# Camera trap distance sampling workshop

## Practical 3: survey design and effort allocation

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### Survey design

Using the duiker study described by Howe, Buckland, Després-Einspenner, & Kühl (2017), this practical helps to design a camera trap distance sampling survey in terms of intensity and spatial arrangement, as well as considering the potential precision we would need when designing a long-term monitoring program. We start by taking a look at the study area in Côte d’Ivoire, where the cameras were deployed according to a systematic grid design with a random start and a 1km spacing between sampling locations.



Figure 1. Study area used by Howe, Buckland, Després-Einspenner, & Kühl (2017)

Maxwell’s duikers were sampled for about 12 weeks using Bushnell camera traps (Model 119576C that gave a horizontal angle of view of 42°) mounted at an orientation of 0° and a height of 0.7–1.0m, and set to high sensitivity. We will treat the study of Howe, Buckland, Després-Einspenner, & Kühl (2017) as a preliminary study and use the estimates from that study to help design a subsequent study building upon information from the previous study. Note that ideally your camera traps should have similar characteristics to those used in the previous study, otherwise you will need to account for that during your design process. Similarly, deploying your cameras with a different orientation or a different height would influence the detectability of your target species of Maxwell’s duikers.

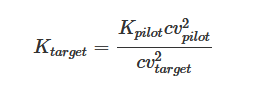
When considering the relationship between precision and spatial sampling intensity (number of locations in our case) information on the number of detections and effort (number of camera sampling locations in this case) from a pilot study is useful, along with information on the dispersion parameter (also known as the variance inflation factor). If the target species were completely evenly distributed across the area of interest and detectability did not differ by location, then the dispersion parameter would be approximately one. There is generally a great deal of variability in camera trap data and the degree of overdispersion can be approximated by



Maxwell’s duikers sleep or rest for most of each night, so Howe, Buckland, Després-Einspenner, & Kühl (2017) recorded 11,180 distances from 6:30:00 to 17:59:59 using a 2 second time step during that interval. In the final analysis after truncation of the data 10,284 remained and we know the number of stations (21) and the precision associated with this study (CV = 0.27). We can approximate the dispersion parameter value using the previous formula, which results in a value of about 750. This is several orders of magnitude larger than dispersion parameter values seen in or human-observation based line transect surveys point transect surveys and highlights the degree of over dispersion in camera trap data compared to other distance sampling data.

### Effort needed for desired precision

Buckland, Rexstad, Marques, & Oedekoven (2015) provide formulas to compute precision achieved from varying levels of sampling effort.



Where

* *Ktarget* necessary number of camera stations
* *Kpilot* number of stations in initial study (21 in Howe, Buckland, Després-Einspenner, & Kühl (2017))
* *cvpilot* coefficient of variation achieved in initial study (0.27 in Howe, Buckland, Després-Einspenner, & Kühl (2017))
* *cvtarget* coefficient of variation desired for final study

We can use this formula for point transect sampling in conjunction with the survey design employed in Howe, Buckland, Després-Einspenner, & Kühl ([2017](file:///C:\Users\WCS\Dropbox\WCS\WorkshopsMeetings\Y2021\CameraTrapDistanceSampling\Practicals%20&%20Solutions\3053333\3053333\CTDS-prac3.html#ref-howeetal)) to estimate the number of camera trap stations needed to achieve a *cvtarget* when estimating duiker density.

If we would like to design a long-term monitoring program for Maxwell’s duikers in Tai NP, then assuming the camera trapping is repeated every year, we can investigate the precision and required effort associated with a given:

* cumulative change to the duiker population over the duration of the monitoring,
* number of annual surveys,
* power to detect change,
* encounter rate.

Launch the RShiny app to investigate the relationship between these various parameters, assuming at least 80% power to detect change and an alpha level of 20%, no more than a 30% overall decline in the population over the course of 15 years of the monitoring program (note that the encounter rate is about 490 given the 10,284 post-truncation detections divided by 21 – the number of camera trap locations). The application uses the equations in Gerrodette (1987) that assume change over time is linear and that precision expressed in terms of the coefficient of variation is constant, i.e., it is independent of abundance and thus would remain unchanged by an increase or decrease in abundance, which is frequently assumed for distance sampling surveys. The RShiny app estimates the coefficient of variation and then uses the previous formula to estimate the number of sampling locations that would be required to achieve that precision. The overall results are reported on the first tab based on the user defined values for the overall change in abundance, the length of the monitoring program (assuming annual surveys), the power, and encounter rate. The relationship between the coefficient of variation and the overall change in abundance is shown graphically on the second tab. On the third tab the relationship between survey effort (number of camera trap locations) and the overall change in abundance is graphed. See how the estimates of precision and effort change when you change any one of the input parameters. What precision and effort is needed to achieve 90% power or if the overall decline is 20% (in both cases leaving the other parameters as they were in the initial scenario)? Examine other scenarios.

Contrast this estimate of necessary stations for duikers with those of Cappelle, Howe, Boesch, & Kühl (2021) for a ~90 day camera deployment (Fig. 5a).

# Spatial arrangement of camera stations

Having computed the necessary amount of sampling effort (*Ktarget)* to achieve the coefficient of variation to have at least 80% power to detect a 30% decline in the population during the 15-year monitoring program for Maxwell’s duikers, the next component of survey design is placement of cameras upon the landscape. Laguardia et al. (2021) and others advocate a systematic arrangement of sampling stations across a study area.

We will use the survey design feature of Distance for Windows to systematically place the desired number of stations throughout the study area. You will need the shape file of the study area, called “Duiker\_study”, created for this example. You can create a geographic project for survey design purposes as follows:

#### Setting up a survey design project in Distance

1. Open the Distance software.

2. Select **File -> New project**... to create a new project.

3. When the **New Project Setup Wizard** pops up select the 2nd *'Design a new survey or simulation*' option and click on **Next**.

4. Select the '*Proceed to Shape Import Wizard*' option and click on **Finish**. Click on **Next** gain to get past the introductory screen.

5. Leave the default ‘Study area’ option as your destination data layer. Browse to the Data folder for this exercise and select the Duiker\_study.shp shapefile and click on **Next**.

6. Allow Distance to *'Copy shapefile to distance project folder*' and check '*Use the coordinate system as the project default*' in this case (the shapefile for this study area is in the geographic coordinate system 'WGS 1984' and click on **Next**. [HINT: If you project your shapefiles before you use them to generate designs using the Distance software, then this can simplify matters and speeds up calculations.]

7. On the next screen uncheck '*Use the same projection as the shapefile*' and in the section on **Map and geographic calculations** set the **Projection of the map data** to ‘*Transverse Mercator*’ and the **Map units** to ‘*Meters’*. Click on the **Parameters…** to set the **Projection Paramaters** to UTM zone 29N as shown below, which is appropriate for this survey area in Tai National Park. Click on **OK** when you have entered the values for the **Projection parameters** and the **Finish** back on the main screen.

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8. When the ‘*Create coverage grid*’ dialogue box pops up select **Yes** (a coverage grid is needed to investigate design properties, which we will not be doing here mainly because a systematic grid design with a random start is straightforward with good design properties, such as even spatial coverage and achieving the same sampling intensity throughout the survey area). In the subsequent **Create New Layer** dialogue box type Grid1000 as your **Layer name** and retain the remainder of the default options before clicking **OK**. Click on **No** in this instance when asked ‘*Would you like to import another shapefile?*’ (If you were designing a stratified design then you would import a shapefile with your strata at this point.)

9. Select **File** > **Project properties**... and click on the **Geographic** tab to check that the **Default coordinate system** is ‘WGS 1984’ and that the **Map and geographic calculations** are set to UTM 29N. If under **Data Layers** you right-click on the **Study Area** and the **Data Layer Properties…** then on the **Geographic** tab you should see that the coordinate system is ‘WGS 1984’.

10. To take a look at the survey region and coverage grid within Distance create a new map in the **Maps** tab by clicking on the **New Map** button (or selecting **Maps** > **New Map** from the menu). Add the layers Study Area and Grid1000 to the map by clicking on the **Add Layer to Map** button (or selecting **Map** > **Add Layer** from the menu).

#### Creating a Survey Design

Now let’s create a designs for systematically laying out a point grid with a random start that can be used to locate the cameras for this survey. Click on the **Designs** tab of the **Project Browser** and then the **New Design** button (or **Designs** > **New Design**… from the menu). Rename your "New Design" something like "Point Grid 70" and then click the **Show Details** button to open the **Design Details** window (or **Designs** > **Design Details**… from the menu). Select the “Point” **Sampler** and set the design **Class** to ‘*Systematic Grid Sampling’*. Click the **Properties** button to set the following properties for this design:

* On the General Properties tab under **Stratum layer**, the Study area layer should be selected. Under **Design coordinate system**, the third option is the default in order to use the previously set up projection.
* In the **Effort Allocation** tab, under **Edge Sampling** select the “*Minus*” option. In the **Allocation by stratum** section leave the **Point Spacing Units** as “*Meter*”. Make sure the **Update effort in real time** check box is ticked. As there is only one survey stratum the ‘*Same effort for all strata’* check box is ticked by default and disabled. Click the **Systematic point grid spacing** radio button. Enter a value of 500 in the Side field and leave the Angle value as zero, as this orientates the point grid in an east-west direction which simplifies field logistics. The Effort is approximated as 70 points and the eventual total number of locations depends on the shape of the survey region, but this should at least give you some indication of what to expect.
* In the **Sampler** tab, select “Meter” for the line sampler width units. Set the Width to 15 to reflect the limited field of view of the camera.
* In the **Coverage Probability** tab, click on **Assume even**, as this is a reasonable assumption for this design, so you do not need to check that the coverage probability is even using simulations.
* Click **OK** to close the **Design Properties** window and return to the design details.

#### Automated generation of new surveys

Click the **Run** button on the Design Details window. A window pops up offering you two choices: (1) Calculate coverage probability statistics, and (2) Generate a new survey. Choose the second option, and give the new Survey a useful name like “SGS500m" and the new layer the same name. Then click **OK**. A **Survey Details** window opens, and the status bar at the top of the Distance window says "Running Survey". The software creates a randomly located point grid based on the design. When it is finished, the **Survey Details Results** tab opens, and you can review some statistics about the new survey. How many points were generated and how close is this to the approximated total survey effort?

Click the **Next >** button to see a map of the point grid. Click **Next>** again to see a list of the points, with coordinates for each. You could, for example, use this to make a survey plan to take into the field. To copy this text to another file, press the **Copy current window** button, 4th from the left on the top toolbar. You can also copy the map of grid points by displaying the map and pressing the copy button, or choosing the menu item **Survey – Results > Copy Map to Clipboard** (another alternative is to open the shapefile in GIS software and to label the point transects there with the labels corresponding to appropriately labelled coordinates you enter into your GPS unit).

Click on **[X]** to close the **Survey Details** window, and click on the **Surveys** tab of the project browser. You can see that your new survey has been added there. If you select it and click the **Show Details** button (3rd from left after the word **Survey**) you get back to the **Survey Details** window **Results** tab. Click on the **Inputs** tab and then **Properties ...** button. Under Data Layers, you can see that the new Sample data layer "**SGS500m**" has been entered as the lowest sample layer. Close the **Survey Properties** and **Survey Details** windows, and click on the **Data** tab of the Project Browser. You can see that the new sample data layer "SGS500m" has been added below the "Study area" data layer. You can repeat the process by creating new ‘*Systematic Grid Sampling’* designs with a different grid spacing. In the same way as before generate survey plans from these designs.

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