TEAM INITIATIVE

TROPICAL ECOLOGY ASSESSMENT AND MONITORING

Tropical Ecology, Assessment and Monitoring (TEAM) Initiative

Avian Monitoring Protocol

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Introduction

Few organisms have been as intensively studied and monitored as birds. The United States and Canada have a long history of avian monitoring, with much of it occurring over large spatial and temporal scales. Examples include the Breeding Bird Survey (www.mbr.nbs.gov/bbs/bbs.html), which monitors population level change in North America, the Monitoring Avian Productivity and Survivorship Program (www.birdpop.org/maps.htm), which collects data on abundance and age-gender structure in birds via mist netting, the Breeding Biology Research and Monitoring Database (pica.wru.umt.edu/BBIRD/default.htm), which monitors nesting success and habitat requirements of breeding birds, and the Christmas Bird Count (www.audobon.org/bird/cbc/index.html), which is based primarily in the US and provides data on winter presence and abundance of birds. A similar monitoring effort is underway in the UK—the British Trust for Ornithology began using a territory mapping approach in 1962 called the Common Bird Census and has recently switched to a transect-based approach (Bibby *et al.* 2000). All of these monitoring protocols provide long-term data on the status and trends in avian abundance, density, and species richness, data that have proven to be extremely valuable in detecting long-term regional or national declines in many songbirds (Robbins *et al.* 1989) and game birds (Church *et al.* 1994, Sauer *et al.* 1994) and in defining conservation actions.

The study of birds in tropical ecosystems has a long history as well. Indeed, the field of tropical ecology is largely based on the study of bird community patterns, assembly rules, and reproductive biology (MacArthur 1969, Terborgh 1977). This research has tended to be behavioral, manipulative, or experimental and has generally focused on the structure and organization of tropical bird communities. Yet this large body of research includes no long-term monitoring programs, based on standardized methodologies, like the programs in North America and the UK listed above. While monitoring has been conducted recently in the tropics to assess the impacts of disturbance (deforestation, logging, hunting) on avian community composition or specific population parameters, the results of these efforts are often difficult to interpret because researchers lack consistently collected, long-term baseline data on tropical avian ecology in the absence, or near absence, of human disturbance. Impact assessments are difficult to conduct and interpret even in species-poor temperate regions; impact assessments in the species-rich tropics are thus especially challenging to carry out, and the lack of baseline information makes the challenge even greater.

Yet establishing a long-term bird monitoring program in the tropics is well worth the trouble. Birds are the most speciose class of terrestrial vertebrates, and they are common and diverse throughout the tropics. They are largely diurnal, making them easier to observe, and many well-trained ornithologists who could assist in monitoring efforts reside throughout the tropics. All tropical habitats contain both generalist and specialist bird species, and thus birds are useful for monitoring both local and regional trends in a variety of community and population parameters.

The TEAM Initiative has established a standardized monitoring protocol for birds for its field stations throughout the tropics. At each of our 50 field stations, located in forests that have not been recently disturbed, data will be gathered using this protocol at multiple monitoring sites. These data will provide a baseline of trends in avian community composition, population density, and selected variables on avian condition. We anticipate that this monitoring network will become as valuable as the numerous long-term monitoring programs that have demonstrated their conservation importance in North America and the UK. A detailed description of TEAM's avian monitoring protocol is contained in the sections below.

Description of the objectives of the protocol

The three primary objectives of the TEAM avian monitoring protocol are (1) to estimate bird community composition and species richness at sites, (2) to track trends in the relative abundance of species, and (3) to estimate density of the more common species at each site. The other, secondary objectives of the protocol are (4) to evaluate habitat associations of resident species and (5) to track the physiological condition of a selected number of species at each site. In order to accomplish these objectives, the protocol relies on a combination of transect and point count methods, supplemented with occasional mist netting.

It should be noted that, because tropical bird species form highly diverse assemblages, it is especially challenging to estimate their richness. The three general methods for estimating bird species richness are (1) indices, which sample unknown proportions of birds over an unknown area, (2) population estimates, which sample a known proportion of birds but with uncertainty about the sample area, and (3) population density estimates, where both the proportion of birds sampled and the area are defined (Sauer, pers. comm.).Because these methods can only yield richness estimates for those species with a possibility of being sampled, the estimates will inevitably miss some species. "Missing species" occur for a number of ecological and behavioral reasons that are generally exacerbated in tropical systems.

Selection of monitoring methods and justification

TEAM's avian monitoring protocol is based on a combination of transect and point centered monitoring methods.

Transect Methods

The following are the three major transect methods for monitoring birds (Wunderle 1994):

- **Strip transects.** For strip transects, fixed boundaries are set on either side of the transect line and observers count all birds detected within these boundaries. Density estimates are based on the census of birds within the area surveyed (the width of the strip). One problem with this methodology is that it fails to account for different levels of detectability among bird species—because of their size or vocalizations, some species can be detected at farther distances than others. The result is a species-specific bias in density estimations.

- **Variable distance transects.** For variable distance transects, observers estimate the distance to each detected bird. Compared to strip transects, this method results in better density estimates for the detected species, but it can be logistically difficult to employ in species-rich areas or in dense vegetation.

- **Line transects.** The line transect is the simplest method because it involves no distance estimates. Consequently, this method allows for estimates of species richness (species lists), but it does not allow for density estimation.

Point Centered Methods

The most widely used methods for estimating bird species density are point centered (see Ralph *et al.* 1993, Wunderle 1994, Bibby *et al.* 2000). Point centered monitoring can also provide information on species richness and habitat use by birds. The various point centered methods, which differ mainly in their approach to distance estimation, can be grouped into the following three categories (Wunderle 1994):

- **Fixed-radius point counts.** Fixed-radius point counts are much like strip transects: a detection distance is defined for the point and all detected birds within the radius are counted. The distance is generally set to 25 meters. Fixed radius counts are effectively indices since the detection rate is unknown and they do not allow for estimates of absolute density.

- **Variable-radius point counts.** Variable-radius point counts are the point-method equivalent of variable distance transects. This approach has several variations, the most logistically demanding of which, called "variable circular plot" or "plot transect" by Bibby *et al.* (2000), is to estimate the exact distance to each detected bird. Another variation is to define concentric rings of different radii around the point, commonly three or more rings of increasing distance from the center. Various software packages can then be used to derive distance estimates for birds detected using this approach (Bibby *et al.* 2000).

- **Point counts without distance estimation.** These are point counts that do not estimate density, and therefore can only be used to construct species lists.

Although the variable circular plot is the method of choice for accurate estimates of density, it is also subject to error when distance estimates are difficult to obtain, such as in tropical forests. Therefore, as a base method TEAM recommends grouping distances into concentric rings, which still allows for estimates of relative density, but with less room for observer error. Data generated by this approach can be analyzed by standard statistical packages. However, in cases where field researchers obtain distance data in an accurate and unbiased manner, TEAM will also calculate densities using the variable circular plot method. Data collected using the variable plot approach can be collapsed into concentric rings for comparison to other sites where the level of field expertise or the forest conditions prohibit using the variable circular plot.

Spatial Layout

All vertebrate sampling and monitoring occurs in the Integrated Monitoring Array (IMA), which is a 1 km^2 area with a 1 ha monitoring plot at its center (see Appendix 2, Figure 1). Each field station will have 4-6 IMAs, depending on the number of 1 ha monitoring plots established at each station, which in turn depends on the number of major vegetation types being monitored. Because birds range over a much wider area than 1 ha, all avian monitoring will be done in the IMA area surrounding the center monitoring plot. Each IMA will consist of six 1-km-long transects, conducted on the IMA trails, located 200 m apart (see Appendix 2, Figure 2, and the *Integrated Monitoring Array Design and Placement Protocol*). Each of these transects will have six locations for point estimates, also set at 200 m intervals. Thus, each IMA will have a total of 6 km of transects and 36 point locations. Point counts will be taken on the major IMA trails, i.e., those lines numbered 1, 3, 5, 7, 9, 11 (see Appendix 2,

Figure 1). Points along the IMA trails will be used for collecting species presence-absence data as well as data for species accumulation curves used to estimate species richness.

Equipment List

Point Counts

High quality waterproof binoculars (9x40 or 10 x 40 recommended)
Waterproof field notebook
Pencils
Waterproof data sheets for point counts
Bird guides appropriate for region

Audio Monitoring

Sony TCM 5000 EV recorder
Sennheiser ME 66 directional microphone
Sennheiser K6 power supply
MC 22 microphone cable
Chromium recording tapes (60 minutes, one side recording only)
Audio recordings appropriate for region

Optional Supplies

Pesola balances (10 x 0.1g; 30 x 0.25g; 60 x 0.5g; 100 x 1g; 300 x 2g; 600 x 5g)
Mist nets (nylon, 12 m wide, 38 mm mesh, 2.6 m high, 4 shelves)

Method

Sampling frequency

Initial monitoring should be done four times a year. This sampling frequency allows the detection of seasonal, annual, and multi-annual trends in the estimates of community composition, richness, and relative density. 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 these four periods of precipitation so that trends can be compared to climatological data to look for temporal correlations.

Protocol: Audio monitoring

Advantages of audio monitoring

Avian surveys in the tropics present a series of difficulties compared to surveys in temperate regions, the most important being (1) the high richness of species in the tropics, including the large number of rare species; (2) a pattern of broad distributions, due in large part to the presense of intra- and interspecific bands; (3) behaviors such as the formation of leks or aggregations around a food resource that shows a fragmented or mobile distribution, such as fruiting trees or army ants; and (4) the absence of exclusive territories in the majority of tropical forest birds. As a consequence, a combination of different techniques has been recommended for avifaunal inventories in the tropics (Karr 1981).

Audio recording of vocalizations is one technique suggested for avian surveys in regions of high species richness (Parker 1991). Avian vocalizations offer the most efficient means of sampling the avifauna in the Neotropics (Parker 1991, Riede 1993), and recording them has the advantage of creating a permanent register of the sampling period .As a consequence, all detected vocalizations can potentially be identified even if experienced observers are not in the field at the time of recording. Registered and adequately stored vocalizations can also offer excellent systematic characters for understanding relationships among species and clarifying species distribution limits (see Braun & Parker 1985). Despite these advantages, few researchers have used this approach for sampling avian communities (Parker & Bailey 1991, Foster *et al.* 1994), although TEAM has adopted audio recording as part of its avian monitoring protocol.

Field methodology

Vocalization recordings should be done simultaneously with the avian census. Thus, in addition to density and richness estimations, audio recordings will be carried out at as many as 216 census points per field station during each of the four annual sampling periods (36 per IMA and up to six IMAs, see “Spatial Layout” above). The entire 10-minute period of observation at each census point should be recorded using a Sony TCM 5000 with a Shenneiser ME 66 directional microphone. This particular microphone is highly directional and has a high sensitivity, allowing for sounds of even relatively low volume to be satisfactorily recorded (Haselmayer & Quinn 2000). One observer should note birds seen and heard in accordance with the census methodology while an assistant handles the recorder and microphone and assumes responsibility for the recording. The microphone should be attached to a support to avoid interference and rumbling caused by direct contact with the operator’s hands. Hold the microphone at an angle of 20° in relation to the horizontal plane. Because the Shenneiser ME 66 microphone is highly directional, the operator must rotate it systematically, 90° every 150 seconds, throughout the 10-minute taping period (see Haselmayer & Quinn 2000).

Use only 60-minute tapes; longer, 90-minute tapes are much thinner and are more easily damaged. In order to guarantee the highest quality of recording, use only one side of the tape, limiting each tape to 30 minutes of recording (Kroodsma *et* *al.* 1996). At the beginning of each tape, record information on the field station, date, and IMA. At the beginning of each 10-minute recording session, record the time, IMA trail number, and point number.

Recordings are transferred to the computer by connecting the line-out of the recorder to the line-in of the computer's sound card. Then, with the sound card's recording software or software such as Sound Forge (www.sonicfoundry.com), use the computer to digitize the recording. This happens during normal tape playback through the computer's line-in. Set the software to digitize the incoming sound in the highest quality format available, typically 16-bit mono, sampling at 44.1kHz. To ensure compatibility, do not set the sampling rate to 48kHz, even if this setting is available, particularly since analogue cassettes don't capture frequencies above 16 kHz very well. Digital audio should be saved as WAV files since the WAV format, in contrast to the MP3 format, ensures no loss of data from compression. Once the recording has been digitized, it can be edited using software such as Sound Forge or Cool Edit 2000 (www.syntrillium.com).

Audio data analysis

The audio recordings will be analyzed to generate separate species lists for each 10-minute session, rather than generating a cumulative species list for all taping periods. According to Haselmayer and Quinn (2000), recordings are good for generating lists of species but cannot be used to estimate the abundance of a particular species or the species diversity of a community. However, a species' frequency of occurance can be generated from lists of species recorded at the various census points. Frequency of occurance, in turn, provides an index of relative abundance, but only for those species that do not occur at all sampled points. Nevertheless, frequency of occurrance can be a useful measurement when the monitoring array includes enough census points to ensure that most species are recorded at fewer than all points.

Protocol: Point counts

Steps for placing transects on the IMA trails, establishing point count locations, and carrying out monitoring activities are as follows.

1. **Place transects.** Use the procedures outlined in the *Integrated Monitoring Array Design and Placement Protocol* to place six parallel transects, 200 meters apart, along IMA trails 1, 3, 5, 7, 9, and 11. The innermost two IMA trails are each 100 meters from the midpoint of the 1 ha plot.

2. **Set point-count locations.** Set a point-count location at the base of each IMA trail, and then every 200 meters along the transect. Each IMA trail will thus have six point-count stations. Center each station on the IMA trail and mark it with a permanent stake according to procedures described in the *Integrated Monitoring Array Design and Placement Protocol*.

3. **Complete station survey.** On each day of monitoring, arrive at the starting point approximately 20 minutes before sunrise so that counting can begin at sunrise. Observers will need approximately 15 minutes to cover each point-count location: 2 minutes to walk the 200 m between points, 10 minutes of actual counting, and 3 minutes for set-up and note taking. Thus, 90 minutes are required to cover one transect. Because each morning's counting effort must be finished by 9:30 a.m., only two transects (180 minutes)—or one third of an IMA—can be covered each day. At least three days are therefore required for a team of highly experienced observers to survey one IMA, and a survey of a six-IMA station would require at least 18 days. However, because more time is required when observers are inexperienced or unfamiliar with the avifauna, we anticipate that 18 days would be the minimum time needed to survey of station with six IMAs.

   Follow standard published procedures for point counts during the survey (e.g., Ralph *et al.* 1993) with the following modifications: For each point, record the number, date, and time. Note birds in the order of observation. Record species present in the following three bands, originating at the point: 0-10 m, 10-25 m, and 25-50m. Record the distance at first observation when possible, but at a minimum record the band within which each bird is observed. Record whether each bird is sitting or in flight when observed.

   Use the appropriate standard field data forms, as discussed in "Data Forms" below. Subsequent to recording, the observations can be grouped into two-, three-, and five-minute intervals so comparisons can later be made to studies that are based on these shorter observation times.

4. **Estimate species richness.** Independent estimates of species richness will be obtained for each survey using the point count data. There will be two estimates, one based on observations and one based on recordings.

Several methods for estimating species richness are available. One method recommended for species-rich habitats is the 20 species count, also called the X species count, the *m*-species count, and the McKinnon count (see Poulson *et al.* 1997, Fjeldsa 1999, Bibby *et al.* 2000). According to this method, all species observed visually or heard at a point-count location are listed in sequence. When a list reaches 20 species, a new list is started. Note that each list consists of 20 *species*; when multiple individuals of the same species are present at a point-count location, the species is only counted the first time an individual is observed. All birds must be listed, including those with unconfirmed identities. However, unconfirmed birds must be "identified" consistently as the lists are compiled. Each subsequent 20-species list will consist of species from one or more of the 20-species lists at previous point-count locations or new, previously unobserved, species. These lists can then be used to plot accumulated numbers of species and singletons (defined as species recorded only once, a category that declines as the number of 20 species lists increases). Plotting continues along the transect lines until the accumulation curve begins to reach a plateau. This plateau represents the observed species richness, which is used in the estimation of total species richness (see "Data Analysis").

Several authors have noted problems with the 20-species count method, particularly when the sampling effort is insufficient to attain asymptotes in high richness sites (Gotelli & Colwell 2001). Under these circumstances, the problem is that, for the same sample effort (or number of 20-species lists), low richness sites are more intensively sampled in terms of number of individuals counted, and thus can have higher richness estimates than richer sites. Herzog *et al.* (2002) provide a methodology for avoiding this bias and conclude that *m*-species approaches are acceptable, even for rapid assessments. They test several richness estimators and provide recommendations based on their analysis of several field data sets.
As an alternative to *m*-species approaches, some authors prefer modified mark-recapture methods, based on closed population density estimation techniques (Boulinier *et al.* 1998, Farnsworth *et al.* 2002). These procedures have the advantage of accounting for heterogeneity in the detection probability of species, a bias present for virtually all richness estimations. Point data can be used to generate the raw data, and programs are available for model selection and analysis (e.g., CAPTURE, White *et al.* 1982).

Regardless of the method used for generating species accumulation curves, multiple methods are available for richness estimation. These have been reviewed by several authors (Colwell & Coddington 1994, Cam *et al.* 2000, 2002) and are discussed further in the section on "Data Analysis."

Protocol: Other methods

Habitat associations
Collect qualitative habitat descriptions for each point sampled. Because of the range of forest types that will be sampled across continents as part of the avian protocol, TEAM does not have a standardized set of quantitative variables to measure habitat at each site. Instead, variables should be determined, *a priori*, on a site-specific basis by the in-country researchers. Qualitative habitat descriptions should be updated with each survey and kept on file. The descriptions should include forest type, degree of canopy, understory and ground cover, density of lianas, presence of any forest gaps, and proximity to water. Each point description must be accompanied by a digital photo of the point, taken pointing forward, i.e., from the "bottom" to the "top" of the IMA. Descriptions and digital photos for each survey period will be archived at both the station and the regional office.

Mist netting and condition monitoring
Mist netting is optional, though strongly encouraged at all sites where possible. It can assist in identifying hard-to-observe understory species, and it also allows researchers to collect data on the physiological condition of birds. This important additional bit of information can be collected at selected sites where staff are experienced in mist netting and determining condition. Select taxa for condition monitoring that can be consistently collected by mist netting in all surveys. Condition monitoring can be done on a seasonal or an annual basis, depending on available human resources. Collect data on sex, age, weight, wing length, and fat condition. Techniques for assessing these variables are outlined in Ralph *et al.* (1993).

Data Forms

Record information collected during the point counts on the Point Count Field Data Form. Use the *m*-Species Field Data Form for 20-species counts, and the Species Count Field Data Form for sample-based assessments.

Data management before field collection should follow the protocols on data handling, management, and archiving.

Data Entry

The avian protocol has two different categories of data. Enter *density estimation data* on the Point Count Field Data Form. Enter *richness estimation* data on two separate format sheets: use the Species Count Field Data Form to list species observed as a function of transect, noting the presence of species in a separate column for each transect of six points. Enter the same information on the *m*-Species Field Data Form, but constructed as 20-species-count lists (see Step 4, "Protocol: Point counts" above). All data should be entered first on paper field data forms then on the corresponding electronic data forms.

Data Analysis

Plotting Species Accumulation Curves

Use the 20-species-count data sets to derive species accumulation curves. Treat each 20-species list as a separate sampling period. For each period, plot the accumulated number of species on the y-axis against the list number, starting with one, on the x-axis. In addition, plot the number of species recorded only once (singletons) on the y-axis, also against the list number on the x-axis. By definition, the very first data point will have 20 accumulated species and 20 singletons. After this, the number of singletons will oscillate but eventually decline gradually. With increased sampling, the species accumulation curve will begin to level off.

Prepare species accumulation curves for each IMA during each sampling period. Archive both the curves and the spreadsheets holding the raw data from the survey sheets for subsequent analysis.

Estimating Species Richness from Species Accumulation Curves

The three basic procedures, reviewed in Colwell and Coddington (1994), for using species accumulation curves to estimate species richness are as follows:

1. **Extrapolation of species area curves.** This approach is based on procedures like rarefaction, asymptotic models such as the negative exponential, and non-asymptotic models like the log-linear. Different extrapolation approaches yield different estimates of richness on the same data set, however, and a best model cannot be determined in the absence of a complete inventory.
2. **Parametric methods.** A separate class of procedures attempt to fit parametric models of relative abundance to curves to estimate richness. Examples of these procedures are the lognormal and the log-series methods. Parametric methods require counts of individuals within species from the survey data, as opposed to the simpler requirement of presence absence data for extrapolation of species accumulation curves. Since the TEAM approach yields count data, this procedure is an option for our analyses.
3. **Non-parametric methods.** Non-parametric methods for estimating richness have less stringent data requirements than parametric methods. Common examples include jackknife and bootstrap methods, and the Chao 1 and Chao 2 estimators. Non-parametric estimators are widely used—the Chao 2, in particular, is widely used in ecology. When the sampling is poor, non-parametric estimators underestimate species richness. However, as the proportion of the fauna observed increases, the bias decreases and estimates converge on the true richness. One of the advantages of the Chao 2 estimator is its ability to perform well with small numbers of samples.

TEAM data should provide an excellent opportunity to compare several methods of species estimation for a long-term data set of a species-rich community over many sites. As a standard for all stations to report, TEAM requires the Chao 1 and Chao 2. Other analyses will be applied upon subsequent examination of the data.

Chao 1 (from Colwell and Coddington 1994)

$$S_1^* = S_{obs} + (a^2 / 2b)$$

where S_{obs} is the observed number of species in a sample, *a* is the observed number of species for which only one individual was observed (called singletons), and *b* is the observed number of species for which only two individuals were observed (called doubletons). Chao 1 requires information on both species and individuals per species.

Chao 2 (from Colwell and Coddington 1994)

$$S_2^* = S_{obs} + (L^2 / 2M)$$

where S_{obs} is the observed number of species in a sample, *L* is the observed number of species encountered in only one sample (called unique species), and *M* is the observed number of species encountered in only two samples. Chao 2 requires only a species list.

Estimating Species Richness using Capture-Recapture Methods

Several recent publications (e.g., Cam *et al.* 2000, 2002) have suggested using capture-recapture models and programs to derive probabilistic non-parametric estimates of species richness. Boulinier *et al.* (1998) applied a capture-recapture approach to the estimation of species richness from breeding bird surveys. They used models that account for heterogeneity in species detectability, a biological reality in all tropical bird surveys, and thus their approach seems especially useful for TEAM protocols. Data for capture-recapture analysis are stored as capture histories, with species listed in rows and sample units in columns (see Table 1). Sample units can be defined in various ways; for the avian protocol, each transect (IMA trail) of six points is defined as a sample unit. As a result, local richness estimates are based on six sample units per IMA, and field station estimates are based on a sample six times the number of IMAs. CAPTURE software (Rexstad & Burnham 1991) is used to analyze the data by selecting the best of several alternative models of detection probabilities and then estimating species richness (Boulinier *et al.* 1998). CAPTURE software and documentation are available online at www.mbr-pwrc.usgs.gov/software.html#distance.

Table 1. Sample sheet of capture histories.

Species \ Transect	1	2	3	4	5	6	…n
Ab	0	0	1	1	0	0	
Cd	1	1	0	1	0	1	
Ef	0	0	0	1	0	1	
Gh	1	1	1	1	1	1	
Ij	1	0	0	0	1	0	
Kl	0	0	1	1	0	1	
…S							

Estimating Density from Point Counts

We recommend that density be estimated using the software package DISTANCE (Buckland *et al.* 2001). This software is downloadable in DOS and Windows versions from the Patuxent Wildlife Research Center software archive along with other software packages useful for monitoring (http://www.mbr-pwrc.usgs.gov/software.html#distance). Several versions are available including version 2.2 for DOS and versions 3.5 and 4.0 for Windows. Akaike's Information Criterion will be used for the selection of the appropriate detection functions (Thomas *et al*. 2002).

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Glossary

Strip transects set fixed boundaries on either side of the transect line and observers count all birds detected within these boundaries. Density estimates are based upon the census of birds within the area surveyed.

Variable-distance transects require the observer to estimate the distance to each detected bird.

Line transects involve no distance estimates. These transects will allow researchers to obtain estimates of species richness but do not allow for density estimation.

Fixed radius point counts are a modification of strip transects where the detection distance is defined for the point and all detected birds within the radius are counted. They do not estimate absolute density.

Variable radius point counts are the point method equivalent of variable distance transects.

Point counts without distance estimation do not estimate density; they only construct species lists.

Species accumulation curves plot the number of species detected with increasing sampling intensity.

Richness is the number of species per sample area.

Data Collection Event – a single 10-minute point count. This consists of all the data collected on the point count data sheet (Appendix 3 in the protocol) as well as the 10-minute audio recording. A single data sheet is used for each 10-minute point count, and a separate one is used for each audio recording.

Appendix 1: Equipment Suppliers

Binocular suppliers: Binoculars.com, http://binoculars.com/

General field supplied, including tapes, notebooks, Pesola balances, etc.: Forestry Suppliers, http://www.forestry-suppliers.com/

Tape recorders, microphones, and other related supplies: Saul Mineroff Electronics, Inc., http://www.mineroff.com/home.htm

Recordings of call and songs: Buteo Books, www.buteobooks.com/multimedia.html

Field Guides: Buteo Books, www.buteobooks.com/

Field Guides: Amazon.com, www.amazon.com

Mist nets: Avinet, www.avinet.com

Appendix 2

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

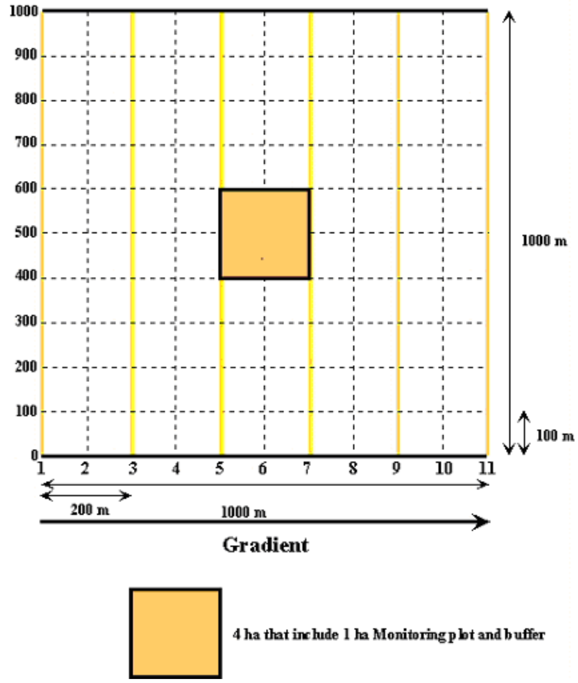

Figure 1. One km transect lines (with arrows) placed along IMA trails on either side of the square 1 ha plot of 100x100 m. Transect lines are placed 200m apart.

Tropical Ecology, Assessment and Monitoring (TEAM)
Initiative Integrated Monitoring Array (IMA)
With Bird Points Counts

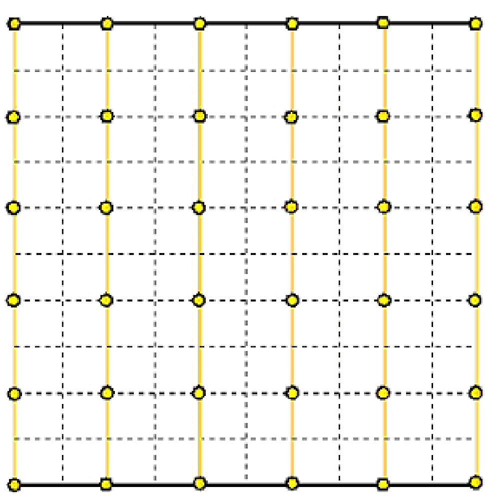

Figure 2. Point counts (yellow circles) located every 200 m along the transects (IMA trails) six per transect.