TROPICAL ECOLOGY, ASSESSMENT, AND MONITORING (TEAM) INITIATIVE

PRIMATE MONITORING PROTOCOL

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Introduction

Primates are among the most conspicuous of tropical mammals, and they are also indicators of low-level disturbance. Many species are susceptible to and avoid human activity and they are also indicators of hunting activity in tropical forests (Peres, 1990). Recent research on the bushmeat crisis in West Africa (Eves and Bakarr, 2001) has shown that many species of primates are hunted and several, including the Western chimpanzee (*Pan troglodytes*), the Diana monkey (*Cercopithecus diana*), red colobus (*Colobus badius*), and several species of mangabey (*Cercocebus* spp.), are severely impacted. In the Neotropics primates can be heavily impacted locally, even in relatively pristine regions (Peres, 1990, 1997; Mittermeier, 1991; de Thoisy et al., 2000). Trends in relative abundance over time might serve as an indicator of levels of disturbance that would not be detected using remote sensing tools. Primates are also charismatic species that can be used to influence conservation decisions, and data on long-term trends in richness, abundance, and density are of great value in implementing policy.

There are a variety of techniques developed for the census of large mammals that are adaptable for primates. These include total and sample counts, line transects with distance estimation, strip transects of fixed width, and quadrat sampling (Wilson et al., 1996). Several of these techniques will allow for the estimation of density of individual species when the assumptions of methods are met. Density estimation is of particular importance for the implementation of management activities, but density estimation can be severely biased when assumptions are violated. In addition, absolute density is not necessary for long-term monitoring activities, and often estimates of relative abundance, when treated in a time series, are more appropriate for these purposes.

Another consideration for the selection of a methodology is the number of species to be studied. Assessing the status of a multi-species community presents additional difficulties in monitoring. Assumptions about density estimation must apply equally well to all species under consideration, and this assumption is clearly violated in most multi-taxa surveys. As a consequence, the estimation of absolute density in multi-species monitoring programs will result in biased estimates for some of the species studied. In such circumstances, data on total species counts (species density) and indices of relative abundance might be both sufficient and more scientifically sound.

Primates are a small component of the overall richness of tropical forested ecosystems, but they are visible, often threatened and endangered, have great public appeal, and can be sensitive indicators of low-level disturbance. Their incorporation into the TEAM monitoring program can easily be built into the array design employed for avian and invertebrate monitoring. In addition, the monitoring of large arboreal mammals will complement the camera trapping protocol for terrestrial mammals and other large vertebrates.

Description of the Objectives of the Protocol

Monitoring can be used for a variety of purposes. The three primary objectives of the TEAM primate monitoring protocol are to: 1) estimate community composition and species richness at sites; 2) track trends in relative abundance of species; 3) evaluate habitat associations of resident species. A secondary objective is to: 4) estimate density of the more common species at each site.

Primate monitoring is generally conducted using general surveys, sweep census methods, or line transect methods (Struhsaker, 2002). Choice of methods will depend upon the data required, and the objectives of the study. More general methods such as broad geographical surveys yield useful information on large-scale patterns of species richness over a variety of habitats, but they lack statistical rigor for sensitive monitoring of long-term trends in either richness or abundance. A brief review of methods useful for monitoring follows.

Selection of monitoring methods and justification

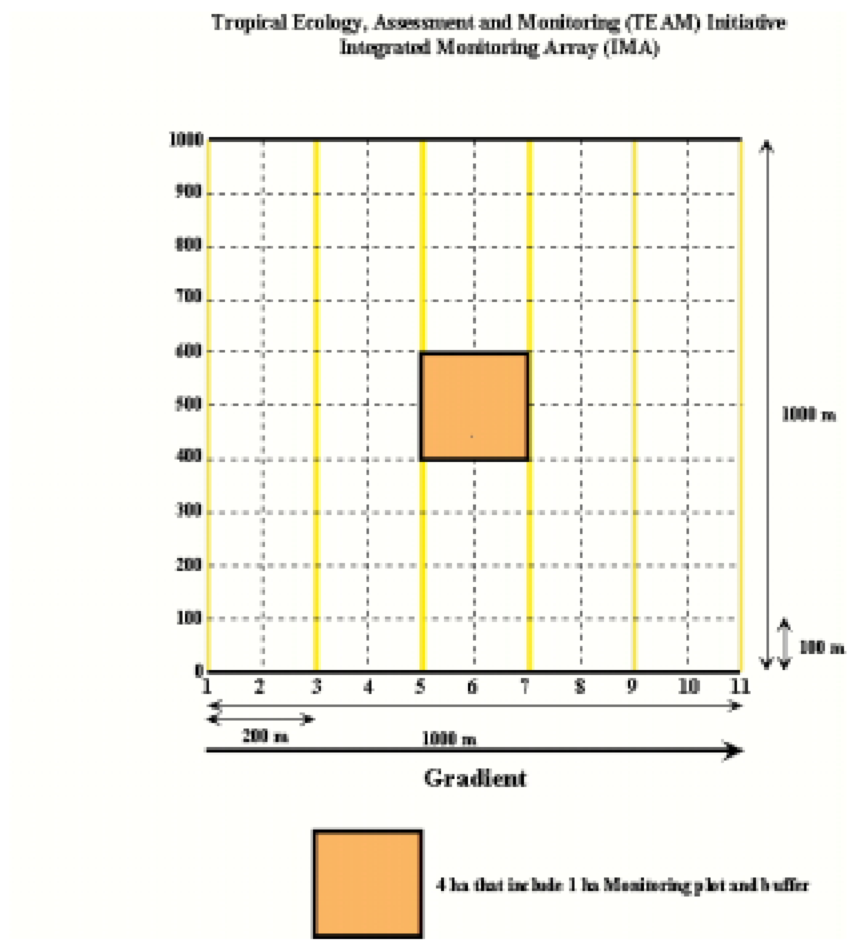
General Surveys: General surveys are a useful tool for initial general assessment of community composition. Very general indices of relative abundance can also be obtained if there is some standardization of either distance walked or time spent in observation. Because general surveys usually do not use a fixed sampling area, and do not use transects that have been cut through the forest, it is very difficult to make comparisons across sites or over time at the same site. They have limited utility for monitoring over large areas or over time. They can be useful in defining the species pool that will be sampled using more rigorous methods.

Sweep Census or Quadrat Census: The sweep census is an attempt to count all individuals of a particular species or set of species within a defined area (National Research Council, 1981; Struhsaker, 2002) and the spatial design is usually either based on quadrats, transects, or a combination of the two. Ideally, regularly spaced transect lines are walked by multiple observers (see Struhsaker, 2002, for a single observer variation on this design) and all individuals or groups observed are marked on a map. After a series of lines are censused, the observers compare maps and attempt to account for any double observations. This method requires an understanding of the movement behavior of the species being observed, so that observers can effectively avoid double counting of fast moving groups or individuals. This approach is a true census, in that an attempt is made to count all individuals present. These data can be used as indices of relative abundance if the methodology is consistent across sites and over time. Since there is no attempt to measure the area of effect of the counts, estimates of absolute density are not possible.

Line-Transects: Line transects are the method of choice for estimates of absolute density, and this approach is widely applied in studies of mammals in general (Wilson et al., 1996) and in primates (National Research Council, 1981; Peres, 1999; Struhsaker, 2002). The method requires the accurate estimation of the distance of each observed animal from the observer, as well as the angle of the observation from the transect line. These two items are then used to calculate the perpendicular distance of the organism from the transect line (Figure 1). In forested areas, the probability of observing a primate will decline the more removed it is from the transect line, so each species should have a characteristic detection function, with the probability of observing an individual declining with distance. These detection functions must be estimated independently for all species in the survey, and their calculation is based upon the histogram of the number of detections as a function of distance. There is an extensive literature on density estimation using transects (Buckland et al., 2001) and a number of downloadable software packages are available (eg. Thomas et al., 1998). When conducting a line transect census of primates, care must be taken to space transect lines to avoid double counting. In addition, lines must be sufficiently long to adequately sample the available habitat, and line placement should not be biased by habitat or ease of access. Finally, line transect methods can be difficult to apply for organisms which travel in social groups, because of difficulties in assigning point sighting distances. This problem has been discussed in other publications (National Research Council, 1981; Struhsaker, 2002).

Spatial Layout

The spatial design is based upon the Integrated Monitoring Array layout and follows the same transects as the Avian Protocol (see Figure 1, at right). The census is conducted using the six 1 km lines that run perpendicular to the gradient. These lines are numbered 1, 3, 5, 7, 9, and 11. The lines must be walked in a specific fashion, as outlined in the methods section. The 200 m distance between lines is sufficient for each individual walking the transect to count independently, but there is a probability of double counting quickly moving groups. Avoidance of double counting is discussed in the methods.



Equipment List

- High quality, waterproof binoculars with 9 or 10 fold magnification.
- Water resistant field notebooks.
- Data sheets printed on waterproof paper.
- Pencils.
- Digital camera.

Methods

Protocol: field procedures

Spatial Array: All vertebrate sampling and monitoring will occur in an array centered on the 1 ha vegetation monitoring plots (Figure 1). Primates range over a much wider area than 1 ha, so all primate monitoring will be done in a 1 km^2 box surrounding the vegetation plot. The array will consist of six 1 km long transects. Transects will be used for the collection of species presence-absence data, for estimates of species richness, and for the collection of census data. All transect lines will be 200 m apart. There will be a total of 6 km of transect lines and in each array. Each field station will have from 4 to 6 of these arrays, depending upon the number of vegetation plots established at each station, for a total of 24 to 36 km of lines per station. This in turn will depend upon the number of major vegetation types that will be monitored.

Sampling Frequency: Sampling must occur at a frequency that will allow the detection of seasonal, annual, and multi-annual trends in the estimates of community composition, richness, and relative density. We propose that initial monitoring be done two times/year. Many tropical areas have a minor and major rainy season, separated by slightly drier periods. Other regions have single peak wet and dry seasons, with transitional periods of wet to dry and dry to wet. Monitoring should be timed to coincide with the major periods of precipitation. Trends can be compared to climatological data to look for temporal correlations.

Field Methodology: The arrays that are present for the avian survey will also be used for the primate work. We will conduct a total census using a transect-based quadrat. This has been successfully applied in previous studies in the tropics (Janson and Terborgh, 1980). The transects are placed 200 m apart; this is farther apart that some previous studies. After initial field testing we will determine if this distance is acceptable for our approach. The census will be conducted 2 times/year. At each census period, each array will be censused six times. The census will be conducted three times in the morning and three times in the early evening for each array. We will compare the census results for each of the two times to determine if census estimates vary depending upon the time of census. If the results are consistent, we will report averages of the six observations. Should there exist strong daily difference in either abundance or community composition, we will keep times separate and present the averages of the three replicates for each time for each site.

The trails will be maintained four times per year to remove larger fallen logs. Prior to conducting each census the trail system will be swept clear of leaves and branches. At the time of the census the trails must be completely clear of all large and small debris.

The census will be conducted by two individuals in a modified sweep census. They will start at the base of one of the census lines and walk the adjacent lines together (Figure 2), noting the species name, group size, location on the map, and direction of movement. The grid stakes will be used as points of reference for the mapping. When they finish the lines, they will meet at the top of the array, briefly examine the map positions to look for groups that might be moving across the array, and then move across the array to descend the next two adjacent lines. The observer on the inner line will move to the adjacent line and the observer that started on the outer line will move to the line to the right of observer two (Figure 2). This will allow an observer to census the line closest to the one he/she just censused, which should reduce the likelihood of double counting of groups on the move. The two observers will then descend those two lines, meet at the bottom to share notes, then move and ascend the last two lines, using the same switch of line positions (Figure 2).

Data Forms (Field and Database)

The information collected during each census is recorded on two separate forms. (TEAM Initiative Primate Protocol - Census Location Mapping; TEAM Initiative Primate Protocol - Line Transect Data Form). The second of these two forms contains columns for optional information on distance to observation and density estimation, and the decision to record these data will depend on each station.

Data Entry

Data should be entered on the mapping data sheets to first confirm number of species and individuals observed. Data should then be entered on the paper copy forms for the line transect, including distance information if collected. Finally, data should be entered on the electronic forms provided.

Data Analysis

The data will be presented as relative abundance data for each array. The census methodology is consistent for all arrays at all sites, allowing for comparison of local and regional differences in relative abundance indices. Richness information will be of limited monitoring value since the number of species at any site is likely to be small. Richness information will prove useful for monitoring for the consistent local disappearance of certain species.

Data to be reported for each census period includes:

- richness and abundance for each of the six surveys (three morning and three afternoon) for each array
- average abundance for the morning and afternoon census periods for each array
- total richness for each array
- total richness for all arrays
- total morning and evening abundance for all arrays (sum of all the means across all arrays.

A sample spreadsheet is attached (Appendix I) showing data presentation.

Instructions for calculating the information needed for the estimation of absolute density are provided (Figure 3). Program DISTANCE, available as a free download at (http://www.mbr-pwrc.usgs.gov/software.html#distance), can be used for density estimation. There are critiques of using data generated from multiple sampling of the same census lines for density estimation that should be considered (Magnusson, 2001).

Habitat Associations: The primate team will map major vegetation and topographical features on the grid array when not conducting the census work. The survey crew that cuts the lines and places the stakes will make an original base map available, but certain features (e.g. gaps) will change over time. Mapping should also include the notation of important fruit or resource trees. Habitat mapping should be complemented with digital photographs.

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Acknowledgements

Thanks to Simone Martins, Yuri Leite, and Steve Ferrari for comments on this draft protocol.

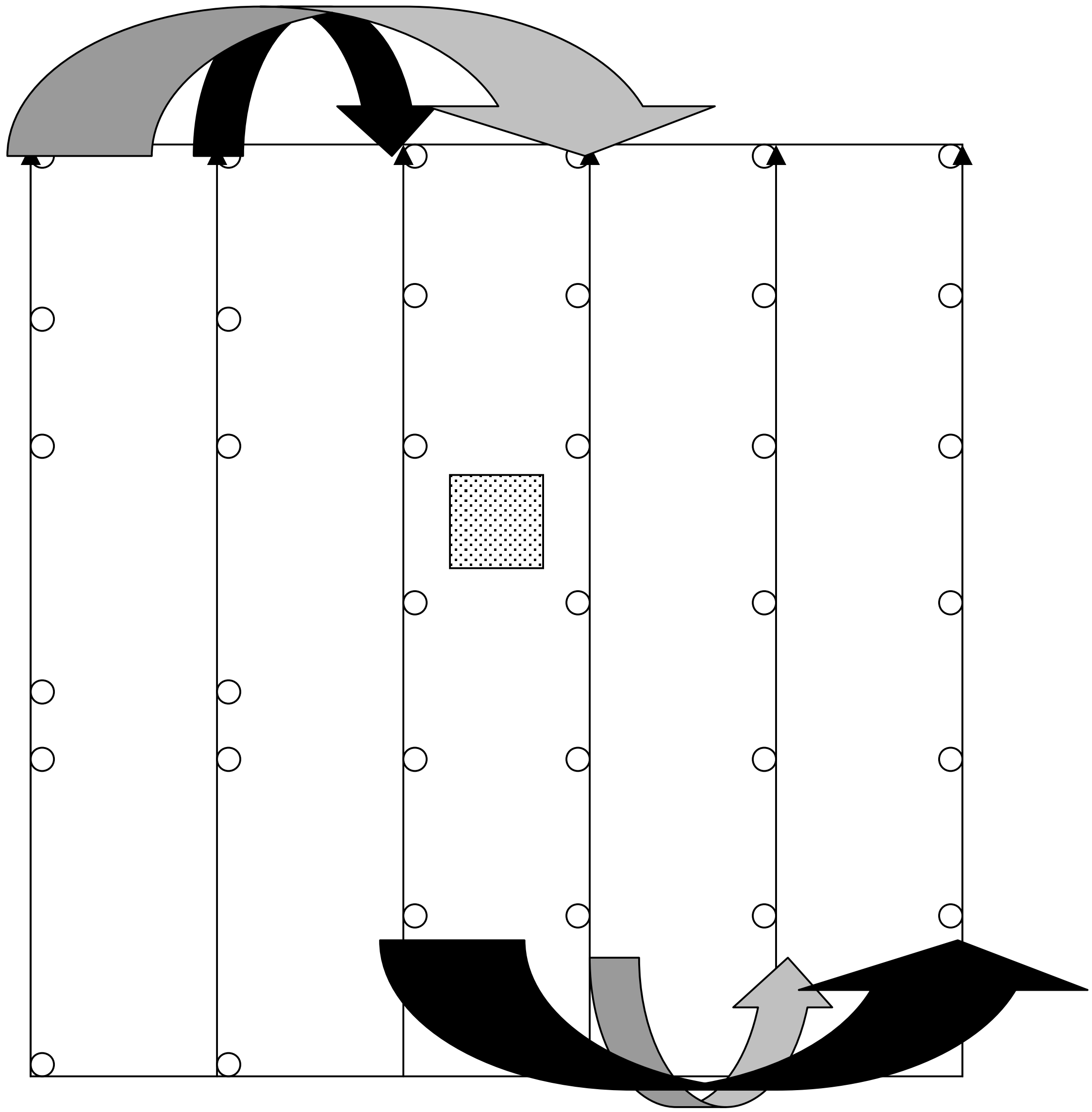


Figure 2. One km transect lines (with arrows) placed on either side of a square 1 ha forest sampling plot of 100x100 m. Transect lines are placed 200 apart. Lines will be walked for primate surveys. Transects will be walked by two observers (black and gray) in one day; at the jump to the next pair of lines, the right-most observer will always move to the closest line for better recognition of possible double counts of moving groups.

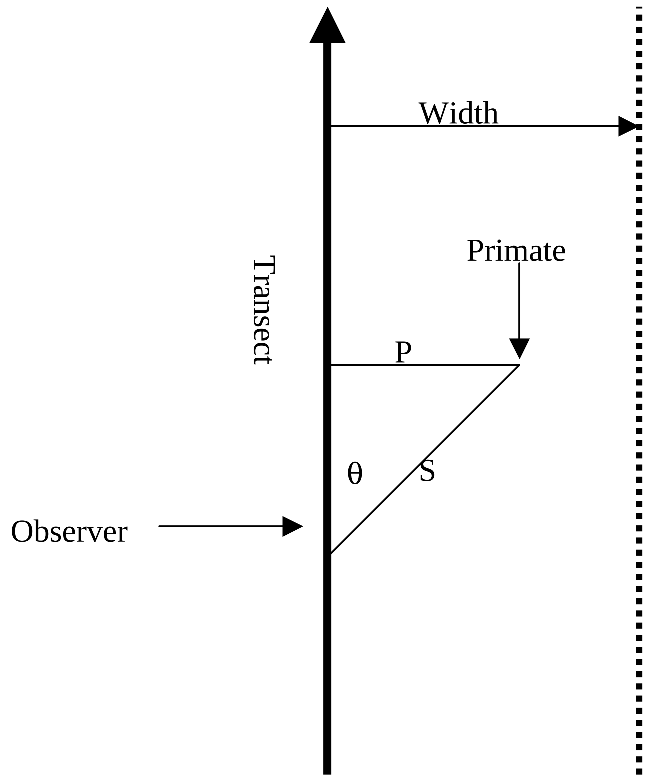
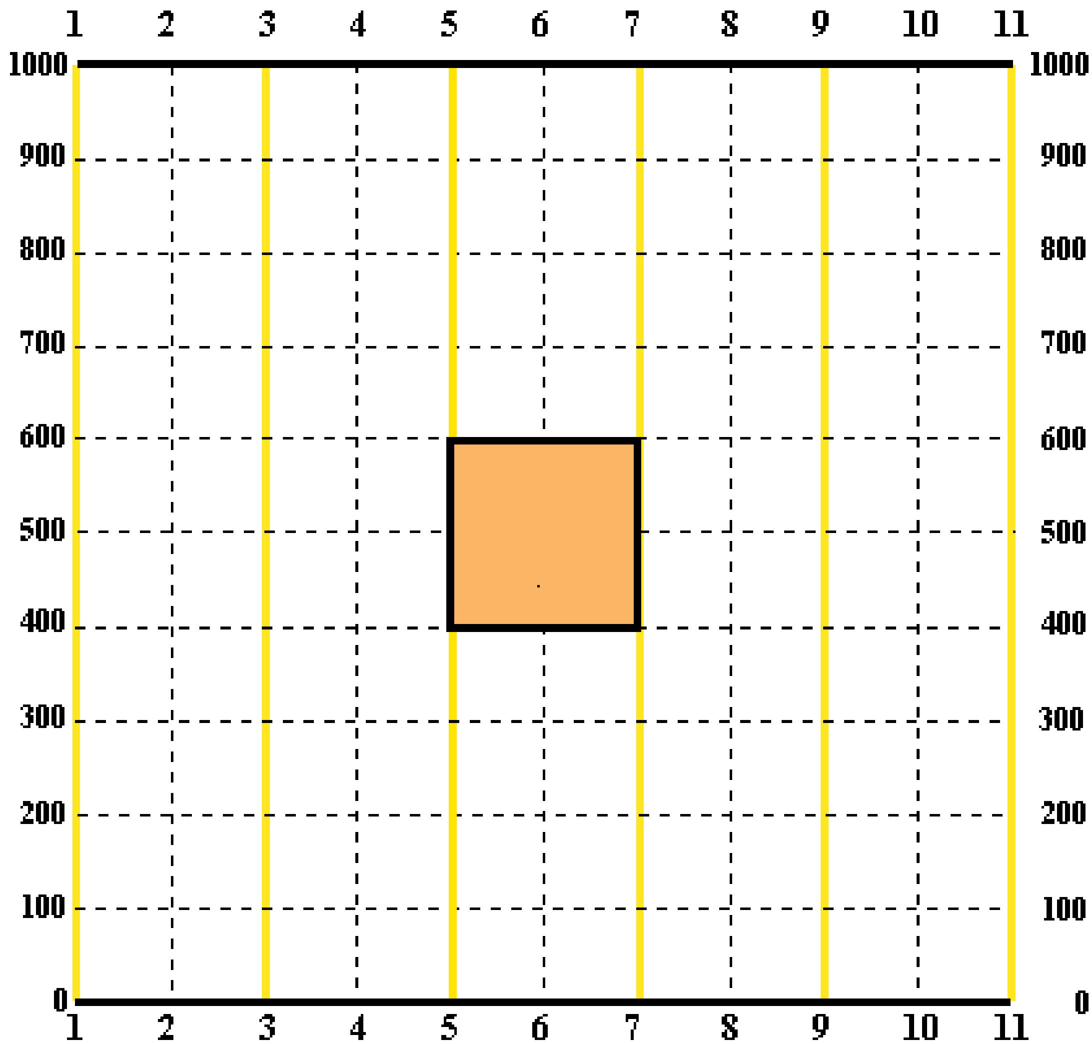


Figure 3. Terminology and variables used in the calculation of density based upon a line transect density estimation approach, where S = the sighting distance, P = the perpendicular distance, and θ = the sighting angle. Perpendicular distance, P, is calculated as: $P = S \sin \theta$.

PRIMATE MAPPING DATA FORM

Tropical Ecology, Assessment and Monitoring (TEAM) Initiative
Integrated Monitoring Array (IMA)



TEAM Inititive Primate Protocol - Line Transect Data Form

Country	Field Station	Plot	Date	Observers

						Distance			
Grid location	Time	Species	Number	Sex Ratio	Age Structure	To animal	Angle	Perpendicular	Within Width

APPENDIX I: Demonstration data summary for a single sample period

Species a

Abundance		**Morning**			**Evening**			
Array	**census 1**	**census 2**	**census 3**	**census 1**	**census 2**	**census 3**	**AM Mean**	**PM Mean**
1	3	0	4	2	4	6	2.333333	4
2	4	0	4	7	2	1	2.666667	3.333333
3	3	3	0	0	5	0	2	1.666667
4	2	6	4	6	0	4	4	3.333333
5	8	0	0	1	5	6	2.666667	4
6	2	5	3	0	0	7	3.333333	2.333333
Totals							2.833333	3.111111

Species b

Abundance		**Morning**			**Evening**			
Array	**census 1**	**census 2**	**census 3**	**census 1**	**census 2**	**census 3**	**AM Mean**	**PM Mean**
1	2	3	3	0	0	7	2.666667	2.333333
2	8	0	3	1	5	6	3.666667	4
3	2	6	0	6	0	1	2.666667	2.333333
4	3	3	0	0	5	0	2	1.666667
5	4	6	4	7	2	1	4.666667	3.333333
6	3	0	4	2	1	6	2.333333	3
Totals							3	2.777778

Species c

Abundance		**Morning**			**Evening**			
Array	**census 1**	**census 2**	**census 3**	**census 1**	**census 2**	**census 3**	**AM Mean**	**PM Mean**
1	0	6	0	6	0	4	2	3.333333
2	3	3	0	0	5	0	2	1.666667
3	3	0	4	2	1	6	2.333333	3
4	2	3	0	6	0	7	1.666667	4.333333
5	4	0	4	7	2	1	2.666667	3.333333
6	8	0	0	1	5	6	2.666667	4
Totals							2.222222	3.277778
Total mean abundance							8.055556	9.166667

Richness

		Morning			**Evening**		**Richness**	
Array	**census 1**	**census 2**	**census 3**	**census 1**	**census 2**	**census 3**	**AM**	**PM**
1	2	2	2	2	1	3	3	3
2	3	1	2	2	3	2	3	3
3	3	2	1	2	2	2	3	3
4	3	3	1	2	1	2	3	3
5	3	1	2	3	3	3	3	3
6	3	1	2	2	2	3	3	3
All Arrays	3	3	2	3	3	3	3	3