with similar habitat relationships were identified. This approach differs from that presented by Thomas et al. (1976), in which 379 species were grouped into 16 life forms according to place of reproduction. For example, they grouped Yellow-bellied Sapsucker with Common Flicker but not with Chestnut-backed Chickadee; whereas evidence from this study showed the Sapsucker and Chickadee were more alike in their pattern of selection of seral stages than were the Sapsucker and Flicker (Table 13).

The results of this study support the general hypothysis that land resource maps can be used to predict the occurrence of wildlife. The occurrence of habitat for a wildlife species can be predicted over vast areas if the areas have been mapped and if one has documented significant differences in use by the species of the mapping units. The prediction can be improved by combining the predictions from two or more maps. If a wildlife species has special needs such as caves, cliffs, open water or nesting snags, then a map of areas within commuting distance of the special feature must be included. The actual presence of a species in its habitat must be determined by spot checking, as it may depend on such factors as pressure from hunters or predators, or on the occurrence of extreme weather conditions.

The predicted amount and spatial arrangement of habitat for a species can be compared with policy objectives to provide criteria for management. The amount of habitat lost or gained with projected plans for timber harvest can be predicted and checked for violation of wildlife management policy objectives. Future habitat availability can be predicted by simulating succession and applying projected forest management activities. The same maps can be used to predict the occurrence of habitat for many different wildlife species. Forest management activities can then be evaluated in terms of available habitat for each of any number of species. This study has provided habitat relationships for six wildlife species with two land resource maps. The data provide examples for developing and testing such a multi-species habitat management system.

SUMMARY

The study was directed towards evaluating the hypothesis that existing land resource maps could be used to predict the occurrence of habitat for many wildlife species, and thereby provide criteria for wildlife management. Forest birds were chosen as the subject wildlife species because of the ease with which birds could be detected and identified to species by their calls.

A rigorous technique for using the calls of birds to determine relative densities of birds in different areas was developed. The technique involved predicting the area censused from each listening station using a mathematical description of the landform and forest canopy around the station. A different area censused was predicted for each bird species and for different levels of background noise with each visit to the station. Bird calls were identified and located in the field during early morning visits to the listening stations. Locations of birds were described as areas within which the bird call must have originated.

The extent to which the areas of a map were censused was determined by intersecting the area censused from each station with each area of the map. The probable number of bird calls originating from within each area of the map was calculated by intersecting the areas of location from each station with the areas of the map. The resulting observed density of bird calls per hectare-hour of listening was used as an index of abundance. The results were summed over areas that were classified as the same mapping type, and the

probability that two mapping types were used at different levels was calculated for all comparisions between mapping types. The technique can use the same field observations with any number of different maps of the census area.

A series of nineteen computer programs were written in FORTRAN to implement the technique. One program was used to prepare a file containing descriptions of the listening stations. Two programs were used to prepare and simplify computer maps, including a map of forest canopy heights. Three programs were involved with using the map of canopy heights to prepare a description of the forest canopy around each station. Three programs were used to prepare, list and plot a three-dimensional landform grid or digital terrain model of the study area; while two programs used the terrain model to prepare a description of the landform around each listening station. One program combined the canopy height description with the landform description for each station to produce a three-dimensional description of the forest canopy around each listening station. A second program plotted cross sections of the combined landform and canopy descriptions for selected stations.

One program was written to check and order field observations which had been keypunched. Another program used the field data with the three-dimensional descriptions of landform and forest canopy to predict the area censused from each station for one species at at time, and to display the areas locating birds of the species by sound. Two programs intersected the areas censused and the areas of locations for each station with the areas of a computer map of land resources to determine the observed density of calls per hectare-hour of listening in each area of the map. One program summarized the results over areas mapped as the same type, and calculated the statistics used to evaluate differences in observed density between mapping types. The final program compared the results between two species or between repeated rounds of census for one species, and presented the results in graphical form.

The method was tested using the University of British Columbia Research Forest as the study area. A total of 163 listening stations were established. Each station was visited for fifteen minutes during each of six rounds of visits. The calls of ten species of birds were located when heard. Computer maps of seral stages and vegetation taxonomic units were prepared. Of the ten bird species related to seral stages, nine showed consistant patterns of selection, while the tenth species (Steller's Jay) was indescriminant of seral stages. All of the six bird species related to vegetation taxonomic units were consistent in their pattern of selection. The detection of consistent patterns both confirms the accuracy of the method by demonstrating repeatable results, and affirms the utility of using land resource maps as indicators of habitat occurrence by exposing the predictable nature of selection of mapping types by wildlife species.

The relationships of ten forest bird species with seral stages, and of six of those species with vegetation mapping units, have been documented for the spring season at the University of British Columbia Research Forest. Each species showed a unique pattern of selection of seral stages, but comparisons between species exposed five groups with similar patterns of selection (groups not mutually exclusive). All of the area mapped for vegetation types was at medium-age seral stage. Consequently the Hairy Woodpecker and Red-breasted Nuthatch, which were restricted to older seral stages, and the Common Flicker and Olived-sided Flycatcher, which used only the oldest and youngest stages, could not be related to vegetation types. Each of the remaining species showed a unique pattern of selection of vegetation types, with comparisons between species exposing three groups with similar patterns (groups not mutually exclusive). Bird species were grouped differently for seral stages than for vegetation types, although in three cases two species were grouped together both times.

Four of the six species related to both maps were more selective of seral stages than of vegetation types. The Yellow-bellied Sapsucker was most restricted by its dependency on older seral stages, Winter Wren and Varied Thrush by their need for medium to old stages, and Swainson's Thrush by its requirement for mediuum-age stages. Each of these species used many different vegetation types. By contrast, Steller's Jay concentrated its use on two vegetation types, while it used all seral stages at similar levels; and Chestnut-backed Chickadee was about equally selective of seral stages and vegetation types.

The results support the hypothesis that land resource maps can be used to predict the occurence of wildlife habitat over vast areas if the areas have been mapped and if significant differences in the habitat value of different mapping units have been documented. The results demonstrate that the prediction can be improved by using two or more maps. The available habitat for a species, predicted before and after applying proposed plans for timber management, can be compared with management objectives for the wildlife species to assess the impact of timber management. The same maps can be used for many wildlife species, thereby providing criteria for multi-species habitat management.

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APPENDIX A

LISTING OF COMPUTER PROGRAMS WRITTEN FOR THIS STUDY.

PROGRAMS PAGE

```
C   STOPREP
C   ROUTINE TO PREPARE STOP POINT INFORMATION ARRAY
C   READS FROM UNIT 3  WRITES ON UNIT 4
C   EXPECTS NEGATIVE STOP NUMBER TO END FILE
C   DEBUG OUTPUT ON UNIT 8
      DIMENSION STOPX(200),STOPY(200),STOPZ(200)
      CNVRTX=2.5189
      CNVRTY=2.5286
C   INPUT NUMBER OF STOPS
      READ(3,2)NSTOPS
 2    FORMAT(I4)
C   PREPARE THE ARRAY
      DO 4 I=1,200
 4    STOPX(I)=-9999.
C   OUTPUT HEADINGS
      WRITE(8,201)NSTOPS
 201  FORMAT(' STOPREP FOR',I5,' STOPS'//)
      WRITE(8,202)
 202  FORMAT('  STOP   EAST X   NORTH Y   ELEVATION Z'/)
C   LOOP OVER STOP POINTS
      DO 60 I=1,NSTOPS
 5    READ(3,6)ISTOP,IX,IY,IZ
 6    FORMAT(I4,2I5,I4)
      IST=ISTOP
      IF(IST.LT.0)IST=-IST
C   CONVERT X Y AND Z TO REAL
      X=IX
      Y=IY
      STOPZ(IST)=IZ
C   PREPARE RAISED ORIGIN IF ISTOP IS NEGATIVE
      ORIGX=0.0
      ORIGY=0.0
      IF(ISTOP.GT.0)GO TO 10
      ORIGX=0.0
      ORIGY=6000.0
C   CONVERT X AND Y TO METERS AND ADD RAISED ORIGIN
 10   STOPX(IST)=X*CNVRTX+ORIGX
      STOPY(IST)=Y*CNVRTY+ORIGY
C   STOP NOT USED IF IX IS NEGATIVE
      IF(IX.LT.0) STOPX(IST)=-999
C   DEBUG OUTPUT
      WRITE(8,50)IST,STOPX(IST),STOPY(IST),STOPZ(IST)
 50   FORMAT(I5,3F10.0)
 60   CONTINUE
C   OUTPUT RESULTING STOP POINT INFORMATION ARRAY
C   USING UNFORMATTED WRITE
 100  WRITE(4)NSTOPS,STOPX,STOPY,STOPZ
      STOP
      END
```

```
C   DIGFIX                  ***  MUST SET ORIGIN   ***
C   PROGRAM TO PLOT DIGITIZED OUTPUT AND
C   PREPARE EASILY USED METRIC POLYGON FILES
C   READS FROM UNIT 3  -  WRITES ON UNIT 4
C   MUST RUN PLOT.Q PAR=(BLANK) TO GET POLYS DRAWN
C   CONSECUTIVELY ON SMALL PAPER
      DIMENSION INCH(20),XMETER(400),YMETER(400)
      DIMENSION XINCH(400),YINCH(400)
C   ORIGIN INCREMENT WILL BE IN METERS FROM MAP ORIGIN
C   USE  0.0 ; 0.0 FOR LOGHIST1 + 2     0.0 ; 6000.0 FOR 3+4+5
C   USE  2000.0 ; 4000.0 FOR KL1 ... 11
      ORIGX=2000.0
      ORIGY=4000.0
C   CONVERSION FACTOR CHANGES DIGITIZER INCHES TO MAP METERS
      CNVRTX=251.89
      CNVRTY=252.86
      J=0
      XMIN=999.0
      XMAX=0.0
      YMIN=999.
      YMAX=0.0
C   INPUT ONE DIGITIZER OUTPUT LINE
 9    READ(3,10)INCH
 10   FORMAT(20I5)
C   INITIALIZE INPUT LINE POSITION COUNTER
      I=1
C   LOOP OVER POLYGON POINT COORDINATE PAIRS
 20   J=J+1
C   CHECK FOR END OF POLYGON
      IF(INCH(I).EQ.-9999)GO TO 60
C   CHECK FOR BLANKS
      IF(INCH(I).NE.0)GO TO 25
      J=J-1
      GO TO 30
C   SAVE POLY COORDINATES IN INCHES
 25   XINCH(J)=INCH(I)
      YINCH(J)=INCH(I+1)
C   CORRECT THE DECIMAL POINT
      XINCH(J)=XINCH(J)*0.01
      YINCH(J)=YINCH(J)*0.01
C   CONVERT TO MAP METERS AND INCREMENT FOR RAISED ORIGIN
      XMETER(J)=XINCH(J)*CNVRTX+ORIGX
      YMETER(J)=YINCH(J)*CNVRTY+ORIGY
C   CHECK FOR MAX AND MIN POINTS
      IF(XINCH(J).LT.XMIN)XMIN=XINCH(J)
      IF(XINCH(J).GT.XMAX)XMAX=XINCH(J)
      IF(YINCH(J).LT.YMIN)YMIN=YINCH(J)
      IF(YINCH(J).GT.YMAX)YMAX=YINCH(J)
```

```
C   INCREMENT INPUT LINE POSITION COUNTER
 30     I=I+2
C   CHECK FOR END OF INPUT LINE
        IF(I.GT.19)GO TO 9
        GO TO 20
C   CHECK FOR END OF FILE - NEGATIVE POLYGON NUMBER
 60     IF(INCH(I+1).LT.1)GO TO 100
C   END OF POLYGON
C   GET NUMBER OF POINTS
        NPT=J-1
C   DETERMINE MAX AND MIN IN METERS
        XMETN=XMIN*CNVRTX+ORIGX
        XMETX=XMAX*CNVRTX+ORIGX
        YMETN=YMIN*CNVRTY+ORIGY
        YMETX=YMAX*CNVRTY+ORIGY
C
C   OUTPUT POLYGON INFORMATION - METRIC
        WRITE(4)INCH(I+1),NPT,XMETN,XMETX,YMETN,YMETX
C   OUTPUT METRIC POLYGON COORDINATES
        CALL POLYWR(NPT,XMETER,YMETER)
C
C   PREPARE PLOT FILE - INCHES
        CALL POLYT(NPT,XINCH,YINCH,XMAX,XMIN,YMIN)
C
C   ZERO POLYGON POINT COUNTER
        J=0
C   PRESET POLYGON RANGE LIMITS
        XMIN=999.0
        XMAX=0.0
        YMIN=999.0
        YMAX=0.0
        GO TO 30
C
C   END OF INPUT FILE - PUT MARKER IN METRIC OUTPUT FILE
 100    NPOLY=-9999
        NPT=0
        WRITE(4)NPOLY,NPT,XMIN,XMAX,YMIN,YMAX
C   TERMINATE PLOT FILE
        CALL PLOTND
        STOP
        END
C
C
        SUBROUTINE POLYWR(NPT,XCOOR,YCOOR)
C   ROUTINE TO FIT AND OUTPUT ARRAY OF POINTS OF A POLYGON
        DIMENSION XCOOR(400),YCOOR(400),X200(200),Y200(200)
        DIMENSION X100(100),Y100(100),X50(50),Y50(50)
        DIMENSION X400(400),Y400(400),X25(25),Y25(25)
        EQUIVALENCE (X400(1),X200(1),X100(1),X50(1),X25(1))
        EQUIVALENCE (Y400(1),Y200(1),Y100(1),Y50(1),Y25(1))
        DO 5 I=1,NPT
        X400(I)=XCOOR(I)
 5      Y400(I)=YCOOR(I)
        IF(NPT.LE.200)GO TO 10
        WRITE(4)XCOOR,YCOOR
        GO TO 100
```

```
 10    IF(NPT.LE.100)GO TO 20
       WRITE(4)X200,Y200
       GO TO 100
 20    IF(NPT.LE.50)GO TO 30
       WRITE(4)X100,Y100
       GO TO 100
 30    IF(NPT.LE.25)GO TO 40
       WRITE(4)X50,Y50
       GO TO 100
 40    WRITE(4)X25,Y25
 100   RETURN
       END
C
C
       SUBROUTINE POLYT(NPT,XCOOR,YCOOR,XMAX,XMIN,YMIN)
C   ROUTINE TO PLOT POLYGONS CONSECUTIVELY - EACH SNUG TO AXIS
       DIMENSION XCOOR(400),YCOOR(400),X(400),Y(400)
C   TRANSLATE POLYGON SNUG TO AXIS
       DO 20 I=1,NPT
       X(I)=XCOOR(I)-XMIN
 20    Y(I)=YCOOR(I)-YMIN
C   PREPARE PLOT FILE
       CALL LINE(X,Y,NPT,1)
C   SHIFT THE ORIGIN
       XMOVE=XMAX-XMIN
       CALL PLOT(XMOVE,0.0,-3)
       RETURN
       END
```

```
C   POLYTHIN
C   ROUTINE TO THIN MAPPING TYPE POLYGONS AND GIVE AREAS
C   WRITTEN BY KIM SCOULLAR
C   READS POLYS ON 3  WRITES THINNED ONES ON 4
       DIMENSION AX(400),AY(400),BX(400),BY(400)
C   SET THINNING TOLERENCE     USED 10.0 FOR LH
       TOL= 5.0
C   SET CONVERSION FACTOR FOR PLOTTING
       CNVRT=1.0/252.4
C   INPUT ONE POLYGON
 10    CALL POLYRD(NA,AX,AY,NPOLY,XMIN,XMAX,YMIN,YMAX,IEND)
C   CHECK FOR END OF POLYGONS
       IF(IEND.EQ.1)GO TO 50
C   THIN THE POLYGON
       CALL THIN(AX,AY,NA,BX,BY,NB,TOL)
C   GET AREA OF THINNED POLYGON
       CALL AREA(BX,BY,NB,PAREA)
C***DEBUG  REMOVE (COMMENT) THE PLOTS
C   PLOT THE ORIGINAL POLYGON
C      CALL PLOT((AX(NA)-XMIN)*CNVRT,(AY(NA)-YMIN)*CNVRT,3)
C      DO 60 I=1,NA
C60    CALL PLOT((AX(I)-XMIN)*CNVRT,(AY(I)-YMIN)*CNVRT,2)
C   MOVE THE ORIGIN
C      CALL MAXMX(XMX)
C      CALL PLOT(XMX+0.5,0.0,-3)
C   PLOT THE THINNED POLYGON
C      CALL PLOT((BX(NB)-XMIN)*CNVRT,(BY(NB)-YMIN)*CNVRT,3)
C      DO 70 I=1,NB
C70    CALL PLOT((BX(I)-XMIN)*CNVRT,(BY(I)-YMIN)*CNVRT,2)
C   MOVE THE ORIGIN
C      CALL MAXMX(XMX)
C      CALL PLOT(XMX+0.5,0.0,-3)
C   OUTPUT THE POLYGON
 50    CALL POLYWR(NB,BX,BY,NPOLY,XMIN,XMAX,
      1     YMIN,YMAX,PAREA,IEND)
C   OUTPUT NUMBER OF POINTS BEFORE AND AFTER THINNING AND AREA
       PHAREA=PAREA/10000.0
       WRITE(8,80)NPOLY,NA,NB,PHAREA
 80    FORMAT(' POLY',I6,5X,'BEFORE',I8,5X,'THINNED',I8,
      15X,'AREA',F7.2,' HECTARES')
C   LOOP OVER POLYGONS
       IF(IEND.EQ.0)GO TO 10
C      CALL PLOTND
       STOP
       END
C
C
       SUBROUTINE THIN(AX,AY,NA,BX,BY,NB,TOL)
C   ROUTINE TO KEEP ONLY POINTS NECCESSARY TO SHAPE OF POLYGON
C   WRITTEN BY KIM SCOULLAR
       DIMENSION AX(NA),AY(NA),BX(NA),BY(NA),KEEP(400)
```

```
C  ZERO THE KEEP ARRAY
      NM=NA-1
      DO 10 I=2,NM
 10   KEEP(I)=0
C  KEEP FIRST AND LAST POINTS OF POLYGON
      KEEP(1)=1
      KEEP(NA)=1
C  PRESET VALUE OF COUNTER FOR NEXT POINT IN LOOP
C  OVER PAIRS OF POINTS TO BE KEPT
 12   INEXT=1
      MOVE=0
C
C  LOOP OVER PAIRS OF POINTS TO BE KEPT
C  UPDATE PRESENT COUNTER
 15   ITHIS=INEXT
C  GET NEXT POINT OF POINTS TO BE KEPT
 17   INEXT=INEXT+1
      IF(INEXT.GT.NA)GO TO 35
      IF(KEEP(INEXT).EQ.0)GO TO 17
C  IF POINTS ARE ADJACENT, NEED NOT CHECK BETWEEN
      IF(INEXT.EQ.ITHIS+1)GO TO 15
C  PRESET LENGTH AND POINT NUMBER OF LONGEST SO FAR
      BIGEST=-1.0
      LONG=0
C  CHECK FOR SLOPE OF KEEP LINE UNDEFINED -IS LINE VERTICAL
      IF(AX(INEXT).NE.AX(ITHIS))GO TO 19
      SLP=9999999.
      GO TO 20
C  GET SLOPE OF KEEP LINE
 19   SLP=(AY(INEXT)-AY(ITHIS))/(AX(INEXT)-AX(ITHIS))
C  CHECK FOR PERPENDICULAR SLOPE UNDEFINED
 20   IF(SLP.NE.0)GO TO 21
      PSLP=9999999.
      GO TO 22
C  GET SLOPE OF PERPENDICULAR LINES
 21   PSLP=-1.0/SLP
C  GET CONSTANT FOR EQUATION OF KEEP LINE
 22   CKEEP=AY(ITHIS)-SLP*AX(ITHIS)
C  LOOP OVER POINTS BETWEEN THOSE TO BE KEPT
      ITP=ITHIS+1
      INM=INEXT-1
      DO 25 IP=ITP,INM
C  GET CONSTANT FOR EQUATION OF TEST LINE
      CTEST=AY(IP)-PSLP*AX(IP)
C  GET INTERCEPT POINT COORDINATES
      XINT=(CTEST-CKEEP)/(SLP-PSLP)
      YINT=SLP*XINT+CKEEP
C  GET LENGTH OF TEST SEGMENT
      TLENG=SQRT((AX(IP)-XINT)**2+(AY(IP)-YINT)**2)
C  CHECK FOR THIS BEING THE LONGEST SO FAR
      IF(TLENG.LT.BIGEST)GO TO 25
C  UPDATE LENGTH OF LONGEST SO FAR
      BIGEST=TLENG
      LONG=IP
 25   CONTINUE
C
```

```
C   KEEP THE POINT WITH THE GREATEST DISTANCE
C   IF THE TOLERENCE HAS BEEN EXCEEDED
        IF(BIGEST.LT.TOL)GO TO 15
        KEEP(LONG)=1
        MOVE=1
        GO TO 15
C
C   CHECK FOR AT LEAST ONE BEING KEPT THIS ROUND
 35     IF(MOVE.EQ.0)GO TO 45
        GO TO 12
C
C   TRANSFER POINTS TO BE KEPT
 45     J=0
        DO 50 I=1,NA
        IF(KEEP(I).EQ.0)GO TO 50
        J=J+1
        BX(J)=AX(I)
        BY(J)=AY(I)
 50     CONTINUE
C   TRANSFER NEW POLYGON SIZE
        NB=J
        RETURN
        END
C
C
        SUBROUTINE POLYWR(NPT,XCOOR,YCOOR,NPOLY,XMIN,XMAX,
      1       YMIN,YMAX,PAREA,IEND)
C   ROUTINE TO FIT AND OUTPUT ARRAY OF POINTS OF A POLYGON
        DIMENSION XCOOR(400),YCOOR(400),X200(200),Y200(200)
        DIMENSION X100(100),Y100(100),X50(50),Y50(50)
        DIMENSION X400(400),Y400(400),X25(25),Y25(25)
        EQUIVALENCE (X400(1),X200(1),X100(1),X50(1),X25(1))
        EQUIVALENCE (Y400(1),Y200(1),Y100(1),Y50(1),Y25(1))
C   CHECK FOR IEND=1  SIGNEL TO END FILE
        IF(IEND.EQ.1)GO TO 100
C   OUTPUT INFORMATION FOR THIS POLYGON
        WRITE(4)NPOLY,NPT,XMIN,XMAX,YMIN,YMAX,PAREA
C
        DO 5 I=1,NPT
        X400(I)=XCOOR(I)
 5      Y400(I)=YCOOR(I)
        IF(NPT.LE.200)GO TO 10
        WRITE(4)XCOOR,YCOOR
        RETURN
 10     IF(NPT.LE.100)GO TO 20
        WRITE(4)X200,Y200
        RETURN
 20     IF(NPT.LE.50)GO TO 30
        WRITE(4)X100,Y100
        RETURN
 30     IF(NPT.LE.25)GO TO 40
        WRITE(4)X50,Y50
        RETURN
 40     WRITE(4)X25,Y25
        RETURN
```

```
C   END THE FILE
 100    NPOLY=-9999
        NPT=0
        WRITE(4)NPOLY,NPT,XMIN,XMAX,YMIN,YMAX,PAREA
        RETURN
        END
C
C
        SUBROUTINE POLYRD(NPT,XCOOR,YCOOR,NPOLY,XMIN,XMAX,
      1      YMIN,YMAX,IEND)
C   ROUTINE TO INPUT METRIC POLYGON FILES - READS FROM 9
C   END OF FILE CAUSES IEND=1 TO BE RETURNED
        DIMENSION XCOOR(400),YCOOR(400),X25(25),Y25(25)
        DIMENSION X400(400),Y400(400),X200(200),Y200(200)
        DIMENSION X100(100),Y100(100),X50(50),Y50(50)
        EQUIVALENCE (X400(1),X200(1),X100(1),X50(1),X25(1))
        EQUIVALENCE (Y400(1),Y200(1),Y100(1),Y50(1),Y25(1))
        IEND=0
        READ(3) NPOLY,NPT,XMIN,XMAX,YMIN,YMAX
C   CHECK FOR END OF FILE
        IF(NPOLY.LT.1)GO TO 100
C   FIT POLYGON INTO SMALLEST POSSIBLE ARRAY
        IF(NPT.LE.200)GO TO 20
        READ(3)X400,Y400
        GO TO 60
 20     IF(NPT.LE.100)GO TO 30
        READ(3)X200,Y200
        GO TO 60
 30     IF(NPT.LE.50)GO TO 40
        READ(3)X100,Y100
        GO TO 60
 40     IF(NPT.LE.25)GO TO 50
        READ(3)X50,Y50
        GO TO 60
 50     READ(3)X25,Y25
 60     DO 70 I=1,NPT
        XCOOR(I)=X400(I)
 70     YCOOR(I)=Y400(I)
        RETURN
 100    IEND=1
        RETURN
        END
C
C
        SUBROUTINE AREA(X,Y,N,PAREA)
C   ROUTINE TO FIND THE AREA OF POLYGON X,Y WITH N POINTS
C   AREA BY COORDINATES - DAVIS AND FOOT  SURVEYING
        DIMENSION X(N),Y(N)
        PAREA=Y(1)*(X(N)-X(2))
        M=N-1
        DO 5 I=2,M
 5      PAREA=PAREA+Y(I)*(X(I-1)-X(I+1))
        PAREA=PAREA+Y(N)*(X(N-1)-X(1))
        PAREA=ABS(0.5*PAREA)
        RETURN
        END
```

```
C   FJ RAXINIT
C   PROGRAM TO INITIALIZE A FOREST AXIS FILE
C
C   WRITTEN BY KIM SCOULLAR
C
C   READS STOP POINTS FROM UNIT 3 - WRITES ON UNIT 4
      DIMENSION AXD1(25,16),AXD2(25,16),NPOLY(25,16)
C***DEBUG  STOP ARRAYS SHOULD BE (200)
      DIMENSION STOPX(200),STOPY(200),STOPZ(200)
C   INPUT THE STOP POINT FILE
      READ(3) NSTOPS,STOPX,STOPY,STOPZ
C   LOOP OVER STOPS
      DO 80 I=1,NSTOPS
C   CHECK FOR UNUSED STOPS
      IF(STOPX(I).LT.0.0)GO TO 80
C   PRESET AXIS VALUES FOR THIS STOP
C   LOOP OVER AXIS
      DO 40 J=1,16
C   LOOP OVER TYPES
      DO 30 K=1,25
C   ZERO THE VALUES
      AXD1(K,J)=0.0
      AXD2(K,J)=0.0
 30   NPOLY(K,J)=0
 40   CONTINUE
C   OUTPUT THE PREPARED ARRAYS
      WRITE(4)AXD1,AXD2,NPOLY
 80   CONTINUE
      STOP
      END
```

```
C   FORAXUPD
C   PROGRAM TO UPDATE FOREST AXIS FILE BY INTERSECTING AXIS
C   WITH ONE FOREST CANOPY-HEIGHT POLYGON FILE
C   WRITTEN BY KIM SCOULLAR
C   READS FOREST TYPE POLYGONS FROM 5   READS FOREST AXIS ON 7
C   READS STOP POINTS ON 3   WRITES NEW FOREST AXIS ON 4
C   TEMPORARY DEBUG OUTPUT ON UNIT 8
      DIMENSION STOPX(200),STOPY(200),STOPZ(200),XINT(30)
      COMMON AXD1(25,16),AXD2(25,16),NPOLY(25,16)
      DIMENSION XRINC(16),YRINC(16),IAXQAD(16),AXANGL(16)
      DIMENSION XCOOR(400),YCOOR(400),XPOLY(8000),YPOLY(8000)
      DIMENSION NPOLYS(60),NPTS(60),XMINS(60),XMAXS(60)
      DIMENSION YMAXS(60),NSIDE(30),YINIT(30),ISTART(60)
      DIMENSION YMINS(60)
      DATA IAXQAD/1,1,1,1,1,4,4,4,4,3,3,3,3,2,2,2/
      DATA AXANGL/0.0,22.5,45.0,67.5,90.0,67.5,45.0,22.5,0.0,
     122.5,45.0,67.5,90.0,67.5,45.0,22.5/
C   INPUT STOP POINT FILE
      READ(3) NSTOPS,STOPX,STOPY,STOPZ
C   PREPARE THE ARRAY OF POLYGONS
C   ZERO THE COUNTERS
      IP=0
      KP=0
C   LOOP OVER POLYGONS
 5    KP=KP+1
C   INPUT ONE POLYGON
      CALL POLYRD(NPT,XCOOR,YCOOR,NPOL,XMIN,XMAX,YMIN,YMAX,
     1      PAREA,IEND)
C   CHECK FOR END OF POLYGONS
      IF(IEND.EQ.1)GO TO 50
C   LOOP OVER POINTS IN POLYGON
      DO 10 K=1,NPT
C   PREPARE THE ARRAYS
      XPOLY(IP+K)=XCOOR(K)
 10   YPOLY(IP+K)=YCOOR(K)
C   PREPARE ARRAYS OF POLYGON INFORMATION
      ISTART(KP)=IP+1
      NPOLYS(KP)=NPOL
      NPTS(KP)=NPT
      XMINS(KP)=XMIN
      XMAXS(KP)=XMAX
      YMINS(KP)=YMIN
      YMAXS(KP)=YMAX
C   INCREMENT POSITION COUNTER
      IP=IP+NPT
      GO TO 5
C   ON ENDFILE SET NUMBER OF POINTS EQUAL ZERO
 50   NPTS(KP)=0
```

```
C   PREPARE REMOTE POINT INCREMENT FOR ANY STOP
C   TO USE SIMPLY ADD TO STOP POINT
        DO 7 INC=1,16
 7      CALL QAD(0.0,0.0,IAXQAD(INC),AXANGL(INC),1200.0,
       1       XRINC(INC),YRINC(INC))
C   UPDATE FOREST AXIS
C   LOOP OVER STOPS
        DO 80 IST=1,NSTOPS
C   CHECK FOR UNUSED STOP
        IF(STOPX(IST).LT.0.0)GO TO 80
C   INPUT FOREST AXIS FOR THIS STOP
        READ(7) AXD1,AXD2,NPOLY
C   INITIALIZE POLYGON COUNTER
        KP=0
C   LOOP OVER FOREST TYPE POLYGONS
 9      KP=KP+1
C   CHECK FOR END OF POLYGONS
        IF(NPTS(KP).EQ.0)GO TO 70
C   SELECT FOR POLYGONS WITHIN RANGE OF THE STOP POINT
C   REJECT THOSE OUTSIDE THE RANGE
        RANGE=1200.0
        IF(XMINS(KP).GT.STOPX(IST)+RANGE)GO TO 60
        IF(XMAXS(KP).LT.STOPX(IST)-RANGE)GO TO 60
        IF(YMINS(KP).GT.STOPY(IST)+RANGE)GO TO 60
        IF(YMAXS(KP).LT.STOPY(IST)-RANGE)GO TO 60
C   POLYGON WITHIN RANGE HAS BEEN FOUND
C   LOOP OVER AXIS
        DO 42 IAX=1,16
C   INTERSECT AXIS WITH POLYGON
        CALL VECPLY(STOPX(IST),STOPY(IST),XPOLY(ISTART(KP)),
       1YPOLY(ISTART(KP)),NPTS(KP),STOPX(IST)+XRINC(IAX),
       1STOPY(IST)+YRINC(IAX),XINT,YINT,NSIDE,NINT,INOUT)
C   INSERT RESULT INTO ARRAYS
C   DID INTERSECTION OCCUR
        IF(NINT.EQ.0)GO TO 42
C   FIND FIRST EMPTY POSITION IN ARRAYS
        IAR=0
 23     IAR=IAR+1
        IF(IAR.GT.25)GO TO 24
        IF(NPOLY(IAR,IAX).EQ.0)GO TO 25
        GO TO 23
 24     CALL SPACE(IST,IAX,IAR)
C   STORE DISTANCE BOUNDS DEFINING LINE SEGMENTS INSIDE
C   WAS STOP POINT OUTSIDE THE POLYGON
 25     IF(INOUT.NE.-1)GO TO 31
C   FIRST POINT IN ARRAYS STARTS PAIR OF BOUNDS
        L=1
        GO TO 39
C   WAS STOP POINT INSIDE POLYGON
 31     IF(INOUT.NE.1)GO TO 32
C   STOP POINT IS FIRST DISTANCE, BUT CALL IT ONE METER
        AXD1(IAR,IAX)=1.
C   SECOND BOUND ON FIRST SEGMENT IS FIRST POINT IN ARRAYS
        CALL SEGLTH(STOPX(IST),STOPY(IST),XINT(1),YINT(1),
       1AXD2(IAR,IAX))
        NPOLY(IAR,IAX)=NPOLYS(KP)
```

```
      IAR=IAR+1
      IF(IAR.GT.25)CALL SPACE(IST,IAX,IAR)
      L=2
      GO TO 39
C  POINT WAS ON LINE
C  WAS STOP POINT ON LINE HEADING IN - EVEN NUMBER OF POINTS
 32   IF(NINT/2*2.NE.NINT) GO TO 33
C  STOP POINT IS FIRST DISTANCE, BUT CALL IT ONE METER
      AXD1(IAR,IAX)=1.
C  SECOND BOUND ON FIRST SEGMENT IS SECOND POINT IN ARRAYS
      CALL SEGLTH(STOPX(IST),STOPY(IST),XINT(2),YINT(2),
     1AXD2(IAR,IAX))
      NPOLY(IAR,IAX)=NPOLYS(KP)
      IAR=IAR+1
      IF(IAR.GT.25)CALL SPACE(IST,IAX,IAR)
      L=3
      GO TO 39
C  POINT ON LINE HEADING OUT-START SECOND POINT IN ARRAYS
 33   L=2
C  STORE REMAINING DISTANCE BOUNDS
 39   DO 41 I=L,29,2
C  CHECK FOR END OF INTERSECTIONS
      IF(I+1.GT.NINT)GO TO 42
      CALL SEGLTH(STOPX(IST),STOPY(IST),XINT(I),YINT(I),
     1AXD1(IAR,IAX))
      CALL SEGLTH(STOPX(IST),STOPY(IST),XINT(I+1),YINT(I+1),
     1AXD2(IAR,IAX))
      NPOLY(IAR,IAX)=NPOLYS(KP)
      IAR=IAR+1
      IF(IAR.GT.25)CALL SPACE(IST,IAX,IAR)
 41   CONTINUE
 42   CONTINUE
 60   GO TO 9
C  OUTPUT THE ARRAYS FOR THIS STOP
 70   WRITE(4)AXD1,AXD2,NPOLY
C     DO 79 KAX=1,16
C     WRITE(8,71)  IST,KAX
C71   FORMAT(2I8)
C     WRITE(8,72) (AXD1(KAR,KAX),KAR=1,20)
C     WRITE(8,72) (AXD2(KAR,KAX),KAR=1,20)
C72   FORMAT(20F6.0)
C     WRITE(8,73) (NPOLY(KAR,KAX),KAR=1,20)
C73   FORMAT(20I6)
      WRITE(8,75)IST
 75   FORMAT(' FORAX UPDATED FOR STOP',I5)
 80   CONTINUE
      STOP
      END
C
C
      SUBROUTINE SPACE(IST,IAX,IAR)
C  ROUTINE TO PUT FARTHEST SEGMENT IN LAST POSITION
      COMMON AXD1(25,16),AXD2(25,16),NPOLY(25,16)
C  IS LAST POSITION ALREADY CLEAR
      IF(NPOLY(25,IAX).EQ.0)GO TO 25
```

```
C   FIND THE FARTHEST
        IBIG=1
        DO 7 I=2,25
 7      IF(AXD1(I,IAX).GT.AXD1(IBIG,IAX))IBIG=I
C   IS FARTHEST AT THE END ALREADY
        IF(IBIG.EQ.25)GO TO 25
C   SAVE FARTHEST TEMPORARILY
        TEMPD1=AXD1(IBIG,IAX)
        TEMPD2=AXD2(IBIG,IAX)
        TEMPLY=NPOLY(IBIG,IAX)
C   PUT END ONE WHERE FARTHEST IS
        AXD1(IBIG,IAX)=AXD1(25,IAX)
        AXD2(IBIG,IAX)=AXD2(25,IAX)
        NPOLY(IBIG,IAX)=NPOLY(25,IAX)
C   PUT FARTHEST IN LAST POSITION
        AXD1(25,IAX)=TEMPD1
        AXD2(25,IAX)=TEMPD2
        NPOLY(25,IAX)=TEMPLY
C   SET IAR FOR LAST POSITION
 25     IAR=25
C   OUTPUT A MESSAGE
        WRITE(6,30)IST,IAX
 30     FORMAT(' MAKE SPACE   STOP',I4,'    AXIS',I4)
        RETURN
        END
C
C
        SUBROUTINE POLYRD(NPT,XCOOR,YCOOR,NPOLY,XMIN,XMAX,
       1      YMIN,YMAX,PAREA,IEND)
C   ROUTINE TO INPUT METRIC POLYGON FILES - READS FROM 5
C   END OF FILE CAUSES IEND=1 TO BE RETURNED
        DIMENSION XCOOR(400),YCOOR(400),X25(25),Y25(25)
        DIMENSION X400(400),Y400(400),X200(200),Y200(200)
        DIMENSION X100(100),Y100(100),X50(50),Y50(50)
        EQUIVALENCE (X400(1),X200(1),X100(1),X50(1),X25(1))
        EQUIVALENCE (Y400(1),Y200(1),Y100(1),Y50(1),Y25(1))
        IEND=0
        READ(5) NPOLY,NPT,XMIN,XMAX,YMIN,YMAX,PAREA
C   CHECK FOR END OF FILE
        IF(NPOLY.LT.1)GO TO 100
C   FIT POLYGON INTO SMALLEST POSSIBLE ARRAY
        IF(NPT.LE.200)GO TO 20
        READ(5)X400,Y400
        GO TO 60
 20     IF(NPT.LE.100)GO TO 30
        READ(5)X200,Y200
        GO TO 60
 30     IF(NPT.LE.50)GO TO 40
        READ(5)X100,Y100
        GO TO 60
 40     IF(NPT.LE.25)GO TO 50
        READ(5)X50,Y50
        GO TO 60
 50     READ(5)X25,Y25
```

```
 60     DO 70 I=1,NPT
        XCOOR(I)=X400(I)
 70     YCOOR(I)=Y400(I)
        RETURN
 100    IEND=1
        RETURN
        END
C
C
        SUBROUTINE QAD(PT1X,PT1Y,IQUAD,ANGLE,DIST,PT2X,PT2Y)
C   DETERMINE THE COORDINATES OF A POINT
C   GIVEN ANGLE, QUADRATE AND DISTANCE FROM A GIVEN POINT
C   CONVERT DISTANCE TO REAL AND ANGLE TO RADIANS
        RANGLE=ANGLE*0.01745
C   DETERMINE X COORDINATE FROM ZERO
        PT2X=DIST*SIN(RANGLE)
        IF(IQUAD.EQ.2.OR.IQUAD.EQ.3) PT2X=-PT2X
C   DETERMINE Y COORDINATE FROM ZERO
        PT2Y=DIST*COS(RANGLE)
        IF(IQUAD.EQ.3.OR.IQUAD.EQ.4) PT2Y=-PT2Y
C   ADD COORDINATES FROM ZERO TO STARTING POINT
        PT2X=PT2X+PT1X
        PT2Y=PT2Y+PT1Y
        RETURN
        END
C
C
        SUBROUTINE SEGLTH(PTA1,PTA2,PTB1,PTB2,RLTH)
C   FIND THE LENGTH OF A LINE SEGMENT DEFINED BY TWO POINTS
        IF(PTA1.EQ.PTB1.AND.PTA2.EQ.PTB2)GO TO 5
C   DETERMINE LENGTH - HYPOTENUES OF RIGHT TRIANGLE
        RLTH=SQRT((PTB1-PTA1)**2+(PTB2-PTA2)**2)
        RETURN
 5      RLTH=0.0
        RETURN
        END
C
C
        SUBROUTINE VECPLY(PX,PY,XX,YY,N,XVECT,YVECT,
       1XINT,YINT,NSIDE,NINT,INOUT)
C   INTERSECTS A VECTOR WITH A POLYGON
C   USES INTEGER COMPARISON - DOES NOT DETECT NARROW CROSSINGS
        INTEGER NSIDE(30),SDINT,SLENG,SXK,IFIX
        INTEGER SXP,SYP,SXI,SYI,SXJ,SYJ,SCEPT
        REAL*4 XLENG, XVECT, YVECT, XINT(30), YINT(30)
        REAL*4 VCOS,VSIN,XVEC,YVEC,CEPT,PXKJ,TEMP,FLOAT
        REAL*4 XX(N),YY(N),XP,YP,XI,YI,XJ,YJ,PXIJ,PXKJ
        REAL*4 PX,PY,XIS,YIS,XJS,YJS,XK,YKS,XKS,PYIJ,SQRT
C    ****************************************************
C    *
C    *   WRITTEN BY DALE TROYER
C    *   MODIFIED BY KIM SCOULLAR
C    *  THIS VERSION RETURNS ONLY ONE POINT FOR EACH CROSSING
C    *
```

```
C    *  PIP DETERMINES IF A POINT IS INSIDE OR OUTSIDE OF *
C    *  A POLYGON.
C    *  THE POINT IN QUESTION IS (PX, PY).
C    *  THE POLYGON IS DEFINED BY ARRAY OF COORDINATE PAIRS
C    *  XX AND YY.
C    *  N IS THE NUMBER OF POINTS IN XX AND YY.
C    *  INOUT IS SET TO 1 IF THE POINT IS INSIDE THE POLYGON.
C    *  INOUT IS SET TO -1 IF POINT IS OUTSIDE THE POLYGON.
C    *  INOUT SET TO 0  IF POINT PX PY IS ON A BOUNDARY LINE.
C    *  XVECT, YVECT DEFINES VECTOR ON WHICH TEST IS MADE.
C    *  XVECT, YVECT CAN BE ANY COODINATE NOT = TO PX, PY.
C    *  XINT, YINT ARE THE POINTS AT WHICH POLYGON INTERSECTS
C    *  THE SEGMENT DEFINED BY THE TWO POINTS.
C    *  VECTOR STARTS AT POINT PX,PY ; CONTINUES TO INFINITY.
C    *  NSIDE IS SIDE NUMBER ON WHICH INTERSECTION OCCURRED.
C    *  IF VECTOR INTERSECTS MORE THAN 1 SIDE INTERSECTIONS
C    *  ARE SORTED SUCH THAT THE INTERSECTIONS NEAREST
C    *  PX,PY ON THE VECTOR COME FIRST.
C    *  THE INTERSECTION FARTHEST FROM PX,PY ALONG
C    *  THE VECTOR WILL BE LAST.
C    *
C    ********************************************************
C
C    ********************************************************
C    * THE POLYGON IS TRANSLATED SUCH THAT THE POINT PX,PY IS
C    * AT THE ORIGIN BY SUBTRACTING PX,PY FROM EVERYTHING.
C    * THE  POLYGON IS THEN ROTATED SUCH THAT THE VECTOR
C    * DEFINED BY XVECT YVECT LIES ON THE Y AXIS.
C    * THIS IS DONE INITIALLY FOR THE FIRST TWO SIDES
C    * AND FOR EACH SIDE AFTER 1 AT A TIME.
C    * THIS AVOIDS STORING POLYGON (WHICH MAY BE LARGE) TWICE.
C    *
C    * WE FIRST ASSUME THE POINT IS OUTSIDE.
C    *
C    ********************************************************
C
      XVEC = XVECT - PX
      YVEC = YVECT - PY
      XLENG = SQRT(XVEC*XVEC+YVEC*YVEC)
      VSIN = XVEC / XLENG
      VCOS = YVEC / XLENG
      NINT = 0
      XIS=XX(1)  - PX
      YIS=YY(1)  - PY
      XJS=XX(2)  - PX
      YJS=YY(2)  - PY
      XI = XIS * VCOS - YIS * VSIN
      YI = XIS * VSIN + YIS * VCOS
C
      XJ = XJS * VCOS - YJS * VSIN
      YJ = XJS * VSIN + YJS * VCOS
      J=2
      INOUT=-1
      SXI=2.0*XI-FLOAT(IFIX(XI))
      IF(SXI.NE.0)GO TO 32
```

```
C  POLYGON STARTS ON VECTOR - WHICH SIDE DOES IT COME FROM
      K=N+1
 30   K=K-1
      XKS=XX(K)-PX
      YKS=YY(K)-PY
      XK=XKS*VCOS-YKS*VSIN
      SXK=2.0*XK-FLOAT(IFIX(XK))
      IF(SXK.EQ.0)GO TO 30
C
C   *****************************************************
C   *
C   * THE PROGRAM COUNTS THE NUMBER OF TIMES A POLYGON LINE
C   * SEGMENT CROSSES THE POSITIVE Y AXES.
C   * IF AN ODD NUMBER OF SEGMENTS CROSS THE POSITIVE Y AXES
C   * THE POINT IS INSIDE.
C   * IF AN EVEN NUMBER OF SEGMENTS CROSS THE POSITIVE Y AXES
C   * THE POINT IS OUTSIDE.
C   *
C   ***************************************************
C
 32   DO 2 I = 1, N
      IF(SXI.NE.0)XK=XI
      XI = XJ
      YI = YJ
      J  = 1 + MOD (J, N)
C    *******PERFORM TRANSLATION OF AXES******
      XJS = XX (J) - PX
      YJS = YY (J) - PY
C    ******PERFORM ROTATION OF AXES******
      XJ = XJS * VCOS - YJS * VSIN
      YJ = XJS * VSIN + YJS * VCOS
C   ****************************************************
C   *
C   * HERE WE RULE OUT ALL SEGMENTS WHOS END POINTS HAVE
C   *  X COORDINATES WITH THE SAME SIGN.
C   * I.E. XI*XJ > ZERO.
C   *
C   *****************************************************
C
      SXI=2.0*XI-FLOAT(IFIX(XI))
      SXJ=2.0*XJ-FLOAT(IFIX(XJ))
      PXIJ=FLOAT(SXI)*FLOAT(SXJ)
      IF (PXIJ.GT.0.15) GO TO 2
C   *****************************************************
C   *
C   * HERE WE RULE OUT ALL SEGMENTS THAT HAVE BOTH Y VALUES
C   * LESS THAN ZERO.
C   *
C   * THESE WILL NOT INTERSECT THE POSITIVE Y AXIS.
C   *
C   *****************************************************
C
      SYI=2.0*YI-FLOAT(IFIX(YI))
      SYJ=2.0*YJ-FLOAT(IFIX(YJ))
      IF (SYI.LT.0.AND.SYJ.LT.0) GO TO 2
```

```
C
C   ***********************************************************
C   *
C   * WE NOW MUST RESORT TO CALCULATION OF THE Y INTERCEPT.
C   * BUT FIRST MUST ENSURE THAT DENOMENATOR OF CALCULATION
C   * WILL NOT BE ZERO.
C   *
C   * THIS WILL OCCUR IF XI = XJ = 0.
C   * IF THIS IS TRUE AND YP IS LESS THAN ZERO, POINT IS ON
C   * THE SEGMENT. OTHERWISE SEGMENT COINCIDES WITH Y AXES
C   * BUT DOES NOT GO THRU ORIGIN.  THIS IS NOT COUNTED AS
C   * AN INTERSECTION WITH THE Y AXES.
C   *
C   ***********************************************************
C
      IF (SXI.EQ.0 .AND. SXJ.EQ.0) GO TO 7
      IF(SXI.EQ.SXJ)GO TO 2
C  DO NOT COUNT SECOND POINT OF THIS SEGMENT ON VECTOR
C  IT WILL BE TAKEN AS FIRST POINT OF NEXT SEGMENT
      IF(SXJ.EQ.0)GO TO 2
C
C   **** CALCULATE Y INTERCEPT *****
C
 8    CEPT = (YI * XJ - XI * YJ) / (XJ - XI)
      SCEPT=2.0*CEPT-FLOAT(IFIX(CEPT))
C  CHECK FOR INT NOT ON VECTOR PART OF LINE
      IF (SCEPT.LT. 0) GO TO 2
C  CHECK FOR A PROPER INTERSECTION OF VECTOR WITH SEGMENT
      IF (SCEPT .GT. 0) GO TO 5
C  VECTOR STARTS ON POLY SEGMENT
      GO TO 2
C  POLY SEGMENT LIES ALONG THE VECTOR
C  CHECK FOR VECTOR STARTING ON THE SEGMENT
 7    PYIJ=FLOAT(SYI)*FLOAT(SYJ)
      IF(PYIJ.GT.0.15)GO TO 2
      IF(SYJ.EQ.0)GO TO 2
C  RECORD THE INTERSECTION
      NINT=NINT+1
      XINT(NINT)=0.0
      YINT(NINT)=0.0
      NSIDE(NINT)=MOD(J+N-2,N)+1
      GO TO 2
C  DO NOT COUNT CROSSING IF BOUNDRY FOLLOWED OR TOUCHED ONLY
C  LOOK FOR FIRST POINT OF SEGMENT ON VECTOR
 5    SXK=2.0*XK-FLOAT(IFIX(XK))
      PXKJ=FLOAT(SXK)*FLOAT(SXJ)
      IF(SXI.EQ.0.AND.PXKJ.GT.0.15)GO TO 2
C  RECORD THE INTERSECTION
      NINT=NINT+1
      XINT(NINT)=0.0
      YINT(NINT)=CEPT
      NSIDE(NINT)=MOD(J+N-2,N)+1
      INOUT = -INOUT
 2    CONTINUE
```

```
C
C   ****************************************************
C   *
C   * SORT THE INTERSECTIONS BY INCREASING Y VALUE.
C   * THE X VALUES ARE ZERO BECAUSE OF THE ROTATION.
C   *
C   ****************************************************
C
      IF (NINT.LT.2) GO TO 69
      ISIZE = NINT - 1
      DO 10 I = 1, ISIZE
      K = I + 1
      DO 10 J = K, NINT
      IF (YINT (J)  .LT.  YINT (I)) GO TO 11
      GO TO 10
 11   TEMP = YINT (J)
      YINT (J) = YINT (I)
      YINT (I) = TEMP
      ITEMP = NSIDE (J)
      NSIDE (J) = NSIDE (I)
      NSIDE (I) = ITEMP
 10   CONTINUE
C
C  CHECK FOR CLOSE INTERSECTIONS
 66   IF(NINT.LT.2)GO TO 69
      NN=NINT-1
      DO 67 I=1,NN
      INTY=2.0*YINT(I)-FLOAT(IFIX(YINT(I)))
      INTYP=2.0*YINT(I+1)-FLOAT(IFIX(YINT(I+1)))
      IF(INTY.NE.INTYP)GO TO 67
C  REMOVE TWO INTERSECTIONS THAT ARE EQUAL IN INTEGER
      NINT=NINT-2
      IF(NINT.EQ.0)GO TO 12
      IF(I.GT.NINT)GO TO 69
      DO 68 J=I,NINT
      YINT(J)=YINT(J+2)
 68   NSIDE(J)=NSIDE(J+2)
      GO TO 66
 67   CONTINUE
C  CHECK FOR VECTOR STARTING ON POLY SEGMENT
 69   IF(NINT.LT.1)GO TO 12
      INTY=2.0*YINT(1)-FLOAT(IFIX(YINT(1)))
      IF(INTY.EQ.0)INOUT=0
C
C    *******************************************************
C    *
C    * THE FOLLOWING TRANSLATES AND ROTATES THE AXES FOR
C    * THE INTERSECTING POINTS.
C    * THE SECOND TERM OF EACH ROTATION EQUATION IS ZERO
C    * BECAUSE THE X VALUES OF THE INTERSECTIONS ARE ZERO
C    * THERFORE TO SAVE COMPUTATION THEY HAVE BEEN REMOVED.
C    *
C    *******************************************************
C
```

```
12    IF (NINT .EQ. 0) RETURN
      DO 9 I = 1, NINT
      XJS = YINT (I) * VSIN
      YJS = YINT (I) * VCOS
      XINT (I) = XJS + PX
      YINT (I) = YJS + PY
9     CONTINUE
      RETURN
      END
```

```
C   FORAXORDER
C   ORDER AND JOIN INTERSECTIONS OF FOREST AXIS WITH FOREST
C   TYPE ISLANDS AND INSERT VISUAL COVERAGE AND CANOPY HEIGHTS
C   WRITTEN BY KIM SCOULLAR
C   READS STOP POINTS ON 3     READS FOREST AXIS ON 7
C   WRITES NEW FOREST AXIS 4    READS FOREST CANOPY HEIGHTS 9
      DIMENSION STOPX(200),STOPY(200),STOPZ(200),DAVE(25)
      DIMENSION AXD1(25,16),AXD2(25,16),NPOLY(25,16)
      DIMENSION FDIST(25,16),FHGT(25,16),DJOIN(25),JTYPE(25)
      DIMENSION CANHGT(250),IHT(10),KOR(25)
C   INPUT CANOPY HEIGHT FILE
C   LOOP OVER EVERY TEN CANOPY POLYGONS
      DO 11 KST=1,25
C   INPUT CANOPY HEIGHT FOR TEN POLYGONS
      READ(9,9) (IHT(JST),JST=1,10)
 9    FORMAT(10I4)
C   INSERT INTO CANOPY HEIGHT ARRAY
      DO 10 JST=1,10
 10   CANHGT(KST*10-10+JST)=IHT(JST)
 11   CONTINUE
C   INPUT STOP POINT FILE
      READ(3) NSTOPS,STOPX,STOPY,STOPZ
C   LOOP OVER STOPS
      DO 80 IST=1,NSTOPS
C   CHECK FOR UNUSED STOPS
      IF(STOPX(IST).LT.0.0)GO TO 80
C   INPUT FOREST AXIS FOR THIS STOP
      READ(7) AXD1,AXD2,NPOLY
C   LOOP OVER AXIS
      DO 40 IAX=1,16
C   INITIALIZE AN ARRAY FOR KEEPING TRACK OF ORDER
      DO 17 J=1,25
 17   KOR(J)=J
C   GET AVERAGE DISTANCE FOR EACH DISTANCE PAIR
      DO 18 I=1,25
 18   DAVE(I)=(AXD1(I,IAX)+AXD2(I,IAX))/2.0
C   SORT INTERSECTION SEGMENTS BY THEIR AVERAGE DISTANCE
      IFIND=1
      DO 25 ISORT=1,24
      IF(IFIND.EQ.0)GO TO 26
      IFIND=0
      DO 24 J=1,24
      IF(DAVE(KOR(J+1)).EQ.0.0)GO TO 25
      IF(DAVE(KOR(J)).LT.DAVE(KOR(J+1)))GO TO 24
      KTEMP=KOR(J)
      KOR(J)=KOR(J+1)
      KOR(J+1)=KTEMP
      IFIND=1
 24   CONTINUE
 25   CONTINUE
 26   CONTINUE
```

```
C  ZERO THE JOIN AXIS
      DO 30 N=1,25
 30   JTYPE(N)=0
C  JOIN AND ORDER AXIS
      DO 31 I=1,24
      IF(NPOLY(KOR(I+1),IAX).EQ.0)GO TO 32
      DJOIN(I)=(AXD2(KOR(I),IAX)+AXD1(KOR(I+1),IAX))/2.0
 31   JTYPE(I)=NPOLY(KOR(I),IAX)
      I=25
 32   DJOIN(I)=AXD2(KOR(I),IAX)
      JTYPE(I)=NPOLY(KOR(I),IAX)
C  MAKE NEW FOREST AXIS  -  INSERT CANOPY HEIGHT
 35   DO 36 JF=1,25
      IF(JTYPE(JF).LE.0)GO TO 37
      FDIST(JF,IAX)=DJOIN(JF)
 36   FHGT(JF,IAX)=CANHGT(JTYPE(JF))
      GO TO 39
 37   DO 38 JG=JF,25
      FDIST(JG,IAX)=9999.
 38   FHGT(JG,IAX)=0.0
 39   CONTINUE
C*** DEBUG  6 LINES
C     WRITE(8,301)IST,IAX
C301  FORMAT(' IST',I4,'   IAX',I4)
C     WRITE(8,302) (FDIST(L,IAX),L=1,20)
C302  FORMAT(20F6.0)
C     WRITE(8,302) (FHGT(L,IAX),L=1,20)
 40   CONTINUE
C  OUTPUT FOREST AXIS FOR THIS STOP
      WRITE(4) FDIST,FHGT
      WRITE(8,305)IST
 305  FORMAT(' FORAX ORDERED FOR STOP',I5)
 80   CONTINUE
      STOP
      END
```

```
C   GRIDMAKE
C   PROGRAM TO INSERT ELEVATION DATA INTO A GRID
C   EACH WEST TO EAST ROW MUST START ON A NEW CARD
C   WITH THE -X,-Y OF THE FIRST POINT GIVEN FIRST
C   END OF GRID DATA MARKED BY ROW OF -999-999
C   WRITTEN BY KIM SCOULLAR
C   READS FROM UNIT 3  WRITES ON UNIT 4
      DIMENSION EGRID(120,260),ICARD(20)
C   PRESET THE ARRAY
      DO 5 I=1,120
      DO 5 J=1,260
 5    EGRID(I,J)=-999.
C   READ REFERENCE COORDINATES AND GRID SPACING
      READ(3,6)IREFX,IREFY,ISPACE
 6    FORMAT(2I8,I4)
C   READ ELEVATION DATA
 61   READ(3,7)(ICARD(I),I=1,20)
 7    FORMAT(20I4)
C   CHECK FOR NEW ROW OR LAST ROW
      IF(ICARD(1).LT.0)GO TO 10
C   SET THE POSITION COUNTER
      NUM=1
C   CHECK FOR END OF ROW
 8    IF(ICARD(NUM).EQ.0)GO TO 61
C   INSERT POINTS IN GRID AND GO TO NEXT POINT
      EGRID(IX,IY)=ICARD(NUM)
      NUM=NUM+1
      IX=IX+1
      IF(IX.GT.120)GO TO 98
      IF(NUM.GT.20)GO TO 61
      GO TO 8
C   CHECK FOR END OF ELEVATION DATA
 10   IF(ICARD(1).EQ.-999)GO TO 100
C   INITIALIZE START POINT FOR NEW ROW
      IX=(-10000*ICARD(1)+ICARD(2)-IREFX)/ISPACE+1
      IY=(-10000*ICARD(3)+ICARD(4)-IREFY)/ISPACE+1
      NUM=5
      GO TO 8
C   ERROR IN GRID DATA
 98   WRITE(6,99)(ICARD(I),I=1,4)
 99   FORMAT(' ERROR IN GRID DATA AT  ',2I4,2X,2I4,'  E====')
C   OUTPUT GRID ARRAY, GRID SPACING AND REFERENCE COORDINATES
 100  WRITE(4)ISPACE,IREFX,IREFY,EGRID
      STOP
      END
```

```
C   GRIDLIST
C   PROGRAM TO LIST GRID OF ELEVATION DATA
C
C   WRITTEN BY KIM SCOULLAR
C
      DIMENSION EGRID(120,260)
C   READS FROM UNIT 3    WRITES ON UNIT 6
      READ(3)ISPACE,IREFX,IREFY,EGRID
      WRITE(6,1)ISPACE,IREFX,IREFY
  1   FORMAT(' GRID SPACING',I3,5X,'EAST',I8,3X,'NORTH',I8)
C   OUTPUT WILL BE IN FIVE PARTS
      DO 4 I=1,5
      WRITE(6,2)I
  2   FORMAT('1',I2)
      IX1=I*24-23
      IX2=I*24
      DO 4 J=1,260
      IY=261-J
      WRITE(6,3) (EGRID(IX,IY),IX=IX1,IX2)
  3   FORMAT(' ',24F5.0)
  4   CONTINUE
      STOP
      END
```

```
C   PERSPLOT
        DIMENSION EGRID(120,260),FGRID(199,117)
        READ(3)ISPACE,IREFX,IREFY,EGRID
        DO 7 I=2,118
        L=I-1
        DO 7 J=48,246
        K=247-J
        FGRID(K,L)=EGRID(I,J)
 7      IF(FGRID(K,L).LT.0.0)FGRID(K,L)=0.0
        CALL PERS(FGRID,199,199,117,1.0,0.16,45.,32.,18.,18.)
        CALL PLOTND
        STOP
        END
```

```
C   TOPAXMAKE
C   PRODUCE AXIAL TOPOGRAPHIC DESCRIPTIONS FROM A POINT
C
C   WRITTEN BY KIM SCOULLAR
C
C   READS ELEVATION GRID, SPACING AND REFERENCE POINT ON 9
C   READS STOP POINT COORDINATES ON 3 - NEG STOP NO. MARKS END
C   OUTPUTS AXIAL TOPOGRAPHIC DESCRIPTIONS ON UNIT 4
C****TEMPORARY DEBUG OUTPUT ON UNIT 8
      DIMENSION EGRID(120,260),TDIST(35,16),TELEV(35,16)
      DIMENSION AXANGL(16),HZLINE(4,48),VTLINE(4,48)
      DIMENSION STOPX(200),STOPY(200),STOPZ(200),IAXQAD(16)
      DATA IAXQAD/1,1,1,1,1,4,4,4,4,3,3,3,3,2,2,2/
      DATA AXANGL/0.0,22.5,45.0,67.5,90.0,67.5,45.0,22.5,0.0,
     122.5,45.0,67.5,90.0,67.5,45.0,22.5/
C   OUTPUTS UNORDERED AXIS INFORMATION ON UNIT 4
C   READ GRID INFORMATION
      READ(9)ISPACE,IREFX,IREFY,EGRID
C   CONVERT SPACING TO REAL
      SPACE=ISPACE
C   READ STOP POINT INFORMATION
      READ(3)NSTOPS,STOPX,STOPY,STOPZ
C   LOOP OVER STOP POINTS
      DO 85 ISTOP=1,NSTOPS
C   CHECK FOR UNUSED STOP
      IF(STOPX(ISTOP).LT.0.0)GO TO 85
C   GET LOCATION OF POINT ON GRID
      ISTX=STOPX(ISTOP)
      ISX=ISTX/ISPACE+1
      ISTY=STOPY(ISTOP)
      ISY=ISTY/ISPACE+1
C   DETERMINE GRID SEGMENT ARRAY BOUNDS FOR INTERSECTION
      IX1=ISX-23
      IF(IX1.LT.1)IX1=1
      IX2=ISX+24
      IF(IX2.GT.120)IX2=120
      IY1=ISY-23
      IF(IY1.LT.1)IY1=1
      IY2=ISY+24
      IF(IY2.GT.260)IY2=260
C   PREPARE GRID LINE SEGMENT COORDINATES FOR INTERSECTION
C   FOUR POINTS ARE X1 Y1 X2 Y2
      NUM=0
      DO 15 I=IY1,IY2
      NUM=NUM+1
      IM=I-1
      HZLINE(1,NUM)=(IX1-1)*ISPACE
      HZLINE(2,NUM)=IM*ISPACE
      HZLINE(3,NUM)=(IX2-1)*ISPACE
 15   HZLINE(4,NUM)=IM*ISPACE
```

```
      NUM=0
      DO 16 I=IX1,IX2
      NUM=NUM+1
      IM=I-1
      VTLINE(1,NUM)=IM*ISPACE
      VTLINE(2,NUM)=(IY1-1)*ISPACE
      VTLINE(3,NUM)=IM*ISPACE
 16   VTLINE(4,NUM)=(IY2-1)*ISPACE
C   LOOP OVER AXIS
      DO 84 IAX=1,16
C   CONSTRUCT THE OBSERVATION LINE SEGMENT - GET REMOTE POINT
      CALL QAD(STOPX(ISTOP),STOPY(ISTOP),IAXQAD(IAX),
     1    AXANGL(IAX),1200.0,RMTX,RMTY)
C   DETERMINE LINE RANGE FOR INTERSECTION
      LNXMN=IX1
      LNXMX=IX2
      LNYMN=IY1
      LNYMX=IY2
C   REDUCE RANGE AS POSSIBLE
      IQUAD=IAXQAD(IAX)
      IF(IQUAD.EQ.1.OR.IQUAD.EQ.4)LNXMN=ISX
      IF(IQUAD.EQ.2.OR.IQUAD.EQ.3)LNXMX=ISX
      IF(IQUAD.EQ.1.OR.IQUAD.EQ.2)LNYMN=ISY
      IF(IQUAD.EQ.3.OR.IQUAD.EQ.4)LNYMX=ISY
C   ZERO THE AXIS POINT PAIR COUNTER
      IPAR=0
C
C   PERFORM INTERSECTION WITH VERTICAL GRID LINES
C   LOOP OVER LINES
      DO 82 LX=LNXMN,LNXMX
C   CALCULATE LINE NUMBER FOR PRESENT LINE
      LNO=LX-IX1+1
C   DO THE INTERSECT
      CALL INTSCT(STOPX(ISTOP),STOPY(ISTOP),RMTX,RMTY,
     1  VTLINE(1,LNO),VTLINE(2,LNO),VTLINE(3,LNO),
     1      VTLINE(4,LNO),PTINTX,PTINTY,ISIT)
C   WAS INTERSECTION WITHIN BOTH SEGMENTS
      IF(ISIT.NE.1)GO TO 82
C   GET GRID POINTS AROUND INTERSECTION
      INTPTY=PTINTY
      MG1Y=INTPTY/ISPACE+1
      MG2Y=MG1Y+1
      GRF1Y=(MG1Y-1)*ISPACE
      GRF2Y=GRF1Y+SPACE
C   INTERPRET LINEARLY BETWEEN THE GRID POINTS
C   COMPUTE ELEVATION OF POINT OF INTERSECTION
      ELVINT=EGRID(LX,MG1Y)+(EGRID(LX,MG1Y)-EGRID(LX,MG2Y))*
     1(GRF1Y-PTINTY)/SPACE
C   COMPUTE DISTANCE FROM STOP POINT TO INTERSECT POINT
      CALL SEGLTH(STOPX(ISTOP),STOPY(ISTOP),
     1      PTINTX,PTINTY,DIST)
C   DO NOT INSERT IF DISTANCE IS LESS THAN MINIMUM
      IF(DIST.LT.30.0)GO TO 82
C   CHECK FOR OUTSIDE GRID DATA
      IF(ELVINT.LT.2.0)ELVINT=2.0
```

```
C   INSERT DISTANCE AND ELEVATION INTO AXIS ARRAY
        IPAR=IPAR+1
        IF(IPAR.GT.35)GO TO 82
        TDIST(IPAR,IAX)=DIST
        TELEV(IPAR,IAX)=ELVINT
 82     CONTINUE
C
C   PERFORM INTERSECTION WITH HORIZONTAL GRID LINES
C   LOOP OVER LINES
        DO 83 LY=LNYMN,LNYMX
C   CALCULATE LINE NUMBER FOR PRESENT LINE
        LNO=LY-IY1+1
C   DO THE INTERSECT
        CALL INTSCT(STOPX(ISTOP),STOPY(ISTOP),RMTX,RMTY,
      1     HZLINE(1,LNO),HZLINE(2,LNO),HZLINE(3,LNO),
      1     HZLINE(4,LNO),PTINTX,PTINTY,ISIT)
C   WAS THE INTERSECTION WITHIN BOTH SEGMENTS
        IF(ISIT.NE.1)GO TO 83
C   GET GRID POINTS AROUND INTERSECTION
        INTPTX=PTINTX
        MG1X=INTPTX/ISPACE+1
        MG2X=MG1X+1
        GRF1X=(MG1X-1)*ISPACE
        GRF2X=GRF1X+SPACE
C   INTERPRET LINEARLY BETWEEN THE GRID POINTS
C   COMPUTE ELEVATION OF POINT OF INTERSECT
        ELVINT=EGRID(MG1X,LY)+(EGRID(MG1X,LY)-EGRID(MG2X,LY))*
      1(GRF1X-PTINTX)/SPACE
C   COMPUTE DISTANCE TO POINT OF INTERSECTION FROM STOP POINT
        CALL SEGLTH(STOPX(ISTOP),STOPY(ISTOP),
      1     PTINTX,PTINTY,DIST)
C   DO NOT INSERT IF DISTANCE IS LESS THAN MINIMUM
        IF(DIST.LT.30.0)GO TO 83
C   CHECK FOR OUTSIDE ELEVATION DATA
        IF(ELVINT.LT.2.0) ELVINT=2.0
C   INSERT DISTANCE AND ELEVATION INTO AXIS ARRAY
        IPAR=IPAR+1
        IF(IPAR.GT.35)GO TO 83
        TDIST(IPAR,IAX)=DIST
        TELEV(IPAR,IAX)=ELVINT
 83     CONTINUE
C   RESET REST OF ARRAYS
 87     IPAR=IPAR+1
        IF(IPAR.GT.35)GO TO 88
        TDIST(IPAR,IAX)=9999.
        TELEV(IPAR,IAX)=0.0
        GO TO 87
 88     CONTINUE
C***DEBUG  6 LINES
C       WRITE(8,90)ISTOP,IAX
C90     FORMAT(' ISTOP',I4,'    IAX',I4)
C       WRITE(8,91) (TDIST(M,IAX),M=1,35)
C91     FORMAT(' ',20F5.0)
C       WRITE(8,91) (TELEV(M,IAX),M=1,35)
 84     CONTINUE
```

```
C  WRITE RESULTS IN UNFORMATTED FORM
      WRITE(4)TDIST,TELEV
      WRITE(8,93)ISTOP
 93   FORMAT(' TOPAX MADE FOR STOP',I5)
 85   CONTINUE
      STOP
      END
C
C
      SUBROUTINE INTSCT(L1P1X,L1P1Y,L1P2X,L1P2Y,L2P1X,L2P1Y,
     1L2P2X,L2P2Y,XINTPT,YINTPT,ISIT)
      IMPLICIT REAL(L)
C  INTERSECT TWO LINE SEGMENTS
C  ISIT = 1 ONLY IF INTERSECTION IS ON BOTH SEGMENTS
      ISIT=0
C  FIRST CHECK FOR VERTICAL LINES - SLOPE UNDEFINED
      IF(L1P1X.EQ.L1P2X.AND.L2P1X.EQ.L2P2X) RETURN
      IF(L1P1X.EQ.L1P2X)GO TO 50
      IF(L2P1X.EQ.L2P2X)GO TO 51
C  NEITHER LINE IS VERTICAL OR UNDEFINED
C  GET SLOPE AND INTERCEPT FOR EACH LINE
      LN1SLP=(L1P1Y-L1P2Y)/(L1P1X-L1P2X)
      LN1C=L1P1Y-L1P1X*LN1SLP
      LN2SLP=(L2P1Y-L2P2Y)/(L2P1X-L2P2X)
      LN2C=L2P1Y-L2P1X*LN2SLP
C  CHECK FOR PARALLEL LINES
      IF(LN1SLP.EQ.LN2SLP) RETURN
C  DETERMINE POINT OF INTERSECTION
      XINTPT=(LN2C-LN1C)/(LN1SLP-LN2SLP)
      YINTPT=XINTPT*LN1SLP+LN1C
C  INTERSECTION POINT HAS BEEN FOUND - IS IT WITHIN SEGMENTS
      MAYBE=0
C  IS IT ON LINE SEGMENT ONE
      IF(L1P1X.LE.XINTPT.AND.XINTPT.LE.L1P2X.OR.
     1L1P2X.LE.XINTPT.AND.XINTPT.LE.L1P1X) MAYBE=MAYBE+1
C  IS IT ON LINE SEGMENT TWO
      IF(L2P1X.LE.XINTPT.AND.XINTPT.LE.L2P2X.OR.
     1L2P2X.LE.XINTPT.AND.XINTPT.LE.L2P1X) MAYBE=MAYBE+1
C  IS IT ON BOTH
      IF(MAYBE.EQ.2) ISIT=1
      RETURN
C  ONE OF THE LINES MAY BE VERTICAL
C LINE ONE MAY BE VERTICAL - CHECK FOR UNDEFINED LINE
 50   IF(L1P1Y.EQ.L1P2Y) RETURN
C  FIND INTERSECTION OF VERTICAL LINE ONE WITH LINE TWO
      XINTPT=L1P1X
      LN2SLP=(L2P1Y-L2P2Y)/(L2P1X-L2P2X)
      LN2C=L2P1Y-L2P1X*LN2SLP
      YINTPT=XINTPT*LN2SLP+LN2C
C  INTERSECTION POINT HAS BEEN FOUND - IS IT ON LINE SEGMENTS
      MAYBE=0
C  IS IT ON THE VERTICAL SEGMENT - LINE ONE
      IF(L1P1Y.LE.YINTPT.AND.YINTPT.LE.L1P2Y.OR.
     1L1P2Y.LE.YINTPT.AND.YINTPT.LE.L1P1Y) MAYBE=MAYBE+1
```

```
C   IS IT ON LINE SEGMENT TWO
       IF(L2P1X.LE.XINTPT.AND.XINTPT.LE.L2P2X.OR.
      1L2P2X.LE.XINTPT.AND.XINTPT.LE.L2P1X) MAYBE=MAYBE+1
C   IS IT ON BOTH
       IF(MAYBE.EQ.2)ISIT=1
       RETURN
C   LINE TWO MAY BE VERTICAL - CHECK FOR UNDEFINED LINE
 51    IF(L2P1Y.EQ.L2P2Y)RETURN
C   FIND INTERSECTION OF LINE ONE WITH VERTICAL LINE TWO
       XINTPT=L2P1X
       LN1SLP=(L1P1Y-L1P2Y)/(L1P1X-L1P2X)
       LN1C=L1P1Y-L1P1X*LN1SLP
       YINTPT=XINTPT*LN1SLP+LN1C
C   INTERSECTION POINT HAS BEEN FOUND - IS IT ON LINE SEGMENTS
       MAYBE=0
C   IS IT ON LINE SEGMENT ONE
       IF(L1P1X.LE.XINTPT.AND.XINTPT.LE.L1P2X.OR.
      1L1P2X.LE.XINTPT.AND.XINTPT.LE.L1P1X) MAYBE=MAYBE+1
C   IS IT ON THE VERTICAL SEGMENT - LINE TWO
       IF(L2P1Y.LE.YINTPT.AND.YINTPT.LE.L2P2Y.OR.
      1L2P2Y.LE.YINTPT.AND.YINTPT.LE.L2P1Y) MAYBE=MAYBE+1
C   IS IT ON BOTH
       IF(MAYBE.EQ.2)ISIT=1
       RETURN
       END
C
C
       SUBROUTINE QAD(PT1X,PT1Y,IQUAD,ANGLE,DIST,PT2X,PT2Y)
C   DETERMINE THE COORDINATES OF A POINT DEFINED BY A
C   GIVEN ANGLE, QUADRATE AND DISTANCE FROM A GIVEN POINT

 SEE PROGRAM FORAXUPD FOR LISTING OF SUBROUTINE QAD

       RETURN
       END
C
C
       SUBROUTINE SEGLTH(PTA1,PTA2,PTB1,PTB2,RLTH)
C   FIND THE LENGTH OF A LINE SEGMENT DEFINED BY TWO POINTS
       IF(PTA1.EQ.PTB1.AND.PTA2.EQ.PTB2)GO TO 5
C   DETERMINE LENGTH - HYPOTENUES OF RIGHT TRIANGLE
       RLTH=SQRT((PTB1-PTA1)**2+(PTB2-PTA2)**2)
       RETURN
 5     RLTH=0.0
       RETURN
       END
```

```
C   TOPAXORDER
C   ROUTINE TO INSERT CLOSE TOPOGRAPHIC FEATURES DATA
C   INTO TOPOGRAPHIC AXIS
C   WRITTEN BY KIM SCOULLAR
C   READS STOP POINTS 3    READS AXIAL TOPO DESCRIPTIONS 5
C   READS CLOSE TOPO DATA 7    WRITES NEW AXIAL TOPO DESCRP 4
C****DEBUG OUTPUT ON UNIT 8
      DIMENSION STOPX(200),STOPY(200),STOPZ(200)
      DIMENSION TDIST(35,16),TELEV(35,16)
C   INPUT THE STOP POINT INFORMATION
      READ(3)NSTOPS,STOPX,STOPY,STOPZ
C   INPUT FIRST LINE OF CLOSE TOPO DATA
      READ(7,10)ICLOS,IDIRCT,IANGLE,IDIST
 10   FORMAT(4I3)
C   LOOP OVER STOPS
      DO 80 IST=1,NSTOPS
C   CHECK FOR UNUSED STOP
      IF(STOPX(IST).LT.0.0)GO TO 80
C   INPUT TOPO AXIS FOR THIS STOP
      READ(5)TDIST,TELEV
C   ZERO RAISED OBSERVER
      RAISOB=0.0
C   IS CLOS TOPO DATA FOR THIS STOP
 19   IF(ICLOS.GT.IST)GO TO 75
      IF(ICLOS.LT.IST)WRITE(6,31)
 31   FORMAT(' ERROR IN CLOSE TOPO FILE')
C   CHECK FOR RAISED OBSERVER DATA
      IF(IDIRCT.EQ.0)GO TO 50
C   DETERMINE CHANGE IN ELEVATION
C   FIRST CHOOSE QUADRATE BY SIGN
      IQUAD=1
      IF(IANGLE.LT.0)IQUAD=-1
C   CONVERT ANGLE TO REAL AND CHANGE SIGN IF NEGATIVE
      A=IANGLE
      A=ABS(A)
C   CONVERT DISTANCE TO REAL
      DIST=IDIST
C   DETERMINE OBSERVER HEIGHT
      OBHT=STOPZ(IST)+4.0+RAISOB
C   CONVERT ANGLE TO RADIANS
      RA=A*0.01745
C   COMPUTE DISTANCE AND ELEVATION - INSERT POINT AT END
      TDIST(35,IDIRCT)=DIST*COS(RA)
      TELEV(35,IDIRCT)=OBHT+DIST*SIN(RA)*IQUAD
      GO TO 70
C   RAISED OBSERVER
C   INSERT IT INTO ARRAY
 50   RAISOB=IDIST
C   INPUT ONE LINE OF CLOSE TOPO DATA
 70   READ(7,10)ICLOS,IDIRCT,IANGLE,IDIST
C   CHECK FOR END OF FILE
      IF(ICLOS.LT.0)ICLOS=9999
      GO TO 19
```

```
C  ORDER THE TOPO AXIS FOR THIS STOP
C  LOOP OVER AXIS
 75    DO 18 IAX=1,16
C  SORT N-1 TIMES
       DO 17 ITIMES=1,34
       MOVE=0
C  LOOP OVER POINTS   GO OUT AXIS
       DO 16 IP=1,34
C  CHECK FOR UNORDERED PAIR
       IF(TDIST(IP,IAX).LT.TDIST(IP+1,IAX))GO TO 16
C  CHECK FOR END OF DATA
       IF(TDIST(IP,IAX).GT.9998..AND.TDIST(IP+1,IAX).GT.9998.)
      1GO TO 16
C  CHECK FOR EQUAL DISTANCE AND SEPARATE BY ONE IF NECCESSARY
       IF(TDIST(IP,IAX).EQ.TDIST(IP+1,IAX))TDIST(IP,IAX)=
      1TDIST(IP,IAX)+1.0
C  REVERSE ORDER OF PAIR   SAVE FIRST ONE
       DIST=TDIST(IP,IAX)
       ELEV=TELEV(IP,IAX)
C  PUT SECOND ONE IN FIRST PLACE
       TDIST(IP,IAX)=TDIST(IP+1,IAX)
       TELEV(IP,IAX)=TELEV(IP+1,IAX)
C  PUT THE OLD FIRST POINT IN THE SECOND POSITION
       TDIST(IP+1,IAX)=DIST
       TELEV(IP+1,IAX)=ELEV
C  RECORD THE MOVE
       MOVE=1
 16    CONTINUE
C  STOP SORT IF NO MOVES MADE
       IF(MOVE.EQ.0)GO TO 18
 17    CONTINUE
C****DEBUG  6 LINES PLUS ABOVE GO TO 89 BECOMES GO TO 18 ***
C89    WRITE(8,90)IST,IAX
C90    FORMAT(' ISTOP',I4,'   IAX',I4)
C      WRITE(8,91) (TDIST(M,IAX),M=1,26)
C91    FORMAT(' ',26F5.0)
C      WRITE(8,91) (TELEV(M,IAX),M=1,26)
 18    CONTINUE
C  OUTPUT TOPO AXIS FOR THIS STOP
       WRITE(4)TDIST,TELEV,RAISOB
       WRITE(8,93)IST
 93    FORMAT(' TOPAX ORDERED FOR STOP',I5)
 80    CONTINUE
       STOP
       END
```

```
C   FORONTOP
C   PROGRAM TO PRODUCE TOPOGRAPHY AXIS PROFILES
C   AND FOREST CANOPY PROFILES
C   WRITTEN BY KIM SCOULLAR
C
C   READS STOP POINTS ON 3  READS TOPO AXIS ON 5
C   READS FOREST AXIS ON 7  WRITES MATRIXES ON 4
C   WRITES DEBUG OUTPUT ON UNIT 8
      DIMENSION STOPX(200),STOPY(200),STOPZ(200),TELEV(35,16)
      DIMENSION FDIST(25,16),FHGT(25,16),TDIST(35,16)
      DIMENSION TOPD(25,16),TOPZ(25,16),NTOP(16),TTD(38)
      DIMENSION FORD(40,16),FORZ(40,16),NFOR(16),TFD(80)
      DIMENSION TD(38),TZ(38),FD(80),FZ(80),TTZ(38),TFZ(80)
C   SET PROFILE THINNING TOLERENCE
      TOL=2.0
C   INPUT STOP POINT INFORMATION
      READ(3)NSTOPS,STOPX,STOPY,STOPZ
C   LOOP OVER STOPS
      DO 80 IST=1,NSTOPS
C   CHECK FOR UNUSED STOP
      IF(STOPX(IST).LT.0.0)GO TO 80
C   INPUT TOPO AXIS FOR THIS STOP
      READ(5)TDIST,TELEV,RAISOB
C   INPUT FOREST AXIS FOR THIS STOP
      READ(7)FDIST,FHGT
C   LOOP OVER AXIS
      DO 75 IAX=1,16
C
C   MAKE TOPOGRAPHY POLYGON
C   FIRST POINT IS STOP POINT
      TD(1)=0.0
      TZ(1)=STOPZ(IST)
C   POINTS FROM CLOSE TOPO AND GRID ARE NEXT
      DO 20 I=1,35
C   CHECK FOR END OF POINTS
      IF(TDIST(I,IAX).GT.9998.)GO TO 25
C   INSERT ONE POINT FROM TOPOG AXIS
      TD(I+1)=TDIST(I,IAX)
 20   TZ(I+1)=TELEV(I,IAX)
C   COMPLETE THE POLYGON WITH TWO BOTTOM CORNER POINTS
C   FIRST THE FAR LOWER CORNER
 25   TD(I+1)=1300.0
      TZ(I+1)=0.0
C   SECOND POINT UNDER STOP POINT
      TD(I+2)=0.0
      TZ(I+2)=0.0
C   RECORD NUMBER OF POINTS IN POLYGONS
      NT=I+2
C
```

```
C   MAKE FOREST CANOPY POLYGON
C   INITIALIZE TOP AXIS AND FOR AXIS ARRAY COUNTERS
       ITOP=1
       IFOR=1
C   GO TO NEXT TOPO POINT IF FIRST DISTANCE IS TEN M OR LESS
 30    IF(TDIST(ITOP,IAX).GT.10.)GO TO 35
       ITOP=ITOP+1
       IF(ITOP.GT.5)GO TO 200
       IF(TDIST(ITOP,IAX).GT.9998.0)GO TO 200
       GO TO 30
C   GO TO NEXT CANOPY HGT IF FIRST ONE ENDS AT TEN M OR LESS
 35    IF(FDIST(IFOR,IAX).GT.10.)GO TO 40
       IFOR=IFOR+1
       IF(IFOR.GT.5)GO TO 200
       IF(FDIST(IFOR,IAX).GT.9998.0)GO TO 200
       GO TO 35
C   SAVE PRESENT CANOPY HGT
 40    PRESHT=FHGT(IFOR,IAX)
C   FIRST POINT IS STOP POINT
       FD(1)=0.0
       FZ(1)=STOPZ(IST)
C   SECOND POINT IS CANOPY HGT ABOVE TOPOG AT TEN METERS
C   GET TOPOG AT TEN METERS BY LINEAR INTERPOLATION
       ZT=TZ(ITOP)+(TZ(ITOP+1)-TZ(ITOP))*
      1(TD(ITOP)-10.0)/(TD(ITOP)-TD(ITOP+1))
C   ADD TWO POINTS TO MATRIX
       FD(2)=10.0
       FZ(2)=ZT
C   INITIALIZE POLYGON POSITION COUNTER
       JFOR=3
C   DO NOT ADD SECOND UNLESS IT IS DIFFERENT
       IF(PRESHT.LT.0.5)GO TO 39
       FD(3)=10.0
       FZ(3)=ZT+PRESHT
       JFOR=4
C   FIND WHICH AXIS HAS CLOSEST POINT
 39    IF(TDIST(ITOP,IAX).LT.FDIST(IFOR,IAX))GO TO 60
       IF(FDIST(IFOR,IAX).LT.TDIST(ITOP,IAX))GO TO 50
C   THEY ARE EQUAL - TOPOG POINT IS NOT NEEDED
       ITOP=ITOP+1
       IF(ITOP.GT.35)GO TO 70
       IF(TDIST(ITOP,IAX).GT.9998.0)GO TO 70
C   INSERT TWO POINTS FOR CANOPY HGT CHANGE
C   FIRST GET TOPOG AT THIS DISTANCE BY LINEAR INTERPOLATION
 50    ZT=TZ(ITOP)+(TZ(ITOP+1)-TZ(ITOP))*
      1(TD(ITOP)-FDIST(IFOR,IAX))/(TD(ITOP)-TD(ITOP+1))
C   FIRST OF TWO POINTS AT PRESENT CANOPY HGT
       FD(JFOR)=FDIST(IFOR,IAX)
       FZ(JFOR)=ZT+PRESHT
       JFOR=JFOR+1
C   CHECK FOR NO MORE ROOM
       IF(JFOR.GE.78)GO TO 70
C   INCREMENT FOREST AXIS COUNTER
       IFOR=IFOR+1
       IF(IFOR.GT.25)GO TO 70
       IF(FDIST(IFOR,IAX).GT.9998.0)GO TO 39
```

```
C  SECOND OF TWO POINTS ONLY IF A CHANGE IN CANOPY HGT OCCURS
      IF(FHGT(IFOR,IAX).EQ.PRESHT)GO TO 39
      PRESHT=FHGT(IFOR,IAX)
      FD(JFOR)=FDIST(IFOR-1,IAX)
      FZ(JFOR)=ZT+PRESHT
      JFOR=JFOR+1
      GO TO 39
C
C TOPOG POINT IS CLOSER - INSERT POINT AT CANOPY HGT ABOVE IT
 60   FD(JFOR)=TDIST(ITOP,IAX)
      FZ(JFOR)=TELEV(ITOP,IAX)+PRESHT
C  INCREMENT BOTH COUNTERS
      JFOR=JFOR+1
C  CHECK FOR NO MORE ROOM
      IF(JFOR.GT.78)GO TO 70
      ITOP=ITOP+1
      IF(ITOP.GT.35)GO TO 70
      IF(TDIST(ITOP,IAX).GT.9998.0)GO TO 70
      GO TO 39
C
C  COMPLETE CANOPY POLYGON WITH TWO BOTTOM POINTS
C  FIRST THE FAR LOWER CORNER
 70   FD(JFOR)=1300.0
      FZ(JFOR)=0.0
      JFOR=JFOR+1
C  LAST POINT UNDER STOP POINT
      FD(JFOR)=0.0
      FZ(JFOR)=0.0
C  RECORD NUMBER OF POINTS IN POLYGON
      NF=JFOR
C***DEBUG  9 LINES
C     WRITE(8,409)IST,IAX
C409  FORMAT(' STOP',I4,'     AXIS',I3)
C     WRITE(8,410) (TD(I),I=1,NT)
C     WRITE(8,410) (TZ(I),I=1,NT)
C     WRITE(8,410) (FD(I),I=1,NF)
C     WRITE(8,410) (FZ(I),I=1,NF)
C410  FORMAT(1X,15F6.0)
C
C  THIN THE PROFILE POLYGONS FOR THIS AXIS
C  FIRST THE TOPOG PROFILE
      PTOL=TOL
 71   CALL PRTHIN(TD,TZ,NT,TTD,TTZ,NTT,PTOL)
C  THIN AGAIN IF STILL TOO BIG TO FIT
      IF(NTT.LE.25)GO TO 73
      DO 72 I=1,NTT
      TD(I)=TTD(I)
 72   TZ(I)=TTZ(I)
      NT=NTT
      PTOL=PTOL+1.0
      GO TO 71
C  TRANSFER THE THINNED POLYGON
 73   DO 74 I=1,NTT
      TOPD(I,IAX)=TTD(I)
 74   TOPZ(I,IAX)=TTZ(I)
      NTOP(IAX)=NTT
```

```
C
C   THIN THE CANOPY PROFILE
        PTOL=TOL
 81     CALL PRTHIN(FD,FZ,NF,TFD,TFZ,NTF,PTOL)
C   THIN AGAIN IF STILL TOO BIG TO FIT
        IF(NTF.LE.40)GO TO 83
        DO 82 I=1,NTF
        FD(I)=TFD(I)
 82     FZ(I)=TFZ(I)
        NF=NTF
        PTOL=PTOL+1.0
        GO TO 81
C   TRANSFER THE THINNED POLYGON
 83     DO 84 I=1,NTF
        FORD(I,IAX)=TFD(I)
 84     FORZ(I,IAX)=TFZ(I)
        NFOR(IAX)=NTF
 75     CONTINUE
C   OUTPUT THE POLYGON MATRIXES AND RAISED OBSERVER DATA
        WRITE(4)TOPD,TOPZ,NTOP,FORD,FORZ,NFOR,RAISOB
        WRITE(8,77)IST
 77     FORMAT(' PROFILE POLYGONS COMPLETED FOR STOP',I5)
 80     CONTINUE
        STOP
C   ERROR MESSAGES
 200    WRITE(6,201)IST,IAX,ITOP,IFOR
 201    FORMAT(' ERROR IN INPUT ARRAYS',4I6)
        STOP
        END
C
C
        SUBROUTINE PRTHIN(AX,AY,NA,BX,BY,NB,TOL)
C   MODIFIED ESPECIALLY FOR FORONTOP
C   ROUTINE TO KEEP ONLY POINTS NECCESSARY TO SHAPE OF POLYGON
C
C   WRITTEN BY KIM SCOULLAR
C
        DIMENSION AX(NA),AY(NA),BX(NA),BY(NA),KEEP(400)
C   ZERO THE KEEP ARRAY
        NM=NA-1
        DO 10 I=2,NM
 10     KEEP(I)=0
C   KEEP FIRST TWO AND LAST TWO POINTS OF POLYGON
        KEEP(1)=1
        KEEP(2)=1
        KEEP(NA-1)=1
        KEEP(NA)=1
C   PRESET VALUE OF COUNTER FOR NEXT POINT IN LOOP
C   OVER PAIRS OF POINTS TO BE KEPT
 12     INEXT=1
        MOVE=0
C
C   LOOP OVER PAIRS OF POINTS TO BE KEPT
C   UPDATE PRESENT COUNTER
 15     ITHIS=INEXT
```

```
C   GET NEXT POINT OF POINTS TO BE KEPT
 17     INEXT=INEXT+1
        IF(INEXT.GT.NA)GO TO 35
        IF(KEEP(INEXT).EQ.0)GO TO 17
C   IF POINTS ARE ADJACENT, NEED NOT CHECK BETWEEN
        IF(INEXT.EQ.ITHIS+1)GO TO 15
C   PRESET LENGTH AND POINT NUMBER OF LONGEST SO FAR
        BIGEST=-1.0
        LONG=0
C   CHECK FOR SLOPE OF KEEP LINE UNDEFINED -IS LINE VERTICAL
        IF(AX(INEXT).NE.AX(ITHIS))GO TO 19
        SLP=9999999.
        GO TO 20
C   GET SLOPE OF KEEP LINE
 19     SLP=(AY(INEXT)-AY(ITHIS))/(AX(INEXT)-AX(ITHIS))
C   CHECK FOR PERPENDICULAR SLOPE UNDEFINED
 20     IF(SLP.NE.0)GO TO 21
        PSLP=9999999.
        GO TO 22
C   GET SLOPE OF PERPENDICULAR LINES
 21     PSLP=-1.0/SLP
C   GET CONSTANT FOR EQUATION OF KEEP LINE
 22     CKEEP=AY(ITHIS)-SLP*AX(ITHIS)
C   LOOP OVER POINTS BETWEEN THOSE TO BE KEPT
        ITP=ITHIS+1
        INM=INEXT-1
        DO 25 IP=ITP,INM
C   GET CONSTANT FOR EQUATION OF TEST LINE
        CTEST=AY(IP)-PSLP*AX(IP)
C   GET INTERCEPT POINT COORDINATES
        XINT=(CTEST-CKEEP)/(SLP-PSLP)
        YINT=SLP*XINT+CKEEP
C   GET LENGTH OF TEST SEGMENT
        TLENG=SQRT((AX(IP)-XINT)**2+(AY(IP)-YINT)**2)
C   CHECK FOR THIS BEING THE LONGEST SO FAR
        IF(TLENG.LT.BIGEST)GO TO 25
C   UPDATE LENGTH OF LONGEST SO FAR
        BIGEST=TLENG
        LONG=IP
 25     CONTINUE
C
C   KEEP THE POINT WITH THE GREATEST DISTANCE
C   IF THE TOLERENCE HAS BEEN EXCEEDED
        IF(BIGEST.LT.TOL)GO TO 15
        KEEP(LONG)=1
        MOVE=1
        GO TO 15
C
C   CHECK FOR AT LEAST ONE BEING KEPT THIS ROUND
 35     IF(MOVE.EQ.0)GO TO 45
        GO TO 12
```

```
C
C   TRANSFER POINTS TO BE KEPT
 45     J=0
        DO 50 I=1,NA
        IF(KEEP(I).EQ.0)GO TO 50
        J=J+1
        BX(J)=AX(I)
        BY(J)=AY(I)
 50     CONTINUE
C   TRANSFER NEW POLYGON SIZE
        NB=J
        RETURN
        END
```

```
C   PROFPLOT
C   PROGRAM TO PLOT THE TOPOGRAPHY AND FOREST CANOPY PROFILES
C   FOR A SINGLE STOP
C   WRITTEN BY KIM SCOULLAR
C
C   READS STOP POINTS ON 3  READS PROFILES ON 5
C   RUN PLOT:Q PAR=  TO GET PLOTS
      DIMENSION STOPX(200)
      DIMENSION TOPD(25,16),TOPZ(25,16),NTOP(16)
      DIMENSION FORD(40,16),FORZ(40,16),NFOR(16)
C   SET STOP NUMBER TO BE PLOTTED
      IST=15
C   SET CONVERSION FACTOR FOR PLOTS
      CNVRT=1.0/252.4
C   INPUT STOP POINT INFORMATION
      READ(3)NSTOPS,STOPX
C   LOOP OVER STOPS
      DO 2 I=1,IST
C   CHECK FOR UNUSED STOP
      IF(STOPX(I).LT.0.0)GO TO 2
C   INPUT PROFILE POLYGONS
      READ(5)TOPD,TOPZ,NTOP,FORD,FORZ,NFOR,RAISOB
 2    CONTINUE
C   LOOP OVER AXIS
      DO 10 IAX=1,16
C   LOOP OVER POINTS OF TOPOG PROFILE POLYGON
      NT=NTOP(IAX)
      DO 4 IPT=1,NT
C   PLOT TOPOG POLYGON
 4    CALL PLOT(TOPD(IPT,IAX)*CNVRT,TOPZ(IPT,IAX)*CNVRT,2)
C   LOOP OVER POINTS OF FOREST CANOPY PROFILE POLYGON
      NF=NFOR(IAX)
      DO 6 IPT=1,NF
C   PLOT FOREST CANOPY POLYGON
 6    CALL PLOT(FORD(IPT,IAX)*CNVRT,FORZ(IPT,IAX)*CNVRT,2)
C   MOVE PLOT AXIS IN PREPARATION FOR NEXT PLOT
      CALL MAXMX(XMX)
 10   CALL PLOT(XMX+1.0,0.0,-3)
      CALL PLOTND
      STOP
      END
```

```
C   SERORDER
C   PROGRAM TO ORDER ONE SERIES OF STOP POINTS
C   READS STOP INFO ON 3   READS DATA ON 5
C   OUTPUTS ORDERED DATA ON 4
       DIMENSION IHEAD(5,200),IOBS(7,2000),IHD(5),IOB(7)
       DIMENSION STOPX(200),IO(200)
C   INPUT STOP INFORMATION
       READ(3) NSTOPS,STOPX
C   PRESET POSITION COUNTER AND ERROR DETECTOR
       IL=1
       IERR=1
C   PRESET STOP NUMBERS
       DO 10 I=1,NSTOPS
 10    IHEAD(1,I)=-9
C   INPUT HEADER LINE
 14    READ(5,15) (IHD(I),I=1,5)
 15    FORMAT(2I3,I7,I2,I3)
C   GET STOP NUMBER
       IST=IHD(1)
C   CHECK FOR END OF FILE
       IF(IST.LT.0)GO TO 50
C   CHECK FOR UNEXPECTED VALUES IN HEADER LINE
       IF(IHD(1).LT.1.OR.IHD(1).GT.163)GO TO 16
       IF(IHD(2).LT.0.OR.IHD(2).GT.9)GO TO 16
       IF(IHD(3).LT.770301.OR.IHD(3).GT.770701)GO TO 16
       IF(IHD(4).LT.0.OR.IHD(4).GT.3)GO TO 16
       IF(IHD(5).LT.0.OR.IHD(5).GT.30)GO TO 16
       GO TO 18
 16    WRITE(6,17)IHD(2),IHD(1)
 17    FORMAT(' ERROR IN DATA *** SERIES',I4,'   STOP',I4,
      1'   IN HEADER  <==='）
       IERR=-1
 18    CONTINUE
C   INSERT HEADER INFO INTO ARRAYS
       DO 20 I=1,5
 20    IHEAD(I,IST)=IHD(I)
C   GET NUMBER OF OBSERVATIONS
       NOB=IHD(5)
C   CHECK FOR NO OBSERVATIONS
       IF(NOB.LT.1)GO TO 14
C   SET POINTER TO START OF LOC OBS FOR THIS STOP
       IO(IST)=IL
C   LOOP OVER OBSERVATIONS
       DO 30 I=1,NOB
C   INPUT ONE LINE OF DATA
       READ(5,25) (IOB(J),J=1,7)
 25    FORMAT(2I2,I3,I2,2I4,I2)
C   CHECK FOR UNEXPECTED VALUES IN OBSERVATIONS
       IF(IOB(1).LT.1.OR.IOB(1).GT.12)GO TO 26
       IF(IOB(2).LT.1.OR.IOB(2).GT.9)GO TO 26
       IF(IOB(3).LT.0.OR.IOB(3).GT.90)GO TO 26
```

```
      IF(IOB(4).LT.1.OR.IOB(4).GT.4)GO TO 26
      IF(IOB(5).LT.0)GO TO 26
      IF(IOB(6).LT.0)GO TO 26
      IF(IOB(7).LT.0.OR.IOB(7).GT.1)GO TO 26
      GO TO 28
 26   WRITE(6,27)IHD(2),IHD(1),I
 27   FORMAT(' ERROR IN DATA *** SERIES',I4,'   STOP',I4,
     1'   LOCATION NUMBER',I3,'   <===')
      IERR=-1
 28   CONTINUE
C  TRANSFER LOCATION INFO INTO ARRAY
      DO 29 J=1,7
 29   IOBS(J,IL)=IOB(J)
      IL=IL+1
      IF(IL.GT.2000)GO TO 40
 30   CONTINUE
      GO TO 14
C
C  ERROR MESSAGE
 40   WRITE(6,41)
 41   FORMAT(' ERROR ** INSUFFICIENT ROOM IN IOBS **   <===')
      STOP
 50   CONTINUE
C  DO NOT OUTPUT IF ERRORS OCCURRED
      IF(IERR.LT.0)STOP
C
C  OUTPUT THE ORDERED STOP VISITS
C  LOOP OVER STOPS
      DO 60 ISTP=1,NSTOPS
C  CHECK FOR UNUSED STOP
      IF(STOPX(ISTP).LT.0.0)GO TO 60
C  CHECK HEADER LINE FOR HAVING BEEN SET
      IF(IHEAD(1,ISTP).LT.0.0)GO TO 100
C  OUTPUT HEADER LINE
      WRITE(4,54)(IHEAD(J,ISTP),J=1,5)
 54   FORMAT(2I3,I7,I2,I3)
C  CHECK FOR OBSERVATIONS
      NOB=IHEAD(5,ISTP)
      IF(NOB.LT.1)GO TO 60
C  OUTPUT OBSERVATIONS
      ISTART=IO(ISTP)
      ISTOP=ISTART+NOB-1
      DO 58 I=ISTART,ISTOP
      WRITE(4,56)(IOBS(J,I),J=1,7)
 56   FORMAT(2I2,I3,I2,2I4,2I2)
 58   CONTINUE
 60   CONTINUE
      STOP
C  ERROR MESSAGE - MISSING DATA
 100  WRITE(6,101) ISTP
 101  FORMAT(' ERROR ** DATA MISSING FOR STOP',I4,' ** <===')
      STOP
      END
```

```
C   COVANDLOC
C   PROGRAM TO SIMULATE AREA COVERED FOR A SPECIES AND
C   TO PROJECT LOCATIONS FOR THAT SPECIES
C   WRITTEN BY KIM SCOULLAR
C   READS TOPO AND FOR CANOPY PROFILES 2   READS FIELD DATA 5
C   READS SPECIES INFO ON 7  READS STOP INFO ON 3
C   WRITES COVERAGE AND LOCATIONAL POLYGONS ON 4
C   TEMPORARY DEBUG OUTPUT ON UNIT 8
C   NEGATIVE STOP IN DATA MEANS NOT VISITED THAT SERIES
      DIMENSION IAXQAD(16),AXANGL(16),STOPX(200),STOPY(200)
      DIMENSION TOPD(25,16),TOPZ(25,16),NTOP(16),ERR(9)
      DIMENSION FORD(40,16),FORZ(40,16),NFOR(16),NTSIDE(30)
      DIMENSION BNOISE(3),TD(25),TZ(25),FD(40),FZ(40)
      DIMENSION TDINT(30),TZINT(30),FDINT(30),FZINT(30)
      DIMENSION NFSIDE(30),COVX(16),COVY(16),OBX(16),OBY(16)
      DIMENSION XLOCAT(4),YLOCAT(4),XLOC(16),YLOC(16)
      REAL*8 SEGLTH
      DATA IAXQAD/1,1,1,1,1,4,4,4,4,3,3,3,3,2,2,2/
      DATA AXANGL/0.0,22.5,45.0,67.5,90.0,67.5,45.0,22.5,0.0,
     122.5,45.0,67.5,90.0,67.5,45.0,22.5/
      DATA ERR/5.0,10.0,20.0,20.0,20.0,20.0,2.0,20.0,2.0/
C***DEBUG  CONVERSION FACTOR FOR PLOTTING
      CNVRT=1.0/252.4
C   SET CANOPY DENSITY FACTOR - HALF DISTANCE OF NO REDUCTION
      DFREE=50.0
C   SET STEP SIZE FOR INCREMENTING TEST DISTANCES
      ISTEP=50
      STEP=ISTEP
      HSTEP=STEP/2.0
C   INITIALIZE TIME RANGE
      MDATE1=999999
      MDATE2=111111
C   INPUT SPECIES INFO
      READ(7,6)NSPEC,IDATE1,IDATE2,MXDAIR,IPOS,CPOS
 6    FORMAT(I3,2I7,I5,I2,F4.1)
C   CONVERT MAX DISTANCE BIRD COULD BE HEARD
      XDAIR=MXDAIR
C   INPUT CANOPY ABSRBTION AND BACKGROUND NOISE FACTORS
C   CANOPY IS AIR EQUIVALENT OF ONE METER OF FOREST
C   BNOISE ACTS MULTIPLICATIVELY TO REDUCE MXDAIR
      READ(7,7)CANOPY,(BNOISE(K),K=1,3)
 7    FORMAT(4F5.2)
C   INPUT STOP POINT INFO
      READ(3)NSTOPS,STOPX,STOPY
C   LOOP OVER STOP VISITS
      DO 19 IST=1,NSTOPS
C   CHECK FOR UNUSED STOP
      IF(STOPX(IST).LT.0.0)GO TO 19
C   INPUT TOPO AND CANOPY PROFILES
      READ(2)TOPD,TOPZ,NTOP,FORD,FORZ,NFOR,RAISOB
C   INPUT STOP VISIT INFORMATION
      READ(5,20)ISTP,ISER,IDATE,NOISEB,NOB
 20   FORMAT(2I3,I7,I2,I3)
```

```
C  CHECK FOR STOP NOT VISITED
      IF(ISTP.LT.0)GO TO 19
C  CHECK DATE TO SEE IF SPECIES WAS ACTIVE
      IF(IDATE.GE.IDATE1.AND.IDATE.LE.IDATE2)GO TO 24
C  SPECIES NOT ACTIVE ON THIS DATE - SKIP SIGHTINGS
      IF(NOB.EQ.0)GO TO 19
      DO 22 I=1,NOB
 22   READ(5,23)ISPEC,IERR,IANGL,IQUAD,MIND,MAXD,IRAP
 23   FORMAT(2I2,I3,I2,2I4,I2)
      GO TO 19
C
C  SPECIES ACTIVE ON THIS DATE - PRODUCE COVERAGE POLYGON
C  REDUCE AUDIBLE DISTANCE IN AIR FOR BACKGROUND NOISE
 24   DAIR=XDAIR
      IF(NOISEB.LT.1)GO TO 25
      DAIR=DAIR*BNOISE(NOISEB)
C  CHECK IF DATE EXPANDS RANGE
 25   IF(IDATE.LT.MDATE1)MDATE1=IDATE
      IF(IDATE.GT.MDATE2)MDATE2=IDATE
C  GET OBSERVATION POINT - CONSIDER RAISED OBSERVER
      OBSERZ=TOPZ(1,1)+2.0+RAISOB
C  INITIALIZE COVERAGE POLYGON LIMITS
      XMX=0.0
      XMN=99999.0
      YMX=0.0
      YMN=99999.0
C  MAKE COVERAGE POLYGON
C  LOOP OVER AXIS
      DO 70 IAX=1,16
C  GET TOPO AND CANOPY PROFILE POLYGONS
      NT=NTOP(IAX)
      DO 31 J=1,NT
      TD(J)=TOPD(J,IAX)
 31   TZ(J)=TOPZ(J,IAX)
      NF=NFOR(IAX)
      DO 32 J=1,NF
      FD(J)=FORD(J,IAX)
 32   FZ(J)=FORZ(J,IAX)
C  INITIALIZE TEST DISTANCE TO MAX DIST IN AIR
      TESTD=XDAIR+HSTEP
C  LOOP OVER TEST DISTANCES
 9    TESTD=TESTD-STEP
      IF(TESTD.LE.HSTEP)GO TO 60
C  GET NUMBER OF POINTS IN EACH PROFILE POLYGON
      JT=NT
      JF=NF
C  GET SECTION OF TOPOG PROFILE THAT CONTAINS TEST DIST
 10   JT=JT-1
      IT=JT-1
      IF(IT.LT.1)GO TO 33
      IF(TESTD.LT.TD(IT))GO TO 10
C  GET SECTION OF CANOPY PROFILE THAT CONTAINS TEST DIST
 11   JF=JF-1
      IF=JF-1
      IF(IF.LT.1)GO TO 33
      IF(TESTD.LT.FD(IF))GO TO 11
```

```
C   GET TOPOG AT TEST DIST BY LINEAR INTERPOLATION
      ZT=TZ(IT)+(TZ(JT)-TZ(IT))*
     1(TD(IT)-TESTD)/(TD(IT)-TD(JT))
C   GET CANOPY AT TEST DIST BY LINEAR INTERPOLATION
      ZF=FZ(IF)+(FZ(JF)-FZ(IF))*
     1(FD(IF)-TESTD)/(FD(IF)-FD(JF))
      GO TO 35
C   ERROR MESSAGE
 33   WRITE(6,34)IST,IAX,IT,IF
 34   FORMAT(' ERROR IN PROFILES',4I4)
C   GET SPECIES CALLING ELEVATION
 35   IF(IPOS.EQ.1)TESTZ=ZT+CPOS
      IF(IPOS.EQ.2)TESTZ=ZF+CPOS
      IF(IPOS.EQ.3)TESTZ=ZT+(ZF-ZT)*CPOS
C   MINIMUM HEIGHT FOR ANY SPECIES IS ONE METER
      IF(TESTZ.LT.ZT+1.0)TESTZ=ZT+1.0
C   CHECK FOR TOPOGRAPHIC CUT OFF AT THIS TEST DISTANCE
      CALL VECPLY(TESTD,TESTZ,TD,TZ,NT,0.0,OBSERZ,TDINT,
     1TZINT,NTSIDE,NTINT,INTOUT)
C   TEST DIST NOT SUCCESSFUL IF ANY INTERSECTION WITH GROUND
      IF(NTINT.GE.1)GO TO 9
C   CHECK TO SEE IF TEST DIST EXCEEDS MAX DIST FOR SOUND
C   CONSIDER INTERSECTIONS WITH FOREST CANOPY
      CALL VECPLY(0.0,OBSERZ,FD,FZ,NF,TESTD,TESTZ,FDINT,
     1FZINT,NFSIDE,NFINT,INFOUT)
C   WORK OUT THE VECTOR OF INTERSECTION
C   START IN AIR MEDIUM AT OBSERVER    1 IS AIR   -1 IS CANOPY
      MED=1
C   INITIALIZE EFFECTIVE DISTANCE
      EFECTD=0.0
C   INITIALIZE PRESENT POINT
      D=0.0
      Z=OBSERZ
C   INITIALIZE TEST DISTANCE
      DTEST=SEGLTH(D,Z,TESTD,TESTZ)
C   CHECK FOR NO INTERSECTIONS
      IF(NFINT.LT.1)GO TO 40
C   LOOP OVER INTERSECTIONS
      DO 37 INT=1,NFINT
C   GET DISTANCES
      DTEST=SEGLTH(D,Z,TESTD,TESTZ)
      DINT=SEGLTH(D,Z,FDINT(INT),FZINT(INT))
C   CHECK FOR TEST POINT BEING CLOSER THAN NEXT INTERSECTION
      IF(DTEST.LE.DINT)GO TO 40
C   INCREMENT EFFECTIVE DISTANCE FOR THIS SEGMENT
      IF(MED.GT.0)GO TO 36
C   DO NOT COUNT FOREST NEAR BIRD OR OBSERVER
      DST=DFREE-SEGLTH(0.0,OBSERZ,D,Z)
      IF(DST.LT.0.0)DST=0.0
      DFIN=DFREE-SEGLTH(FDINT(INT),FZINT(INT),TESTD,TESTZ)
      IF(DFIN.LT.0.0)DFIN=0.0
      DCAN=DINT-(DST+DFIN)
      IF(DCAN.LT.0.0)DCAN=0.0
      DFR=DINT-DCAN
      EFECTD=EFECTD+DFR+DCAN*CANOPY
      GO TO 42
```

```
 36    EFECTD=EFECTD+DINT
C   SWITCH MEDIUMS
 42    MED=MED*(-1)
C   ADVANCE THE PRESENT POINT
       D=FDINT(INT)
 37    Z=FZINT(INT)
C   LAST POINT IS TEST POINT
 40    IF(MED.GT.0)GO TO 44
C   DO NOT COUNT FOREST NEAR OBSERVER OR BIRD
       DST=DFREE-SEGLTH(0.0,OBSERZ,D,Z)
       IF(DST.LT.0.0)DST=0.0
       DCAN=DTEST-(DST+DFREE)
       IF(DCAN.LT.0.0)DCAN=0.0
       DFR=DTEST-DCAN
       EFECTD=EFECTD+DFR+DCAN*CANOPY
       GO TO 45
 44    EFECTD=EFECTD+DTEST
C   WAS DISTANCE SUCCESSFUL
 45    IF(EFECTD.LT.DAIR)GO TO 60
       GO TO 9
C
C   HAVE GREATEST SUCCESSFUL DISTANCE
 60    SUCESD=TESTD+HSTEP
       IF(SUCESD.LT.HSTEP)SUCESD=HSTEP
C   GET POINT AT SUCCESSFUL DISTANCE, THIS AXIS FROM THIS STOP
       CALL QAD(STOPX(IST),STOPY(IST),IAXQAD(IAX),AXANGL(IAX),
      1SUCESD,X,Y)
C   CHECK FOR MINS AND MAXES
       IF(X.GT.XMX)XMX=X
       IF(X.LT.XMN)XMN=X
       IF(Y.GT.YMX)YMX=Y
       IF(Y.LT.YMN)YMN=Y
C   STORE POINT IN COVERAGE POLYGON ARRAY
       COVX(IAX)=X
 70    COVY(IAX)=Y
C   PREPARE NUMBER OF POINTS
       NCOV=-16
C   GET AREA OF COVERAGE POLYGON
       CALL AREA(COVX,COVY,16,AREAC)
C   OUTPUT THE COVERAGE POLYGON AND INFORMATION
       WRITE(4)NCOV,COVX,COVY,XMX,XMN,YMX,YMN,AREAC,IST
C***DEBUG  6LINES
       AREAHC=AREAC/10000.
       WRITE(8,711)IST,NSPEC,AREAHC
 711   FORMAT(' COVERAGE COMPLETED FOR STOP',I5,'    SPECIES',
      1I5,'    AREA COVERED',F8.2)
C      WRITE(8,712) (COVX(I),I=1,16)
C      WRITE(8,712) (COVY(I),I=1,16)
C712   FORMAT(1X,16F8.1)
C***DEBUG  REMOVE PLOTS  12 LINES
       XPL=STOPX(IST)-XDAIR
       YPL=STOPY(IST)-XDAIR
```

```
C   PLOT AXIS ON STOP POINT
       CALL PLOT((STOPX(IST)-XPL)*CNVRT,XDAIR*2.0*CNVRT,3)
       CALL PLOT((STOPX(IST)-XPL)*CNVRT,0.0,2)
       CALL PLOT(0.0,(STOPY(IST)-YPL)*CNVRT,3)
       CALL PLOT(XDAIR*2.0*CNVRT,(STOPY(IST)-YPL)*CNVRT,2)
C   PLOT COVERAGE POLYGON
       CALL PLOT((COVX(16)-XPL)*CNVRT,(COVY(16)-YPL)*CNVRT,3)
       DO 701 I=1,16
 701   CALL PLOT((COVX(I)-XPL)*CNVRT,(COVY(I)-YPL)*CNVRT,2)
C
C   MAKE LOCATION POLYGONS
C   ARE THERE ANY LOCATIONAL OBSERVATIONS
       IF(NOB.EQ.0)GO TO 18
C   LOOP OVER LOCATIONAL OBSERVATIONS
       DO 90 IOB=1,NOB
C   INPUT ONE OBSERVATION
       READ(5,75)ISPEC,IERR,IANGL,IQUAD,MIND,MAXD,IRAP
 75    FORMAT(2I2,I3,I2,2I4,I2)
C   CHECK FOR THIS SPECIES
       IF(ISPEC.NE.NSPEC)GO TO 90
C   CHECK FOR RANGEFINDER DATA
       IF(IERR.EQ.7)GO TO 79
C   GET AND CHECK MINIMUM DISTANCE
       DMIN=MIND
       IF(DMIN.LT.1.0)DMIN=1.0
C   GET AND CHECK MAXIMUM DISTANCE
       DMAX=MAXD
       IF(MAXD.EQ.0)DMAX=XDAIR
       IF(DMAX.LT.DMIN+10.0)DMAX=DMIN+10.0
       GO TO 78
C   RANGEFINDER DATA - GET SLOPE DISTANCE
 79    DSLOPE=MIND
       IF(DSLOPE.LT.6.0)DSLOPE=6.0
C   GET SLOPE DISTANCE ERROR - BASE OF RANGEFINDER IS 0.5 M
       ERRD=ABS(DSLOPE-TAN(ATAN(DSLOPE/0.5)-0.05)*0.5)
       IF(ERRD.LT.5.0)ERRD=5.0
C   GET SLOPE DISTANCE PLUS ERROR AND MINUS ERROR
       DSLMAX=DSLOPE+ERRD
       DSLMIN=DSLOPE-ERRD
C   CORRECT FOR SLOPE - FIRST CONVERT PERCENT SLOPE TO RADIANS
       SLOPE=MAXD
       SLOPE=ATAN(SLOPE/100.0)*0.01745
       DMIN=COS(SLOPE)*DSLMIN
       DMAX=COS(SLOPE)*DSLMAX
C   EXPAND ANGLE FOR VERY CLOSE DISTANCES
C   GET THE ANNGLE
 78    ERRANG=ERR(IERR)
C   GET AVERAGE DISTANCE
       DAVE=(DMIN+DMAX)/2.0
C   GET ANGLE FOR 10 METERS THICKNESS AT AVERAGE DISTANCE
       AMIN=(ATAN(10.0/DAVE)/2.0)*57.30
C   INCREASE ANGLE IF NECESSARY
       IF(ERRANG.LT.AMIN)ERRANG=AMIN
C   GET ANGLE PLUS ERROR
       APLUS=IANGL
       APLUS=APLUS+ERRANG
```

```
C   INITIALIZE ANGLE PLUS ERROR QUADRAT
      IQPLUS=IQUAD
C   CHECK FOR ANGLE GREATER THAN 90 DEGREES
      IF(APLUS.LE.90.0)GO TO 77
C   GET AMOUNT OF OVERSHOOT
      OVERSH=APLUS-90.0
C   GET NEW ANGLE
      APLUS=90.0-OVERSH
C   GET NEW QUADRAT
      IQPLUS=4
      IF(IQUAD.EQ.2)IQPLUS=3
      IF(IQUAD.EQ.3)IQPLUS=2
      IF(IQUAD.EQ.4)IQPLUS=1
C   GET ANGLE MINUS ERROR
 77   AMINUS=IANGL
      AMINUS=AMINUS-ERRANG
C   INITIALIZE ANGLE MINUS ERROR QUADRAT
      IQMNUS=IQUAD
C   CHECK FOR ANGLE LESS THAN 0 DEGREES
      IF(AMINUS.GE.0.0)GO TO 80
C   GET AMOUNT OF OVERSHOOT
      OVERSH=0.0-AMINUS
C   GET NEW ANGLE
      AMINUS=OVERSH
C   GET NEW QUADRAT
      IQMNUS=2
      IF(IQUAD.EQ.2)IQMNUS=1
      IF(IQUAD.EQ.3)IQMNUS=4
      IF(IQUAD.EQ.4)IQMNUS=3
C   PREPARE LOCATION POLYGON
C   FIRST POINT AT DMIN, ANGLE PLUS
 80   CALL QAD(STOPX(IST),STOPY(IST),IQPLUS,APLUS,DMIN,
     1XLOCAT(1),YLOCAT(1))
C   SECOND POINT AT DMAX, ANGLE PLUS
      CALL QAD(STOPX(IST),STOPY(IST),IQPLUS,APLUS,DMAX,
     1XLOCAT(2),YLOCAT(2))
C   THIRD POINT AT DMAX, ANGLE MINUS
      CALL QAD(STOPX(IST),STOPY(IST),IQMNUS,AMINUS,DMAX,
     1XLOCAT(3),YLOCAT(3))
C   FOURTH POINT AT DMIN, ANGLE MINUS
      CALL QAD(STOPX(IST),STOPY(IST),IQMNUS,AMINUS,DMIN,
     1XLOCAT(4),YLOCAT(4))
C***DEBUG  4 LINES
C     WRITE(8,713) (XLOCAT(I),I=1,4)
C     WRITE(8,713) (YLOCAT(I),I=1,4)
C713  FORMAT(1X,4F8.1)
C   REDUCE LOCATION POLYGON FOR COVERAGE LIMITS
      CALL INTPLY(XLOCAT,YLOCAT,4,COVX,COVY,16,XLOC,YLOC,
     1NLOC,1,16,AREAL,NINTPY)
C   CHECK FOR NO INTERSECTION - BAD DATA
      IF(NINTPY.LT.1)GO TO 90
C   INITIALIZE LOCATION POLYGON LIMITS
      XMX=0.0
      XMN=99999.0
      YMX=0.0
      YMN=99999.0
```

```
C  GET MAX AND MIN VALUES
      DO 81 I=1,NLOC
      IF(XLOC(I).GT.XMX)XMX=XLOC(I)
      IF(XLOC(I).LT.XMN)XMN=XLOC(I)
      IF(YLOC(I).GT.YMX)YMX=YLOC(I)
 81   IF(YLOC(I).LT.YMN)YMN=YLOC(I)
C  OUTPUT THE LOCATION POLYGON
      AREAHL=AREAL/10000.
      IF(AREAHL.LT.0.001)GO TO 90
      WRITE(4)NLOC,XLOC,YLOC,XMX,XMN,YMX,YMN,AREAL,IST
      WRITE(8,731)NSPEC,AREAHL
 731  FORMAT('      LOCATION PROJECTED FOR SPECIES',
     1I5,'    WITH AREA',F8.2)
C***DEBUG  REMOVE PLOTS  4 LINES
      CALL PLOT((XLOC(NLOC)-XPL)*CNVRT,
     1     (YLOC(NLOC)-YPL)*CNVRT,3)
      DO 702 I=1,NLOC
 702  CALL PLOT((XLOC(I)-XPL)*CNVRT,(YLOC(I)-YPL)*CNVRT,2)
 90   CONTINUE
C***DEBUG  3 LINES
 18   CALL MAXMX(XMXPL)
      CALL PLOT(XMXPL+1.0,0.0,-3)
 19   CONTINUE
C
C  END FILE WITH A ZERO NPOLY
 500  NLOC=0
      WRITE(4)NLOC,XLOC,YLOC,XMX,XMN,YMX,YMN,AREAL,IST
      WRITE(4)NSPEC,ISER,MDATE1,MDATE2
C***DEBUG  2 LINES
      CALL PLOTND
      STOP
      END
C
C
      SUBROUTINE QAD(PT1X,PT1Y,IQUAD,ANGLE,DIST,PT2X,PT2Y)
C  DETERMINE THE COORDINATES OF A POINT DEFINED BY A
C  GIVEN ANGLE, QUADRATE AND DISTANCE FROM A GIVEN POINT

 SEE PROGRAM FORAXUPD FOR LISTING OF SUBROUTINE QAD

      RETURN
      END
C
C
      SUBROUTINE VECPLY(PX,PY,XX,YY,N,XVECT,YVECT,
     1XINT,YINT,NSIDE,NINT,INOUT)
C  INTERSECTS A VECTOR WITH A POLYGON

 SEE PROGRAM FORAXUPD FOR LISTING OF SUBROUTINE VECPLY

      RETURN
      END
C
C
```

```
      SUBROUTINE INTPLY(AAX,AAY,NA,BBX,BBY,NB,ABX,ABY,NAB,
     1NAB1,NAB2,ABAREA,NINTPY)
C  INTEGER VERSION USING REAL FOR CALCULATIONS
C  ROUTINE TO INTERSECT TWO POLYGONS
C  AX,AY IS FIRST POLYGON WITH NA POINTS
C  BX,BY IS OTHER POLYGON WITH NB POINTS
C  ABX,ABY IS INTERSECTION POLYGONS EACH WITH NAB POINTS
C  THERE MAY BE NAB1 INTERSECTION POLYGONS
C  EACH MAY HAVE AS MANY AS NAB2 POINTS
C  TO BE SURE, NAB2=NA+NB
C  THE LARGEST NAB1 POLYGONS ARE RETURNED
C  FASTER IF AX,AY IS SMALLEST
C
C  WRITTEN BY KIM SCOULLAR
C
      REAL*4 AAX(NA),AAY(NA),BBX(NB),BBY(NB),ABAREA(NAB1)
      REAL*8 BX(400),BY(400),AX(400),AY(400),FX1,FX2,FY1,FY2
      REAL*4 ABX(NAB1,NAB2),ABY(NAB1,NAB2)
      REAL*4 POLYX(800),POLYY(800)
      REAL*8 XINT(30),YINT(30),X,Y,RESTRX,RESTRY,TOL,SEGLTH
      INTEGER NAB(NAB1),NSIDE(30)
      TOL=0.5
      NSHIFT=0
C  TRANSFER POLYGONS A AND B TO WORKING ARRAYS
      DO 80 I=1,NA
      AX(I)=AAX(I)
 80   AY(I)=AAY(I)
      DO 81 I=1,NB
      BX(I)=BBX(I)
 81   BY(I)=BBY(I)
      GO TO 78
C  POINT MOVED HAS CAUSED INCONSISTENT RESULTS
C  SHIFT ONE POLYGON AND TRY AGAIN
 71   X=0.0
      Y=0.0
      CALL MOVEPT(X,Y,NSHIFT)
      X=X*3.0
      Y=Y*3.0
      DO 73 I=1,NA
      AX(I)=AX(I)+X
 73   AY(I)=AY(I)+Y
C  CHECK FOR FIRST POINT OF A BEING ON LINE
 78   NMVE=0
 82   CALL PIP(AX(NA),AY(NA),BX,BY,NB,AX(1),AY(1),
     1XINT,YINT,NSIDE,NINT,INOUT,0)
      IF(INOUT.NE.0)GO TO 84
C  FIRST POINT IS ON LINE - MOVE IT AND CHECK AGAIN
      CALL MOVEPT(AX(1),AY(1),NMVE)
      GO TO 82
C  INITIALIZE COUNTER FOR POLYGON INTERSECTION
 84   NINTPY=0
C  INITIALIZE POSITION COUNTER FOR A
      KA=0
C  LOOP OVER POINTS IN A
 2    KA=KA+1
```

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C   CHECK FOR END OF A WITH NO INTERSECTIONS - ALWAYS OUT
        IF(KA.GT.NA)GO TO 160
C   PREPARE NEXT POINT COUNTER
        LA=KA+1
        IF(LA.GT.NA)LA=1
        IF(INOUT.EQ.-1)GO TO 86
C   FIRST POINT IS INSIDE - PREPARE TO START AN INTPLY
        X=AX(KA)
        Y=AY(KA)
        LINE=0
        GO TO 9
C   FIRST POINT OUTSIDE--INTERSECT SEGMENT OF A WITH POLYGON B
 86     NMVE=0
 88     CALL PIP(AX(KA),AY(KA),BX,BY,NB,AX(LA),AY(LA),
       1XINT,YINT,NSIDE,NINT,INOUT,0)
        IF(INOUT.NE.0)GO TO 89
C   SECOND POINT IS ON LINE - MOVE IT AND CHECK AGAIN
        CALL MOVEPT(AX(LA),AY(LA),NMVE)
        GO TO 88
C   CHECK FOR INTERSECTION
 89     IF(NINT.LT.1)GO TO 2
C   PREPARE TO START INTERSECTION POLYGON
        X=XINT(1)
        Y=YINT(1)
        LINE=1
C
C   START AN INTERSECTION POLYGON
C   SAVE STARTING POINT--FIRST INTERSCTN WITH B OR START OF A
 9      FX1=X-TOL
        FX2=X+TOL
        FY1=Y-TOL
        FY2=Y+TOL
        L=1
        GO TO 96
C   CHECK FOR COMPLETED POLY--NO INTERSCTNS OR ALWAYS ON LINE
 99     IF(FX1.LT.X.AND.FX2.GT.X.AND.
       1      FY1.LT.Y.AND.FY2.GT.Y)GO TO 120
C   CHECK FOR POLYGON ALREADY DONE AS FIRST ONE
        IF(KA.GT.NA)GO TO 130
C   LOOK FOR INTERSECTION WITH B ON THIS SEGMENT
 96     NMVE=0
 98     CALL PIP(X,Y,BX,BY,NB,AX(LA),AY(LA),
       1XINT,YINT,NSIDE,NINT,INOUT,LINE)
        IF(INOUT.NE.0)GO TO 10
C   HAVE SECOND POINT ON LINE - MOVE IT AND TRY AGAIN
        CALL MOVEPT(AX(LA),AY(LA),NMVE)
        GO TO 98
C   CHECK FOR AN INTERSECTION
 10     IF(NINT.LT.1)GO TO 13
C   HAVE AN INTERSECTION
C   PREPARE TO MAKE AN INT POLY
C   RECORD FIRST POINT OF SEGMENT
        POLYX(L)=X
        POLYY(L)=Y
        L=L+1
        IF(L.GT.800)GO TO 71
```

```
 12    X=XINT(1)
       Y=YINT(1)
C   PREPARE TO FOLLOW B
       RESTRX=X
       RESTRY=Y
       IB=NSIDE(1)
C   GET DIRECTION ON B OR ABORT FOLLOW B
       CALL UPDOWN(X,Y,IB,BX,BY,NB,AX,AY,NA,IDIR,JB)
       IF(IDIR.EQ.0)GO TO 71
       LINE=1
       GO TO 19
C   NO USEABLE INTERSECTIONS ON THIS SEGMENT
C   RECORD FIRST POINT OF SEGMENT
 13    POLYX(L)=X
       POLYY(L)=Y
       L=L+1
       IF(L.GT.800)GO TO 71
C   GO TO NEXT SEGMENT
       LINE=0
       KA=KA+1
       X=AX(LA)
       Y=AY(LA)
       LA=KA+1
       IF(LA.GT.NA)LA=1
       GO TO 99
C
C
C   FOLLOW B ADDING POINTS
C   LOOK FOR FIRST INTERSECTION WITH A
 19    NMVE=0
 21    CALL PIP(X,Y,AX,AY,NA,BX(JB),BY(JB),
      1XINT,YINT,NSIDE,NINT,INOUT,LINE)
       IF(INOUT.NE.0)GO TO 18
C   HAVE SECOND POINT ON LINE - MOVE IT AND TRY AGAIN
       CALL MOVEPT(BX(JB),BY(JB),NMVE)
       GO TO 21
C   CHECK FOR AN INTERSECTION
 18    IF(NINT.LT.1)GO TO 23
C   RECORD FIRST POINT OF SEGMENT
       POLYX(L)=X
       POLYY(L)=Y
       L=L+1
       IF(L.GT.800)GO TO 71
 17    X=XINT(1)
       Y=YINT(1)
C   PREPARE TO SWITCH TO A
 22    IA=NSIDE(1)
C   GET DIRECTION ON A OR ABORT SWITCH TO A
       CALL UPDOWN(X,Y,IA,AX,AY,NA,BX,BY,NB,IDIR,JA)
       IF(IDIR.EQ.0)GO TO 71
       LINE=1
       GO TO 30
```

```
C  NO INTERSECT ON THIS SEGMENT - ADD FIRST POINT
 23    POLYX(L)=X
       POLYY(L)=Y
       L=L+1
       IF(L.GT.800)GO TO 71
C  GO TO NEXT SEGMENT
       LINE=0
       X=BX(JB)
       Y=BY(JB)
       IB=JB
       JB=JB+IDIR
       IF(JB.LT.1)JB=NB
       IF(JB.GT.NB)JB=1
       GO TO 19
C
C  CHECK FOR END OF INTERSECT POLYGON
 30    IF(FX1.LT.X.AND.FX2.GT.X.AND.
     1     FY1.LT.Y.AND.FY2.GT.Y)GO TO 100
C  CHECK FOR POLYGON ALREADY DONE EARLIER
       IF(IA.LT.KA)GO TO 110
       IF(IA.EQ.KA.AND.SEGLTH(AX(KA),AY(KA),X,Y).LT.
     1SEGLTH(AX(KA),AY(KA),FX1+TOL,FY1+TOL))GO TO 110
C
C  FOLLOW A ADDING POINTS
C  CHECK FOR STARTING POINT
 33    IF(FX1.LT.X.AND.FX2.GT.X.AND.
     1     FY1.LT.Y.AND.FY2.GT.Y)GO TO 100
C  CHECK FOR POLYGON ALREADY DONE AS FIRST ONE
       IF(NINTPY.GT.0.AND.IA.EQ.1)GO TO 110
C  LOOK FOR INTERSECTION WITH B
       NMVE=0
 34    CALL PIP(X,Y,BX,BY,NB,AX(JA),AY(JA),
     1XINT,YINT,NSIDE,NINT,INOUT,LINE)
       IF(INOUT.NE.0)GO TO 35
C  HAVE SECOND POINT ON LINE - MOVE IT AND TRY AGAIN
       CALL MOVEPT(AX(JA),AY(JA),NMVE)
       GO TO 34
C  CHECK FOR INTERSECTION
 35    IF(NINT.LT.1)GO TO 40
C  INTERSECT HAS BEEN FOUND
C  CHECK FOR START POINT
       IF(FX1.LT.XINT(1).AND.FX2.GT.XINT(1).AND.
     1FY1.LT.YINT(1).AND.FY2.GT.YINT(1))GO TO 100
C  RECORD FIRST POINT OF SEGMENT
       POLYX(L)=X
       POLYY(L)=Y
       L=L+1
       IF(L.GT.800)GO TO 71
 42    X=XINT(1)
       Y=YINT(1)
C  PREPARE FOR SWITCH TO B
       IB=NSIDE(1)
```

```
C   GET DIRECTION ON B OR ABORT SWITCH TO B
       CALL UPDOWN(X,Y,IB,BX,BY,NB,AX,AY,NA,IDIR,JB)
       IF(IDIR.EQ.0)GO TO 71
       LINE=1
       GO TO 19
C   NO INTERSECTION ON THIS SEGMENT - ADD FIRST POINT
 40    POLYX(L)=X
       POLYY(L)=Y
       L=L+1
       IF(L.GT.800)GO TO 71
C   GO TO NEXT SEGMENT
       LINE=0
       IA=JA
       X=AX(JA)
       Y=AY(JA)
       JA=JA+IDIR
       IF(JA.LT.1)JA=NA
       IF(JA.GT.NA)JA=1
       GO TO 33
C
C   END OF AN INTERSECT POLYGON HAS BEEN FOUND
C   GET NUMBER OF POINTS IN POLYGON
 100   NPTS=L-1
C   GET AREA OF POLYGON
       CALL AREA(POLYX,POLYY,NPTS,PAREA)
C   DO NOT BOTHER IF AREA IS LESS THAN MINIMUM
       IF(PAREA.LT.10.0)GO TO 170
C   CHECK FOR ROOM IN ARRAY OF INTERSECTION POLYGONS
       IF(NINTPY.GE.NAB1)GO TO 103
C   INCREMENT POLYGON COUNTER
       NINTPY=NINTPY+1
C   STORE THE INTERSECTION POLYGON
       MPTS=0
       DO 102 I=1,NPTS
C   DO NOT KEEP POINT IF CLOSE TO NEXT POINT
       IPLS=I+1
       IF(IPLS.GT.NPTS)IPLS=1
       IF(SQRT((POLYX(IPLS)-POLYX(I))**2+(POLYY(IPLS)
      1     -POLYY(I))**2).LT.1.0)GO TO 102
       MPTS=MPTS+1
       ABX(NINTPY,MPTS)=POLYX(I)
       ABY(NINTPY,MPTS)=POLYY(I)
 102   CONTINUE
C   ABORT IF LESS THAN THREE POINTS KEPT
       IF(MPTS.GT.2)GO TO 126
       NINTPY=NINTPY-1
       GO TO 170
C   STORE AREA AND NUMBER OF POINTS
 126   ABAREA(NINTPY)=PAREA
       NAB(NINTPY)=MPTS
C   CONTINUE SEARCH FOR INTERSECT POLYGONS
       GO TO 170
C   NO ROOM - MUST REPLACE ONE WITH LESS AREA
 103   NINTPY=NINTPY+1
```

```
C  FIND ONE WITH LEAST AREA
      ISMALL=1
      DO 104 I=1,NAB1
 104  IF(ABAREA(I).LT.ABAREA(ISMALL))ISMALL=I
C  IF PRESENT POLYGON IS SMALLEST THEN FORGET IT
      IF(ABAREA(ISMALL).GE.ABAREA(NINTPY))GO TO 170
C  REPLACE SMALLEST WITH PRESENT INTERSECTION POLYGON
      DO 105 I=1,NPTS
      ABX(ISMALL,I)=POLYX(I)
 105  ABY(ISMALL,I)=POLYY(I)
C  REPLACE AREA AND NUMBER OF POINTS
      ABAREA(ISMALL)=PAREA
      NAB(ISMALL)=NPTS
C  CONTINUE SEARCH FOR INTERSECTION POLYGONS
      GO TO 170
C
C  ABORT INTERSECTION POLYGON - IT HAS BEEN DONE ALREADY
C CONTINUE SEARCH FOR MORE
 110  GO TO 170
C
C  INTERSECT POLYGON IS A - A INSIDE B OR A AND B IDENTICAL
 120  NINTPY=1
      NPTS=L-1
      DO 121 I=1,NPTS
      ABX(1,I)=POLYX(I)
 121  ABY(1,I)=POLYY(I)
C  STORE AREA AND NUMBER OF POINTS
      CALL AREA(POLYX,POLYY,NPTS,PAREA)
      ABAREA(1)=PAREA
      NAB(1)=NPTS
C  END ROUTINE
      RETURN
C
C  ABORT INTERSECT POLYGON AND END ROUTINE
 130  RETURN
C
C  END OF A WITH NO INTERSECTIONS - A ALWAYS OUTSIDE
C  CHECK FOR B INSIDE A - RETURN IF NO INTERSECTION
 160  CALL PIP(BX(1),BY(1),AX,AY,NA,BX(2),BY(2),
     1XINT,YINT,NSIDE,NINT,INOUT,0)
      IF(INOUT.EQ.-1) RETURN
C  B IS INSIDE - IT IS THE ONLY INTERSECT POLYGON
 161  NINTPY=1
C  INSERT B INTO INTERSECT POLYGON ARRAY
      DO 162 I=1,NB
      ABX(1,I)=BBX(I)
 162  ABY(1,I)=BBY(I)
C  STORE AREA AND NUMBER OF POINTS
      CALL AREA(BBX,BBY,NB,PAREA)
      ABAREA(1)=PAREA
      NAB(1)=NB
      RETURN
C
```

```
C  CONTINUE SEARCH FOR INTERSECT POLYGONS
 170   NMVE=0
 171   CALL PIP(RESTRX,RESTRY,BX,BY,NB,AX(LA),AY(LA),
      1XINT,YINT,NSIDE,NINT,INOUT,1)
       IF(INOUT.NE.0)GO TO 173
C  HAVE SECOND POINT ON LINE - MOVE IT AND TRY AGAIN
       CALL MOVEPT(AX(LA),AY(LA),NMVE)
       GO TO 171
C  CHECK FOR AN INTERSECTION
 173   IF(NINT.LT.1)GO TO 172
C  START AN INTERSECTION POLYGON
 174   X=XINT(1)
       Y=YINT(1)
       LINE=1
       GO TO 9
C  NO INTERSECTION - CONTINUE TO SEARCH
C  LOOP OVER POINTS IN A
 172   KA=KA+1
C  CHECK FOR END OF A
       IF(KA.GT.NA)RETURN
C  PREPARE NEXT POINT COUNTER
       LA=KA+1
       IF(LA.GT.NA)LA=1
C  INTERSECT THIS SEGMENT OF A WITH POLYGON B
       NMVE=0
 175   CALL PIP(AX(KA),AY(KA),BX,BY,NB,AX(LA),AY(LA),
      1XINT,YINT,NSIDE,NINT,INOUT,0)
       IF(INOUT.NE.0)GO TO 178
C  HAVE SECOND POINT ON LINE - MOVE IT AND TRY AGAIN
       CALL MOVEPT(AX(LA),AY(LA),NMVE)
       GO TO 175
C  CHECK FOR AN INTERSECTION
 178   IF(NINT.LT.1)GO TO 172
C  PREPARE TO START AN INTERSECTION POLYGON
 176   X=XINT(1)
       Y=YINT(1)
       LINE=1
       GO TO 9
C  END OF ROUTINE
       END
C
C
       SUBROUTINE PIP(XVECT,YVECT,XX,YY,N,PX,PY,
      1XINT,YINT,NSIDE,NINT,INOUT,LINE)
C  INTERSECTS A VECTOR WITH A POLYGON
       INTEGER NSIDE(30),IGNOR,LINE
       REAL*8 XLENG,XVECT,YVECT,XINT(30),YINT(30),SEGLTH
       REAL*8 VCOS,VSIN,XVEC,YVEC,CEPT,TEMP,EPT,DIFF
       REAL*8 XX(N),YY(N),XP,YP,XI,YI,XJ,YJ,DSQRT,XCEPT
       REAL*8 PX,PY,XIS,YIS,XJS,YJS,XK,YKS,XKS,TEST
       REAL*8 PXIJ,PYIJ,PXKJ,DIST,RADIUS,DABS,CLOS
C   ***************************************************
C   *
C   *   WRITTEN BY DALE TROYER
C   *   MODIFIED BY KIM SCOULLAR
C   *
```

```
C    *  INTPLY VERSION - DESIGNED TO WORK BACKWARDS
C    *  PIP DETERMINES IF A POINT IS INSIDE OR OUTSIDE OF *
C    *  A POLYGON.
C    *  THE POINT IN QUESTION IS (PX, PY).
C    *  THE POLYGON IS DEFINED BY ARRAY OF COORDINATE PAIRS
C    *  XX AND YY.
C    *  N IS THE NUMBER OF POINTS IN XX AND YY.
C    *  INOUT IS SET TO 1 IF THE POINT IS INSIDE THE POLYGON.
C    *  INOUT IS SET TO -1 IF POINT IS OUTSIDE THE POLYGON.
C    *  IF POINT PX PY IS ON A BOUNDARY LINE IT WILL BE MOVED
C    *  XVECT, YVECT DEFINES VECTOR ON WHICH TEST IS MADE.
C    *  XVECT, YVECT CAN BE ANY COODINATE NOT = TO PX, PY.
C    *  XINT, YINT ARE POINTS AT WHICH POLYGON INTERSECTS
C    *  THE SEGMENT DEFINED BY THE TWO POINTS.
C    *  VECTOR STARTS AT POINT PX PY AND GOES TO INFINITY.
C    *  NSIDE IS SIDE NUMBER ON WHICH INTERSECTION OCCURRED.
C    *  IF SEGMENT INTERSECTS MORE THAN 1 SIDE, INTERSECTIONS
C    *  ARE SORTED SUCH THAT THE INTERSECTIONS NEAREST
C    *  XVECT,YVECT ON THE SEGMENT COME FIRST.
C    *  THE INTERSECTION CLOSEST TO PX,PY ALONG
C    *  THE SEGMENT WILL BE LAST.
C    *
C    ******************************************************
C
C    ******************************************************
C    * THE POLYGON IS TRANSLATED SUCH THAT THE POINT PX,PY IS
C    * AT THE ORIGIN BY SUBTRACTING PX,PY FROM EVERYTHING.
C    * THE  POLYGON IS THEN ROTATED SUCH THAT THE VECTOR
C    * DEFINED BY XVECT YVECT LIES ON THE Y AXIS.
C    * THIS IS DONE INITIALLY FOR THE FIRST TWO SIDES
C    * AND FOR EACH SIDE AFTER 1 AT A TIME.
C    * THIS AVOIDS STORING POLYGON (WHICH MAY BE LARGE) TWICE.
C    *
C    * WE FIRST ASSUME THE POINT IS OUTSIDE.
C    *
C    ******************************************************
C
      XVEC = XVECT - PX
      YVEC = YVECT - PY
      XLENG =DSQRT(XVEC*XVEC+YVEC*YVEC)
      VSIN = XVEC / XLENG
      VCOS = YVEC / XLENG
 30   NINT = 0
      XJS=XX(1) - PX
      YJS=YY(1) - PY
      XJ = XJS * VCOS - YJS * VSIN
      YJ = XJS * VSIN + YJS * VCOS
      J=1
      INOUT=-1
C  CHECK FOR FIRST POINT OF POLYGON BEING NEAR THE VECTOR
      IF(XJ.LT.-0.5.OR.XJ.GT.0.5)GO TO 32
C  POLYGON STARTS ON VECTOR - MOVE THE START POINT
 31   IF(XJ.GE.0.0)XJ=0.7
      IF(XJ.LT.0.2)XJ=-0.7
      XJS=XJ*VCOS+YJ*VSIN
```

```
      YJS=YJ*VCOS-XJ*VSIN
      XX(J)=XJS+PX
      YY(J)=YJS+PY
      GO TO 30
C
C   *********************************************************
C   *
C   * THE PROGRAM COUNTS THE NUMBER OF TIMES A POLYGON LINE
C   * SEGMENT CROSSES THE POSITIVE Y AXES.
C   *
C   * IF AN ODD NUMBER OF SEGMENTS CROSS THE POSITIVE Y AXES
C   * THE POINT IS INSIDE.
C   *
C   * IF AN EVEN NUMBER OF SEGMENTS CROSS THE POSITIVE Y AXES
C   * THE POINT IS OUTSIDE.
C   *
C   *******************************************************
C
 32   DO 2 I = 1, N
      XI = XJ
      YI = YJ
      J  = I+1
      IF(J.GT.N)J=1
C    *******PERFORM TRANSLATION OF AXES******
      XJS = XX (J) - PX
      YJS = YY (J) - PY
C    ******PERFORM ROTATION OF AXES******
      XJ = XJS * VCOS - YJS * VSIN
      YJ = XJS * VSIN + YJS * VCOS
C  CHECK FOR SECOND POINT OF SEGMENT BEING NEAR THE VECTOR
      IF(XJ.LT.-0.5.OR.XJ.GT.0.5)GO TO 34
C  SECOND POINT IS NEAR VECTOR - MOVE IT
      GO TO 31
C   ********************************************************
C   *
C   * HERE WE RULE OUT ALL SEGMENTS WHOS END POINTS HAVE
C   *  X COORDINATES WITH THE SAME SIGN.
C   * I.E. XI*XJ > ZERO.
C   *
C   ********************************************************
C
 34   PXIJ=XI * XJ
      IF (PXIJ.GT.0.15) GO TO 2
C   ********************************************************
C   *
C   * HERE WE RULE OUT ALL SEGMENTS THAT HAVE BOTH Y VALUES
C   * LESS THAN ZERO.
C   *
C   * THESE WILL NOT INTERSECT THE POSITIVE Y AXIS.
C   *
C   ********************************************************
C
      IF (YI.LT.-0.7.AND.YJ.LT.-0.7) GO TO 2
C
```

```
C   *****************************************************
C   *
C   * WE NOW MUST RESORT TO CALCULATION OF THE Y INTERCEPT.
C   *
C   *****************************************************
C
C  CALCULATE Y AND X INTERCEPTS
C
      EPT=YI*XJ-XI*YJ
 8    CEPT=EPT / (XJ-XI)
      DIFF=YJ-YI
      IF(DIFF.NE.0.0)GO TO 53
      XCEPT=999.
      GO TO 56
 53   XCEPT=EPT/DIFF
 56   DIST=DSQRT(CEPT*CEPT+XCEPT*XCEPT)
      IF(DIST.NE.0.0)GO TO 54
      RADIUS=0.0
      GO TO 57
 54   RADIUS=CEPT*XCEPT/DIST
C  CHECK FOR VECTOR STARTING ON LINE
 57   IF(RADIUS.LT.-0.5.OR.RADIUS.GT.0.5)GO TO 58
      NINT=NINT+1
      YINT(NINT)=0.0
      NSIDE(NINT)=I
      GO TO 2
C  CHECK FOR INT NOT ON VECTOR PART OF LINE
 58   IF (CEPT.LT.0.0) GO TO 2
C  HAVE A PROPER INTERSECTION OF VECTOR WITH SEGMENT
C  RECORD THE INTERSECTION
      NINT=NINT+1
      YINT(NINT)=CEPT
      NSIDE(NINT)=I
      INOUT = -INOUT
 2    CONTINUE
C
C  ****************************************************
C  *
C  * SORT THE INTERSECTIONS BY DECREASING Y VALUE.
C  * THE X VALUES ARE ZERO BECAUSE OF THE ROTATION.
C  *
C  ****************************************************
C
      IF (NINT.LT.2) GO TO 64
      ISIZE = NINT - 1
      DO 10 I = 1, ISIZE
      K = I + 1
      DO 10 J = K, NINT
      IF (YINT (J)  .GT.  YINT (I)) GO TO 11
      GO TO 10
 11   TEMP = YINT (J)
      YINT (J) = YINT (I)
      YINT (I) = TEMP
      ITEMP = NSIDE (J)
      NSIDE (J) = NSIDE (I)
      NSIDE (I) = ITEMP
```

```
 10    CONTINUE
C  CHECK FOR VECTOR STARTING ON POLY SEGMENT
 64    IF(NINT.LT.1)GO TO 12
       IF(YINT(NINT).GT.0.2)GO TO 13
       INOUT=0
C
C  GET THE INT CLOSEST TO THE SECOND POINT
 13    IGNOR=0
       CLOS=9999.
       DO 14 I=1,NINT
C  LOOK FOR INT CLOSEST TO SECOND POINT
       TEST=DABS(YINT(I)-XLENG)
       IF(TEST.GT.CLOS)GO TO 14
C  THIS IS CLOSEST TO DATE
       IGNOR=I
       CLOS=TEST
 14    CONTINUE
C
C   ********************************************************
C   *
C   * THE FOLLOWING TRANSLATES AND ROTATES THE AXES FOR
C   * THE INTERSECTING POINTS.
C   * THE SECOND TERM OF EACH ROTATION EQUATION IS ZERO
C   * BECAUSE THE X VALUES OF THE INTERSECTIONS ARE ZERO
C   * THERFORE TO SAVE COMPUTATION THEY HAVE BEEN REMOVED.
C   *
C   ********************************************************
C
 12    IF (NINT .EQ. 0) RETURN
       J=0
       DO 9 I = 1, NINT
C  CHECK FOR SECOND POINT ON LINE TO BE IGNORED
       IF(LINE.EQ.0)GO TO 67
       IF(I.EQ.IGNOR)GO TO 9
C  CHECK FOR INTS AT OR BEYOND END OF SECOND POINT
 67    IF(YINT(I).GT.XLENG)GO TO 9
       J=J+1
       XJS = YINT (I) * VSIN
       YJS = YINT (I) * VCOS
       XINT(J) = XJS + PX
       YINT(J) = YJS + PY
       NSIDE(J)=NSIDE(I)
 9     CONTINUE
       NINT=J
C***DEBUG  3 LINES PLUS GO TO 15 ABOVE INSTEAD OF RETURN
C15    WRITE(8,16)PX,PY,XVECT,YVECT,NINT,INOUT,XINT(1),YINT(1)
C16    FORMAT(' PIP',4F10.2,2I4,2F10.2)
       RETURN
       END
C
C
       SUBROUTINE AREA(X,Y,N,PAREA)
C  ROUTINE TO FIND THE AREA OF POLYGON X,Y WITH N POINTS
C  AREA BY COORDINATES - DAVIS AND FOOT  SURVEYING
       DIMENSION X(N),Y(N)
       IF(N.GT.2)GO TO 3
```

```
      PAREA=0.0
      RETURN
 3    PAREA=Y(1)*(X(N)-X(2))
      M=N-1
      DO 5 I=2,M
 5    PAREA=PAREA+Y(I)*(X(I-1)-X(I+1))
      PAREA=PAREA+Y(N)*(X(N-1)-X(1))
      PAREA=ABS(0.5*PAREA)
      RETURN
      END
C
C
      FUNCTION SEGLTH(P1X,P1Y,P2X,P2Y)
C  FIND THE DISTANCE BETWEEN TWO POINTS
      REAL*8 DSQRT,SEGLTH,P1X,P1Y,P2X,P2Y
      IF(P1X.EQ.P2X.AND.P1Y.EQ.P2Y) GO TO 5
C  LENGTH IS HYPOTENUES OF RIGHT TRIANGLE
      SEGLTH=DSQRT((P2X-P1X)**2+(P2Y-P1Y)**2)
      RETURN
 5    SEGLTH=0.0
      RETURN
      END
C
C
      SUBROUTINE UPDOWN(X,Y,J2,X2,Y2,N2,X1,Y1,N1,IDIR,JB)
      INTEGER NS(30),IFIX
      REAL*8 X2(N2),Y2(N2),XT(30),YT(30),X,Y
      REAL*8 SEGLTH,X1(N1),Y1(N1)
      REAL*4 FLOAT
C  ROUTINE TO PREPARE INFORMATION FOR INTERSECTION DECISIONS
C  X,Y IS POINT OF INTERSECTION ON SIDE J2 OF POLYGON 2
C  IDIR IS DIRECTION CHOSEN - JB IS NEXT POINT
C
C GET INOUT UP AND DOWN FROM INTERSECTION ON POLY 2
 20   K2=J2+1
      IF(K2.GT.N2)K2=1
C  MOVE POINT TO INT IF IT IS CLOSE
      IF(SEGLTH(X,Y,X2(K2),Y2(K2)).GT.0.2)GO TO 21
      X2(K2)=X
      Y2(K2)=Y
      K2=K2+1
      IF(K2.GT.N2)K2=1
 21   I2=J2
      IF(SEGLTH(X,Y,X2(I2),Y2(I2)).GT.0.2)GO TO 18
      X2(I2)=X
      Y2(I2)=Y
      I2=I2-1
      IF(I2.LT.1)I2=N2
C TRY POINT UP
 18   NMVE=0
 22   CALL PIP(X,Y,X1,Y1,N1,X2(K2),Y2(K2),
     1XT,YT,NS,NT,IOU,1)
      IF(IOU.NE.0)GO TO 23
C  POINT UP IS ON LINE - MOVE IT AND TRY AGAIN
 19   CALL MOVEPT(X2(K2),Y2(K2),NMVE)
```

```
C   CHECK FOR MIN DISTANCE
        IF(SEGLTH(X,Y,X2(K2),Y2(K2)).GT.0.2)GO TO 22
        GO TO 19
C   REVERSE INOUT FOR EACH INTERSECTION
 23     IF(NT.LT.1)GO TO 25
        DO 24 I=1,NT
 24     IOU=-IOU
C
C TRY POINT DOWN
 25     NMVE=0
 26     CALL PIP(X,Y,X1,Y1,N1,X2(I2),Y2(I2),
       1XT,YT,NS,NT,IOD,1)
        IF(IOD.NE.0)GO TO 28
C   POINT DOWN IS ON LINE - MOVE IT AND TRY AGAIN
 27     CALL MOVEPT(X2(I2),Y2(I2),NMVE)
C   CHECK FOR MIN DISTANCE
        IF(SEGLTH(X,Y,X2(I2),Y2(I2)).GT.0.2)GO TO 26
        GO TO 27
C   REVERSE INOUT FOR EACH INTERSECTION
 28     IF(NT.LT.1)GO TO 30
        DO 29 I=1,NT
 29     IOD=-IOD
C
C   ESTABLISH DIRECTION AND NEXT POINT
 30     IF(IOU.EQ.IOD)GO TO 35
        IF(IOD.EQ.1)GO TO 33
C   DIRECTION IS FORWARD FOR IN
        IDIR=1
        JB=K2
        GO TO 50
C   DIRECTION IS BACK FOR IN
 33     IDIR=-1
        JB=I2
        GO TO 50
C   ABANDON SWITCHING
 35     IDIR=0
 50     CONTINUE
        RETURN
        END
C
C
        SUBROUTINE MOVEPT(X,Y,NMVE)
C   ROUTINE TO MOVE A POINT THAT WOULD OTHERWISE FALL ON LINE
C   N IS THE NUMBER OF TIMES THIS WILL BE THAT YOU HAVE MOVED
C   CALL WITH NMVE PRESET TO ZERO
        REAL*8 X,Y
        DIMENSION M(48)
        DATA M(1),M(2),M(3),M(4),M(5)/1,2,3,3,4/
        DATA M(6),M(7),M(8),M(9),M(10)/4,1,1,1,2/
        DATA M(11),M(12),M(13),M(14),M(15)/2,2,3,3,3/
        DATA M(16),M(17),M(18),M(19),M(20)/3,4,4,4,4/
```

```
      DATA M(21),M(22),M(23),M(24),M(25)/1,1,1,1,1/
      DATA M(26),M(27),M(28),M(29),M(30)/2,2,2,2,2/
      DATA M(31),M(32),M(33),M(34),M(35)/3,3,3,3,3/
      DATA M(36),M(37),M(38),M(39),M(40)/3,4,4,4,4/
      DATA M(41),M(42),M(43),M(44),M(45)/4,4,1,1,1/
      DATA M(46),M(47),M(48)/1,1,1/
C
      NMVE=NMVE+1
      MVE=M(NMVE)
      GO TO(10,11,12,13),MVE
 10   X=X+0.35
      RETURN
 11   Y=Y+0.35
      RETURN
 12   X=X-0.35
      RETURN
 13   Y=Y-0.35
      RETURN
      END
```

```
C   HABDEXINIT
C   PROGRAM TO ESTABLISH INITIAL COVERAGE AREA
C   AND SITING VALUE ARRAYS
C   WRITTEN BY KIM SCOULLAR
C
C   WRITES ON UNIT 4
        DIMENSION TOTCOV(500),TOTBRD(500),NCOVS(500),NLOCS(500)
        DIMENSION SUMZ(500),SUMZSQ(500),NZ(500),SUMNC(500)
C   ZERO THE ARRAYS
        DO 10 I=1,500
        TOTCOV(I)=0.0
        TOTBRD(I)=0.0
        SUMZ(I)=0.0
        SUMZSQ(I)=0.0
        NZ(I)=0
        SUMNC(I)=0.0
        NCOVS(I)=0
 10     NLOCS(I)=0
        WRITE(4)TOTCOV,TOTBRD,NCOVS,NLOCS,SUMZ,SUMZSQ,NZ,SUMNC
        STOP
        END
```

```
C   HABDEX
C   MUST RUN HABDEXINIT FIRST
C   PROGRAM TO INTERSECT AREAS OF COVERAGE AND LOCATION FOR A
C   SPECIES WITH TYPE ISLANDS OF A CLASSIFICATION MAP AND TO
C   DETERMINE A USE INDEX OF EACH TYPE ISLAND BY THE SPECIES
C   WRITTEN BY KIM SCOULLAR
C   READS CLASSIFICATION TYPE POLYGONS ON 3
C   READS COVERAGE AND LOCATIONS ON 7
C   READS ARRAYS OF INT AND RATING ON 5
C   WRITES ARRAYS OF COV AND LOC ON 4
C   OUTPUTS RESULTS ON 8
      DIMENSION XCOOR(400),YCOOR(400),XPOLY(8000),YPOLY(8000)
      DIMENSION NPOLYS(60),NPTS(60),XMINS(60),XMAXS(60)
      DIMENSION YMINS(60),YMAXS(60),COVX(16),COVY(16)
      DIMENSION NLOC(20),XMXL(20),XMNL(20),YMXL(20),YMNL(20)
      DIMENSION AREAL(20),ABX(5,400),ABY(5,400),NAB(5)
      DIMENSION TOTCOV(500),TOTBRD(500),XL(16),YL(16)
      DIMENSION PAREAS(60),NCOVS(500),NLOCS(500),XLOC(20,16)
      DIMENSION SUMZ(500),SUMZSQ(500),NZ(500),SUMNC(500)
      DIMENSION ISTART(60),X(16),Y(16),ABAREA(5),YLOC(20,16)
C   INITIALIZE END SWITCH
      IFIN=0
C   INPUT ONE FILE OF CLASSIFICATION TYPE ISLANDS POLYGONS
C   PREPARE THE ARRAY OF POLYGONS
C   ZERO THE COUNTERS
      IP=0
      KP=0
C   LOOP OVER POLYGONS
 5    KP=KP+1
C   INPUT ONE POLYGON
      CALL POLYRD(NPT,XCOOR,YCOOR,NPOL,XMIN,XMAX,
     1     YMIN,YMAX,PAREA,IEND)
C   CHECK FOR END OF POLYGONS
      IF(IEND.EQ.1)GO TO 15
C   LOOP OVER POINTS IN POLYGON
      DO 10 K=1,NPT
C   PREPARE THE ARRAYS
      XPOLY(IP+K)=XCOOR(K)
 10   YPOLY(IP+K)=YCOOR(K)
C   PREPARE ARRAYS OF POLYGON INFORMATION
      ISTART(KP)=IP+1
      NPOLYS(KP)=NPOL
      NPTS(KP)=NPT
      XMINS(KP)=XMIN
      XMAXS(KP)=XMAX
      YMINS(KP)=YMIN
      YMAXS(KP)=YMAX
      PAREAS(KP)=PAREA
C   INCREMENT POSITION COUNTER
      IP=IP+NPT
      GO TO 5
```

```
C  ON ENDFILE SET # POINTS = ZERO AND SAVE # OF CLASS POLYS
 15    NPTS(KP)=0
       KPLYS=KP-1
C  INPUT THE ARRAYS OF AREAS OF INT FOR EACH CLASS POLY
       READ(5)TOTCOV,TOTBRD,NCOVS,NLOCS,SUMZ,SUMZSQ,NZ,SUMNC
C  INPUT FIRST COVERAGE POLYGON
       READ(7)NCOV,COVX,COVY,CXMX,CXMN,CYMX,CYMN,AREAC,IST
C  RESET NUMBER OF POINTS
 19    NCOV=16
C  OUTPUT STOP AND AREA COVERED
       AREACH=AREAC/10000.0
       WRITE(8,17)IST,AREACH
 17    FORMAT(' STOP',I4,'     AREA COVERED',F7.2)
C  LOOP OVER LOCATION POLYGONS - INITIALIZE COUNTER
       L=0
C  READ LOCATION POLYGONS
 21    READ(7)N,X,Y,XMX,XMN,YMX,YMN,AREAXY,IST
C  CHECK FOR END OF FILE
       IF(N.EQ.0)GO TO 26
C  CHECK FOR END OF LOCATION POLYGONS
       IF(N.LT.0)GO TO 30
C  THIS IS NEXT LOCATION POLYGON - INCREMENT COUNTER
       L=L+1
C  INSERT IT INTO ARRAY
       DO 23 I=1,N
       XLOC(L,I)=X(I)
 23    YLOC(L,I)=Y(I)
C  INSERT REST OF INFORMATION
       NLOC(L)=N
       XMXL(L)=XMX
       XMNL(L)=XMN
       YMXL(L)=YMX
       YMNL(L)=YMN
       AREAL(L)=AREAXY
       GO TO 21
C  END OF CENSUS DATA FILE - SET END SWITCH
 26    IFIN=1
C
C  INTERSECT COVERAGE AND LOCATIONS WITH CLASSFCTN POLYGONS
 30    CONTINUE
C  LOOP OVER CLASSIFICATION POLYGONS
       DO 38 KP=1,KPLYS
C  SELECT FOR POLYS WITHIN RANGE OF COVERAGE
C  REJECT THOSE OUTSIDE THE RANGE - GO TO NEXT ONE
       IF(CXMX.LT.XMINS(KP))GO TO 38
       IF(CXMN.GT.XMAXS(KP))GO TO 38
       IF(CYMX.LT.YMINS(KP))GO TO 38
       IF(CYMN.GT.YMAXS(KP))GO TO 38
C  CLASS POLY IN RANGE OF COVERAGE POLY - DO INTERSECTION
       CALL INTPLY(COVX,COVY,NCOV,XPOLY(ISTART(KP)),
     1      YPOLY(ISTART(KP)),NPTS(KP),ABX,ABY,
     1      NAB,5,400,ABAREA,NINTPY)
C  CHECK FOR NO INTERSECTIONS - GO TO NEXT ONE
       IF(NINTPY.LT.1)GO TO 38
```

```
C   SUM THE AREAS OF INTERSECTION
      ARC=0.0
      DO 33 I=1,NINTPY
 33   ARC=ARC+ABAREA(I)
C   DISREGARD VERY SMALL INTERSECTIONS TO AVOID ROUNDOFF ERROR
      ARCH=ARC/10000.0
      IF(ARCH.LT.0.01)GO TO 38
      NPOL=NPOLYS(KP)
      TOTCOV(NPOL)=TOTCOV(NPOL)+ARCH
C   INCREMENT COVERAGE COUNTER
      NCOVS(NPOL)=NCOVS(NPOL)+1
C   OUTPUT INFO ON CLASSIFICATION POLYGON IN RANGE
      PAREAH=PAREAS(KP)/10000.0
      PARC=ARC/PAREAS(KP)*100.0
      WRITE(8,312)NPOL,PAREAH,ARCH,PARC
 312  FORMAT(10X,'POLYGON NUMBER',I5,'    AREA OF POLYGON',
     1     F8.2,'     AREA COVERED',F7.2,
     1     '      PERCENT COVERED',F7.2)
C   ZERO BIRDS PER UNIT AREA AND NUMBER OF LOCATIONS
      TBIRDS=0.0
      NLCS=0
C   CHECK FOR LOCATION POLYGONS
      IF(L.LT.1)GO TO 315
C   LOOP OVER LOCATION POLYGONS
 313  DO 36 I=1,L
C   CHECK FOR CLASS POLY WITHIN RANGE OF LOCATION POLY
      IF(XMXL(I).LT.XMINS(KP))GO TO 36
      IF(XMNL(I).GT.XMAXS(KP))GO TO 36
      IF(YMXL(I).LT.YMINS(KP))GO TO 36
      IF(YMNL(I).GT.YMAXS(KP))GO TO 36
C   CLASS POLY IS WITHIN RANGE OF LOCATION POLY
C   GET THE LOCATION POLYGON
      NLC=NLOC(I)
      DO 34 J=1,NLC
      XL(J)=XLOC(I,J)
 34   YL(J)=YLOC(I,J)
C   DO THE INTERSECT
      CALL INTPLY(XL,YL,NLOC(I),XPOLY(ISTART(KP)),
     1     YPOLY(ISTART(KP)),NPTS(KP),ABX,ABY,
     1     NAB,5,400,ABAREA,NINTPY)
C   CHECK FOR NO INTERSECTIONS - GO TO NEXT LOCATION
      IF(NINTPY.LT.1)GO TO 36
C   SUM THE AREAS OF INTERSECTION
      ARL=0.0
      DO 35 K=1,NINTPY
 35   ARL=ARL+ABAREA(K)
      BIRDS=ARL/AREAL(I)
C   TRANSFORM THE OBSERVATIONS USING ROOT OF AREA COVERED
      Z=BIRDS/SQRT(ARCH)
C   SUM THE Z AND SQUARES OF Z
      SUMZ(NPOL)=SUMZ(NPOL)+Z
      SUMZSQ(NPOL)=SUMZSQ(NPOL)+Z*Z
      TBIRDS=TBIRDS+BIRDS
C   OUTPUT INFO ON LOCATION POLY IN RANGE
      AREALH=AREAL(I)/10000.0
      IF(AREALH.LT.0.001)AREALH=0.001
```

```
      ARLH=ARL/10000.0
      IF(ARLH.LT.0.001) ARLH=0.001
      WRITE(8,314) BIRDS,AREALH,ARLH
 314  FORMAT(15X,'BIRDS',F6.2,'    AREA OF LOCATION',F7.2,
     1'    AREA IN POLYGON',F7.2)
C  UPDATE NUMBER OF LOCATIONS IN RANGE
      NLOCS(NPOL)=NLOCS(NPOL)+1
      NLCS=NLCS+1
 36   CONTINUE
C  OUTPUT BIRD DENSITY FOR THIS POLY THIS STOP
 315  TBIRDH=TBIRDS/ARCH
      WRITE(8,316)TBIRDS,TBIRDH
 316  FORMAT(15X,'TOTAL BIRDS',F6.2,5X,
     1     'BIRDS PER HECTARE',F7.3)
C  SUM THE SITINGS AND RECORD NUMBER
C  SITING IS AREA OF INTERSCTN OF LOCATN POLY WITH CLASS POLY
C  DIVIDED BY TOTAL AREA OF LOCATION POLYGON
      TOTBRD(NPOL)=TOTBRD(NPOL)+TBIRDS
      IF(NLCS.LT.1)NLCS=1
      NZ(NPOL)=NZ(NPOL)+NLCS
      SUMNC(NPOL)=SUMNC(NPOL)+NLCS*ARCH
C  GO TO NEXT CLASS POLY
 38   CONTINUE
C
C  END OF CLASS POLY ARRAYS - CHECK FOR END OF FIELD DATA
 70   IF(IFIN.EQ.1)GO TO 100
C  PREPARE COVERAGE POLYGON
      DO 72 M=1,16
      COVX(M)=X(M)
 72   COVY(M)=Y(M)
      CXMX=XMX
      CXMN=XMN
      CYMX=YMX
      CYMN=YMN
      AREAC=AREAXY
      GO TO 19
C
C  END OF BOTH FILES - OUTPUT ARRAYS OF COVERAGE AND SITINGS
C  INPUT INFO ON DATA SET
 100  READ(7)ISPEC,ISER,IDATE1,IDATE2
C  LABEL THE OUTPUT
      WRITE(8,101)ISPEC,ISER,IDATE1,IDATE2
 101  FORMAT('1 SPECIES',I4,5X,'SERIES',I4,5X,
     1     'TIME PERIOD',2I9//)
      WRITE(8,110)
 110  FORMAT(' POLYGON   TOTAL AREA   NUMBER    NUMBER OF',
     1'    TOTAL     BIRDS PER')
      WRITE(8,111)
 111  FORMAT(' NUMBER    COVERED    OF VISITS  LOCATIONS',
     1'    BIRDS      HECTARE'/)
C  SUMMARISE RESULTS TO DATE - LOOP OVER CLASS POLYS
      DO 105 KP=1,KPLYS
      NP=NPOLYS(KP)
      BPHEC=0.0
      IF(TOTCOV(NP).LT.0.001)GO TO 102
      BPHEC=TOTBRD(NP)/TOTCOV(NP)
```

```
 102   WRITE(8,104)NP,TOTCOV(NP),NCOVS(NP),NLOCS(NP),
     1      TOTBRD(NP),BPHEC
 104   FORMAT(I7,F11.2,I11,I11,F12.2,F11.3)
 105   CONTINUE
C   OUTPUT UPDATED ARRAYS
       WRITE(4)TOTCOV,TOTBRD,NCOVS,NLOCS,SUMZ,SUMZSQ,NZ,SUMNC
       STOP
       END
C
C
       SUBROUTINE POLYRD(NPT,XCOOR,YCOOR,NPOLY,XMIN,XMAX,
     1      YMIN,YMAX,PAREA,IEND)
C   ROUTINE TO INPUT METRIC POLYGON FILES - READS FROM 3
C   END OF FILE CAUSES IEND=1 TO BE RETURNED
       DIMENSION XCOOR(400),YCOOR(400),X25(25),Y25(25)
       DIMENSION X400(400),Y400(400),X200(200),Y200(200)
       DIMENSION X100(100),Y100(100),X50(50),Y50(50)
       EQUIVALENCE (X400(1),X200(1),X100(1),X50(1),X25(1))
       EQUIVALENCE (Y400(1),Y200(1),Y100(1),Y50(1),Y25(1))
       IEND=0
       READ(3) NPOLY,NPT,XMIN,XMAX,YMIN,YMAX,PAREA
C   CHECK FOR END OF FILE
       IF(NPOLY.LT.1)GO TO 100
C   FIT POLYGON INTO SMALLEST POSSIBLE ARRAY
       IF(NPT.LE.200)GO TO 20
       READ(3)X400,Y400
       GO TO 60
  20   IF(NPT.LE.100)GO TO 30
       READ(3)X200,Y200
       GO TO 60
  30   IF(NPT.LE.50)GO TO 40
       READ(3)X100,Y100
       GO TO 60
  40   IF(NPT.LE.25)GO TO 50
       READ(3)X50,Y50
       GO TO 60
  50   READ(3)X25,Y25
  60   DO 70 I=1,NPT
       XCOOR(I)=X400(I)
  70   YCOOR(I)=Y400(I)
       RETURN
 100   IEND=1
       RETURN
       END
C
C
       SUBROUTINE INTPLY(AAX,AAY,NA,BBX,BBY,NB,ABX,ABY,NAB,
     1NAB1,NAB2,ABAREA,NINTPY)
C   ROUTINE TO INTERSECT TWO POLYGONS

  SEE PROGRAM COVANDLOC FOR SUBROUTINE INTPLY
      AND ASSOCIATED SUBROUTINES PIP, AREA,
      SEGLTH, UPDOWN AND MOVEPT

       RETURN
       END
```

```
C   SUMERIZE
C   PROGRAM TO SUMERIZE RESULTS OF ALL SERIES
C   FOR ONE SPECIES BY CLASS TYPES
C   INPUTS HABITAT DATA ON 5     INPUTS POLYGON TYPES ON 7
C   OUTPUTS TABLE ON 8
       DIMENSION IPT(10),ITYPE(500),TYPCOV(40),TYPBRD(40)
       DIMENSION TOTCOV(500),TOTBRD(500),NCOVS(500),NLOCS(500)
       DIMENSION NTYPC(40),NTYPL(40),SUMZ(500),SUMZSQ(500)
       DIMENSION NZ(500),SUMNC(500),TYPZSQ(40),NTYPZ(40)
       DIMENSION DCELL(40,20),WCELL(40,20),NCELL(40,20)
       DIMENSION SERBRD(40,20),KSER(20),KTYP(40),SAMPLE(40,20)
       DIMENSION PROBR(40,40),PROBL(40,40),DWTAVE(40),NORD(40)
       DIMENSION WTYPE(40),WSUMC(40,20),WSUMNC(40,20)
       DIMENSION TYPZ(40),TYPNC(40),VZCELL(40,20),SUMBRD(20)
C
C   PRESET DATA SET COUNTER
       NSER=0
C   PRESET ARRAY OF POLYGON TYPES
       DO 5 I=1,500
 5     ITYPE(I)=-99
C   INPUT POLYGON CLASSIFICATION TYPES
C   LOOP OVER EVERY TEN POLYGONS
       DO 15 KP=1,50
C   INPUT TYPE FOR TEN POLYGONS
       READ(7,12) (IPT(I),I=1,10)
 12    FORMAT(10I3)
C   INSERT INTO POLYGON TYPE ARRAY
       DO 14 JP=1,10
 14    ITYPE(KP*10-10+JP)=IPT(JP)
C   CHECK FOR END OF DATA
       IF(IPT(10).LT.-97)GO TO 20
 15    CONTINUE
C
C   INPUT ARRAYS OF COVERAGE AND SITINGS
 20    READ(5,END=120)TOTCOV,TOTBRD,NCOVS,NLOCS,
      1       SUMZ,SUMZSQ,NZ,SUMNC
C   PREPARE ARRAYS(TYPE,SERIES)
C   INCREMENT DATA SET COUNTER
       NSER=NSER+1
C   PRESET SUMMARY ARRAYS
       DO 25 I=1,40
       TYPCOV(I)=0.0
       TYPBRD(I)=0.0
       NTYPC(I)=0
       NTYPL(I)=0
       TYPZ(I)=0.0
       TYPZSQ(I)=0.0
       NTYPZ(I)=0
 25    TYPNC(I)=0.0
C
```

```
C   ASSIGN DATA ON EACH POLYGON TO ITS TYPE
C   LOOP OVER POLYGONS
      DO 80 I=1,500
      ITY=ITYPE(I)
C   CHECK FOR END OF POLYGONS
      IF(ITY.LT.-97)GO TO 90
C   ADD DATA TO APROPRIATE TYPE
      TYPCOV(ITY)=TYPCOV(ITY)+TOTCOV(I)
      TYPBRD(ITY)=TYPBRD(ITY)+TOTBRD(I)
      NTYPC(ITY)=NTYPC(ITY)+NCOVS(I)
      NTYPL(ITY)=NTYPL(ITY)+NLOCS(I)
      TYPZ(ITY)=TYPZ(ITY)+SUMZ(I)
      TYPZSQ(ITY)=TYPZSQ(ITY)+SUMZSQ(I)
      NTYPZ(ITY)=NTYPZ(ITY)+NZ(I)
 80   TYPNC(ITY)=TYPNC(ITY)+SUMNC(I)
C
C   OUTPUT SUMMARY OF TYPES
C   FIRST PRINT HEADINGS
 90   WRITE(8,92)
 92   FORMAT('1',/////)
      WRITE(8,93)
 93   FORMAT(8X,' POLYGON    NUMBER     NUMBER OF',
     1'    TOTAL   SAMPLING    BIRD DENSITY',
     1'    DENSITY   DEGREES  VARIANCE')
      WRITE(8,94)
 94   FORMAT(8X,'  TYPE     OF VISITS   LOCATIONS',
     1'    BIRDS   INTENSITY      INDEX',
     1'           STANDARD     OF      ABOUT')
      WRITE(8,95)
 95   FORMAT(19X,'THAT HIT     THAT HIT ',
     1'               (HEC-HRS)  (BIRDS/HEC-HR)',
     1'    ERROR     FREEDOM      Z',/)
C   LOOP OVER TYPES
      DO 98 IT=1,40
C   COMPUTE SAMPLING INTENSITY IN HEC-HR
      SAMPL=TYPCOV(IT)/4.0
      SAMPLE(IT,NSER)=SAMPL
C   ZERO SUMMARY VARIABLES
      DCELL(IT,NSER)=0.0
      WCELL(IT,NSER)=0.0
C   SAVE TOTAL BIRDS FOR THE CELL
      SERBRD(IT,NSER)=TYPBRD(IT)
      BDENS=0.0
      DENSE=0.0
      NDOF=0
      VARD=0.0
      VARZ=0.0
      IF(SAMPL.LT.0.01)GO TO 96
C   COMPUTE BIRD DENSITY INDEX
      BDENS=TYPBRD(IT)/SAMPL
C   COMPUTE VARIANCE ABOUT Z
      IF(NTYPZ(IT).LT.2)GO TO 96
      VARZ=(TYPZSQ(IT)-TYPZ(IT)**2/NTYPZ(IT))/(NTYPZ(IT)-1)
      VARD=VARZ*TYPNC(IT)/TYPCOV(IT)**2
```

```
C   COMPUTE STANDARD ERROR IN BIRDS PER HEC-HR
        DENSE=SQRT(VARD)*4.0
        NDOF=NTYPZ(IT)-1
C   TRANSFER RESULTS TO SUMMARY ARRAYS
C   UNITS ARE BIRDS PER HEC-15 MIN
        DCELL(IT,NSER)=TYPBRD(IT)/TYPCOV(IT)
        WCELL(IT,NSER)=TYPCOV(IT)**2/TYPNC(IT)
        WSUMC(IT,NSER)=TYPCOV(IT)
        WSUMNC(IT,NSER)=TYPNC(IT)
 96     NCELL(IT,NSER)=NTYPZ(IT)
        VZCELL(IT,NSER)=VARZ
C   OUTPUT DATA
        WRITE(8,97)IT,NTYPC(IT),NTYPL(IT),
       1TYPBRD(IT),SAMPL,BDENS,DENSE,NDOF,VARZ
 97     FORMAT(8X,I5,I12,I12,F11.1,F10.1,F13.3,F13.4,I10,F10.4)
 98     CONTINUE
        GO TO 20
C   ARRAYS(TYPE,SERIES) HAVE BEEN PREPARED
 120    CONTINUE
C
C   ELIMINATE LOW SERIES AND TYPES WITH LITTLE DATA
C   LOOP OVER SERIES TO FIND ONE WITH MOST BIRDS
        BIGBRD=0.0
        DO 130 IS=1,NSER
        SUMBRD(IS)=0.0
        DO 129 IT=1,40
 129    SUMBRD(IS)=SUMBRD(IS)+SERBRD(IT,IS)
 130    IF(SUMBRD(IS).GT.BIGBRD) BIGBRD=SUMBRD(IS)
C   KEEP ALL SERIES THAT HAVE AT LEAST ONE-FIFTH OF BIGGEST
        IKEEP=0
        BIGBRD=BIGBRD*0.2
        DO 140 IS=1,NSER
        IF(SUMBRD(IS).LT.BIGBRD)GO TO 140
        IKEEP=IKEEP+1
        KSER(IKEEP)=IS
 140    CONTINUE
        NSER=IKEEP
C   KEEP TYPES WITH G.E. 8 D.F. AND SAMP INTENS G.E. 1 BPH-HR
        IKEEP=0
        DO 150 IT=1,40
C   CHECK FOR LITTLE OR NO DATA FOR THIS TYPE
        DO 145 I=1,NSER
        IS=KSER(I)
        IF(NCELL(IT,IS).LT.9)GO TO 150
        IF(SAMPLE(IT,IS).LT.1.0)GO TO 150
 145    CONTINUE
        IKEEP=IKEEP+1
        KTYP(IKEEP)=IT
 150    CONTINUE
        NTYP=IKEEP
C
```

```
C  CALCULATE THE POOLED VARIATION ABOUT Z
C  AND ASSOCIATED DEGREES OF FREEDOM
      DFPOOL=0.0
      SUM=0.0
      DO 160 I=1,NTYP
      IT=KTYP(I)
      DO 155 J=1,NSER
      IS=KSER(J)
      IF(VZCELL(IT,IS).LT.0.001)GO TO 155
      DFCELL=NCELL(IT,IS)-1
      DFPOOL=DFPOOL+DFCELL
      SUM=SUM+DFCELL*VZCELL(IT,IS)
 155  CONTINUE
 160  CONTINUE
      VZPOOL=SUM/DFPOOL
      RTVZ=SQRT(VZPOOL)
C
C  COMPUTE DEGREES OF FREEDOM FOR COMBINED PROBABILITIES
      DFCOMB=2*NSER
C
C  COMPUTE WEIGHTED AVERAGE DENSITY FOR TYPES OVER SERIES
C  AND CONFIDENCE INTERVAL ON THE DIFFERENCE BETWEEN TYPES
      DWTMAX=0.0
      DWTMIN=9999.0
      DO 190 I=1,NTYP
      IT=KTYP(I)
      WN=0.0
      WD=0.0
      DWT=0.0
      DO 185 J=1,NSER
      IS=KSER(J)
      WN=WN+WSUMC(IT,IS)
      WD=WD+WSUMNC(IT,IS)
      DWT=DWT+SERBRD(IT,IS)
 185  CONTINUE
      WTYPE(IT)=WN*WN/WD
      DWTAVE(IT)=DWT/WN
      IF(DWTAVE(IT).GT.DWTMAX)DWTMAX=DWTAVE(IT)
      IF(DWTAVE(IT).LT.DWTMIN)DWTMIN=DWTAVE(IT)
 190  CONTINUE
C
C  COMPUTE F STATISTIC FOR EFFECT OF TYPES
C  AND INTERACTION OF TYPES WITH TIME
C  GET VARIANCE AMOUNG TYPES - LOOP OVER SERIES
      VZTYPS=0.0
      DO 200 I=1,NSER
      IS=KSER(I)
C  GET THE WEIGHTED MEAN D FOR THAT SERIES
      SUMWD=0.0
      SUMW=0.0
      DO 203 J=1,NTYP
      IT=KTYP(J)
      SUMWD=SUMWD+DCELL(IT,IS)*WCELL(IT,IS)
 203  SUMW=SUMW+WCELL(IT,IS)
      DBAR=SUMWD/SUMW
```

```
C   SUM THE SQUARES OF THE DIFFERENCES TO GET VARIANCE
        DO 205 J=1,NTYP
        IT=KTYP(J)
 205    VZTYPS=VZTYPS+WCELL(IT,IS)*(DCELL(IT,IS)-DBAR)**2
 200    CONTINUE
C   COMPUTE DEGREES OF FREEDOM AND VARIANCE
        DFTYPS=NSER*(NTYP-1)
        VZTYPS=VZTYPS/DFTYPS
C   COMPUTE F STATISTIC
        F=VZTYPS/VZPOOL
C   GET PROBABILITY OF EXCEEDING THE OBSERVED F VALUE
        EXCEED=FPROB(F,DFTYPS,DFPOOL)
C
C   OUTPUT WEIGHTED AVE DENSITY AND HABITAT RATING FOR TYPES
C   PRINT HEADINGS
        WRITE(8,210)
 210    FORMAT('1',//////,8X,' CLASSIFICATION TYPES ORDERED',
       1' BY WEIGHTED AVERAGE DENSITY',/)
        WRITE(8,211)
 211    FORMAT(8X,'    CLASSIFICATION   AVERAGE    RELATIVE')
        WRITE(8,212)
 212    FORMAT(17X,'TYPE',8X,'DENSITY  HABITAT_VALUE',/)
C   PRODUCE RELATIVE RATING BY SORTING
C   PREPARE ARRAY OF ORDER
        DO 913 I=1,NTYP
 913    NORD(I)=KTYP(I)
        NTIMES=NTYP-1
        DO 915 I=1,NTIMES
        MOVE=0
        DO 914 J=1,NTIMES
        IF(DWTAVE(NORD(J)).GE.DWTAVE(NORD(J+1)))GO TO 914
        MOVE=1
        NTEMP=NORD(J+1)
        NORD(J+1)=NORD(J)
        NORD(J)=NTEMP
 914    CONTINUE
        IF(MOVE.EQ.0)GO TO 213
 915    CONTINUE
C   OUTPUT RATINGS OF TYPES
 213    DO 220 I=1,NTYP
        IT=NORD(I)
C   CALCULATE RELATIVE HABITAT INDEX
        HABDEX=DWTAVE(IT)/DWTMAX
        DWTHHR=DWTAVE(IT)*4.0
        WRITE(8,215)IT,DWTHHR,HABDEX
 215    FORMAT(8X,I13,F14.3,F11.3)
 220    CONTINUE
C   OUTPUT VARIANCES AND DGREES OF FREEDOM
        WRITE(8,221)VZPOOL,DFPOOL
 221    FORMAT(//,8X,' VARIANCE WITHIN CELLS(SERIES,TYPES)',
       1F9.5,' (VAR Z)',/,13X,'WITH',F8.0,' DEGREES OF FREEDOM')
        WRITE(8,222)
 222    FORMAT(13X,'USED IN ALL T TESTS AND DENOMINATOR',
       1' OF F RATIO')
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      WRITE(8,223)VZTYPS,DFTYPS
 223  FORMAT(/,8X,' VARIANCE AMOUNG TYPES WITHIN SERIES',
     1F9.5,/,13X,'WITH',F8.0,' DEGREES OF FREEDOM')
      WRITE(8,224)
 224  FORMAT(13X,'USED IN NUMERATOR OF F RATIO')
C  OUTPUT F AND PROBABILITY OF EXCEEDING ITS VALUE
      WRITE(8,225) F
 225  FORMAT(/,8X,' F RATIO',F8.4,
     1  ' FOR VARIATION BETWEEN TYPES ',/,13X,
     1  'INCLUDING INTERACTION BETWEEN TYPE AND TIME')
      IF(EXCEED.LT.0.0000001)EXCEED=0.0
      WRITE(8,226) EXCEED
 226  FORMAT(13X,'PROBABILITY',F10.7,
     1   ' OF EXCEEDING BY CHANCE')
C
C  OUTPUT LEVELS OF SIGNIFICANT DIFFERENCES
C  FIRST OUTPUT HEADINGS
      WRITE(8,230)
 230  FORMAT('1',/////)
      WRITE(8,231)
 231  FORMAT(8X,' RESULTS OF T TESTS FOR ALL COMPARISONS',
     1' BETWEEN TYPES',/,8X,' WITH CONFIDENCE FOR REJECTING',
     1' NULL HYPOTHYSIS A_EQ_B',/,8X,' AND 95% CONFIDENCE',
     1' INTERVAL FOR ALL DIFFERENCES',/)
      WRITE(8,232)
 232  FORMAT(8X,' TYPE TYPE     T   ALTERNATE_HYPOTHYSIS',
     1'  CONFIDENCE_LIMITS_FOR')
      WRITE(8,233)
 233  FORMAT(8X,'   A    B    VALUE   A_GT_B   A_LT_B',
     1'     LOWER  A_MINUS_B  UPPER',/)
C  GET ALL COMPARISONS
      DO 240 J=2,NTYP
      IT1=KTYP(J-1)
      DO 238 K=J,NTYP
      IT2=KTYP(K)
C  CALCULATE DIFFERENCE BETWEEN TYPES
C  AND CONFIDENCE INTERVAL FOR THE DIFFERENCE IN BPH-HR
      DIFF=DWTAVE(IT1)-DWTAVE(IT2)
      SZRW=RTVZ*SQRT(1.0/WTYPE(IT1)+1.0/WTYPE(IT2))
      T025=TINVR(DFPOOL,0.025)
      DIFMN=(DIFF-T025*SZRW)*4.0
      DIFMX=(DIFF+T025*SZRW)*4.0
C  CALCULATE T VALUE AND PROBABILITY
      T=DIFF/SZRW
      TPROB=FPROB(T*T,1.0,DFPOOL)
C  NULL HYPOTHESIS D1 EQUALS D2
C  ALTERNATE HYPOTHESIS D1 GT D2  RIGHT TAIL
      PRT=0.5*TPROB
      IF(T.LT.0.0)PRT=1.0-PRT
C  ALTERNATE HYPOTHESIS D1 LT D2  LEFT TAIL
      PLT=0.5*TPROB
      IF(T.GT.0.0)PLT=1.0-PLT
C  CONVERT DIFFERENCE TO BPH-HR
      DIFF=DIFF*4.0
```

```
C  OUTPUT RESULTS
      WRITE(8,235)IT1,IT2,T,PRT,PLT,DIFMN,DIFF,DIFMX
  235 FORMAT(8X,I4,I5,F9.3,2F9.4,3F9.3)
  238 CONTINUE
  240 CONTINUE
      WRITE(8,249)
  249 FORMAT('1')
      STOP
      END
C
C
      FUNCTION FPROB(EF,EFNUM,EFDEN)
C   RETURNS PROBABILITY OF A VALUE AS HIGH AS 'EF' IN AN
C   F-DISTRIBUTION WITH 'EFNUM' DEGREES OF FREEDOM IN THE
C   NUMERATOR AND 'EFDEN' IN THE DENOMINATOR.

 U.B.C. COMPUTING CENTER LIBRARY ROUTINE.

      RETURN
      END
C
      FUNCTION  TINVR(DF,P)
C     RATIONAL APPROXIMATION TO THE INVERSE T DISTRIBUTION

  U.B.C. COMPUTING CENTER LIBRARY ROUTINE.

      RETURN
      END
```

```
C   COMPARE
C   PROGRAM TO COMPARE SUMMARIES       OUTPUT ON UNIT 8
C   READS TABLES A ON 5       READS TABLES B ON 7
        DIMENSION KORD(40),LORD(40),ASIG(40,40),BSIG(40,40)
        DIMENSION INDEXA(40),INDEXB(40),OUT(40),S(40),W(40)
        DATA C,EL,BLANK,R,E,EX/'C','L',' ','R','E','X'/
        DATA S(1),S(2),S(3),S(4)/'  1','  2','  3','  4'/
        DATA S(5),S(6),S(7),S(8)/'  5','  6','  7','  8'/
        DATA S(9),S(10),S(11),S(12)/'  9',' 10',' 11',' 12'/
        DATA S(13),S(14),S(15)/' 13',' 14',' 15'/
        DATA S(16),S(17),S(18),S(19)/' 16',' 17',' 18',' 19'/
        DATA S(20),S(21),S(22),S(23)/' 20',' 21',' 22',' 23'/
        DATA S(24),S(25),S(26),S(27)/' 24',' 25',' 26',' 27'/
        DATA S(28),S(29),S(30)/' 28',' 29',' 30'/
        DATA S(31),S(32),S(33),S(34)/' 31',' 32',' 33',' 34'/
        DATA S(35),S(36),S(37),S(38)/' 35',' 36',' 37',' 38'/
        DATA S(39),S(40),W(1),W(2)/' 39',' 40','0.0','.25'/
        DATA W(3),W(4),W(5)/'0.5','.75','1.0'/
        DATA BAR,DASH,BXX,DXX,BL3NK/'|','---',' XX','-XX','   '/
C
C   PREPARE TO INPUT ORDER
C   ZERO VECTOR OF ORDER AND ARRAYS OF SIGNIFICANCE
        DO 50 I=1,40
        KORD(I)=0
        LORD(I)=0
        DO 50 J=1,40
        ASIG(I,J)=BLANK
        BSIG(I,J)=BLANK
 50     CONTINUE
C   INPUT LINES LOOKING FOR HEADING OF TABLE A
 55     READ(5,56)CT,ELT
 56     FORMAT(9X,A1,A1)
        IF(CT.NE.C.OR.ELT.NE.EL)GO TO 55
C   INPUT LINES LOOKING FOR HEADING OF TABLE B
 60     READ(7,61)CT,ELT
 61     FORMAT(9X,A1,A1)
        IF(CT.NE.C.OR.ELT.NE.EL)GO TO 60
C   LOOP TO START OF TABLE A
        DO 65 I=1,4
        READ(5,61)CT,ELT
 65     CONTINUE
C   LOOP TO START OF TABLE B
        DO 67 I=1,4
        READ(7,61)CT,ELT
 67     CONTINUE
```

```
C  INPUT ORDER OF TYPES FOR TABLE A
      NA=0
      DO 80 I=1,40
      READ(5,70)IT,DWTHHR,HABDEX
 70   FORMAT(8X,I13,F14.3,F11.3)
      IF(IT.LT.1.OR.IT.GT.40)GO TO 85
      KORD(I)=IT
      INDEXA(I)=(HABDEX+0.049)/0.05
      NA=NA+1
 80   CONTINUE
      IF(NA.GT.30)NA=30
C  INPUT ORDER OF TYPES FOR TABLE B
 85   NB=0
      DO 90 I=1,40
      READ(7,88)IT,DWTHHR,HABDEX
 88   FORMAT(8X,I13,F14.3,F11.3)
      IF(IT.LT.1.OR.IT.GT.40)GO TO 95
      LORD(I)=IT
      INDEXB(I)=(HABDEX+0.049)/0.05
      NB=NB+1
 90   CONTINUE
      IF(NB.GT.30)NB=30
C
C  INPUT LINES LOOKING FOR HEADINGS OF SECOND TABLE A
 95   READ(5,96)RT,ET
 96   FORMAT(9X,A1,A1)
      IF(RT.NE.R.OR.ET.NE.E)GO TO 95
C  INPUT LINES LOOKING FOR HEADINGS OF SECOND TABLE B
 105  READ(7,106)RT,ET
 106  FORMAT(9X,A1,A1)
      IF(RT.NE.R.OR.ET.NE.E)GO TO 105
C  LOOP TO START OF SECOND TABLE A
      DO 110 I=1,6
      READ(5,96)RT,ET
 110  CONTINUE
C  LOOP TO START OF SECOND TABLE B
      DO 112 I=1,6
      READ(7,96)RT,ET
 112  CONTINUE
C
C  FILL SIGNIFICANCE TABLE A
 120  READ(5,121,END=150)IT1,IT2,T,PLT,PRT
 121  FORMAT(8X,I4,I5,F9.3,2F9.4)
C  CHECK FOR IT1 SIGNIFICANTLY GREATER
      IF(PLT.GE.0.05)GO TO 125
      ASIG(IT1,IT2)=EX
      GO TO 120
C  CHECK FOR IT2 SIGNIFICANTLY GREATER
 125  IF(PRT.GE.0.05)GO TO 120
      ASIG(IT2,IT1)=EX
      GO TO 120
```

```
C  FILL SIGNIFICANCE TABLE B
 150   READ(7,151,END=160)IT1,IT2,T,PLT,PRT
 151   FORMAT(8X,I4,I5,F9.3,2F9.4)
C  CHECK FOR IT1 SIGNIFICANTLY GREATER
       IF(PLT.GE.0.05)GO TO 155
       BSIG(IT1,IT2)=EX
       GO TO 150
C  CHECK FOR IT2 SIGNIFICANTLY GREATER
 155   IF(PRT.GE.0.05)GO TO 150
       BSIG(IT2,IT1)=EX
       GO TO 150
 160   CONTINUE
C
C  OUTPUT RELATIVE HABITAT INDEX GRAPH A
       WRITE(8,171)
 171   FORMAT('1',/////,8X,' RELATIVE LEVEL OF USE OF TYPES',/)
C  PRINTER BAR GRAPH  20 LINES HIGH
       IDONE=0
       DO 174 I=1,21
       IM=21-I
       IMT=IM/5*5
       DO 172 J=1,NA
       IF(J.LE.IDONE)GO TO 972
       OUT(J)=BL3NK
       IF(IM.EQ.IMT)OUT(J)=DASH
       IF(INDEXA(J).NE.IM)GO TO 172
       OUT(J)=S(KORD(J))
       IDONE=J
       GO TO 172
 972   OUT(J)=BXX
       IF(IMT.EQ.IM)OUT(J)=DXX
 172   CONTINUE
       AX=BLANK
       IF(IMT.EQ.IM)AX=W(IM/5+1)
       WRITE(8,173)AX,BAR,(OUT(K),K=1,NA),BAR
 173   FORMAT(8X,A3,A1,40A3)
 174   CONTINUE
C
C  OUTPUT SIGNIFICANCE TABLES
C TABLE A   TOP LABELS
       WRITE(8,164)
 164   FORMAT(//,8X,' SIGNIFICANT DIFFERENCES IN USE',
      1  ' OF TYPES  (P=0.05)',/)
       WRITE(8,165)(KORD(I),I=1,NA)
 165   FORMAT(11X,40I3)
C  LOOP OVER LINES
       DO 170 I=1,NA
       WRITE(8,167)KORD(I),(ASIG(KORD(J),KORD(I)),J=1,NA)
 167   FORMAT(9X,I2,40(2X,A1))
 170   CONTINUE
       WRITE(8,165)(KORD(I),I=1,NA)
C
```

```
C  OUTPUT RELATIVE HABITAT INDEX GRAPH B
      WRITE(8,181)
 181  FORMAT('1',/////,8X,' RELATIVE LEVEL OF USE OF TYPES',/)
      IDONE=0
      DO 184 I=1,21
      IM=21-I
      IMT=IM/5*5
      DO 182 J=1,NB
      IF(J.LE.IDONE)GO TO 982
      OUT(J)=BL3NK
      IF(IMT.EQ.IM)OUT(J)=DASH
      IF(INDEXB(J).NE.IM)GO TO 182
      OUT(J)=S(LORD(J))
      IDONE=J
      GO TO 182
 982  OUT(J)=BXX
      IF(IMT.EQ.IM)OUT(J)=DXX
 182  CONTINUE
      AX=BLANK
      IF(IMT.EQ.IM)AX=W(IM/5+1)
      WRITE(8,183)AX,BAR,(OUT(K),K=1,NB),BAR
 183  FORMAT(8X,A3,A1,40A3)
 184  CONTINUE
C
C TABLE B   TOP LABELS
      WRITE(8,974)
 974  FORMAT(//,8X,' SIGNIFICANT DIFFERENCES IN USE',
     1  ' OF TYPES  (P=0.05)',/)
      WRITE(8,175) (LORD(I),I=1,NB)
 175  FORMAT(11X,40I3)
C  LOOP OVER LINES
      DO 180 I=1,NB
      WRITE(8,177)LORD(I),(BSIG(LORD(J),LORD(I)),J=1,NB)
 177  FORMAT(9X,I2,40(2X,A1))
 180  CONTINUE
      WRITE(8,175) (LORD(I),I=1,NB)
C
```

```
C   COMPARISONS
C   FIND ALL CONTRASTS
        WRITE(8,185)
 185    FORMAT('1',8X,'CONTRASTS')
        CONT=0.0
        DO 190 I=1,40
        DO 190 J=1,40
        IF(ASIG(I,J).NE.EX.OR.BSIG(J,I).NE.EX)GO TO 190
        WRITE(8,187)I,J
 187    FORMAT(9X,2I4)
        CONT=CONT+1.0
 190    CONTINUE
C
C   FIND ALL REINFORCEMENTS
        WRITE(8,195)
 195    FORMAT(/,9X,'REINFORCEMENTS')
        REIN=0.0
        DO 200 I=1,40
        DO 200 J=1,40
        IF(ASIG(I,J).NE.EX.OR.BSIG(I,J).NE.EX)GO TO 200
        WRITE(8,197)I,J
 197    FORMAT(9X,2I4)
        REIN=REIN+1.0
 200    CONTINUE
C
C   CONTRAST TO REINFORCEMENT RATIO
        RATIO=0.0
        IF(REIN.GT.0.001)RATIO=CONT/REIN
        WRITE(8,208)CONT
 208    FORMAT(/,8X,' NUMBER OF CONTRASTS',F5.0)
        WRITE(8,209)REIN
 209    FORMAT(8X,' NUMBER OF REINFORCEMENTS',F5.0)
        TOTCOM=CONT+REIN
        WRITE(8,212)TOTCOM
 212    FORMAT(8X,' TOTAL COMPARISONS IN COMMON',F5.0)
        WRITE(8,210)RATIO
 210    FORMAT(8X,' CONTRAST TO REINFORCEMENT RATIO',F7.3)
        WRITE(8,220)
 220    FORMAT('1')
        STOP
        END
```

APPENDIX B

TABLES RELATING USE BY TEN BIRD SPECIES TO SERAL STAGES.

BIRD SPECIES PAGE

TABLE 7. DEFINITION OF SERAL STAGE NUMBERS

SERAL STAGE	YEARS SINCE CUTTING OR BURNING	AGE OF EXAMPLES CENSUSED
1	1 TO 5	2, 3, 4, 5
2	6 TO 5	6,7,8,9,10,11,12,13,14,15
3	16 TO 5	16,17,19,20,24
4	36 TO 5	46, 51
5	76 TO 5	109, 137
6	155 TO 5	APPROX 250
7	LAKE	
8	MARSH	

COMMON FLICKER WITH SERAL STAGES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
6	0.107	1.000
1	0.101	0.939
2	0.087	0.810
3	0.036	0.338
5	0.035	0.323
8	0.030	0.276
4	0.026	0.241
7	0.011	0.104

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.01003 (VAR Z)
WITH 4575. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.04215
WITH 35. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 4.2011 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0 OF EXCEEDING BY CHANCE

COMMON FLICKER WITH SERAL STAGES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE	TYPE	T	ALTERNATE_HYPOTHYSIS		CONFIDENCE_LIMITS_FOR		
A	B	VALUE	A_GT_B	A_LT_B	LOWER	A_MINUS_B	UPPER
1	2	0.613	0.2698	0.7302	-0.030	0.014	0.058
1	3	2.713	0.0033	0.9967	0.018	0.064	0.111
1	4	3.390	0.0004	0.9996	0.032	0.075	0.118
1	5	2.797	0.0026	0.9974	0.020	0.066	0.112
1	6	-0.275	0.6084	0.3916	-0.053	-0.007	0.040
1	7	3.687	0.0001	0.9999	0.042	0.089	0.137
1	8	1.097	0.1363	0.8637	-0.056	0.071	0.198
2	3	4.237	0.0000	1.0000	0.027	0.050	0.074
2	4	7.503	0.0000	1.0000	0.045	0.061	0.077
2	5	4.467	0.0000	1.0000	0.029	0.052	0.075
2	6	-1.729	0.9581	0.0419	-0.043	-0.020	0.003
2	7	5.833	0.0000	1.0000	0.050	0.076	0.101
2	8	0.930	0.1761	0.8239	-0.063	0.057	0.177
3	4	0.966	0.1670	0.8330	-0.011	0.010	0.032
3	5	0.121	0.4520	0.5480	-0.025	0.002	0.028
3	6	-5.150	1.0000	0.0000	-0.098	-0.071	-0.044
3	7	1.698	0.0447	0.9553	-0.004	0.025	0.054
3	8	0.108	0.4572	0.5428	-0.114	0.007	0.128
4	5	-0.835	0.7980	0.2020	-0.029	-0.009	0.012
4	6	-7.636	1.0000	0.0000	-0.102	-0.081	-0.060
4	7	1.231	0.1092	0.8908	-0.009	0.015	0.038
4	8	-0.062	0.5246	0.4754	-0.124	-0.004	0.116
5	6	-5.352	1.0000	0.0000	-0.099	-0.072	-0.046
5	7	1.608	0.0539	0.9461	-0.005	0.023	0.052
5	8	0.081	0.4678	0.5322	-0.116	0.005	0.126
6	7	6.540	0.0000	1.0000	0.067	0.096	0.125
6	8	1.255	0.1048	0.8952	-0.044	0.077	0.198
7	8	-0.297	0.6169	0.3831	-0.140	-0.018	0.103

YELLOW-BELLIED SAPSUCKER WITH SERAL STAGES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
6	0.334	1.000
8	0.299	0.895
5	0.258	0.774
7	0.092	0.277
2	0.090	0.269
3	0.043	0.130
4	0.042	0.127
1	0.037	0.111

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.01853 (VAR Z)
WITH 6935. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.36654
WITH 42. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 19.7829 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0 OF EXCEEDING BY CHANCE

YELLOW-BELLIED SAPSUCKER WITH SERAL STAGES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE A	TYPE B	T VALUE	ALTERNATE_HYPOTHYSIS A_GT_B	A_LT_B	CONFIDENCE_LIMITS_FOR LOWER	A_MINUS_B	UPPER
1	2	-2.118	0.9829	0.0171	-0.101	-0.053	-0.004
1	3	-0.240	0.5949	0.4051	-0.057	-0.006	0.045
1	4	-0.220	0.5870	0.4130	-0.052	-0.005	0.042
1	5	-8.382	1.0000	0.0000	-0.273	-0.221	-0.169
1	6	-11.325	1.0000	0.0000	-0.348	-0.297	-0.245
1	7	-2.023	0.9784	0.0216	-0.109	-0.055	-0.002
1	8	-3.553	0.9998	0.0002	-0.406	-0.262	-0.117
2	3	3.353	0.0004	0.9996	0.019	0.046	0.073
2	4	5.048	0.0000	1.0000	0.029	0.047	0.066
2	5	-11.735	1.0000	0.0000	-0.197	-0.169	-0.140
2	6	-17.431	1.0000	0.0000	-0.271	-0.244	-0.217
2	7	-0.164	0.5650	0.4350	-0.034	-0.003	0.029
2	8	-2.977	0.9985	0.0015	-0.347	-0.209	-0.071
3	4	0.080	0.4683	0.5317	-0.023	0.001	0.025
3	5	-13.065	1.0000	0.0000	-0.247	-0.215	-0.183
3	6	-17.999	1.0000	0.0000	-0.322	-0.290	-0.259
3	7	-2.741	0.9969	0.0031	-0.084	-0.049	-0.014
3	8	-3.613	0.9998	0.0002	-0.394	-0.255	-0.117
4	5	-16.677	1.0000	0.0000	-0.241	-0.216	-0.191
4	6	-23.237	1.0000	0.0	-0.316	-0.291	-0.267
4	7	-3.398	0.9997	0.0003	-0.079	-0.050	-0.021
4	8	-3.665	0.9999	0.0001	-0.393	-0.256	-0.119
5	6	-4.541	1.0000	0.0000	-0.108	-0.075	-0.043
5	7	9.079	0.0000	1.0000	0.130	0.166	0.202
5	8	-0.571	0.7161	0.2839	-0.179	-0.040	0.098
6	7	13.415	0.0000	1.0000	0.206	0.241	0.277
6	8	0.494	0.3105	0.6895	-0.104	0.035	0.174
7	8	-2.902	0.9981	0.0019	-0.346	-0.206	-0.067

HAIRY WOODPECKER WITH SERAL STAGES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
6	0.069	1.000
5	0.048	0.702
8	0.025	0.358
2	0.023	0.335
7	0.018	0.261
4	0.011	0.164
1	0.007	0.100
3	0.005	0.072

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.00576 (VAR Z)
WITH 5779. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.02239
WITH 42. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 3.8896 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0 OF EXCEEDING BY CHANCE

HAIRY WOODPECKER WITH SERAL STAGES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE A	TYPE B	T VALUE	ALTERNATE_HYPOTHYSIS A_GT_B	A_LT_B	CONFIDENCE_LIMITS_FOR LOWER	A_MINUS_B	UPPER
1	2	-1.189	0.8828	0.1172	-0.043	-0.016	0.011
1	3	0.138	0.4452	0.5548	-0.026	0.002	0.030
1	4	-0.329	0.6290	0.3710	-0.030	-0.004	0.022
1	5	-2.896	0.9981	0.0019	-0.070	-0.041	-0.013
1	6	-4.346	1.0000	0.0000	-0.090	-0.062	-0.034
1	7	-0.747	0.7724	0.2276	-0.040	-0.011	0.018
1	8	-0.444	0.6716	0.3284	-0.096	-0.018	0.061
2	3	2.495	0.0063	0.9937	0.004	0.018	0.032
2	4	2.372	0.0089	0.9911	0.002	0.012	0.022
2	5	-3.404	0.9997	0.0003	-0.040	-0.025	-0.011
2	6	-6.259	1.0000	0.0000	-0.060	-0.046	-0.031
2	7	0.618	0.2683	0.7317	-0.011	0.005	0.021
2	8	-0.042	0.5166	0.4834	-0.076	-0.002	0.073
3	4	-0.970	0.8339	0.1661	-0.019	-0.006	0.006
3	5	-5.096	1.0000	0.0000	-0.060	-0.043	-0.027
3	6	-7.589	1.0000	0.0000	-0.080	-0.064	-0.047
3	7	-1.399	0.9190	0.0810	-0.031	-0.013	0.005
3	8	-0.515	0.6968	0.3032	-0.095	-0.020	0.055
4	5	-5.557	1.0000	0.0000	-0.050	-0.037	-0.024
4	6	-8.791	1.0000	0.0000	-0.070	-0.058	-0.045
4	7	-0.876	0.8093	0.1907	-0.022	-0.007	0.008
4	8	-0.354	0.6382	0.3618	-0.088	-0.013	0.061
5	6	-2.397	0.9917	0.0083	-0.037	-0.021	-0.004
5	7	3.228	0.0006	0.9994	0.012	0.030	0.049
5	8	0.618	0.2682	0.7318	-0.051	0.024	0.099
6	7	5.455	0.0000	1.0000	0.033	0.051	0.069
6	8	1.154	0.1243	0.8757	-0.031	0.044	0.119
7	8	-0.175	0.5693	0.4307	-0.082	-0.007	0.069

OLIVE-SIDED FLYCATCHER WITH SERAL STAGES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
2	0.177	1.000
6	0.172	0.974
5	0.162	0.917
1	0.150	0.848
3	0.123	0.693
7	0.053	0.299
4	0.045	0.257
8	0.0	0.0

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.02175 (VAR Z)
WITH 2064. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.12682
WITH 14. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 5.8299 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0 OF EXCEEDING BY CHANCE

OLIVE-SIDED FLYCATCHER WITH SERAL STAGES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE A	TYPE B	T VALUE	ALTERNATE_HYPOTHYSIS A_GT_B	A_LT_B	CONFIDENCE_LIMITS_FOR LOWER	A_MINUS_B	UPPER
1	2	-0.514	0.6964	0.3036	-0.129	-0.027	0.076
1	3	0.497	0.3095	0.6905	-0.081	0.027	0.135
1	4	2.061	0.0197	0.9803	0.005	0.105	0.204
1	5	-0.222	0.5877	0.4123	-0.119	-0.012	0.095
1	6	-0.408	0.6583	0.3417	-0.129	-0.022	0.084
1	7	1.699	0.0448	0.9552	-0.015	0.097	0.209
1	8	0.985	0.1625	0.8375	-0.149	0.150	0.449
2	3	1.885	0.0298	0.9702	-0.002	0.054	0.111
2	4	6.824	0.0000	1.0000	0.094	0.131	0.169
2	5	0.531	0.2977	0.7023	-0.040	0.015	0.069
2	6	0.169	0.4328	0.5672	-0.049	0.005	0.058
2	7	3.798	0.0001	0.9999	0.060	0.124	0.188
2	8	1.220	0.1113	0.8887	-0.108	0.177	0.461
3	4	2.961	0.0016	0.9984	0.026	0.077	0.128
3	5	-1.202	0.8853	0.1147	-0.104	-0.039	0.025
3	6	-1.522	0.9359	0.0641	-0.114	-0.050	0.014
3	7	1.881	0.0300	0.9700	-0.003	0.070	0.143
3	8	0.840	0.2006	0.7994	-0.164	0.123	0.409
4	5	-4.678	1.0000	0.0000	-0.166	-0.117	-0.068
4	6	-5.155	1.0000	0.0000	-0.175	-0.127	-0.079
4	7	-0.246	0.5970	0.4030	-0.067	-0.007	0.052
4	8	0.315	0.3765	0.6235	-0.238	0.045	0.329
5	6	-0.319	0.6250	0.3750	-0.072	-0.010	0.052
5	7	3.010	0.0013	0.9987	0.038	0.109	0.180
5	8	1.112	0.1332	0.8668	-0.124	0.162	0.448
6	7	3.310	0.0005	0.9995	0.049	0.119	0.190
6	8	1.181	0.1188	0.8812	-0.114	0.172	0.458
7	8	0.360	0.3593	0.6407	-0.235	0.053	0.341

STELLER'S JAY WITH SERAL STAGES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
3	0.271	1.000
1	0.271	0.998
5	0.197	0.727
2	0.191	0.704
6	0.167	0.616
4	0.141	0.520
7	0.074	0.272

VARIANCE WITHIN CELLS(SERIES,TYPES)   0.02442 (VAR Z)
    WITH   5139. DEGREES OF FREEDOM
    USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES   0.11932
    WITH   36. DEGREES OF FREEDOM
    USED IN NUMERATOR OF F RATIO

F RATIO 4.8863 FOR VARIATION BETWEEN TYPES
    INCLUDING INTERACTION BETWEEN TYPE AND TIME
    PROBABILITY 0.0   OF EXCEEDING BY CHANCE

STELLER'S JAY WITH SERAL STAGES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE A	TYPE B	T VALUE	ALTERNATE_HYPOTHYSIS A_GT_B	A_LT_B	CONFIDENCE_LIMITS_FOR LOWER	A_MINUS_B	UPPER
1	2	1.807	0.0354	0.9646	-0.007	0.080	0.166
1	3	-0.014	0.5053	0.4947	-0.092	-0.001	0.091
1	4	2.982	0.0014	0.9986	0.044	0.130	0.215
1	5	1.602	0.0546	0.9454	-0.016	0.073	0.163
1	6	2.260	0.0119	0.9881	0.014	0.103	0.193
1	7	4.195	0.0000	1.0000	0.105	0.197	0.289
2	3	-3.571	0.9998	0.0002	-0.124	-0.080	-0.036
2	4	3.345	0.0004	0.9996	0.021	0.050	0.079
2	5	-0.302	0.6186	0.3814	-0.047	-0.006	0.035
2	6	1.146	0.1260	0.8740	-0.017	0.024	0.064
2	7	5.056	0.0000	1.0000	0.072	0.117	0.163
3	4	6.149	0.0000	1.0000	0.089	0.130	0.172
3	5	2.883	0.0020	0.9980	0.024	0.074	0.124
3	6	4.066	0.0000	1.0000	0.054	0.104	0.154
3	7	7.150	0.0000	1.0000	0.143	0.198	0.252
4	5	-2.897	0.9981	0.0019	-0.094	-0.056	-0.018
4	6	-1.357	0.9126	0.0874	-0.064	-0.026	0.012
4	7	3.074	0.0011	0.9989	0.024	0.067	0.110
5	6	1.244	0.1068	0.8932	-0.017	0.030	0.077
5	7	4.698	0.0000	1.0000	0.072	0.123	0.175
6	7	3.568	0.0002	0.9998	0.042	0.093	0.145

CHESTNUT-BACKED CHICKADEE WITH SERAL STAGES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
6	0.762	1.000
4	0.459	0.603
5	0.456	0.598
7	0.266	0.349
3	0.252	0.330
2	0.250	0.327
1	0.048	0.063

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.06919 (VAR Z)
WITH 2423. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.22183
WITH 36. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 3.2063 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0 OF EXCEEDING BY CHANCE

CHESTNUT-BACKED CHICKADEE WITH SERAL STAGES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE A	TYPE B	T VALUE	ALTERNATE_HYPOTHYSIS A_GT_B	A_LT_B	CONFIDENCE_LIMITS_FOR LOWER	A_MINUS_B	UPPER
1	2	-1.421	0.9223	0.0777	-0.480	-0.202	0.077
1	3	-1.345	0.9106	0.0894	-0.500	-0.204	0.093
1	4	-2.919	0.9982	0.0018	-0.688	-0.411	-0.135
1	5	-2.716	0.9967	0.0033	-0.703	-0.408	-0.113
1	6	-4.546	1.0000	0.0000	-1.022	-0.714	-0.406
1	7	-1.139	0.8725	0.1275	-0.593	-0.218	0.157
2	3	-0.028	0.5112	0.4888	-0.145	-0.002	0.141
2	4	-4.367	1.0000	0.0000	-0.304	-0.210	-0.116
2	5	-2.919	0.9982	0.0018	-0.345	-0.206	-0.068
2	6	-6.070	1.0000	0.0000	-0.678	-0.513	-0.347
2	7	-0.118	0.5468	0.4532	-0.287	-0.016	0.254
3	4	-2.908	0.9982	0.0018	-0.348	-0.208	-0.068
3	5	-2.314	0.9896	0.0104	-0.378	-0.204	-0.031
3	6	-5.123	1.0000	0.0000	-0.706	-0.511	-0.315
3	7	-0.096	0.5382	0.4618	-0.304	-0.014	0.275
4	5	0.051	0.4798	0.5202	-0.132	0.003	0.139
4	6	-3.646	0.9999	0.0001	-0.466	-0.303	-0.140
4	7	1.414	0.0788	0.9212	-0.075	0.194	0.462
5	6	-3.128	0.9991	0.0009	-0.498	-0.306	-0.114
5	7	1.298	0.0972	0.9028	-0.097	0.190	0.478
6	7	3.232	0.0006	0.9994	0.195	0.497	0.798

RED-BREASTED NUTHATCH WITH SERAL STAGES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
5	0.225	1.000
6	0.129	0.574
2	0.025	0.113
7	0.024	0.108
4	0.011	0.049
1	0.010	0.044
3	0.009	0.041

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.01500 (VAR Z)
WITH 2628. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.12113
WITH 30. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 8.0753 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0 OF EXCEEDING BY CHANCE

RED-BREASTED NUTHATCH WITH SERAL STAGES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE A	TYPE B	T VALUE	ALTERNATE_HYPOTHYSIS A_GT_B	A_LT_B	CONFIDENCE_LIMITS_FOR LOWER	A_MINUS_B	UPPER
1	2	-0.406	0.6576	0.3424	-0.090	-0.015	0.059
1	3	0.017	0.4932	0.5068	-0.078	0.001	0.079
1	4	-0.029	0.5115	0.4885	-0.075	-0.001	0.073
1	5	-5.331	1.0000	0.0000	-0.294	-0.215	-0.136
1	6	-2.946	0.9984	0.0016	-0.199	-0.119	-0.040
1	7	-0.340	0.6330	0.3670	-0.098	-0.015	0.069
2	3	0.815	0.2074	0.7926	-0.023	0.016	0.055
2	4	1.011	0.1561	0.8439	-0.014	0.014	0.042
2	5	-9.757	1.0000	0.0000	-0.240	-0.200	-0.160
2	6	-4.996	1.0000	0.0000	-0.145	-0.104	-0.063
2	7	0.038	0.4848	0.5152	-0.048	0.001	0.049
3	4	-0.094	0.5374	0.4626	-0.039	-0.002	0.035
3	5	-9.029	1.0000	0.0000	-0.263	-0.216	-0.169
3	6	-4.963	1.0000	0.0000	-0.167	-0.120	-0.073
3	7	-0.549	0.7086	0.2914	-0.069	-0.015	0.039
4	5	-10.952	1.0000	0.0000	-0.252	-0.214	-0.176
4	6	-5.946	1.0000	0.0000	-0.157	-0.118	-0.079
4	7	-0.560	0.7121	0.2879	-0.060	-0.013	0.034
5	6	3.870	0.0001	0.9999	0.047	0.096	0.144
5	7	7.128	0.0000	1.0000	0.145	0.201	0.256
6	7	3.694	0.0001	0.9999	0.049	0.105	0.161

WINTER WREN WITH SERAL STAGES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
5	2.880	1.000
4	2.019	0.701
6	1.515	0.526
3	1.058	0.367
1	0.872	0.303
2	0.560	0.194
7	0.312	0.108

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.10805 (VAR Z)
WITH 4071. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 3.49067
WITH 36. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 32.3066 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0 OF EXCEEDING BY CHANCE

WINTER WREN WITH SERAL STAGES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE A	TYPE B	T VALUE	ALTERNATE_HYPOTHYSIS A_GT_B	A_LT_B	CONFIDENCE_LIMITS_FOR LOWER	A_MINUS_B	UPPER
1	2	1.980	0.0239	0.9761	0.003	0.312	0.621
1	3	-1.113	0.8672	0.1328	-0.515	-0.187	0.142
1	4	-7.193	1.0000	0.0000	-1.460	-1.147	-0.834
1	5	-11.497	1.0000	0.0000	-2.350	-2.008	-1.666
1	6	-3.741	0.9999	0.0001	-0.981	-0.644	-0.306
1	7	3.071	0.0011	0.9989	0.202	0.559	0.916
2	3	-6.358	1.0000	0.0000	-0.652	-0.498	-0.345
2	4	-24.673	1.0000	0.0	-1.575	-1.459	-1.343
2	5	-25.054	1.0000	0.0	-2.501	-2.320	-2.138
2	6	-10.915	1.0000	0.0000	-1.127	-0.955	-0.784
2	7	2.335	0.0098	0.9902	0.040	0.248	0.455
3	4	-11.685	1.0000	0.0000	-1.122	-0.960	-0.799
3	5	-16.744	1.0000	0.0000	-2.035	-1.821	-1.608
3	6	-4.373	1.0000	0.0000	-0.662	-0.457	-0.252
3	7	6.195	0.0000	1.0000	0.510	0.746	0.982
4	5	-8.984	1.0000	0.0000	-1.049	-0.861	-0.673
4	6	5.536	0.0000	1.0000	0.325	0.503	0.682
4	7	15.677	0.0000	1.0000	1.493	1.706	1.920
5	6	11.809	0.0000	1.0000	1.138	1.364	1.591
5	7	19.734	0.0	1.0000	2.312	2.567	2.822
6	7	9.506	0.0000	1.0000	0.955	1.203	1.451

VARIED THRUSH WITH SERAL STAGES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
6	0.177	1.000
5	0.172	0.972
4	0.115	0.647
8	0.082	0.464
3	0.051	0.290
2	0.049	0.277
7	0.035	0.199
1	0.018	0.101

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.01407 (VAR Z)
WITH 5485. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.09960
WITH 42. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 7.0766 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0 OF EXCEEDING BY CHANCE

VARIED THRUSH WITH SERAL STAGES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE	TYPE	T	ALTERNATE_HYPOTHYSIS		CONFIDENCE_LIMITS_FOR		
A	B	VALUE	A_GT_B	A_LT_B	LOWER	A_MINUS_B	UPPER
1	2	-1.266	0.8972	0.1028	-0.079	-0.031	0.017
1	3	-1.297	0.9027	0.0973	-0.084	-0.033	0.017
1	4	-4.030	1.0000	0.0000	-0.144	-0.097	-0.050
1	5	-5.945	1.0000	0.0000	-0.205	-0.154	-0.104
1	6	-6.181	1.0000	0.0000	-0.210	-0.159	-0.109
1	7	-0.646	0.7408	0.2592	-0.070	-0.017	0.035
1	8	-0.865	0.8064	0.1936	-0.210	-0.064	0.081
2	3	-0.178	0.5706	0.4294	-0.028	-0.002	0.023
2	4	-7.082	1.0000	0.0000	-0.084	-0.066	-0.048
2	5	-9.106	1.0000	0.0000	-0.150	-0.123	-0.097
2	6	-9.737	1.0000	0.0000	-0.154	-0.128	-0.102
2	7	0.894	0.1855	0.8145	-0.016	0.014	0.044
2	8	-0.468	0.6800	0.3200	-0.172	-0.033	0.106
3	4	-5.240	1.0000	0.0000	-0.087	-0.063	-0.040
3	5	-7.750	1.0000	0.0000	-0.152	-0.121	-0.090
3	6	-8.236	1.0000	0.0000	-0.156	-0.126	-0.096
3	7	0.934	0.1753	0.8247	-0.018	0.016	0.050
3	8	-0.432	0.6672	0.3328	-0.171	-0.031	0.109
4	5	-4.584	1.0000	0.0000	-0.082	-0.058	-0.033
4	6	-5.141	1.0000	0.0000	-0.086	-0.063	-0.039
4	7	5.501	0.0000	1.0000	0.051	0.079	0.108
4	8	0.461	0.3225	0.6775	-0.106	0.033	0.171
5	6	-0.315	0.6238	0.3762	-0.036	-0.005	0.026
5	7	7.836	0.0000	1.0000	0.103	0.137	0.171
5	8	1.263	0.1033	0.8967	-0.050	0.090	0.230
6	7	8.253	0.0000	1.0000	0.108	0.142	0.176
6	8	1.333	0.0912	0.9088	-0.045	0.095	0.235
7	8	-0.653	0.7431	0.2569	-0.188	-0.047	0.094

SWAINSON'S THRUSH WITH SERAL STAGES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
4	0.525	1.000
3	0.273	0.519
6	0.167	0.319
2	0.141	0.268
5	0.131	0.249
7	0.054	0.102
1	0.032	0.062

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.02343 (VAR Z)
WITH 1534. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.53240
WITH 12. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 22.7269 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0 OF EXCEEDING BY CHANCE

SWAINSON'S THRUSH WITH SERAL STAGES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE A	TYPE B	T VALUE	ALTERNATE_HYPOTHYSIS A_GT_B	A_LT_B	CONFIDENCE_LIMITS_FOR LOWER	A_MINUS_B	UPPER
1	2	-1.536	0.9376	0.0624	-0.247	-0.108	0.030
1	3	-3.186	0.9993	0.0007	-0.388	-0.240	-0.092
1	4	-7.000	1.0000	0.0000	-0.631	-0.493	-0.355
1	5	-1.326	0.9074	0.0926	-0.244	-0.098	0.047
1	6	-1.804	0.9643	0.0357	-0.281	-0.135	0.012
1	7	-0.274	0.6079	0.3921	-0.172	-0.021	0.130
2	3	-3.264	0.9994	0.0006	-0.211	-0.132	-0.053
2	4	-12.829	1.0000	0.0000	-0.443	-0.384	-0.325
2	5	0.257	0.3987	0.6013	-0.065	0.010	0.085
2	6	-0.677	0.7508	0.2492	-0.103	-0.026	0.050
2	7	2.012	0.0222	0.9778	0.002	0.087	0.172
3	4	-6.282	1.0000	0.0000	-0.331	-0.252	-0.174
3	5	3.036	0.0012	0.9988	0.050	0.142	0.233
3	6	2.227	0.0131	0.9869	0.013	0.105	0.198
3	7	4.303	0.0000	1.0000	0.119	0.219	0.319
4	5	10.370	0.0000	1.0000	0.320	0.394	0.469
4	6	9.216	0.0000	1.0000	0.282	0.358	0.434
4	7	10.940	0.0000	1.0000	0.387	0.471	0.556
5	6	-0.797	0.7872	0.2128	-0.126	-0.036	0.053
5	7	1.571	0.0582	0.9418	-0.019	0.077	0.174
6	7	2.279	0.0114	0.9886	0.016	0.114	0.212

APPENDIX C

TABLES RELATING USE BY SIX BIRD SPECIES TO VEGETATION TYPES.

BIRD SPECIES PAGE

TABLE 8. DEFINITION OF VEGETATION TYPE NUMBERS

VEGETATION TYPES GROUPED AT PLANT ALLIANCE LEVEL.
TYPES NAMED AT ASSOCIATION OR SUB-ASSOCIATION LEVEL.

TYPE	ECOSYSTEM UNITS
1	EXPOSED ROCK
2	(LICHEN)-GAULTHERIA-DOUGLAS FIR
	LICHEN-GAULTHERIA-LODGEPOLE PINE-DOUGLAS FIR
3	GAULTHERIA-WESTERN HEMLOCK-DOUGLAS FIR
	MAHONIA-GAULTHERIA-WESTERN HEMLOCK-DOUGLAS FIR
4	MOSS-WESTERN HEMLOCK
	MAHONIA-MOSS-WESTERN REDCEDAR-WESTERN HEMLOCK
5	MOSS-(POLYSTICHUM)-WESTERN REDCEDAR-WESTERN HEMLOCK
6	VACCINIUM-GAULTHERIA-DOUGLAS FIR-WESTERN HEMLOCK
	VACCINIUM-MOSS-WESTERN HEMLOCK
7	BLECHNUM-AMABILIS FIR-WESTERN HEMLOCK
	STREPTOPUS-BLECHNUM-AMABILIS FIR-WESTERN HEMLOCK
	BLECHNUM-WESTERN HEMLOCK-WESTERN REDCEDAR
8	RIBES-VINE MAPLE
	POLYPODIUM-GAULTHERIA-DOUGLAS FIR-WESTERN REDCEDAR
	POLYPODIUM-POLYSTICHUM-DOUGLAS FIR-WESTERN REDCEDAR
	MAHONIA-POLYSTICHUM-DOUGLAS FIR-WESTER REDCEDAR
9	TIARELLA-POLYSTICHUM-WESTERN REDCEDAR
	RUBUS-POLYSTICHUM-WESTERN REDCEDAR
	ADIANTUM-POLYSTICHUM-WESTERN REDCEDAR
10	POLYSTICHUM-OPLOPANAX-WESTERN REDCEDAR
	RIBES-OPLOPANAX-WESTERN REDCEDAR
11	VACCINIUM-LYSICHITUM-WESTERN REDCEDAR
	VACCINIUM-LYSICHITUM-YELLOW CEDAR-WESTERN REDCEDAR
12	ATHYRIUM-ARUNCUS-RED ALDER-SITKA ALDER
13	MARSH
14	LAKE

THE FOLLOWING TYPES ARE COMPOSITES OF ABOVE TYPES
THE FIRST REPRESENTS 50% OR MORE OF THE TOTAL AREA

15	2-3	26	7-11
16	3-4	27	8-6
17	MARSH-11	28	6-9
18	11-9	29	8-9
19	9-8	30	11-7
20	9-11	31	7-8
21	6-8	32	2-8
22	2-6	33-38	NOT USED
23	1-2	39	OTHER SERAL STAGES
24	8-5	40	NUMBER NOT USED
25	5-6		

YELLOW-BELLIED SAPSUCKER WITH VEGETATION TYPES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
2	0.091	1.000
39	0.084	0.927
13	0.083	0.915
5	0.076	0.835
20	0.073	0.809
6	0.062	0.686
11	0.053	0.587
12	0.046	0.507
19	0.041	0.457
21	0.038	0.420
10	0.031	0.344
9	0.025	0.277
29	0.025	0.276
7	0.025	0.271
14	0.021	0.233
27	0.019	0.214
26	0.013	0.140
22	0.011	0.122
8	0.011	0.118
3	0.0	0.0

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.00675 (VAR Z)
WITH 7441. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.00915
WITH 114. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 1.3558 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0073623 OF EXCEEDING BY CHANCE

YELLOW-BELLIED SAPSUCKER WITH VEGETATION TYPES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE	TYPE	T	ALTERNATE_HYPOTHYSIS		CONFIDENCE_LIMITS_FOR		
A	B	VALUE	A_GT_B	A_LT_B	LOWER	A_MINUS_B	UPPER
2	3	1.485	0.0687	0.9313	-0.029	0.091	0.211
2	5	0.377	0.3532	0.6468	-0.063	0.015	0.093
2	6	0.743	0.2288	0.7712	-0.047	0.028	0.104
2	7	1.489	0.0683	0.9317	-0.021	0.066	0.153
2	8	2.074	0.0191	0.9809	0.004	0.080	0.156
2	9	1.711	0.0435	0.9565	-0.010	0.066	0.141
2	10	1.446	0.0741	0.9259	-0.021	0.060	0.140
2	11	0.933	0.1755	0.8245	-0.041	0.037	0.116
2	12	1.038	0.1498	0.8502	-0.040	0.045	0.129
2	13	0.180	0.4284	0.5716	-0.077	0.008	0.092
2	14	1.746	0.0404	0.9596	-0.009	0.070	0.148
2	19	1.260	0.1039	0.8961	-0.027	0.049	0.126
2	20	0.447	0.3273	0.6727	-0.059	0.017	0.093
2	21	1.332	0.0914	0.9086	-0.025	0.053	0.130
2	22	1.740	0.0410	0.9590	-0.010	0.080	0.170
2	26	1.573	0.0578	0.9422	-0.019	0.078	0.175
2	27	1.663	0.0482	0.9518	-0.013	0.071	0.155
2	29	1.575	0.0576	0.9424	-0.016	0.066	0.148
2	39	0.159	0.4369	0.5631	-0.076	0.007	0.089
3	5	-1.524	0.9363	0.0637	-0.173	-0.076	0.022
3	6	-1.279	0.8996	0.1004	-0.158	-0.062	0.033
3	7	-0.459	0.6770	0.3230	-0.130	-0.025	0.080
3	8	-0.219	0.5867	0.4133	-0.107	-0.011	0.085
3	9	-0.517	0.6974	0.3026	-0.121	-0.025	0.070
3	10	-0.613	0.7301	0.2699	-0.131	-0.031	0.069
3	11	-1.063	0.8560	0.1440	-0.152	-0.053	0.045
3	12	-0.876	0.8093	0.1907	-0.149	-0.046	0.057
3	13	-1.584	0.9434	0.0566	-0.186	-0.083	0.020
3	14	-0.423	0.6639	0.3361	-0.119	-0.021	0.077
3	19	-0.841	0.7999	0.2001	-0.138	-0.041	0.055
3	20	-1.501	0.9333	0.0667	-0.169	-0.073	0.022
3	21	-0.768	0.7787	0.2213	-0.135	-0.038	0.059
3	22	-0.202	0.5800	0.4200	-0.118	-0.011	0.096
3	26	-0.219	0.5866	0.4134	-0.126	-0.013	0.101
3	27	-0.372	0.6450	0.3550	-0.122	-0.019	0.083
3	29	-0.487	0.6868	0.3132	-0.126	-0.025	0.076
3	39	-1.631	0.9485	0.0515	-0.185	-0.084	0.017
5	6	0.931	0.1758	0.8242	-0.015	0.014	0.042
5	7	1.916	0.0277	0.9723	-0.001	0.051	0.104
5	8	4.283	0.0000	1.0000	0.035	0.065	0.095
5	9	3.493	0.0002	0.9998	0.022	0.051	0.079
5	10	2.136	0.0163	0.9837	0.004	0.045	0.086
5	11	1.194	0.1163	0.8837	-0.014	0.023	0.060
5	12	1.215	0.1122	0.8878	-0.018	0.030	0.078
5	13	-0.297	0.6166	0.3834	-0.055	-0.007	0.040

5	14	3.005	0.0013	0.9987	0.019	0.055	0.090
5	19	2.085	0.0186	0.9814	0.002	0.034	0.067
5	20	0.153	0.4392	0.5608	-0.028	0.002	0.033
5	21	2.166	0.0152	0.9848	0.004	0.038	0.072
5	22	2.235	0.0127	0.9873	0.008	0.065	0.122
5	26	1.820	0.0344	0.9656	-0.005	0.063	0.131
5	27	2.342	0.0096	0.9904	0.009	0.056	0.104
5	29	2.312	0.0104	0.9896	0.008	0.051	0.094
5	39	-0.370	0.6445	0.3555	-0.052	-0.008	0.036
6	7	1.526	0.0635	0.9365	-0.011	0.038	0.086
6	8	4.586	0.0000	1.0000	0.030	0.052	0.074
6	9	3.610	0.0002	0.9998	0.017	0.037	0.057
6	10	1.707	0.0440	0.9560	-0.005	0.031	0.067
6	11	0.567	0.2853	0.7147	-0.022	0.009	0.040
6	12	0.730	0.2328	0.7672	-0.027	0.016	0.060
6	13	-0.942	0.8269	0.1731	-0.064	-0.021	0.022
6	14	2.734	0.0031	0.9969	0.012	0.041	0.071
6	19	1.611	0.0536	0.9464	-0.005	0.021	0.046
6	20	-0.973	0.8348	0.1652	-0.034	-0.011	0.011
6	21	1.715	0.0432	0.9568	-0.003	0.024	0.052
6	22	1.889	0.0294	0.9706	-0.002	0.051	0.104
6	26	1.497	0.0673	0.9327	-0.015	0.050	0.115
6	27	1.966	0.0247	0.9753	0.000	0.043	0.086
6	29	1.917	0.0277	0.9723	-0.001	0.037	0.075
6	39	-1.096	0.8635	0.1365	-0.061	-0.022	0.017
7	8	0.555	0.2895	0.7105	-0.035	0.014	0.063
7	9	-0.022	0.5085	0.4915	-0.049	-0.001	0.048
7	10	-0.229	0.5904	0.4096	-0.063	-0.007	0.050
7	11	-1.044	0.8517	0.1483	-0.083	-0.029	0.025
7	12	-0.676	0.7505	0.2495	-0.083	-0.021	0.041
7	13	-1.859	0.9685	0.0315	-0.120	-0.058	0.003
7	14	0.130	0.4484	0.5516	-0.049	0.004	0.056
7	19	-0.651	0.7425	0.2575	-0.068	-0.017	0.034
7	20	-1.939	0.9737	0.0263	-0.098	-0.049	0.001
7	21	-0.509	0.6946	0.3054	-0.065	-0.013	0.038
7	22	0.386	0.3499	0.6501	-0.055	0.014	0.083
7	26	0.298	0.3828	0.6172	-0.067	0.012	0.090
7	27	0.165	0.4344	0.5656	-0.056	0.005	0.066
7	29	-0.013	0.5051	0.4949	-0.059	-0.000	0.058
7	39	-1.984	0.9764	0.0236	-0.118	-0.059	-0.001
8	9	-1.290	0.9014	0.0986	-0.036	-0.014	0.008
8	10	-1.095	0.8633	0.1367	-0.057	-0.021	0.016
8	11	-2.585	0.9951	0.0049	-0.075	-0.043	-0.010
8	12	-1.552	0.9396	0.0604	-0.080	-0.035	0.009
8	13	-3.220	0.9994	0.0006	-0.116	-0.072	-0.028
8	14	-0.663	0.7464	0.2536	-0.041	-0.010	0.020
8	19	-2.251	0.9878	0.0122	-0.058	-0.031	-0.004
8	20	-5.092	1.0000	0.0000	-0.087	-0.063	-0.039
8	21	-1.853	0.9680	0.0320	-0.056	-0.027	0.002
8	22	-0.013	0.5049	0.4951	-0.054	-0.000	0.054
8	26	-0.059	0.5237	0.4763	-0.068	-0.002	0.064
8	27	-0.394	0.6532	0.3468	-0.052	-0.009	0.035
8	29	-0.718	0.7635	0.2365	-0.053	-0.014	0.025
8	39	-3.598	0.9998	0.0002	-0.113	-0.073	-0.033

9	10	-0.334	0.6307	0.3693	-0.042	-0.006	0.030
9	11	-1.777	0.9622	0.0378	-0.059	-0.028	0.003
9	12	-0.935	0.8252	0.1748	-0.065	-0.021	0.023
9	13	-2.631	0.9957	0.0043	-0.101	-0.058	-0.015
9	14	0.269	0.3940	0.6060	-0.025	0.004	0.033
9	19	-1.266	0.8972	0.1028	-0.042	-0.016	0.009
9	20	-4.218	1.0000	0.0000	-0.071	-0.048	-0.026
9	21	-0.920	0.8213	0.1787	-0.041	-0.013	0.015
9	22	0.520	0.3014	0.6986	-0.039	0.014	0.067
9	26	0.376	0.3533	0.6467	-0.052	0.012	0.077
9	27	0.262	0.3968	0.6032	-0.037	0.006	0.048
9	29	0.007	0.4973	0.5027	-0.038	0.000	0.038
9	39	-2.964	0.9985	0.0015	-0.098	-0.059	-0.020
10	11	-1.011	0.8440	0.1560	-0.065	-0.022	0.021
10	12	-0.550	0.7088	0.2912	-0.067	-0.015	0.038
10	13	-1.945	0.9741	0.0259	-0.104	-0.052	0.000
10	14	0.476	0.3171	0.6829	-0.032	0.010	0.052
10	19	-0.518	0.6977	0.3023	-0.049	-0.010	0.029
10	20	-2.237	0.9873	0.0127	-0.079	-0.042	-0.005
10	21	-0.334	0.6309	0.3691	-0.047	-0.007	0.033
10	22	0.651	0.2575	0.7425	-0.041	0.020	0.081
10	26	0.510	0.3052	0.6948	-0.053	0.019	0.090
10	27	0.445	0.3282	0.6718	-0.040	0.012	0.064
10	29	0.253	0.4002	0.5998	-0.042	0.006	0.054
10	39	-2.122	0.9831	0.0169	-0.102	-0.053	-0.004
11	12	0.287	0.3869	0.6131	-0.042	0.007	0.057
11	13	-1.185	0.8820	0.1180	-0.079	-0.030	0.019
11	14	1.669	0.0476	0.9524	-0.006	0.032	0.070
11	19	0.669	0.2517	0.7483	-0.023	0.012	0.046
11	20	-1.213	0.8873	0.1127	-0.053	-0.020	0.012
11	21	0.819	0.2064	0.7936	-0.021	0.015	0.052
11	22	1.424	0.0773	0.9227	-0.016	0.042	0.100
11	26	1.151	0.1248	0.8752	-0.029	0.041	0.110
11	27	1.359	0.0871	0.9129	-0.015	0.034	0.083
11	29	1.236	0.1082	0.8918	-0.017	0.028	0.073
11	39	-1.325	0.9074	0.0926	-0.076	-0.031	0.015
12	13	-1.251	0.8945	0.1055	-0.095	-0.037	0.021
12	14	1.001	0.1584	0.8416	-0.024	0.025	0.074
12	19	0.192	0.4239	0.5761	-0.042	0.005	0.051
12	20	-1.201	0.8851	0.1149	-0.072	-0.027	0.017
12	21	0.325	0.3725	0.6275	-0.040	0.008	0.056
12	22	1.041	0.1489	0.8511	-0.031	0.035	0.101
12	26	0.863	0.1940	0.8060	-0.042	0.033	0.109
12	27	0.902	0.1835	0.8165	-0.031	0.027	0.084
12	29	0.757	0.2246	0.7754	-0.033	0.021	0.075
12	39	-1.358	0.9128	0.0872	-0.093	-0.038	0.017
13	14	2.518	0.0059	0.9941	0.014	0.062	0.110
13	19	1.780	0.0375	0.9625	-0.004	0.042	0.087
13	20	0.423	0.3362	0.6638	-0.035	0.010	0.054
13	21	1.871	0.0307	0.9693	-0.002	0.045	0.092
13	22	2.157	0.0155	0.9845	0.007	0.072	0.137
13	26	1.831	0.0336	0.9664	-0.005	0.070	0.146
13	27	2.177	0.0148	0.9852	0.006	0.064	0.121
13	29	2.110	0.0175	0.9825	0.004	0.058	0.112

13	39	-0.039	0.5157	0.4843	-0.056	-0.001	0.053
14	19	-1.201	0.8852	0.1148	-0.054	-0.020	0.013
14	20	-3.297	0.9995	0.0005	-0.083	-0.052	-0.021
14	21	-0.951	0.8292	0.1708	-0.052	-0.017	0.018
14	22	0.344	0.3654	0.6346	-0.047	0.010	0.067
14	26	0.241	0.4046	0.5954	-0.060	0.008	0.077
14	27	0.068	0.4729	0.5271	-0.046	0.002	0.049
14	29	-0.175	0.5694	0.4306	-0.048	-0.004	0.040
14	39	-2.772	0.9972	0.0028	-0.108	-0.063	-0.018
19	20	-2.307	0.9895	0.0105	-0.059	-0.032	-0.005
19	21	0.209	0.4171	0.5829	-0.028	0.003	0.035
19	22	1.078	0.1404	0.8596	-0.025	0.030	0.086
19	26	0.846	0.1989	0.8011	-0.038	0.029	0.096
19	27	0.952	0.1707	0.8293	-0.023	0.022	0.067
19	29	0.786	0.2160	0.7840	-0.025	0.016	0.057
19	39	-1.995	0.9770	0.0230	-0.085	-0.043	-0.001
20	21	2.362	0.0091	0.9909	0.006	0.035	0.065
20	22	2.263	0.0118	0.9882	0.008	0.062	0.116
20	26	1.813	0.0349	0.9651	-0.005	0.061	0.127
20	27	2.415	0.0079	0.9921	0.010	0.054	0.098
20	29	2.412	0.0079	0.9921	0.009	0.048	0.088
20	39	-0.518	0.6979	0.3021	-0.051	-0.011	0.030
21	22	0.940	0.1735	0.8265	-0.029	0.027	0.083
21	26	0.737	0.2307	0.7693	-0.042	0.025	0.093
21	27	0.783	0.2168	0.7832	-0.028	0.019	0.065
21	29	0.603	0.2731	0.7269	-0.029	0.013	0.056
21	39	-2.082	0.9813	0.0187	-0.089	-0.046	-0.003
22	26	-0.039	0.5157	0.4843	-0.083	-0.002	0.080
22	27	-0.253	0.5999	0.4001	-0.074	-0.008	0.057
22	29	-0.440	0.6701	0.3299	-0.076	-0.014	0.048
22	39	-2.282	0.9887	0.0113	-0.136	-0.073	-0.010
26	27	-0.177	0.5702	0.4298	-0.082	-0.007	0.068
26	29	-0.333	0.6305	0.3695	-0.085	-0.012	0.060
26	39	-1.917	0.9724	0.0276	-0.144	-0.071	0.002
27	29	-0.204	0.5806	0.4194	-0.059	-0.006	0.048
27	39	-2.338	0.9903	0.0097	-0.119	-0.065	-0.010
29	39	-2.287	0.9889	0.0111	-0.110	-0.059	-0.008

STELLER'S JAY WITH VEGETATION TYPES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
12	0.329	1.000
11	0.313	0.951
20	0.179	0.544
6	0.167	0.508
8	0.166	0.505
9	0.151	0.459
27	0.128	0.390
10	0.119	0.362
19	0.114	0.347
22	0.113	0.344
5	0.113	0.344
39	0.081	0.246
7	0.079	0.239
21	0.047	0.142
14	0.045	0.138
13	0.037	0.112
29	0.026	0.078
26	0.012	0.037

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.01662 (VAR Z)
WITH 5413. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.03380
WITH 102. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 2.0329 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0 OF EXCEEDING BY CHANCE

STELLER'S JAY WITH VEGETATION TYPES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE A	TYPE B	T VALUE	ALTERNATE_HYPOTHYSIS A_GT_B	A_LT_B	CONFIDENCE_LIMITS_FOR LOWER	A_MINUS_B	UPPER
5	6	-1.598	0.9449	0.0551	-0.120	-0.054	0.012
5	7	0.567	0.2854	0.7146	-0.085	0.034	0.153
5	8	-1.419	0.9220	0.0780	-0.126	-0.053	0.020
5	9	-1.117	0.8679	0.1321	-0.104	-0.038	0.028
5	10	-0.119	0.5473	0.4527	-0.101	-0.006	0.090
5	11	-4.368	1.0000	0.0000	-0.289	-0.200	-0.110
5	12	-3.659	0.9999	0.0001	-0.331	-0.216	-0.100
5	13	1.383	0.0834	0.9166	-0.032	0.076	0.185
5	14	1.665	0.0480	0.9520	-0.012	0.068	0.148
5	19	-0.027	0.5108	0.4892	-0.077	-0.001	0.075
5	20	-1.845	0.9675	0.0325	-0.136	-0.066	0.004
5	21	1.563	0.0591	0.9409	-0.017	0.066	0.150
5	22	-0.000	0.5000	0.5000	-0.114	-0.000	0.114
5	26	1.208	0.1135	0.8865	-0.063	0.101	0.265
5	27	-0.275	0.6083	0.3917	-0.122	-0.015	0.092
5	29	1.910	0.0281	0.9719	-0.002	0.088	0.177
5	39	0.674	0.2501	0.7499	-0.062	0.032	0.127
6	7	1.571	0.0581	0.9419	-0.022	0.088	0.198
6	8	0.026	0.4894	0.5106	-0.057	0.001	0.058
6	9	0.657	0.2558	0.7442	-0.032	0.016	0.064
6	10	1.122	0.1311	0.8689	-0.036	0.048	0.132
6	11	-3.702	0.9999	0.0001	-0.223	-0.146	-0.069
6	12	-2.988	0.9986	0.0014	-0.268	-0.162	-0.056
6	13	2.595	0.0047	0.9953	0.032	0.130	0.229
6	14	3.627	0.0001	0.9999	0.056	0.122	0.187
6	19	1.692	0.0454	0.9546	-0.008	0.053	0.114
6	20	-0.446	0.6720	0.3280	-0.065	-0.012	0.041
6	21	3.377	0.0004	0.9996	0.050	0.120	0.190
6	22	1.007	0.1570	0.8430	-0.051	0.054	0.158
6	26	1.927	0.0270	0.9730	-0.003	0.155	0.312
6	27	0.785	0.2161	0.7839	-0.058	0.039	0.136
6	29	3.573	0.0002	0.9998	0.064	0.141	0.219
6	39	2.047	0.0203	0.9797	0.004	0.086	0.169
7	8	-1.496	0.9327	0.0673	-0.202	-0.087	0.027
7	9	-1.283	0.9003	0.0997	-0.182	-0.072	0.038
7	10	-0.607	0.7281	0.2719	-0.170	-0.040	0.090
7	11	-3.653	0.9999	0.0001	-0.360	-0.234	-0.108
7	12	-3.375	0.9996	0.0004	-0.395	-0.250	-0.105
7	13	0.590	0.2777	0.7223	-0.098	0.042	0.182
7	14	0.551	0.2907	0.7093	-0.085	0.033	0.152
7	19	-0.597	0.7249	0.2751	-0.152	-0.035	0.081
7	20	-1.748	0.9597	0.0403	-0.213	-0.100	0.012
7	21	0.517	0.3027	0.6973	-0.089	0.032	0.153
7	22	-0.468	0.6802	0.3198	-0.179	-0.034	0.110
7	26	0.701	0.2416	0.7584	-0.119	0.067	0.252

7	27	-0.699	0.7578	0.2422	-0.188	-0.049	0.089
7	29	0.827	0.2040	0.7960	-0.073	0.053	0.179
7	39	-0.031	0.5123	0.4877	-0.131	-0.002	0.127
8	9	0.521	0.3011	0.6989	-0.042	0.015	0.073
8	10	1.032	0.1511	0.8489	-0.042	0.047	0.137
8	11	-3.442	0.9997	0.0003	-0.230	-0.147	-0.063
8	12	-2.876	0.9980	0.0020	-0.273	-0.163	-0.052
8	13	2.454	0.0071	0.9929	0.026	0.129	0.233
8	14	3.245	0.0006	0.9994	0.048	0.121	0.194
8	19	1.479	0.0696	0.9304	-0.017	0.052	0.121
8	20	-0.407	0.6580	0.3420	-0.075	-0.013	0.049
8	21	3.053	0.0011	0.9989	0.043	0.119	0.196
8	22	0.950	0.1712	0.8288	-0.056	0.053	0.162
8	26	1.879	0.0301	0.9699	-0.007	0.154	0.314
8	27	0.731	0.2323	0.7677	-0.064	0.038	0.140
8	29	3.288	0.0005	0.9995	0.057	0.141	0.224
8	39	1.893	0.0292	0.9708	-0.003	0.085	0.174
9	10	0.744	0.2284	0.7716	-0.052	0.032	0.116
9	11	-4.104	1.0000	0.0000	-0.239	-0.162	-0.085
9	12	-3.282	0.9995	0.0005	-0.284	-0.178	-0.072
9	13	2.271	0.0116	0.9884	0.016	0.114	0.213
9	14	3.139	0.0009	0.9991	0.040	0.106	0.171
9	19	1.172	0.1207	0.8793	-0.025	0.037	0.098
9	20	-1.035	0.8496	0.1504	-0.082	-0.028	0.025
9	21	2.918	0.0018	0.9982	0.034	0.104	0.174
9	22	0.705	0.2405	0.7595	-0.067	0.038	0.142
9	26	1.726	0.0422	0.9578	-0.019	0.139	0.296
9	27	0.459	0.3232	0.6768	-0.074	0.023	0.120
9	29	3.161	0.0008	0.9992	0.048	0.125	0.203
9	39	1.662	0.0483	0.9517	-0.013	0.070	0.153
10	11	-3.672	0.9999	0.0001	-0.297	-0.194	-0.090
10	12	-3.250	0.9994	0.0006	-0.336	-0.210	-0.083
10	13	1.342	0.0898	0.9102	-0.038	0.082	0.202
10	14	1.516	0.0648	0.9352	-0.022	0.074	0.169
10	19	0.101	0.4599	0.5401	-0.087	0.005	0.097
10	20	-1.353	0.9119	0.0881	-0.147	-0.060	0.027
10	21	1.443	0.0746	0.9254	-0.026	0.072	0.170
10	22	0.090	0.4640	0.5360	-0.120	0.006	0.131
10	26	1.218	0.1117	0.8883	-0.065	0.107	0.279
10	27	-0.152	0.5604	0.4396	-0.128	-0.009	0.110
10	29	1.764	0.0389	0.9611	-0.010	0.093	0.197
10	39	0.696	0.2432	0.7568	-0.069	0.038	0.146
11	12	-0.256	0.6010	0.3990	-0.138	-0.016	0.106
11	13	4.683	0.0000	1.0000	0.161	0.276	0.392
11	14	5.863	0.0000	1.0000	0.178	0.268	0.357
11	19	4.523	0.0000	1.0000	0.113	0.199	0.285
11	20	3.250	0.0006	0.9994	0.053	0.134	0.214
11	21	5.643	0.0000	1.0000	0.174	0.266	0.358
11	22	3.236	0.0006	0.9994	0.079	0.200	0.321
11	26	3.494	0.0002	0.9998	0.132	0.301	0.469
11	27	3.170	0.0008	0.9992	0.070	0.185	0.299
11	29	5.720	0.0000	1.0000	0.189	0.287	0.386
11	39	4.443	0.0000	1.0000	0.130	0.232	0.334
12	13	4.190	0.0000	1.0000	0.155	0.292	0.429

12	14	4.817	0.0000	1.0000	0.168	0.283	0.399
12	19	3.729	0.0001	0.9999	0.102	0.215	0.327
12	20	2.700	0.0035	0.9965	0.041	0.150	0.259
12	21	4.696	0.0000	1.0000	0.164	0.282	0.400
12	22	2.993	0.0014	0.9986	0.074	0.216	0.357
12	26	3.377	0.0004	0.9996	0.133	0.317	0.500
12	27	2.903	0.0019	0.9981	0.065	0.201	0.336
12	29	4.853	0.0000	1.0000	0.181	0.303	0.426
12	39	3.868	0.0001	0.9999	0.122	0.248	0.374
13	14	-0.155	0.5616	0.4384	-0.117	-0.009	0.100
13	19	-1.440	0.9251	0.0749	-0.183	-0.077	0.028
13	20	-2.759	0.9971	0.0029	-0.243	-0.142	-0.041
13	21	-0.179	0.5709	0.4291	-0.121	-0.010	0.101
13	22	-1.107	0.8657	0.1343	-0.212	-0.076	0.059
13	26	0.268	0.3944	0.6056	-0.155	0.025	0.204
13	27	-1.385	0.9169	0.0831	-0.221	-0.091	0.038
13	29	0.188	0.4255	0.5745	-0.105	0.011	0.127
13	39	-0.725	0.7657	0.2343	-0.163	-0.044	0.075
14	19	-1.780	0.9624	0.0376	-0.145	-0.069	0.007
14	20	-3.758	0.9999	0.0001	-0.203	-0.134	-0.064
14	21	-0.036	0.5144	0.4856	-0.085	-0.002	0.082
14	22	-1.168	0.8785	0.1215	-0.182	-0.068	0.046
14	26	0.396	0.3461	0.6539	-0.131	0.033	0.197
14	27	-1.522	0.9359	0.0641	-0.190	-0.083	0.024
14	29	0.430	0.3338	0.6662	-0.070	0.020	0.109
14	39	-0.740	0.7703	0.2297	-0.129	-0.035	0.059
19	20	-1.943	0.9740	0.0260	-0.130	-0.065	0.001
19	21	1.664	0.0481	0.9519	-0.012	0.067	0.147
19	22	0.018	0.4927	0.5073	-0.110	0.001	0.112
19	26	1.235	0.1085	0.8915	-0.060	0.102	0.264
19	27	-0.263	0.6037	0.3963	-0.118	-0.014	0.090
19	29	2.012	0.0222	0.9778	0.002	0.089	0.175
19	39	0.722	0.2352	0.7648	-0.057	0.033	0.124
20	21	3.525	0.0002	0.9998	0.059	0.132	0.206
20	22	1.204	0.1143	0.8857	-0.041	0.066	0.173
20	26	2.055	0.0200	0.9800	0.008	0.167	0.326
20	27	1.002	0.1582	0.8418	-0.049	0.051	0.150
20	29	3.715	0.0001	0.9999	0.072	0.153	0.234
20	39	2.247	0.0124	0.9876	0.013	0.098	0.184
21	22	-1.119	0.8683	0.1317	-0.183	-0.066	0.050
21	26	0.410	0.3409	0.6591	-0.131	0.035	0.200
21	27	-1.459	0.9277	0.0723	-0.191	-0.081	0.028
21	29	0.448	0.3271	0.6729	-0.071	0.021	0.114
21	39	-0.687	0.7541	0.2459	-0.131	-0.034	0.063
22	26	1.082	0.1396	0.8604	-0.082	0.101	0.284
22	27	-0.219	0.5866	0.4134	-0.149	-0.015	0.119
22	29	1.417	0.0783	0.9217	-0.034	0.088	0.209
22	39	0.511	0.3048	0.6952	-0.092	0.032	0.157
26	27	-1.274	0.8986	0.1014	-0.294	-0.116	0.063
26	29	-0.156	0.5620	0.4380	-0.182	-0.013	0.155
26	39	-0.785	0.7838	0.2162	-0.240	-0.069	0.103
27	29	1.757	0.0395	0.9605	-0.012	0.103	0.217
27	39	0.788	0.2153	0.7847	-0.070	0.047	0.165
29	39	-1.054	0.8539	0.1461	-0.158	-0.055	0.047

CHESTNUT-BACKED CHICKADEE WITH VEGETATION TYPES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
21	1.012	1.000
5	0.957	0.946
20	0.574	0.567
9	0.491	0.486
6	0.387	0.383
10	0.339	0.335
11	0.327	0.324
12	0.252	0.249
8	0.237	0.234
19	0.146	0.144
7	0.106	0.104
22	0.093	0.091

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.06841 (VAR Z)
WITH 1717. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.12779
WITH 66. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 1.8681 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0000419 OF EXCEEDING BY CHANCE

CHESTNUT-BACKED CHICKADEE WITH VEGETATION TYPES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE	TYPE	T	ALTERNATE_HYPOTHYSIS		CONFIDENCE_LIMITS_FOR		
A	B	VALUE	A_GT_B	A_LT_B	LOWER	A_MINUS_B	UPPER
5	6	4.086	0.0000	1.0000	0.296	0.569	0.843
5	7	3.632	0.0001	0.9999	0.391	0.851	1.310
5	8	3.980	0.0000	1.0000	0.365	0.720	1.074
5	9	3.529	0.0002	0.9998	0.207	0.465	0.724
5	10	3.115	0.0009	0.9991	0.229	0.617	1.006
5	11	3.390	0.0004	0.9996	0.265	0.629	0.993
5	12	3.259	0.0006	0.9994	0.280	0.704	1.128
5	19	5.630	0.0000	1.0000	0.528	0.811	1.093
5	20	2.665	0.0039	0.9961	0.101	0.383	0.665
5	21	-0.269	0.6059	0.3941	-0.457	-0.055	0.347
5	22	3.809	0.0001	0.9999	0.419	0.864	1.309
6	7	1.274	0.1014	0.8986	-0.152	0.281	0.715
6	8	0.921	0.1786	0.8214	-0.170	0.150	0.470
6	9	-0.981	0.8366	0.1634	-0.312	-0.104	0.104
6	10	0.262	0.3965	0.6035	-0.309	0.048	0.405
6	11	0.355	0.3615	0.6385	-0.270	0.060	0.390
6	12	0.670	0.2516	0.7484	-0.260	0.135	0.530
6	19	1.995	0.0231	0.9769	0.004	0.241	0.479
6	20	-1.545	0.9388	0.0612	-0.423	-0.186	0.050
6	21	-3.296	0.9995	0.0005	-0.996	-0.624	-0.253
6	22	1.383	0.0833	0.9167	-0.123	0.295	0.712
7	8	-0.527	0.7010	0.2990	-0.620	-0.131	0.357
7	9	-1.784	0.9627	0.0373	-0.810	-0.386	0.038
7	10	-0.892	0.8137	0.1863	-0.747	-0.234	0.280
7	11	-0.878	0.8100	0.1900	-0.717	-0.222	0.274
7	12	-0.531	0.7023	0.2977	-0.687	-0.146	0.395
7	19	-0.179	0.5711	0.4289	-0.479	-0.040	0.399
7	20	-2.092	0.9817	0.0183	-0.906	-0.468	-0.029
7	21	-3.392	0.9996	0.0004	-1.430	-0.906	-0.382
7	22	0.046	0.4815	0.5185	-0.544	0.013	0.571
8	9	-1.623	0.9477	0.0523	-0.562	-0.254	0.053
8	10	-0.475	0.6826	0.3174	-0.525	-0.102	0.320
8	11	-0.444	0.6713	0.3287	-0.490	-0.090	0.309
8	12	-0.065	0.5260	0.4740	-0.470	-0.015	0.440
8	19	0.546	0.2925	0.7075	-0.236	0.091	0.419
8	20	-2.018	0.9781	0.0219	-0.664	-0.337	-0.009
8	21	-3.494	0.9998	0.0002	-1.209	-0.775	-0.340
8	22	0.597	0.2753	0.7247	-0.330	0.145	0.619
9	10	0.861	0.1946	0.8054	-0.194	0.152	0.498
9	11	1.011	0.1562	0.8438	-0.154	0.164	0.482
9	12	1.218	0.1118	0.8882	-0.146	0.239	0.624
9	19	3.078	0.0011	0.9989	0.125	0.346	0.566
9	20	-0.735	0.7689	0.2311	-0.302	-0.082	0.137
9	21	-2.828	0.9976	0.0024	-0.881	-0.520	-0.159
9	22	1.916	0.0278	0.9722	-0.009	0.399	0.807

10	11	0.054	0.4784	0.5216	-0.419	0.012	0.442
10	12	0.355	0.3615	0.6385	-0.395	0.087	0.569
10	19	1.042	0.1487	0.8513	-0.171	0.194	0.558
10	20	-1.263	0.8966	0.1034	-0.598	-0.234	0.130
10	21	-2.848	0.9978	0.0022	-1.135	-0.672	-0.209
10	22	0.967	0.1669	0.8331	-0.254	0.247	0.748
11	12	0.319	0.3748	0.6252	-0.387	0.075	0.538
11	19	1.055	0.1457	0.8543	-0.156	0.182	0.519
11	20	-1.431	0.9238	0.0762	-0.583	-0.246	0.091
11	21	-3.032	0.9988	0.0012	-1.127	-0.684	-0.242
11	22	0.956	0.1695	0.8305	-0.247	0.235	0.717
12	19	0.519	0.3018	0.6982	-0.295	0.106	0.508
12	20	-1.571	0.9418	0.0582	-0.723	-0.321	0.080
12	21	-3.021	0.9987	0.0013	-1.252	-0.759	-0.266
12	22	0.592	0.2769	0.7231	-0.369	0.160	0.688
19	20	-3.396	0.9996	0.0004	-0.675	-0.428	-0.181
19	21	-4.489	1.0000	0.0000	-1.244	-0.866	-0.487
19	22	0.247	0.4026	0.5974	-0.370	0.053	0.477
20	21	-2.274	0.9884	0.0116	-0.816	-0.438	-0.060
20	22	2.229	0.0130	0.9870	0.058	0.481	0.904
21	22	3.526	0.0002	0.9998	0.408	0.919	1.430

WINTER WREN WITH VEGETAION TYPES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
5	3.158	1.000
12	2.830	0.896
7	2.671	0.846
19	2.194	0.695
10	2.181	0.691
20	2.121	0.672
9	2.109	0.668
8	2.108	0.667
21	1.740	0.551
6	1.584	0.502
29	1.410	0.446
11	1.263	0.400
22	1.146	0.363
27	1.112	0.352
13	0.756	0.240
39	0.664	0.210

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.14886 (VAR Z)
WITH 3458. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.53872
WITH 90. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 3.6189 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0 OF EXCEEDING BY CHANCE

WINTER WREN WITH VEGETATION TYPES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE A	TYPE B	T VALUE	ALTERNATE_HYPOTHYSIS A_GT_B	A_LT_B	CONFIDENCE_LIMITS_FOR LOWER	A_MINUS_B	UPPER
5	6	7.258	0.0000	1.0000	1.149	1.574	1.999
5	7	1.327	0.0924	0.9076	-0.233	0.487	1.206
5	8	4.048	0.0000	1.0000	0.541	1.050	1.559
5	9	4.869	0.0000	1.0000	0.627	1.049	1.471
5	10	3.382	0.0004	0.9996	0.411	0.977	1.544
5	11	7.483	0.0000	1.0000	1.398	1.894	2.391
5	12	1.017	0.1547	0.8453	-0.304	0.328	0.960
5	13	7.389	0.0000	1.0000	1.764	2.401	3.039
5	19	3.932	0.0000	1.0000	0.483	0.964	1.444
5	20	4.371	0.0000	1.0000	0.572	1.037	1.502
5	21	5.176	0.0000	1.0000	0.881	1.418	1.955
5	22	6.058	0.0000	1.0000	1.361	2.012	2.663
5	27	6.692	0.0000	1.0000	1.447	2.046	2.646
5	29	5.898	0.0000	1.0000	1.167	1.748	2.329
5	39	8.967	0.0000	1.0000	1.948	2.494	3.039
6	7	-3.286	0.9995	0.0005	-1.736	-1.087	-0.439
6	8	-2.555	0.9947	0.0053	-0.926	-0.524	-0.122
6	9	-3.606	0.9998	0.0002	-0.811	-0.525	-0.240
6	10	-2.473	0.9933	0.0067	-1.070	-0.597	-0.124
6	11	1.625	0.0521	0.9479	-0.066	0.320	0.707
6	12	-4.439	1.0000	0.0000	-1.797	-1.246	-0.696
6	13	2.918	0.0018	0.9982	0.271	0.827	1.383
6	19	-3.270	0.9995	0.0005	-0.977	-0.611	-0.245
6	20	-3.046	0.9988	0.0012	-0.883	-0.537	-0.191
6	21	-0.700	0.7579	0.2421	-0.594	-0.156	0.282
6	22	1.501	0.0667	0.9333	-0.134	0.438	1.010
6	27	1.806	0.0355	0.9645	-0.040	0.472	0.984
6	29	0.695	0.2436	0.7564	-0.317	0.174	0.664
6	39	4.028	0.0000	1.0000	0.472	0.920	1.367
7	8	1.564	0.0590	0.9410	-0.143	0.563	1.269
7	9	1.704	0.0442	0.9558	-0.085	0.562	1.209
7	10	1.284	0.0996	0.9004	-0.259	0.490	1.239
7	11	3.957	0.0000	1.0000	0.710	1.408	2.105
7	12	-0.389	0.6515	0.3485	-0.959	-0.159	0.641
7	13	4.670	0.0000	1.0000	1.111	1.915	2.718
7	19	1.362	0.0866	0.9134	-0.209	0.477	1.163
7	20	1.597	0.0552	0.9448	-0.125	0.550	1.226
7	21	2.511	0.0060	0.9940	0.204	0.931	1.658
7	22	3.670	0.0001	0.9999	0.710	1.525	2.340
7	27	3.949	0.0000	1.0000	0.785	1.559	2.333
7	29	3.253	0.0006	0.9994	0.501	1.261	2.021
7	39	5.368	0.0000	1.0000	1.274	2.007	2.740
8	9	-0.005	0.5018	0.4982	-0.400	-0.001	0.398
8	10	-0.260	0.6024	0.3976	-0.622	-0.073	0.477
8	11	3.473	0.0003	0.9997	0.368	0.844	1.321

8	12	-2.294	0.9891	0.0109	-1.339	-0.722	-0.105
8	13	4.259	0.0000	1.0000	0.729	1.351	1.973
8	19	-0.368	0.6436	0.3564	-0.547	-0.086	0.374
8	20	-0.057	0.5227	0.4773	-0.457	-0.013	0.431
8	21	1.390	0.0823	0.9177	-0.151	0.368	0.887
8	22	2.964	0.0015	0.9985	0.326	0.962	1.599
8	27	3.348	0.0004	0.9996	0.413	0.996	1.579
8	29	2.425	0.0077	0.9923	0.134	0.698	1.262
8	39	5.366	0.0000	1.0000	0.916	1.444	1.971
9	10	-0.299	0.6175	0.3825	-0.543	-0.072	0.399
9	11	4.323	0.0000	1.0000	0.462	0.845	1.229
9	12	-2.578	0.9950	0.0050	-1.269	-0.721	-0.173
9	13	4.788	0.0000	1.0000	0.799	1.352	1.906
9	19	-0.462	0.6778	0.3222	-0.448	-0.085	0.277
9	20	-0.068	0.5272	0.4728	-0.354	-0.012	0.330
9	21	1.663	0.0482	0.9518	-0.066	0.369	0.804
9	22	3.313	0.0005	0.9995	0.393	0.963	1.533
9	27	3.833	0.0001	0.9999	0.487	0.997	1.507
9	29	2.807	0.0025	0.9975	0.211	0.699	1.187
9	39	6.365	0.0000	1.0000	1.000	1.445	1.890
10	11	3.342	0.0004	0.9996	0.379	0.917	1.455
10	12	-1.912	0.9720	0.0280	-1.315	-0.649	0.016
10	13	4.166	0.0000	1.0000	0.754	1.424	2.094
10	19	-0.051	0.5204	0.4796	-0.537	-0.014	0.510
10	20	0.230	0.4090	0.5910	-0.450	0.060	0.569
10	21	1.500	0.0668	0.9332	-0.135	0.441	1.017
10	22	2.968	0.0015	0.9985	0.351	1.035	1.718
10	27	3.303	0.0005	0.9995	0.434	1.069	1.703
10	29	2.449	0.0072	0.9928	0.154	0.771	1.388
10	39	5.095	0.0000	1.0000	0.933	1.516	2.100
11	12	-5.059	1.0000	0.0000	-2.174	-1.566	-0.959
11	13	1.624	0.0522	0.9478	-0.105	0.507	1.119
11	19	-4.086	1.0000	0.0000	-1.377	-0.931	-0.484
11	20	-3.908	1.0000	0.0000	-1.287	-0.857	-0.427
11	21	-1.842	0.9672	0.0328	-0.984	-0.476	0.031
11	22	0.368	0.3563	0.6437	-0.509	0.118	0.744
11	27	0.519	0.3019	0.6981	-0.421	0.152	0.724
11	29	-0.519	0.6981	0.3019	-0.700	-0.146	0.407
11	39	2.278	0.0114	0.9886	0.084	0.599	1.115
12	13	5.593	0.0000	1.0000	1.347	2.073	2.800
12	19	2.097	0.0180	0.9820	0.041	0.636	1.230
12	20	2.389	0.0085	0.9915	0.127	0.709	1.291
12	21	3.335	0.0004	0.9996	0.449	1.090	1.731
12	22	4.467	0.0000	1.0000	0.945	1.684	2.423
12	27	4.854	0.0000	1.0000	1.024	1.718	2.412
12	29	4.106	0.0000	1.0000	0.742	1.420	2.098
12	39	6.556	0.0000	1.0000	1.518	2.166	2.813
13	19	-4.704	1.0000	0.0000	-2.037	-1.438	-0.839
13	20	-4.556	1.0000	0.0000	-1.951	-1.364	-0.777
13	21	-2.987	0.9986	0.0014	-1.629	-0.983	-0.338
13	22	-1.027	0.8477	0.1523	-1.132	-0.389	0.354
13	27	-0.998	0.8408	0.1592	-1.054	-0.355	0.343
13	29	-1.877	0.9697	0.0303	-1.336	-0.654	0.029
13	39	0.277	0.3908	0.6092	-0.560	0.092	0.745

19	20	0.350	0.3632	0.6368	-0.338	0.073	0.485
19	21	1.812	0.0350	0.9650	-0.037	0.454	0.946
19	22	3.347	0.0004	0.9996	0.434	1.049	1.663
19	27	3.796	0.0001	0.9999	0.523	1.082	1.641
19	29	2.852	0.0022	0.9978	0.245	0.784	1.324
19	39	5.994	0.0000	1.0000	1.030	1.530	2.030
20	21	1.567	0.0587	0.9413	-0.096	0.381	0.858
20	22	3.174	0.0008	0.9992	0.373	0.975	1.577
20	27	3.623	0.0001	0.9999	0.463	1.009	1.555
20	29	2.652	0.0040	0.9960	0.185	0.711	1.236
20	39	5.879	0.0000	1.0000	0.971	1.457	1.942
21	22	1.767	0.0387	0.9613	-0.065	0.594	1.254
21	27	2.024	0.0215	0.9785	0.020	0.628	1.236
21	29	1.096	0.1365	0.8635	-0.260	0.330	0.920
21	39	3.800	0.0001	0.9999	0.521	1.076	1.631
22	27	0.093	0.4628	0.5372	-0.677	0.034	0.745
22	29	-0.745	0.7718	0.2282	-0.960	-0.264	0.431
22	39	1.417	0.0782	0.9218	-0.185	0.481	1.148
27	29	-0.903	0.8167	0.1833	-0.946	-0.298	0.349
27	39	1.426	0.0770	0.9230	-0.168	0.448	1.063
29	39	2.447	0.0072	0.9928	0.148	0.746	1.343

VARIED THRUSH WITH VEGETATION TYPES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
12	0.250	1.000
5	0.216	0.863
7	0.199	0.798
10	0.175	0.702
22	0.168	0.672
11	0.165	0.662
9	0.165	0.660
6	0.153	0.611
26	0.116	0.464
29	0.108	0.430
19	0.106	0.425
39	0.105	0.422
20	0.103	0.413
8	0.093	0.371
27	0.073	0.291
13	0.050	0.201
2	0.028	0.111
21	0.022	0.087
14	0.021	0.083

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.01562 (VAR Z)
WITH 5946. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.02964
WITH 90. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 1.8970 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0000009 OF EXCEEDING BY CHANCE

VARIED THRUSH WITH VEGETATION TYPES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE A	TYPE B	T VALUE	ALTERNATE_HYPOTHYSIS A_GT_B	A_LT_B	CONFIDENCE_LIMITS_FOR LOWER	A_MINUS_B	UPPER
2	5	-2.256	0.9879	0.0121	-0.351	-0.188	-0.025
2	6	-1.548	0.9392	0.0608	-0.283	-0.125	0.033
2	7	-1.889	0.9706	0.0294	-0.349	-0.172	0.006
2	8	-0.796	0.7871	0.2129	-0.225	-0.065	0.095
2	9	-1.696	0.9551	0.0449	-0.296	-0.137	0.021
2	10	-1.705	0.9559	0.0441	-0.317	-0.148	0.022
2	11	-1.628	0.9482	0.0518	-0.303	-0.138	0.028
2	12	-2.435	0.9925	0.0075	-0.401	-0.222	-0.043
2	13	-0.249	0.5983	0.4017	-0.198	-0.022	0.153
2	14	0.085	0.4663	0.5337	-0.157	0.007	0.172
2	19	-0.950	0.8288	0.1712	-0.240	-0.078	0.083
2	20	-0.927	0.8231	0.1769	-0.235	-0.075	0.084
2	21	0.071	0.4716	0.5284	-0.157	0.006	0.169
2	22	-1.526	0.9365	0.0635	-0.320	-0.140	0.040
2	26	-0.883	0.8113	0.1887	-0.284	-0.088	0.108
2	27	-0.504	0.6929	0.3071	-0.220	-0.045	0.130
2	29	-0.916	0.8200	0.1800	-0.250	-0.080	0.091
2	39	-0.909	0.8183	0.1817	-0.245	-0.078	0.090
5	6	2.155	0.0156	0.9844	0.006	0.063	0.120
5	7	0.320	0.3745	0.6255	-0.083	0.016	0.116
5	8	3.874	0.0001	0.9999	0.061	0.123	0.185
5	9	1.711	0.0436	0.9564	-0.007	0.051	0.109
5	10	0.940	0.1737	0.8263	-0.044	0.040	0.124
5	11	1.299	0.0970	0.9030	-0.026	0.050	0.126
5	12	-0.666	0.7473	0.2527	-0.135	-0.034	0.067
5	13	3.391	0.0003	0.9997	0.070	0.165	0.261
5	14	5.256	0.0000	1.0000	0.122	0.195	0.268
5	19	3.217	0.0007	0.9993	0.043	0.109	0.176
5	20	3.655	0.0001	0.9999	0.052	0.112	0.173
5	21	5.449	0.0000	1.0000	0.124	0.194	0.263
5	22	0.900	0.1841	0.8159	-0.056	0.048	0.151
5	26	1.512	0.0653	0.9347	-0.030	0.100	0.229
5	27	2.991	0.0014	0.9986	0.049	0.143	0.236
5	29	2.462	0.0069	0.9931	0.022	0.108	0.194
5	39	2.728	0.0032	0.9968	0.031	0.110	0.189
6	7	-1.002	0.8419	0.1581	-0.138	-0.047	0.045
6	8	2.473	0.0067	0.9933	0.012	0.060	0.107
6	9	-0.572	0.7162	0.2838	-0.054	-0.012	0.030
6	10	-0.603	0.7267	0.2733	-0.096	-0.023	0.051
6	11	-0.390	0.6516	0.3484	-0.077	-0.013	0.051
6	12	-2.053	0.9799	0.0201	-0.190	-0.097	-0.004
6	13	2.316	0.0103	0.9897	0.016	0.103	0.189
6	14	4.267	0.0000	1.0000	0.071	0.132	0.193
6	19	1.712	0.0435	0.9565	-0.007	0.047	0.100
6	20	2.155	0.0156	0.9844	0.004	0.050	0.095

6	21	4.498	0.0000	1.0000	0.074	0.131	0.188
6	22	-0.315	0.6237	0.3763	-0.111	-0.015	0.080
6	26	0.586	0.2790	0.7210	-0.086	0.037	0.159
6	27	1.853	0.0320	0.9680	-0.005	0.080	0.165
6	29	1.163	0.1224	0.8776	-0.031	0.045	0.121
6	39	1.358	0.0873	0.9127	-0.021	0.047	0.116
7	8	2.213	0.0135	0.9865	0.012	0.107	0.201
7	9	0.735	0.2312	0.7688	-0.057	0.034	0.126
7	10	0.427	0.3346	0.6654	-0.086	0.024	0.134
7	11	0.640	0.2611	0.7389	-0.070	0.034	0.138
7	12	-0.803	0.7890	0.2110	-0.174	-0.051	0.073
7	13	2.456	0.0070	0.9930	0.030	0.149	0.268
7	14	3.446	0.0003	0.9997	0.077	0.179	0.280
7	19	1.875	0.0304	0.9696	-0.004	0.093	0.190
7	20	2.024	0.0215	0.9785	0.003	0.096	0.189
7	21	3.497	0.0002	0.9998	0.078	0.177	0.277
7	22	0.488	0.3127	0.6873	-0.094	0.031	0.157
7	26	1.108	0.1339	0.8661	-0.064	0.083	0.231
7	27	2.112	0.0174	0.9826	0.009	0.127	0.244
7	29	1.613	0.0534	0.9466	-0.020	0.092	0.203
7	39	1.731	0.0417	0.9583	-0.012	0.094	0.200
8	9	-2.918	0.9982	0.0018	-0.121	-0.072	-0.024
8	10	-2.086	0.9815	0.0185	-0.160	-0.083	-0.005
8	11	-2.077	0.9811	0.0189	-0.141	-0.073	-0.004
8	12	-3.210	0.9993	0.0007	-0.253	-0.157	-0.061
8	13	0.928	0.1767	0.8233	-0.047	0.043	0.133
8	14	2.164	0.0152	0.9848	0.007	0.072	0.137
8	19	-0.448	0.6731	0.3269	-0.072	-0.013	0.045
8	20	-0.397	0.6543	0.3457	-0.062	-0.010	0.041
8	21	2.244	0.0124	0.9876	0.009	0.071	0.133
8	22	-1.498	0.9329	0.0671	-0.174	-0.075	0.023
8	26	-0.364	0.6421	0.3579	-0.148	-0.023	0.102
8	27	0.447	0.3274	0.6726	-0.068	0.020	0.108
8	29	-0.361	0.6411	0.3589	-0.095	-0.015	0.065
8	39	-0.341	0.6335	0.3665	-0.085	-0.013	0.060
9	10	-0.275	0.6084	0.3916	-0.085	-0.010	0.064
9	11	-0.016	0.5060	0.4940	-0.065	-0.001	0.064
9	12	-1.785	0.9628	0.0372	-0.178	-0.085	0.008
9	13	2.576	0.0050	0.9950	0.027	0.115	0.202
9	14	4.604	0.0000	1.0000	0.083	0.144	0.206
9	19	2.127	0.0167	0.9833	0.005	0.059	0.113
9	20	2.628	0.0043	0.9957	0.016	0.062	0.108
9	21	4.849	0.0000	1.0000	0.085	0.143	0.201
9	22	-0.064	0.5254	0.4746	-0.099	-0.003	0.093
9	26	0.779	0.2180	0.7820	-0.074	0.049	0.172
9	27	2.122	0.0169	0.9831	0.007	0.092	0.177
9	29	1.467	0.0713	0.9287	-0.019	0.057	0.134
9	39	1.692	0.0454	0.9546	-0.009	0.060	0.128
10	11	0.219	0.4133	0.5867	-0.079	0.010	0.099
10	12	-1.313	0.9054	0.0946	-0.186	-0.075	0.037
10	13	2.309	0.0105	0.9895	0.019	0.125	0.232
10	14	3.515	0.0002	0.9998	0.068	0.155	0.241
10	19	1.669	0.0476	0.9524	-0.012	0.069	0.150
10	20	1.860	0.0315	0.9685	-0.004	0.072	0.148

10	21	3.593	0.0002	0.9998	0.070	0.153	0.237
10	22	0.126	0.4497	0.5503	-0.106	0.007	0.121
10	26	0.848	0.1983	0.8017	-0.078	0.059	0.196
10	27	1.925	0.0271	0.9729	-0.002	0.103	0.207
10	29	1.360	0.0869	0.9131	-0.030	0.068	0.166
10	39	1.494	0.0676	0.9324	-0.022	0.070	0.162
11	12	-1.574	0.9422	0.0578	-0.190	-0.084	0.021
11	13	2.262	0.0119	0.9881	0.015	0.115	0.215
11	14	3.626	0.0001	0.9999	0.066	0.145	0.223
11	19	1.598	0.0550	0.9450	-0.013	0.059	0.132
11	20	1.825	0.0340	0.9660	-0.005	0.062	0.129
11	21	3.729	0.0001	0.9999	0.068	0.144	0.219
11	22	-0.047	0.5189	0.4811	-0.110	-0.003	0.105
11	26	0.732	0.2320	0.7680	-0.083	0.049	0.182
11	27	1.854	0.0319	0.9681	-0.005	0.093	0.191
11	29	1.251	0.1055	0.8945	-0.033	0.058	0.149
11	39	1.396	0.0814	0.9186	-0.024	0.060	0.144
12	13	3.253	0.0006	0.9994	0.079	0.200	0.320
12	14	4.358	0.0000	1.0000	0.126	0.229	0.332
12	19	2.848	0.0022	0.9978	0.045	0.144	0.243
12	20	3.036	0.0012	0.9988	0.052	0.147	0.242
12	21	4.426	0.0000	1.0000	0.127	0.228	0.329
12	22	1.266	0.1027	0.8973	-0.045	0.082	0.209
12	26	1.769	0.0384	0.9616	-0.014	0.134	0.282
12	27	2.924	0.0017	0.9983	0.058	0.177	0.296
12	29	2.472	0.0067	0.9933	0.029	0.142	0.255
12	39	2.628	0.0043	0.9957	0.037	0.144	0.252
13	14	0.590	0.2776	0.7224	-0.068	0.029	0.127
13	19	-1.178	0.8805	0.1195	-0.149	-0.056	0.037
13	20	-1.170	0.8789	0.1211	-0.142	-0.053	0.036
13	21	0.580	0.2811	0.7189	-0.067	0.028	0.124
13	22	-1.889	0.9705	0.0295	-0.240	-0.118	0.004
13	26	-0.893	0.8141	0.1859	-0.211	-0.066	0.079
13	27	-0.388	0.6510	0.3490	-0.137	-0.023	0.092
13	29	-1.042	0.8513	0.1487	-0.165	-0.057	0.051
13	39	-1.056	0.8545	0.1455	-0.158	-0.055	0.047
14	19	-2.407	0.9919	0.0081	-0.155	-0.085	-0.016
14	20	-2.543	0.9945	0.0055	-0.146	-0.082	-0.019
14	21	-0.032	0.5126	0.4874	-0.074	-0.001	0.071
14	22	-2.740	0.9969	0.0031	-0.253	-0.147	-0.042
14	26	-1.431	0.9237	0.0763	-0.226	-0.095	0.035
14	27	-1.065	0.8565	0.1435	-0.148	-0.052	0.044
14	29	-1.927	0.9730	0.0270	-0.175	-0.087	0.002
14	39	-2.033	0.9789	0.0211	-0.166	-0.085	-0.003
19	20	0.105	0.4582	0.5418	-0.054	0.003	0.060
19	21	2.486	0.0065	0.9935	0.018	0.084	0.151
19	22	-1.196	0.8842	0.1158	-0.163	-0.062	0.040
19	26	-0.152	0.5602	0.4398	-0.137	-0.010	0.118
19	27	0.719	0.2362	0.7638	-0.058	0.033	0.125
19	29	-0.032	0.5126	0.4874	-0.085	-0.001	0.082
19	39	0.020	0.4922	0.5078	-0.076	0.001	0.077
20	21	2.651	0.0040	0.9960	0.021	0.081	0.141
20	22	-1.307	0.9044	0.0956	-0.162	-0.065	0.032
20	26	-0.203	0.5805	0.4195	-0.137	-0.013	0.111

20	27	0.688	0.2458	0.7542	-0.056	0.030	0.117
20	29	-0.109	0.5435	0.4565	-0.083	-0.004	0.074
20	39	-0.062	0.5248	0.4752	-0.073	-0.002	0.069
21	22	-2.772	0.9972	0.0028	-0.250	-0.146	-0.043
21	26	-1.431	0.9238	0.0762	-0.223	-0.094	0.035
21	27	-1.066	0.8568	0.1432	-0.144	-0.051	0.043
21	29	-1.955	0.9747	0.0253	-0.172	-0.086	0.000
21	39	-2.072	0.9808	0.0192	-0.163	-0.084	-0.005
22	26	0.680	0.2483	0.7517	-0.098	0.052	0.202
22	27	1.546	0.0610	0.9390	-0.026	0.095	0.216
22	29	1.031	0.1512	0.8488	-0.055	0.061	0.176
22	39	1.116	0.1322	0.8678	-0.047	0.063	0.173
26	27	0.592	0.2768	0.7232	-0.100	0.043	0.187
26	29	0.120	0.4521	0.5479	-0.130	0.009	0.147
26	39	0.155	0.4384	0.5616	-0.124	0.011	0.145
27	29	-0.642	0.7396	0.2604	-0.141	-0.035	0.071
27	39	-0.636	0.7375	0.2625	-0.133	-0.033	0.068
29	39	0.044	0.4823	0.5177	-0.092	0.002	0.096

SWAINSON'S THRUSH WITH VEGETATION TYPES

CLASSIFICATION TYPES ORDERED BY WEIGHTED AVERAGE DENSITY

CLASSIFICATION TYPE	AVERAGE DENSITY	RELATIVE HABITAT_VALUE
12	1.046	1.000
11	0.902	0.862
7	0.710	0.679
10	0.645	0.617
9	0.632	0.604
20	0.593	0.567
5	0.579	0.553
8	0.560	0.535
21	0.556	0.532
6	0.527	0.503
22	0.370	0.353
19	0.333	0.318
29	0.219	0.209
27	0.200	0.191
39	0.157	0.150
13	0.063	0.060
14	0.006	0.006

VARIANCE WITHIN CELLS(SERIES,TYPES) 0.04190 (VAR Z)
WITH 1753. DEGREES OF FREEDOM
USED IN ALL T TESTS AND DENOMINATOR OF F RATIO

VARIANCE AMONG TYPES WITHIN SERIES 0.18477
WITH 32. DEGREES OF FREEDOM
USED IN NUMERATOR OF F RATIO

F RATIO 4.4096 FOR VARIATION BETWEEN TYPES
INCLUDING INTERACTION BETWEEN TYPE AND TIME
PROBABILITY 0.0 OF EXCEEDING BY CHANCE

SWAINSON'S THRUSH WITH VEGETATION TYPES

RESULTS OF T TESTS FOR ALL COMPARISONS BETWEEN TYPES
WITH CONFIDENCE FOR REJECTING NULL HYPOTHYSIS A_EQ_B
AND 95% CONFIDENCE INTERVAL FOR ALL DIFFERENCES

TYPE A	TYPE B	T VALUE	ALTERNATE_HYPOTHYSIS A_GT_B	A_LT_B	CONFIDENCE_LIMITS_FOR LOWER	A_MINUS_B	UPPER
5	6	0.482	0.3149	0.6851	-0.160	0.052	0.264
5	7	-0.650	0.7422	0.2578	-0.527	-0.131	0.265
5	8	0.152	0.4394	0.5606	-0.226	0.019	0.264
5	9	-0.494	0.6892	0.3108	-0.264	-0.053	0.158
5	10	-0.418	0.6621	0.3379	-0.379	-0.067	0.246
5	11	-2.086	0.9815	0.0185	-0.626	-0.323	-0.019
5	12	-2.329	0.9900	0.0100	-0.861	-0.468	-0.074
5	13	3.104	0.0010	0.9990	0.190	0.516	0.841
5	14	4.534	0.0000	1.0000	0.325	0.572	0.820
5	19	2.017	0.0219	0.9781	0.007	0.246	0.485
5	20	-0.124	0.5491	0.4509	-0.247	-0.015	0.217
5	21	0.168	0.4332	0.5668	-0.241	0.023	0.286
5	22	1.084	0.1392	0.8608	-0.169	0.209	0.587
5	27	2.250	0.0123	0.9877	0.049	0.378	0.708
5	29	2.293	0.0110	0.9890	0.052	0.360	0.668
5	39	2.852	0.0022	0.9978	0.132	0.422	0.712
6	7	-0.969	0.8338	0.1662	-0.554	-0.183	0.188
6	8	-0.321	0.6258	0.3742	-0.235	-0.033	0.169
6	9	-1.292	0.9018	0.0982	-0.265	-0.105	0.055
6	10	-0.831	0.7969	0.2031	-0.399	-0.119	0.161
6	11	-2.721	0.9967	0.0033	-0.645	-0.375	-0.105
6	12	-2.764	0.9971	0.0029	-0.888	-0.520	-0.151
6	13	3.081	0.0010	0.9990	0.168	0.464	0.759
6	14	4.963	0.0000	1.0000	0.315	0.520	0.726
6	19	1.946	0.0259	0.9741	-0.002	0.194	0.390
6	20	-0.701	0.7584	0.2416	-0.253	-0.067	0.120
6	21	-0.258	0.6016	0.3984	-0.254	-0.029	0.195
6	22	0.874	0.1910	0.8090	-0.195	0.157	0.509
6	27	2.136	0.0164	0.9836	0.027	0.326	0.626
6	29	2.194	0.0142	0.9858	0.033	0.308	0.583
6	39	2.841	0.0023	0.9977	0.115	0.370	0.625
7	8	0.754	0.2254	0.7746	-0.240	0.150	0.541
7	9	0.413	0.3397	0.6603	-0.292	0.078	0.448
7	10	0.291	0.3857	0.6143	-0.371	0.065	0.501
7	11	-0.874	0.8090	0.1910	-0.621	-0.192	0.238
7	12	-1.326	0.9075	0.0925	-0.834	-0.336	0.161
7	13	2.846	0.0022	0.9978	0.201	0.647	1.093
7	14	3.517	0.0002	0.9998	0.311	0.703	1.096
7	19	1.911	0.0281	0.9719	-0.010	0.377	0.764
7	20	0.597	0.2752	0.7248	-0.266	0.117	0.499
7	21	0.749	0.2269	0.7731	-0.249	0.154	0.556
7	22	1.375	0.0847	0.9153	-0.145	0.340	0.825
7	27	2.227	0.0130	0.9870	0.061	0.510	0.959
7	29	2.225	0.0131	0.9869	0.058	0.491	0.924
7	39	2.580	0.0050	0.9950	0.133	0.553	0.974

8	9	-0.703	0.7590	0.2410	-0.273	-0.072	0.129
8	10	-0.549	0.7085	0.2915	-0.391	-0.086	0.220
8	11	-2.260	0.9880	0.0120	-0.638	-0.342	-0.045
8	12	-2.457	0.9929	0.0071	-0.875	-0.487	-0.098
8	13	3.048	0.0012	0.9988	0.177	0.497	0.816
8	14	4.535	0.0000	1.0000	0.314	0.553	0.792
8	19	1.930	0.0269	0.9731	-0.004	0.227	0.458
8	20	-0.296	0.6163	0.3837	-0.257	-0.034	0.190
8	21	0.028	0.4890	0.5110	-0.252	0.004	0.259
8	22	1.000	0.1587	0.8413	-0.183	0.190	0.562
8	27	2.177	0.0148	0.9852	0.036	0.359	0.683
8	29	2.220	0.0133	0.9867	0.040	0.341	0.642
8	39	2.791	0.0027	0.9973	0.120	0.403	0.686
9	10	-0.094	0.5376	0.4624	-0.293	-0.013	0.266
9	11	-1.962	0.9750	0.0250	-0.539	-0.270	-0.000
9	12	-2.207	0.9863	0.0137	-0.783	-0.414	-0.046
9	13	3.788	0.0001	0.9999	0.274	0.569	0.863
9	14	5.993	0.0000	1.0000	0.421	0.625	0.830
9	19	3.015	0.0013	0.9987	0.105	0.299	0.494
9	20	0.407	0.3420	0.6580	-0.147	0.039	0.224
9	21	0.664	0.2534	0.7466	-0.148	0.076	0.300
9	22	1.463	0.0718	0.9282	-0.089	0.262	0.613
9	27	2.830	0.0024	0.9976	0.132	0.432	0.731
9	29	2.951	0.0016	0.9984	0.139	0.413	0.688
9	39	3.659	0.0001	0.9999	0.221	0.475	0.730
10	11	-1.418	0.9218	0.0782	-0.611	-0.256	0.098
10	12	-1.811	0.9649	0.0351	-0.835	-0.401	0.033
10	13	3.055	0.0011	0.9989	0.208	0.582	0.956
10	14	4.068	0.0000	1.0000	0.331	0.639	0.947
10	19	2.035	0.0210	0.9790	0.011	0.313	0.614
10	20	0.345	0.3652	0.6348	-0.244	0.052	0.348
10	21	0.545	0.2929	0.7071	-0.232	0.089	0.410
10	22	1.287	0.0992	0.9008	-0.144	0.276	0.695
10	27	2.313	0.0104	0.9896	0.068	0.445	0.822
10	29	2.335	0.0098	0.9902	0.068	0.427	0.785
10	39	2.792	0.0026	0.9974	0.145	0.489	0.832
11	12	-0.664	0.7465	0.2535	-0.573	-0.145	0.283
11	13	4.488	0.0000	1.0000	0.472	0.838	1.205
11	14	5.871	0.0000	1.0000	0.596	0.895	1.194
11	19	3.819	0.0001	0.9999	0.277	0.569	0.861
11	20	2.111	0.0174	0.9826	0.022	0.308	0.594
11	21	2.169	0.0151	0.9849	0.033	0.345	0.658
11	22	2.523	0.0059	0.9941	0.118	0.532	0.945
11	27	3.716	0.0001	0.9999	0.331	0.701	1.071
11	29	3.820	0.0001	0.9999	0.332	0.683	1.033
11	39	4.358	0.0000	1.0000	0.410	0.745	1.080
12	13	4.343	0.0000	1.0000	0.539	0.983	1.427
12	14	5.226	0.0000	1.0000	0.650	1.040	1.430
12	19	3.635	0.0001	0.9999	0.329	0.714	1.099
12	20	2.334	0.0099	0.9901	0.072	0.453	0.834
12	21	2.400	0.0083	0.9917	0.090	0.490	0.891
12	22	2.744	0.0031	0.9969	0.193	0.677	1.160
12	27	3.711	0.0001	0.9999	0.399	0.846	1.293
12	29	3.765	0.0001	0.9999	0.396	0.828	1.259

12	39	4.167	0.0000	1.0000	0.471	0.890	1.308
13	14	0.345	0.3650	0.6350	-0.265	0.057	0.378
13	19	-1.676	0.9531	0.0469	-0.585	-0.270	0.046
13	20	-3.356	0.9996	0.0004	-0.840	-0.530	-0.220
13	21	-2.894	0.9981	0.0019	-0.827	-0.493	-0.159
13	22	-1.399	0.9190	0.0810	-0.737	-0.307	0.123
13	27	-0.692	0.7556	0.2444	-0.526	-0.137	0.251
13	29	-0.825	0.7954	0.2046	-0.526	-0.156	0.214
13	39	-0.516	0.6970	0.3030	-0.449	-0.094	0.262
14	19	-2.737	0.9969	0.0031	-0.560	-0.326	-0.092
14	20	-5.088	1.0000	0.0000	-0.813	-0.587	-0.361
14	21	-4.171	1.0000	0.0000	-0.808	-0.550	-0.291
14	22	-1.904	0.9714	0.0286	-0.738	-0.363	0.011
14	27	-1.166	0.8782	0.1218	-0.520	-0.194	0.132
14	29	-1.372	0.9149	0.0851	-0.516	-0.212	0.091
14	39	-1.031	0.8486	0.1514	-0.436	-0.150	0.136
19	20	-2.355	0.9907	0.0093	-0.478	-0.261	-0.044
19	21	-1.749	0.9598	0.0402	-0.474	-0.224	0.027
19	22	-0.198	0.5783	0.4217	-0.406	-0.037	0.332
19	27	0.812	0.2085	0.7915	-0.187	0.132	0.452
19	29	0.752	0.2261	0.7739	-0.183	0.114	0.411
19	39	1.239	0.1078	0.8922	-0.103	0.176	0.455
20	21	0.300	0.3822	0.6178	-0.206	0.037	0.281
20	22	1.204	0.1144	0.8856	-0.141	0.224	0.588
20	27	2.453	0.0071	0.9929	0.079	0.393	0.707
20	29	2.525	0.0058	0.9942	0.084	0.375	0.666
20	39	3.145	0.0008	0.9992	0.164	0.437	0.709
21	22	0.949	0.1714	0.8286	-0.199	0.186	0.571
21	27	2.064	0.0196	0.9804	0.018	0.356	0.694
21	29	2.089	0.0184	0.9816	0.021	0.337	0.654
21	39	2.615	0.0045	0.9955	0.100	0.399	0.699
22	27	0.767	0.2215	0.7785	-0.264	0.170	0.603
22	29	0.711	0.2387	0.7613	-0.266	0.151	0.568
22	39	1.035	0.1504	0.8496	-0.191	0.213	0.617
27	29	-0.097	0.5387	0.4613	-0.392	-0.019	0.355
27	39	0.238	0.4059	0.5941	-0.316	0.044	0.403
29	39	0.360	0.3596	0.6404	-0.277	0.062	0.401