PURPOSE

We will learn field procedures for surveying bird populations with the variable circular plot technique. We will concurrently gather data on habitat variable in plots centered at each survey point. The field data will generate population density estimates for bird species and will also be used to characterize the habitat in which the survey was conducted. Based on the data, we will seek relationships between bird community parameters (community density and species richness) and habitat variables. We will further seek to determine how individual species influence these community patterns. In addition, we will determine how the relative densities of species relate to species diversity.

DESCRIPTION

The procedure we will use involves estimating the horizontal distance from a survey point to birds encountered during a prescribed sampling period.   Because birds are recorded in any direction from the point and the distances recorded are variable in magnitude, the procedure is named the **variable circular plot**. The period for counting birds is long enough to maximize the probability that individuals present will be detected but short enough to minimize movement of individuals in and out of the plot. Based on the distance data gathered, a detectability curve is constructed that illustrates the probability of a species' detection at increasing distances from the sample point. The detectability curve serves as the basis for estimating population densities.

Habitat evaluation involves measurement of habitat parameters at each survey point.

THEORY

Key to making density estimates is development of a **detectability curve** , such that for the Black-throated Blue
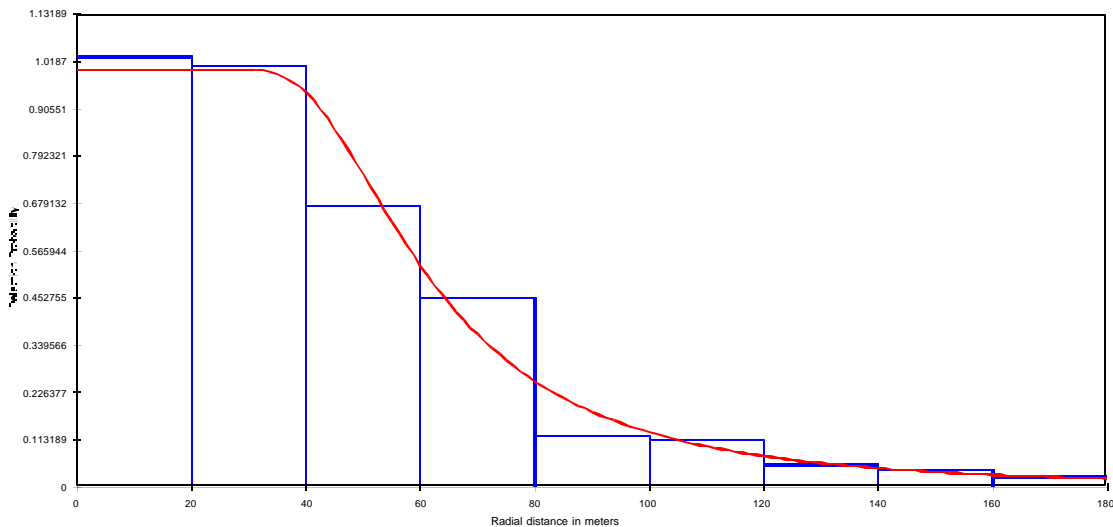
Warbler shown here (generated from real data). The curve is fitted to the observed probability of species detection at increasing distances from the survey point. Ideally, the curve should show 100% detectability near the survey point and declining detectability at greater distances from the point. The **mathematical model** for the curve is called a hazard rate model with a cosine correction. Development of such models is via application of integral calculus techniques. Once the shape of the detectability curve is modeled, it is possible to compute population density.

Computing densities of species using this technique can lead to a synthetic data set that looks very different from the raw data. Species might be encountered frequently but at great distances, leading to computed densities being low, whereas other species encountered less frequently but at close range may have high densities.

Data on absolute densities of species also relates to the concept of species diversity- a community measure that has as its components species richness- the number of species present in an area- and species evenness- how evenly among the species individuals are distributed. It is traditionally thought that evenness is at its lowest in winter, when conditions are variable and food may be in limited supply- conditions that lead to few species prospering and most simply struggling along.

Habitat analyses are accomplished through assignment of a rank to each of five habitat parameters that we will measure. Such data are called **categorical** in that each parameter is evaluated in terms of a limited group of categories. For example, soil moisture may be high, moderate or low. Categorical variables are analyzed in ways separate from those of **continuous** variables (those that take on a continuous range of values). Continuous variables are generally analyzed with **parametric** statistical procedures- those that assume data come from a probability distribution, like the normal distribution (the bell-shaped curve with the mean corresponding to the most frequently observed value). In parametric statistics, inferences are made about the parameters of the distribution, like the mean and variance. In contrast, categorical variables are often (but no longer always) analyzed using **non-parametric** procedures- those with fewer underlying assumptions. They often do not assume that the data come from some underlying distribution. A drawback of non-parametric analyses is that they are frequently less powerful that parametric analyses.

METHODS

Population surveys: fifteen survey points are to be established along a transect line that will pass through about three km of forest habitat. Survey points are placed about 200 m apart to improve **sampling independence** (data from one sample point do not influence data from another). Surveys begin at first light and the following are collected at each point.

TEAM 1: the location and elevation of the point is recorded using a global positioning device. After the first point, the distance to the previous point is also measured using global positioning. During an eight minute sampling period, all bird species encountered are recorded and the horizontal distance to each individual estimated.

Habitat surveys: the variables to be measured are 1) forest type, 2) understory cover, 3) canopy closure, 4) tree diameter and 5) moisture regime. Each is estimated for a 70 m radius plot.

TEAM 2: divide the circular plot into four quarters and choose at random five canopy trees in each of the four quarters. Count the numbers that are deciduous vs. those that are evergreen. Based on these counts, estimate to the nearest 10% which of the following categories applies for the plot as a whole: 1) deciduous (<20% conifer), 2) mixed (20-60%), 3) conifer (>70%).

TEAM 3: divide the circular plot into four quarters and evaluate each quarter for shrub density (not ground cover but shrubs 1-4 m high: 1) mostly without shrub cover, 2) moderate cover, 3) mostly continuous shrub cover. Average the four quarters to determine coverage for the plot as a whole.

TEAM 4: divide the circular plot into four quarters and evaluate each quarter for soil moisture regime: 1) swampy with mud or standing water, 2) mesic, well drained, 3) dry and rocky or gravelly. Average the four quarters to determine coverage for the plot as a whole.

TEAM 5: divide the circular plot into four quarters and choose at random five canopy trees in each of the four quarters. Measure their diameters at breast height (dbh) and evaluate for each quarter tree diameter: 1) diameters averaging <15 cm, 2) diameters averaging >15 - <45 cm., diameters averaging >45 cm. Average the four quarters to determine diameter for the plot as a whole.

TEAM 6: divide the circular plot into four quarters and evaluate each quarter for canopy cover to the nearest 10%: 1) <40%, 2) 40-60%, 3) 70% or more. Average the four quarters to determine coverage for the plot as a whole.

ANALYSIS

1. Tables

   a. *Table 1. Habitat conditions*: Make a summary table of the five habitat variables (dbh, canopy cover, shrub cover, forest type soil, moisture) at each of the 15 sample points.

   b. *Table 2. Bird censuses:* Make a table of bird census data showing all individuals of all species encountered at each of the 15 sample points.

   c. *Table 3. Bird frequencies*: For the data in Table 2, count the number of individuals/ species at each of the survey points.

2. Graphs

   a. *Habitat variables:* Determine which of the survey plots fall best into each of the three categories for each habitat variable, with 1 = wet or low (e.g. low cover), 2 = moist or moderate cover, and 3 = dry or high cover. Similarly divide elevation data for each plot into low, moderate and high. These values will form the x axis in graphs of bird data vs. habitat. By plotting bird (the y axis) vs. habitat data, any trends that appear to relate birds to habitats will be illustrated. Such an analysis is always a first step in seeking relationships between variables and is referred to as **exploratory data analysis**.

   b. *Population density vs. habitat variables:* For the three most common species (e.g. Black-capped Chickadee and Tufted Titmouse), find the average number of individuals of each species present at each category of a habitat variable (total individuals / number of sample points within the category). Do this for each habitat variable. You will, therefore, produce a set of six graphs (one for each habitat variable) like this one:
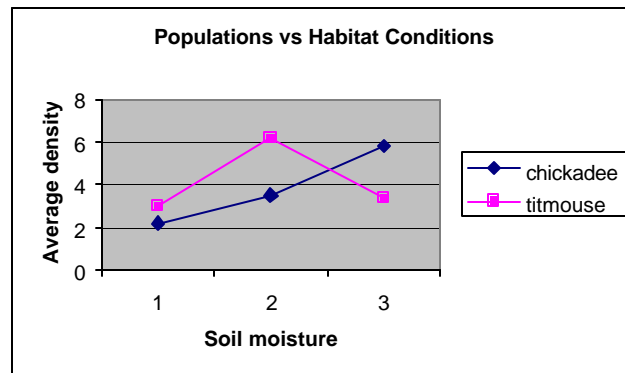
   c. *Species richness vs. habitat variables:* Find the average number of species present at each category of a habitat variable (total species / number of sample points within the category). Do this for each habitat variable. You will, therefore, produce a set of graphs (one for each habitat variable) like this one:

Species Richness
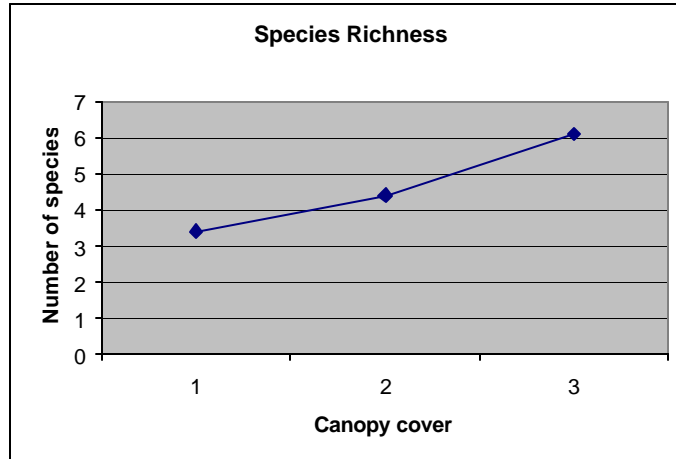
d. Total population density vs. habitat variables: Find the average number of individuals of all species present at each category of a habitat variable (total individuals / number of sample points within the category). Do this for each habitat variable. You will, therefore, produce a set of graphs (one for each habitat variable) like this one:

Total Populations
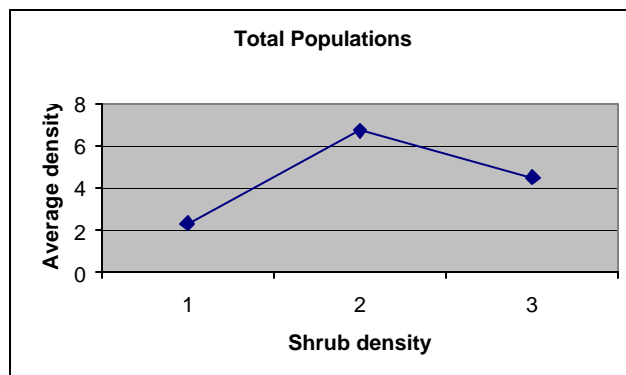
3. Use vs. availability analysis

Although examining the original data is always the first step in any analysis, it is not the last step. In an investigation like this one, it is also of great value to examine percentages. For example, out of the 15 survey points, what percent are in categories 1, 2 and 3 for each of the habitat variables? Furthermore, what percent of the total number of birds encountered were present at these three habitat categories? By comparing the availability of habitats to their use by birds, we gain a sense of whether habitats are used in proportion to their availability or whether there is evidence that particular habitats are favored or avoided. Following is an example for forest cover and community density (what percent of all individuals encountered were present at each of the habitat categories):

Forest Cover vs. Community Density
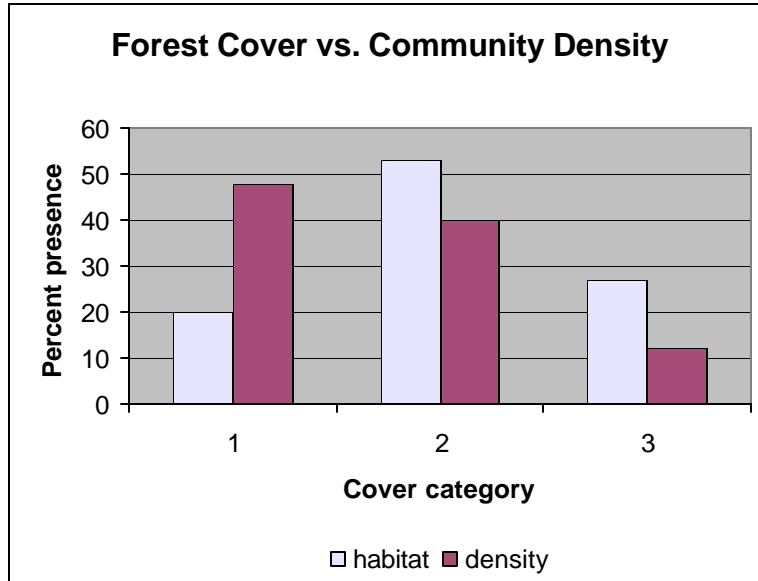
In this example, the percent of individuals present in open forest (1) is greater than the percent availability of the habitat (nearly half the birds present were in 20% of the habitat), suggesting that a greater proportion of individuals prefer this environment. Birds were present at a frequency less than availability for semi-open (2) and closed (3) forest- particularly closed forest.

Such analyses should be performed for the (1) top three most common species, (2) community density and (3) species richness. In the latter instance, first determine the species pool- the total number of species encountered- and then calculate the percent of species present at each habitat category.

4. Absolute density computation

We will use the freely available program DISTANCE to compute absolute population densities for each species present on our survey transect. DISTANCE requires large numbers of observations in order to generate meaningful detectability curves, so we will supplement our data with previously recorded data from an EXCEL file. The format of the data is as follows:

Region	Year	Season	Transect	Point	Effort	Species	Distance	Flock
MA	2003	WINTER	TR53	P794	1	BCCH	70	1
MA	2003	WINTER	TR53	P794	1	WBNU	90	1
MA	2003	WINTER	TR53	P795	1	BCCH	85	2
MA	2003	WINTER	TR53	P795	1	RBNU	70	1
MA	2003	WINTER	TR53	P796	1	BCCH	25	2
MA	2003	WINTER	TR53	P796	1	GCKI	30	2
MA	2003	WINTER	TR53	P796	1	WBNU	150	1
MA	2003	WINTER	TR53	P796	1	CAWR	190	1
MA	2003	WINTER	TR53	P796	1	CEWA	50	1

Append your data to this file as follows: **Region**: MA, **Year**: 2012, **Season**: WINTER, **Transect**: TR500, **Point**: (number these sequentially after the final point number in the file; e.g. if the last number is P1857, your survey point 1 becomes P1858, point 2 is P1859, etc, **Effort**: 1, **Species**: use US Fish and Wildlife Service four letter codes for the species encountered; e.g Black-capped Chickadee is BCCH, **Distance**: type the horizontal distance recorded for each individual encountered, **Flock**: for flocking species, e.g. chickadee, titmouse (TUTI), nuthatch (WBNU), goldfinch (AMGO), crow (COCR), robin (AMRO), enter the number of individuals found at a survey point. For

these species, average all their detection distances and make only one species entry/ survey point. Once the data has been appended, save the EXCEL file as a TEXT AND TAB delimited file with the name VCPLOT.

Open program DISTANCE and click on **new project**. This will bring up a new project setup wizard. Click through to Step 2 and choose **point transect** and **clusters of objects**. Click next and choose **meters** and **sq. kilometers** for Distance and Area. Click through to Step 5 and choose **Proceed to Data Import Wizard**. Find your data file (VCPLOT) in the import screen and choose it, which will bring you to the data import wizard. Click through to Step 3 and click on the *Ignore* box above MA and choose **Region**. Click on the box beneath Region and choose **Label**. Now click on the *Ignore* box above the point number (e.g. P1162) and choose **Point Transect**. Click the box beneath and choose **Label**. Next click on *Ignore* above the effort column and again choose **Point Transect**. Click the box beneath and choose **Survey Effort**. Go back to the year column and click on *Ignore*, again choosing **Point Transect**. Click the box beneath and type in the word **Year**. Now click on *Ignore* above the season column, choose **Point Transect** and type in **Season** below. Do the same for the transect column, typing **Transect** in the space below **Point Transect**. Next click on *Ignore* over the distance column, choosing **Observation** followed by **Radial Distance** below. Now click on *Ignore* over the flock column and choose **Observation** followed by **Flock**. Finally, click on *Ignore* over the species column, choose **Observation** and type in **Species** below.

Now click on the **Data Explorer** icon to preview the data, making sure they are properly encoded. Click on the **Analysis Browser** icon and press the **New Analysis** icon. Next click on the **Show Details** icon and choose the INPUT tab on the right side of the screen. Click on the upper *Edit* button and a data filter box will appear. Choose **Observation** for *Layer Name* , **Species** for *Field Name,* choose =, and type in the four-letter code for a species (e.g. **BCCH**) to be analyzed in the right box.

Click OK and click on the lower *Edit* button, which will bring up a model definition box. On the Estimate tab choose *Use Stratum Layer* with a layer name of **Region**. For the levels of resolution of estimates choose **Global** and **Stratum** for *Density*, **Stratum** for *Encounter Rate* and **Global** for *Detection Function* and *Cluster Size*. Leave other settings at their default values. On the *Detection Function* tab select **Uniform** as a key function and **Cosine** as the series expansion. Also select **Uniform/ Simple Polynomial, Half normal/ Cosine, Half normal/ Hermite Polynomial** and **Hazard rate/ Cosine.** Leave other settings and other tabs at their defaults.

To determine population density for a species, first do an exploratory analysis by clicking on *Run*. Now click on the RESULTS tab and scroll through the results to examine the detectability curves generated. Examine the curve showing the most distance intervals (generally Detection Probability Plot 3) and determine at which interval detection probability drops below 0.10. By clicking forward to the Chi Square test screen, you can determine at what distance this occurs. Now go back to the INPUT tab and click on the upper *Edit* button. Click on the *Intervals* tab, click in the *Transform distance data* box, choose **5** as the *Number of intervals* and enter the 0.10 detection distance in *Cutpoint 5*. This is called **truncating** the data, which tends to produce better fitting detectability models. Also click on *Automatic equal intervals* and then click *OK* and *Run*.

Finding the model that best estimates population density is an iterative process. Experiment with changing the number of cutpoints and the truncation distance. Continue until you find a model that exhibits close conformation to the data where detection probability at 0 distance is close to 100%. You can evaluate the fit of the model by examining the chi-square statistic. If the probability of a greater chi-square value is >0.05, the model can be concluded to fit the data reasonably. To find the density estimates generated, go to the end of the results to *Estimation Summary- Density & Abundance*. To further evaluate the success of the model, examine the values on this page for %CV- the coefficient of variation. This statistic gives information about how much variation is present in the estimate.

Repeat this process for each species encountered until you have estimated each of their densities. Sample size for estimating density should be >60 observations.

Once densities have been computed, take the data and arrange it from most to least dense species and then graph it as follows:

Community Evenness
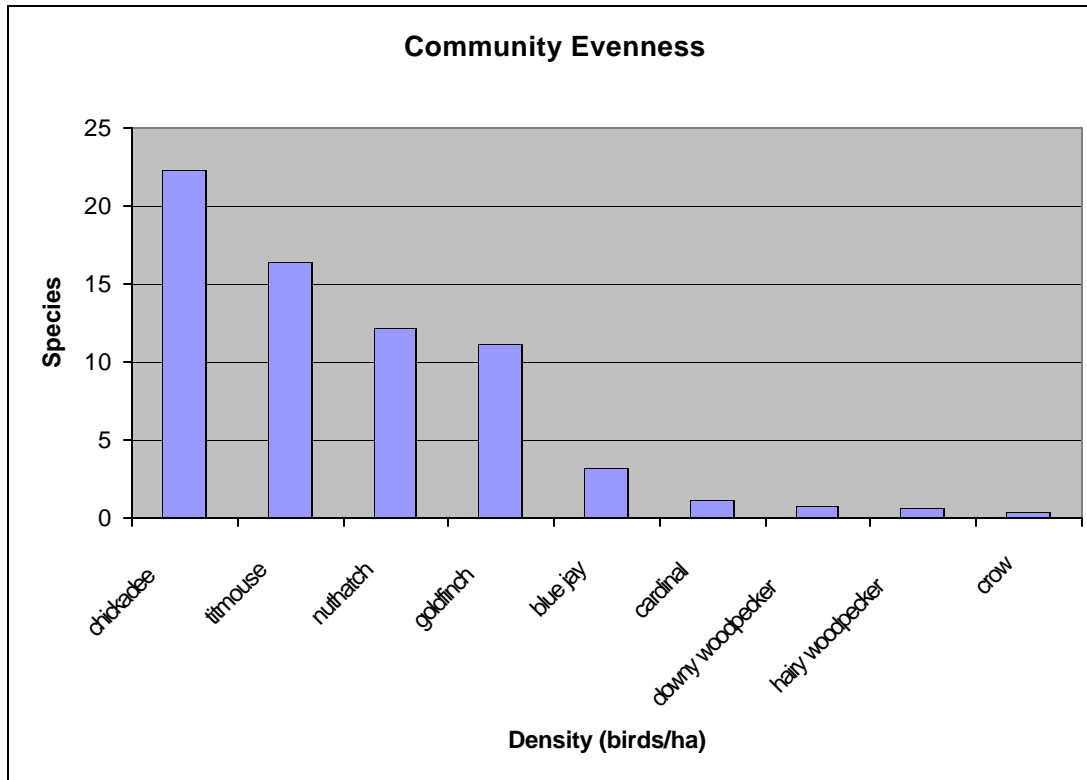
Doing so provides a view of how densities are distributed among the species. From it, conclusions may be drawn about the nature of evenness in this system.

INTERPRETATION

1. Formulate hypotheses to be tested that relate population data to habitat data. Also formulate hypotheses that relate to the computed population densities of the species to community diversity and its components. Keep in mind the value of use vs. availability analyses in evaluating hypotheses as you develop these.

2. In the *Background* section of the *Introduction*, describe not only what the variable circular plot method is, but how it compares with other methods (like line transect surveys) that are used for estimating population densities. What are the advantages and disadvantages of VCP compared to other methods?

3. Make sure to report all your data in tables in the *Results* section of your lab report. In the *Analysis* portion of the *Results*, report what trends are apparent in population vs. habitat and what the comparative population densities of the species are.

4. In the *Conclusions*, evaluate your hypotheses. Support or reject (not prove or disprove) your hypotheses based solely on your data. Describe which of your findings provide support or negative evidence for your hypotheses.

5. Discuss in your *Conclusions* the role of random chance in influencing what you found. If you conducted the same survey on different days, would you expect to obtain the same results? In other words, did <u>experimental</u> error play any role in the findings? What might it be?

6. Discuss the relative strengths and weaknesses of using the variable circular plot method compared to other methods of population estimation.

7. How might the populations densities computed be converted to estimates of total population for a region?

Forest Type Data

Point	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Shrub Density Data

Point	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Moisture Regime Data

Point	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Tree Diameter Data

Point	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Canopy Closure Data

Point	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

Bird Census/GPS Data

Point	Time	Species	Distance	Coordinates
1				
2				
3				
4				
5				
6				
7				

8			
9			
10			
11			
12			
13			
14			
15			