

AERIAL WILDLIFE SURVEY MANUAL

Aerial Procedures Manual v 0.9 (Uganda)



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With supplementary material for Uganda Wildlife Authority

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WCS FLIGHT
PROGRAMME
PROCEDURES
MANUAL

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1 Introduction to aerial surveys

This is the first version of a manual which will be of assistance in conducting aerial wildlife surveys. It is intended as a manual of procedures for use in the field and in the lab, and may be used for training and reference. This is intended as a 'living document' which will develop over time (either in whole or in part), and comes paired with an online set of resources. If you find something that needs expansion, or alternative methods that you find more useful, please get in touch with us and make suggestions.

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We discuss theory of aerial surveys in brief, focusing instead on the practical application of methods in the field and procedures for running analyses and working with data. A 'further reading' appendix will direct you to more comprehensive discussions of theory and alternative methods.

This manual describes two commonly-used aerial direct count methods. Direct count techniques rely on observation of visible target animals in a population, where it is assumed that you can see the entire population; in contrast, indirect methods either do not assume that you can see the entire population, or rely on other indicators (tracks, dung) to determine the population size.

Sample counts, a subtype here referred to as "Systematic Reconnaissance Flights" (SRF), involve taking samples of part of a population, and then estimating the total population size.

Total counts involve an exhaustive search of an entire survey area, usually counting only one or two species.

1.1 How to use this manual

Some notes on the format:

- The main text in each chapter discusses principles and theory, in brief.
- Procedures for field and lab are numbered, indicating the exact order for each process
(see the first example on the right).
- Code or instrument instructions which refer to text you will see on-screen in an application or GPS are in **monotype font in blue**.
- Things you should BEWARE of are in orange-titled boxes, labelled "Caution!". Ignore these at your peril!
- Tips and hints are indicated in blue-titled boxes (see opposite) with "Tips and tricks" or "Hints". These are intended to make life easier for you.

- c. Right-click on one of the points on the graph, and select **Add trendline ...**. On the "Type" tab select linear; on the "Options" tab select **"Display equation on chart"**, then OK.
- d. The equation gives you: $y = \text{slope } x + \text{intercept}$ – i.e. in the example opposite, slope = 1.18 and intercept = -3,282.
- e. The plot should be very linear, with the plotted points following the trend line closely.

Caution!

- Good survey design can save a survey design can give you ent instructions here attempt to be design by a statistician or spec
- Here, we present some basic p more complete discussion of th Griffiths (1978), Jachmann (20 Bibliography (section 9).

Tips

- Before spending too much time on blocks, consider the next section o intensity in the previous section, a more accurate financial planning; i previous steps if your budget is lim budget sufficient to cover a wider a
- Using an even-number starting po the pilot to navigate.

2 Systematic Reconnaissance Flights

2.1 Introduction

Systematic reconnaissance flights (SRF), also called aerial strip counts, are sample counts that typically use parallel transects. They are the most commonly used type of survey in East Africa. The SRF method was described and widely adopted from Norton-Griffiths' 1978 "Counting Animals" (Norton-Griffiths 1978), which used the Jolly II statistics (Jolly 1969) and developed a standard method for strip transects as employed in East Africa.

The methods outlined in this manual use the method and calculations as described in Norton-Griffiths and Jolly, with some small modifications, which are highlighted in this text.

In SRF, observers count wildlife in defined counting strips on both sides of the aircraft; both strips together make up each transect – each transect is a single sample. Transects are thus flight lines that cover the entire sample area, and it is assumed that the distribution of animals between samples is similar to that found in each sample (Figure 2, Figure 3).

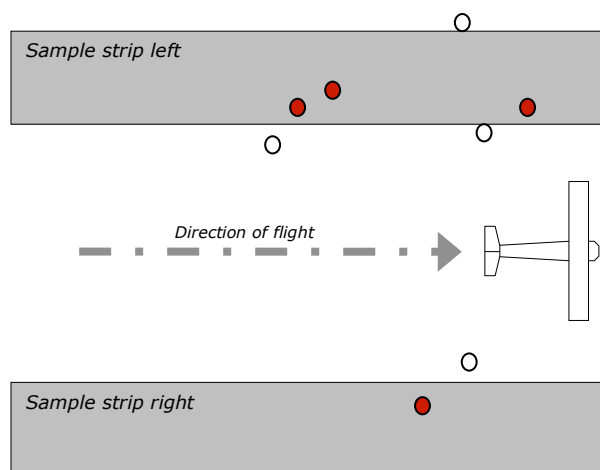


Figure 1: Dual counting strips along flight line.

The objects that lie within the sample area (grey strips) would be counted, and are indicated in filled circles (red); the objects outside the sample (hollow circles) are not counted.

Density is then calculated from:

- Numbers seen in the strip;
- Area of strip.

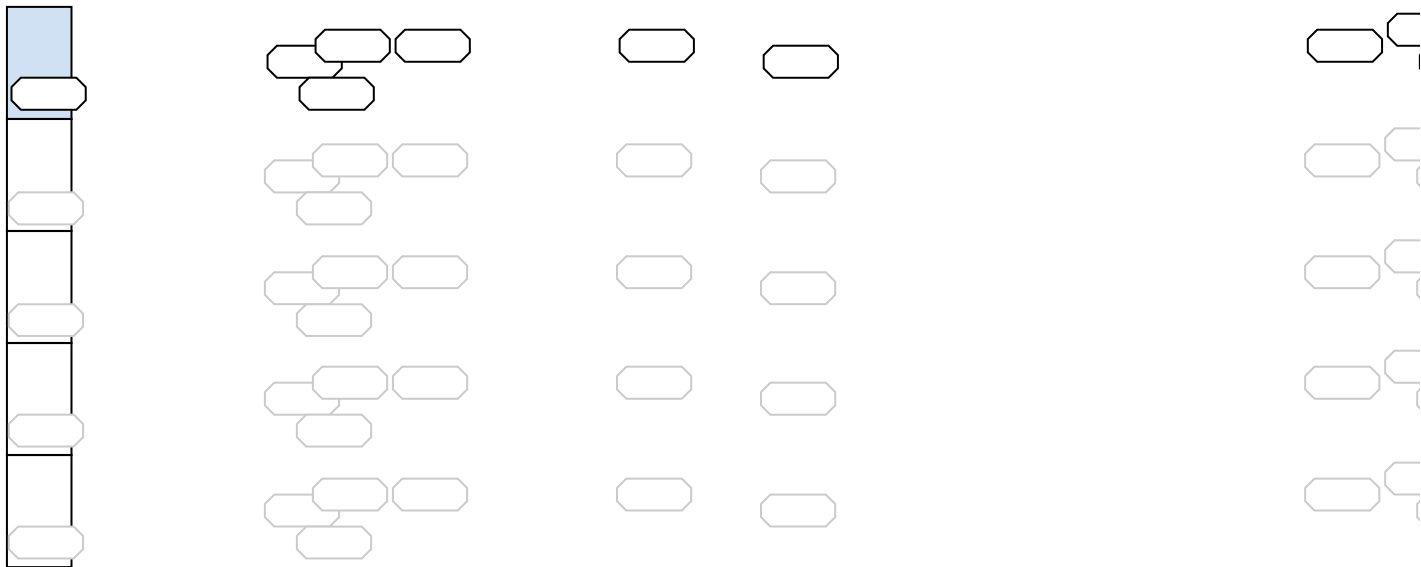


Figure 2: Counts are made in single transect, multiplied up to make estimate.

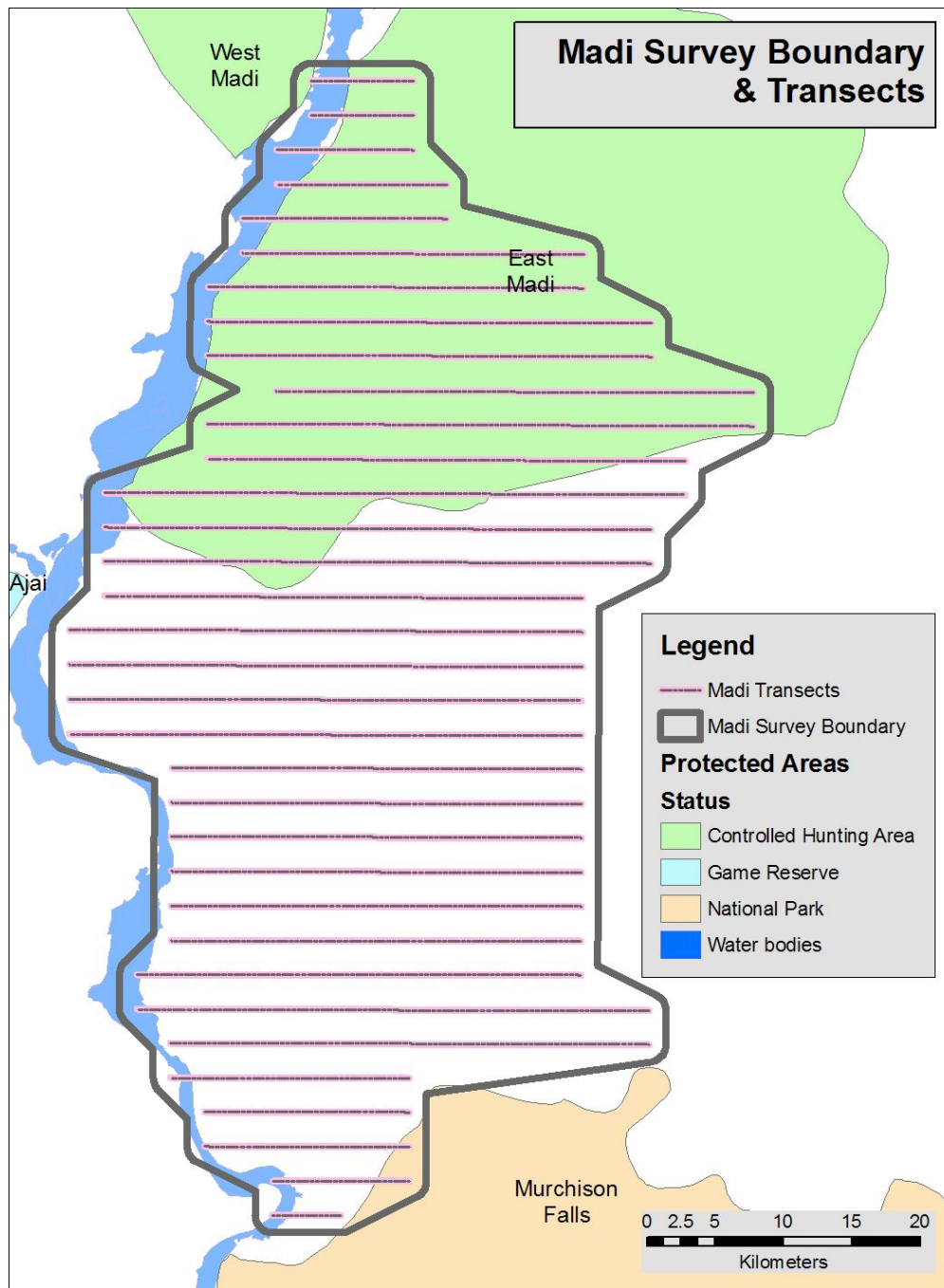


Figure 3: Example of survey boundary and transects flown.



Figure 4: Parallel streamers on Cessna wing strut, and view of strip.

The counting strips on each side of the aircraft are defined by parallel rods fixed to the aircraft wing struts (the red, straight rods in Figure 4). Observers count only the animals that are seen in between these rods.

2.2 Planning & Logistics

Survey planning should begin at least several months in advance. Aircraft and crew availability should be confirmed as soon as a survey is proposed, and provisional notification made so that the aircraft operator and the survey crew can 'block out' the time in their schedules. Draft survey plans, expected outputs and budgets should be reviewed as early as possible and confirmed.

Components:

- Determination of survey boundaries.
- Scheduling of crew & aircraft availability
- Flight & survey permissions & notifications to managers
- Budgeting (software tool) for money and time requirements
- Logistics: equipment, fuel, accommodation, ground support, food.
- Survey design: transect allocation for accuracy and precision.
- Timing of survey for seasonal limitations and equivalence with previous surveys.

2.2.1 Notifications

Once schedules are approximately known, it is important to send notifications to area managers and confirm permissions from authorities.

- The Civil Aviation Authority and military may require special permissions for low-level aerial survey;
- Protected areas under the management of other agencies than your own may require special permission from various offices and these permissions should be sought early on.

One step which is often forgotten about is to inform other conservation actors in the area – researchers with an interest in the ecosystem and organisations involved in conservation. These other parties are often very interested in the conduct and outcome of these surveys, and may be able to offer valuable advice as to planning or even fundraising.

2.2.2 Equipment list

See Appendix (section **Error! Reference source not found.**) for the master equipment list. This should be reviewed at least one month before the survey. In particular you need to confirm access to specialised equipment such as the streamers and GPS units.

Forms, general stationery and other equipment should be again reviewed and prepared one to two weeks before the crew is to depart to the field.

2.2.3 Survey design

In many cases a survey design will already exist, and the same survey plan has been flown many times before. It may be necessary to redesign some surveys or survey entirely new areas, so this section covers the principles of basic survey design and layout of transects.

There are several main considerations:

- Survey boundaries: what area are we interested in? Has it changed from the past?
- Financial: how much money is available? This is unfortunately usually the main limiting factor.
- Time: when should the survey be scheduled? How much time is available to complete it once started? It is important to finish a survey quickly so that changes in ecological conditions and animal movements are minimised.
- Aircraft and crew availability: the number of aircraft available for a large survey area is extremely important, and the likely availability of aircraft must be researched early on (see Aircraft, 2.2.4.1)
- What species populations are being estimated? If a previous design has been used, were the errors around estimates very large? If so it may be better to redesign the survey.

Caution!

- Good survey design can save a huge amount of time and money, and bad survey design can give you entirely inappropriate results. Though the instructions here attempt to be complete, it is worthwhile passing any survey design by a statistician or specialist in surveys.
- Here, we present some basic principles of designing a sample count. For a more complete discussion of the theory behind sample counts, read Norton-Griffiths (1978), Jachmann (2001) and review the suggested literature in the Bibliography (section 5.4).

2.2.3.1 Basic principles

1. You should attempt to have a minimum of 20 transects in a given survey block or stratum, and better yet 30 or more.
2. In general, the more transects you have, the greater the precision you will have, but there is a principle of 'diminishing returns' above a certain point. Jachmann (2001) notes that with elephant sample counts, greater than 10% coverage (area sampled compared to whole survey block) gives very little added benefit; one should try to have more than 5% coverage.
3. Transects should cut across ecological gradients or gradients of known wildlife density (Figure 5).
4. Stratification into ecological zones and density areas may greatly enhance the precision of the final result. Stratification however can rarely be made for more than one species in any survey design, unless they tend to be found in the same habitats.

Terminology

- Intensity: the amount of work that goes into a sample count – refers to more transects and/or a greater percentage of area sampled. Note that those are NOT necessarily the same thing (Figure 6)!
- “Coverage” usually refers to the percentage of area sampled (total strip width) divided by the total area. Most surveys use 5 to 10% coverage, though lower (1%) and higher (20%) are seen. This is a direct function of strip width and spacing between transects.
- Home base: this is where the aircraft is based when it’s not on surveys with you (i.e. Kampala, Iringa (Tz), etc.).
- Field base: the airstrip in the field where the aircraft operates from.
- Ferry: the trip from home base to the field base.
- Transect: the actual flight line flown while counting animals.
- Transit: the ‘dead time’ from the field base to the beginning of the transect.
- Dry cost: the hourly cost of flying an aircraft excluding fuel – maintenance, insurance, etc. This is usually quoted by the operator.
- Wet cost: the hourly cost of flying an aircraft in total, all inclusive. Operators will often charge a fixed ‘positioning’ fee on top of this.

2.2.3.2 Delineate survey boundaries

This is the first stage of examining an area: what area do we want to look at, why, and what are we expecting to find? It is extremely important to use local knowledge of the survey area to design the boundaries – a protected area ecologist, warden, researchers with long experience of the area.

- Previous surveys may have been done in the area, and you should review the history of surveys and wildlife in the area.
- What are the target species? Where are they found?
- Were previous survey boundaries adequate? Often survey reports will indicate if the next survey should include other areas, or exclude them – this is a message for you as the next survey designer!
- Have ecological conditions changed, warranting a change in the survey area? Wildlife may be known to have reduced or extended its range, or agriculture may have taken over a large part of the area.
- Does the survey adequately cover protected areas?
- Are there special requests from donors, researchers, or wardens?

Once you have an idea of the above questions:

1. Draw the survey boundaries.
2. If the survey covers a protected area, ensure that a buffer is included around its boundaries (2-5 km).
3. Calculate the area using GIS software or on paper.

2.2.3.3 Determine survey intensity and strata

Stratification of a survey area involves dividing the survey area into zones of different survey intensity – this may be done to increase accuracy (focussing on areas of higher animal abundance) or for reconnaissance of previously unsurveyed areas, for example.

Surveying areas of higher abundance at a higher intensity and vice-versa maximises the value of your time and money. Jachmann (2001) suggests that a difference of density by a factor of three makes it worthwhile to consider stratification; however, he also notes that the spatial variation in density between species is never constant, and one species' stratification may not be suitable for another.

Dividing the survey area into ecological or other units that are sampled individually can make for a more manageable survey. This typically means survey blocks of 4-5,000 km².

Transect spacing is often made to fit the UTM grid – 1 km, 2.5, 5, 10 or 20 km spacings are typical. This is dependent on the available budget and the number of transects needed.

2.2.3.4 *Transect orientation*

In a survey block (or stratum), transect orientation describes the direction of flight of the aircraft – i.e. north-south, east-west, or 125°-305°.

Most surveys have traditionally used an east-west or north-south orientation, for ease of navigation and sometimes to enable easy assignment of observations to UTM grid squares.

Transect orientation should be thought about carefully, and the following rules and illustrations show why:

- **Orient transects east-west unless you have a good reason to do otherwise:** flying east-west means that the pilot and FSO face the sun on alternating transects, but not the rear seat observers. This is important to improve visibility by the RSOs. A non-east-west transect would cause problems:
 - One RSO would always have the sun in their eyes;
 - Even minor glare on an old Cessna window usually makes it fog up badly, also reducing visibility;
 - Animals often stand in the shade of trees, and on a north-south transect they would always be hidden or the observer would be looking into the deep shade (in contrast, flying east-west would give a chance to see the animal in profile).
- **Transects should cut across ecological or density gradients:** precision partly relies on having the same number of animals in every transect, so it is better to sample from one density to another in each transect, if possible (Figure 5).
 - If you have old survey data, you can plot the density of animals across the survey area and look for patterns.
 - During the dry season, rivers and other water bodies almost always create gradients from low (dry) to high (wet) areas; in the absence of other information, plan transects to cut across rivers and wetlands.
- **Maximise the number of samples by drawing them perpendicular to the long axis of the survey area:** this has a big effect on a long narrow survey zone (Figure 6).
- **In areas of strong wind, the transects should be laid out to fly parallel with the prevailing winds.**

- A strong crosswind causes the plane to 'crab' (fly at an angle) and this is both tiring for the pilots and causes the strip to be increased by an unknown amount.
- It may be better to simply choose times of day or of the year with less wind, as flying in strong winds will also change your ground speed beyond controllable levels.

On a recent WCS survey in Malawi, the aircraft was forced to fly at a ground speed of 240 km/h on the downwind legs (with full flaps), and could manage no more than 150 km/h on the upwind (no flaps and full power!). A ground speed of 150 km/h is a nice leisurely pace to see everything, but 240 km/h is far too fast and observations are missed.

Caution!

- Ensure that the ecological conditions you are using to design transect layout and stratification are current for the season when you plan to survey, and are recent enough to be valuable (don't use data from twenty years ago without having a good look at possible changes).

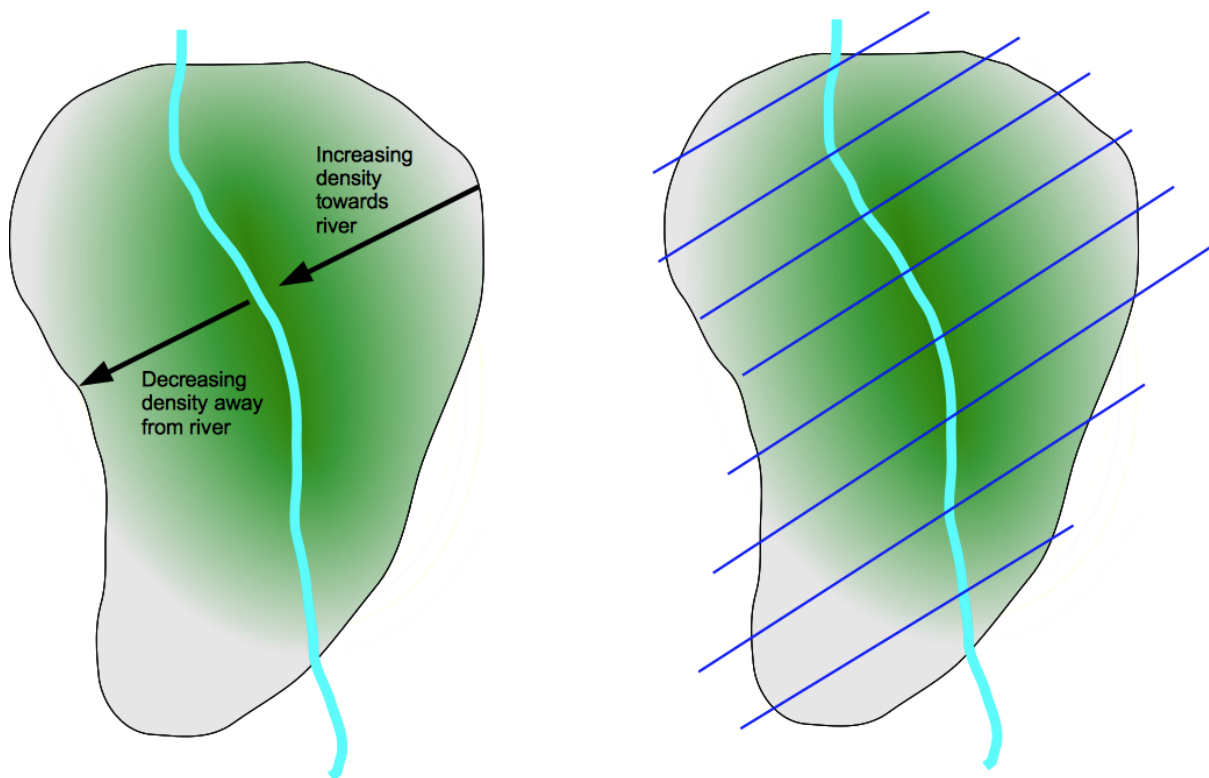


Figure 5: Orient transects perpendicular to ecological or density gradients.

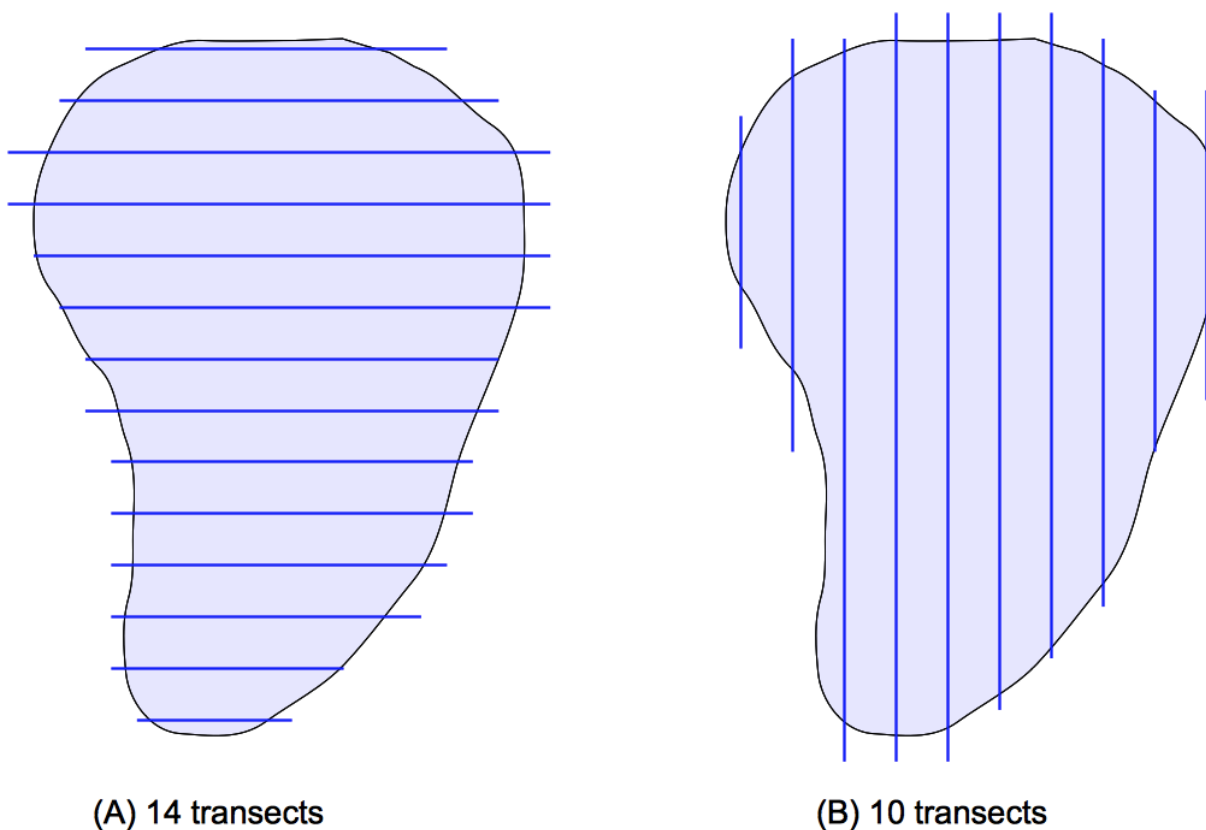


Figure 6: Maximising number of samples through transect orientation.

Note that the transect length and sample area should be about the same in both cases, but the number of samples is increased.

2.2.3.5 Allocate transects & create draft flight plans

Transects are allocated before the survey begins; flight plans are usually worked out on a day-to-day basis with the pilots, but advance planning can, again, be very valuable in terms of time and resources.

In brief, transects are laid out using a GIS system and data:

- For each survey block, draw a 'baseline' perpendicular to the orientation of the transects.
- Transects are laid out perpendicularly to this baseline on a regular interval, either geographic (lat-lon) or UTM (metres).
- Though the interval between transects is regular within a block, the starting point may be chosen randomly or alternatively from an even coordinate.
- Start and end points are selected from one edge of the survey area to the other.

Standards for transects:

- Transects should take no more than 45 minutes, ideally no more than 30. Long transects (>45 minutes) may be broken into smaller pieces; this may be done at natural features such as hills, or even rivers, if the rivers are wide enough to be a barrier to animal movement.
- Check the terrain: strongly undulating terrain or mountains is difficult or impossible to fly over, and may have to be excluded. Review with a pilot. Large areas of difficult terrain that may still be flown should either be counted as a block count or at least sampled and analysed as a separate stratum.



The following instructions are one way of allocating transects along systematic UTM lines, as per the method used by Uganda Wildlife Authority (UWA) and WCS Uganda. QGIS instructions are included here as it is a free package that can do everything required; ArcGIS will also work well. For this example a set of transects will be placed on the Madi area using UTM zone 36 (example data available on the website), for east-west transects at 5 km spacing, and 2.5km between subunits.

Prepare QGIS with the correct plugins:

1. Start QGIS and ensure you are online;
2. Select Plugins: Fetch Python Plugins
3. Go to the Repositories tab and click "Add 3rd Party Repositories", then OK. The plugin list will load from the online sites.
4. Go to the Plugins tab and type fTools in the Filter box. Select fTools from the list and click Install/upgrade plugin to install it.
5. You will now have a new menu called Vector with a set of really useful tools for editing and processing the map – these are used below to generate a grid and extract properties from the map.

Digitise transects and create endpoints:

1. Open QGIS.
2. Set the project properties to UTM:

- a. **File:Project Properties...**
 - b. **Coordinate Reference System** tab: enable "**on the fly CRS**", and select "**WGS 80 / UTM zone 36N**" in the list.
 - c. Click **OK**.
3. Add the map of your survey area:
 - a. Click  **Add Vector Layer**, **Browse** to select the .SHP file, and click **Open**.
4. Make sure the added layer is displaying correctly; you must know what its datum was, and set it:
 - a. Right-click on the shapefile in the "**Layers**" list on the left, and select **Properties**;
 - b. Select **General** from the list on the left, then click **Specify CRS**. In this example I know that my shapefile is in Lat-Lon WGS84, and I select this from the list, then press **OK**.
 - c. Press OK to confirm the layer properties.
5. Zoom to the layer: click  or right-click the layer and select "**Zoom to layer**".
6. Add a buffer if necessary (if your shapefile does not already include one):
 - a. **Vector: Geoprocessing Tools: Buffer(s)**
 - b. Indicate the buffer distance in metres (i.e. 2500);
 - c. Choose a filename and location;
 - d. Click OK and then accept addition of the buffer to the view.
7. Determine the E-W and N-S extents of the survey boundary:
 - a. Y Max: Position the mouse over the northernmost edge of the survey boundary and read the second (Y or northing) number in the **Coordinates** box at the bottom of the screen. Round this up to the nearest multiple of 10,000 – i.e. if you get 442,000 make Y-Max = 450,000.
 - b. Y Min: do the same at the southernmost edge, but round down – i.e. if you have 394,200 make this 390,000.
 - c. X Max: do the same for the easternmost edge, and round up;
 - d. X Min: do the same for the westernmost edge, and round down.
8. Create a regular grid of points:
 - a. Select **Vector: Research Tools: Regular Points**
 - b. Click the **Input Coordinates** radio button then enter the values from the last step in the labelled boxes.
 - c. Select a **spacing value** (in metres) – we want to have subunits (east-west) on a 2.5 km interval, and will use this as the minimum as the 5km spacing is a multiple (if you plan to use a different, non-multiple spacing, a different method will have to be used, as QGIS does not allow for different X and Y spacing values).
 - d. Click **Browse** and choose a location and name for the file, e.g. **Madi_points**.
 - e. Click **OK** then confirm to add the new layer to the view.

- f. Right click the new layer and select **Properties**, then **Symbology** and change the symbol size to 1 (or as required to make it display nicely). Press OK.
9. Set 'snapping' so that created lines will line up exactly with your grid.
 - a. **File: Document Properties**, select the **General** tab, then **Snapping options**.
 - b. Tick the box next to the point layer, then select a **Tolerance** – I suggest 8 pixels (change this from 'map units') (the higher the tolerance, the further away from the point the cursor will 'snap').
 - c. Click **OK**, then **OK** to return to the map.
10. Make a new shapefile for the transects.
 - a. **Layer: New: New Shapefile Layer ...**
 - b. Choose 'line'
 - c. Choose the **CRS** (UTM zone 36N, WGS 84),.
 - d. Add one attribute: **Name** "Transect", **Type** "Whole Number", then click Add to Attributes list.
 - e. Choose name for the file and location (**Browse**)
 - f. **OK**
11. Edit and digitise the transects.
 - a. Right-click and select **Toggle Editing**.
 - b. Click a point to start each transect, and right-click to stop at the end.
 - c. Draw the lines from point to point, starting and ending at the closest points in line that are just outside the survey zone. Click close to the points (within the 8 pixels (screen dots) as suggested above) and they will line up exactly. If they look out of line, redo the line (control-Z to undo).
 - d. Each line will now be a multiple of 2.5km long; make sure that you select lines that are 5km apart, though.
12. Calculate transect numbers:
 - a. Right-click the layer and select **Open Attribute Table**.
 - b. You should still be editing, but click **Toggle Editing Mode** (pen icon) below if not;
 - c. Click the calculator icon to bring up the calculation window;
 - d. Select "**update existing field**" and confirm **Transect** is selected;
 - e. Click the **rownum** button, then type "*** 10**" in the **Field Calculator Expression** box just after the rownum text.
 - f. **OK**
13. Calculate transect lengths
 - a. Click the calculator icon to bring up the calculation window;
 - b. In the "**Output field name**" enter "Length";
 - c. Click the **length** button, then type "**/ 1000**" in the **Field Calculator Expression** box just after the length text (this calculates the length in kilometres instead of metres).
 - d. **OK**.
14. Stop editing (click **Toggle Edit** button again) and confirm to save the file.

15. Make a layer with start and end points:

- a. Select **Vector: Geometry Tools: Extract Nodes**
- b. Select the name of the transect layer, then Browse to select the name of the point layer you will create. Click OK.

At this point you have a transect shapefile and an endpoint shapefile which may be uploaded to a GPS (see the section on GPS data, 5.6).

Tips


- Before spending too much time on allocation of transects in your survey blocks, consider the next section on budgeting. Having calculated the survey intensity in the previous section, and thus the total flying hours, lets you do more accurate financial planning; it may be that you have to go back to previous steps if your budget is limited, or even if it turns out that you have a budget sufficient to cover a wider area!
- Using an even-number starting point in UTM or Lat-Lon can make it easier for the pilot to navigate.
- If you want to start on a different N-S point, select a different Y-Min (southernmost) point and QGIS will calculate points starting up from there.
- If transects are numbered with multiples of 10, you can add additional adjacent transects in between or at the ends of other transects and give them similar names, i.e. 11, 15. This is especially useful when you have to break a transect and fly the remainder on another day. As it becomes a separate sample, it needs a separate number!

When learning about statistical sampling, you may have had it drummed into you by lecturers that one should try to do random sampling, choosing plots and transects at random locations across the area of interest – why, then, do we here suggest laying out systematic transects on set intervals?

Random sampling is meant to remove biases caused by prior selection of survey areas – to stop the way in which we choose samples from affecting our results. Systematic sampling, relative to distances along a baseline, is still random with respect to the distribution of wildlife! Unless, of course, the animals are somehow lining themselves up with latitude/longitude lines ... this could conceivably happen if there are human landscape features on the same grid, such as roads or fences, but this is very unlikely.

2.2.3.6 Subunit Allocation

The following instructions again rely on the plugins installed previously.

1. Ensure you have your transect and 2.5km grid loaded, as in the previous examples.
 - a. If not, add them ( **add vector layer** button) (e.g. Madi Points and Transects from the example above).
2. Make a new shapefile composed of the points that intersect your transects, and that have the number of the transect included:
 - a. Intersect tool: **Vector: Geoprocessing Tools: Intersect**
 - b. The **Input vector layer** should be the points layer;

- c. The **Intersect layer** should be the transect layer;
 - d. **Browse** to select a new shapefile name.
 - e. Click OK, and confirm to add the file to the view.
3. This subunit file may be uploaded to the FSO GPS to show the edges of subunits.

Caution

- These instructions work for setting up a new survey area. In Uganda many survey zones already have survey boundaries and subunits allocated.

2.2.4 Budget

In a perfect world, we would have an unlimited amount of money available to do our wildlife surveys – in this case we would look at the desired survey intensity and area and simply submit a budget. In reality this usually happens the other way around, or becomes a process of negotiation. It is often necessary to come up with a rough survey plan and budget, then go back to donors or financial managers and figure out what might be possible, then go back and trim or expand your initial survey plan on that basis.

The details of organisational budgeting are beyond the scope of this manual (though this is a section that should be developed), as are the details of field budgets for the various protected areas. However, the largest part of a survey budget is almost always the aircraft, crew and fuel, and this manual presents a budgeting tool for development of survey costs estimates.

It is possible to do basic budgeting with the following information:

1. Target survey area size;
2. Average survey intensity (if you are stratifying, this is the average for the whole survey area);
3. Fuel costs per litre and/or hourly costs for aircraft;
4. Aircraft home base and field base positions;
5. Crew costs per day.

2.2.4.1 Aircraft

Use the “SRF Budget Tool 0.1.xlsx” from the Counting Animals website or the CD included with this manual. <http://countinganimals.underdiverwaterman.com>

Things you must know to get a decent estimate:

- Transect kilometres to be flown = $(\text{area of survey})/(\text{average spacing})$
- Fuel cost per litre, and cost of getting fuel to the site.
- Aircraft cost: if you are quoted a “dry” cost (without fuel), you still need to figure out fuel; if you are quoted a “wet” cost, fuel cost is included and is not a consideration BUT you still need to plan for the number of drums needed on site and their transport costs to the site.
- Home base location for aircraft and location of field bases.

Instructions: each number (after 0) here refers to the label on the spreadsheet (1-13):

0. Open the spreadsheet tool (this works in both Excel and OpenOffice).

As with other software tools, the cells highlighted in green are the variables you should fill in and change. In this case, the bright green cells are the ones which have a very large impact on the final cost; the cells in darker green have less of an impact but are still important to fill in properly.

1. If the aircraft provider has given you a dry cost, enter this here. If there is no per-hour cost for the aircraft, enter 0.
2. Fuel consumption is typically 55 litres/hour for a Cessna 182 and 65/hour for a Cessna 206; check with the provider, as it may vary considerably from this.
3. The number of aircraft available has an enormous impact on the cost and time required. Enter the likely figure, then play by increasing or reducing it – it is often surprising just how much this affects the final numbers!
4. Fuel cost (in USD) per litre, excluding positioning costs. If you have been given a wet cost (fuel included in aircraft cost), put 0 here.
5. How far is it for the aircraft to come from home base to the field? This will probably be given to you by the operator, but can be estimated off the map.
6. How many km of transects are likely to be flown? Divide the survey area by the average spacing. It's a good idea to add a bit (20%) if you are unsure about spacing in the case of stratification.
7. How long is a typical transect? Measure this on the map or from old survey reports.
8. How long does it take to turn the aircraft at the end of a transect? This is a minor effect and can be left at 2 minutes.
9. How long does it take to go from the field base (airstrip) to the beginning of transects? The easy way to estimate this is to draw a line two-thirds of the way to the survey boundaries from each field base, and take the average from north, south, east and west directions. Divide this average distance (in km) by 180 (the speed) and multiply by two (for return flight) to get this average transit time.
10. Flying speed should be 180 km/h on average.
11. How many hours per day will be spent actually counting animals? This is the transect flying time excluding transit, i.e. the amount of time the RSOs are counting. This should NOT exceed 5.5 hours (e.g. 3 in the morning, 2.5 in the afternoon), and is often realistically about 5 hours.
12. Positioning time is the amount of time required before and after the survey for getting the aircraft into position; this means added days of crew fees.
13. What is the cost of the pilot, per day? This may be an allowance or other fee (local currency).
14. What is the observer (FSO / RSO) fee per day (local currency)?
15. What is the USD rate?

After entering or checking all of these numbers, the system gives you some really important numbers! These are listed in order as they are found on the sheet (see example in Figure 7), with the most crucial figures highlighted in boxes:

- **Survey days:** how many aircraft-days will actually be spent surveying, total?

- **Work days:** This previous figure is aircraft days so if you have more aircraft, this is the number of days that will be actually worked in the field.
- **Rest days:** assuming 4 days working / 1 day off (a good assumption and rest days should always be planned anyway), how many 'down' days are there?

• **Total time on survey:** this is the total amount of time estimated to have the team and aircraft in the field.

• **Total km:** total of all survey km flown (operators may ask for this for budgeting).

• **Ferry:** km to send aircraft back and forth to home base.

• **Hours:** total flying hours for the aircraft, from the time they leave home to the time they return (i.e. including ferry, transit and transect flying).

• **Fuel:** the number of litres of fuel needed for the whole project.

• **Drums:** assuming 200L drums of fuel, this is how many you should need.

• **Pilot / observers:** the number of person-days you'll need to feed, water and accommodate the crew.

• **Crew:** the USD cost of the crew (pilots + observers) for the entire survey, including positioning time.

• **Fuel:** the exact USD cost of fuel used (if you are using drums, multiply the drum cost times the number of drums instead).

• **Aircraft dry cost:** based on the number of hours, the cost of the aircraft excluding fuel.

Category / Items		Units	Notes
Aircraft			
Dry cost (1)	350	hr	Base cost per hour to fly aircraft (typically \$350 for C182)
Fuel consumption (2)	60	lt/hr	Cessna 182- 55/hr; C206 - 65/hr (max figures)
No. aircraft (3)	1	planes	Huge effect on no. days for large surveys.
Fuel cost (4)	2	Per litre	Price of fuel, without positioning costs.
Survey			
Home-base roundtrip (5)	3,000	km	Travel from aircraft's home base to survey area.
Transect km (6)	9,000	km	Total km of transects (quick calc: km2/avg spacing)
Average length (7)	60	km	Maximum 45 minutes = 135km, better <100km
Turns	150	turns	
Avg. turn (8)	2.00	min	Dependent on spacing; 2 minute average is fine.
Average transit time (9)	1.00	hr	Roundtrip base to begin/end transect.
Speed (10)	180	km/hr	Ideally 170-180, typically 190. *
Transect hours	50.00	hr	
Survey/day (11)	5.00	hr	3 hrs morning / 2.5 afternoon LARGE
Survey days	10.00	Days	Total days of flying required on survey (transect + transit).
Work days	10.00	Days	Days of flying
Rest time	2.00	Days	Days off (4 days on, 1 day off)
TOTAL TIME ON SURVEY	12.00	Days	
TOTAL KM	11,700.00	km	Total km flown on survey - transect, turns, transit.
Ferry	3,000.00		Km flown by all aircraft to get to and return from home base.
Hours	81.67		Total hours of flying
Fuel	4,900	Litres	Fuel requirements
	25.00	Drums	Drums of fuel required (rounded up)
Staff			
Positioning time (12)	2	days	Total days before and after for setup / packing up.
Pilot	14	Days	
Observers	42	Days	
Pilot daily fee(13)	250,000	per day	Local currency cost / day
Observer daily allowance (14)	200,000	per day	Local currency cost / day
USD Rate	5,000	rate	Local currency in USD (15)

Figure 7: Budget tool example.

Caution!

- These figures must, as always, be looked at carefully to see if they are realistic. What did previous surveys cost? Are there conditions that don't apply to this sheet?
- It is worthwhile adding a contingency fee of at least 20% to the final estimate.
- Aircraft maintenance intervals can add a lot of cost: ferry flights back to home base, extra down days for crew in the field, etc. This is NOT included in this estimate, and for a large survey extra ferry and 'positioning' costs should be estimated more accurately.

2.2.4.2 Time

The estimates for time in the field should now be considered together with the availability of crew and aircraft and the seasonal requirements for doing the survey.

2.2.4.3 Other costs

There are many other considerations for planning a survey which are not included in detail in this manual. A brief checklist follows:

1. Fuel positioning costs: how will you get fuel drums to the field bases? Is there a fuel drum deposit cost?
2. Food and accommodation for crew and ground staff.
3. Security for aircraft from the elements and/or theft.
4. Power for laptops.
5. Batteries for GPS and other equipment – it is usually worth buying a good set of rechargeable batteries; they pay for themselves within a couple of weeks and reduce waste in the field.

2.3 Crew

Experience and diligence are extremely important in proper conduction of any scientific enterprise, and this is no exception. Consistency of method is vital for accuracy and for analysis of long-term trends, and each member of the crew must meet certain standards.

Selection of experienced and capable staff is vital – it is important for the entire crew to function well together and for the data produced to be reliable and properly recorded. Pilots must be able to fly the transect plan with good height and speed control, RSOs must be able to recognise all the species in the target area, have good vision and endurance, and FSOs must be able to accurately and reliably record height data and assist the pilot in navigation.

However, it is also important to balance the need for experienced staff with the need to give experience to junior staff, and to involve the ecological staff of a given protected area in surveys. Accordingly it may be necessary to allocate extra time for training, both on the ground and in the air.

2.3.1 Pilots

The pilot is responsible for flying the aircraft, navigating to, from and along transects, and for the safety of the crew.

A commercial license is not necessarily a legal requirement for survey flying, depending on the status of the aircraft. However, a pilot should have a minimum of:

- 200 hours of PIC (pilot in charge) hours logged;
- 20 hours of survey flying at low level, with a proven ability to maintain 350 feet a.g.l. and keep ground speed at or near 180km/h even with a moderate tailwind.

Where the pilot does not have sufficient survey flying experience, he/she should be paired with an experienced pilot who can act as FSO and assist and train the primary pilot; alternatively he/she may take the FSO (co-pilot's) position and alternate flying with FSO duties under the instruction of the PIC.

2.3.2 Front Seat Observers

The Front Seat Observer records height above ground from the radar altimeter, assists the pilot in navigation, and calls out beginning and end of transects and subunits to the rest of the crew.

Experience of the FSO position is less crucial than other crew duties, and is an excellent starting point for inexperienced staff. However, FSOs should be at a minimum able to:

- Use a GPS effectively;
- Understand map reading and basic navigation;
- Be able to write and communicate clearly.

2.3.3 Rear Seat Observers

Rear Seat Observers (RSOs) are responsible for spotting and enumerating animals in the strip. They watch carefully for animals in the strip ahead of the aircraft and within the strip next to them, and use cameras to photograph larger groups of animals.

RSOs must be able to:

- Identify all species in the target area with 100% accuracy;
- Have the endurance to count for up to three hour counting sessions;
- Be able to reliably operate cameras and estimate groups in the counting strip.

RSOs must have a minimum of 4 hours of training, and have been checked by the monitoring ecologist as to accuracy (recognition) and diligence in spotting (during training or test flights).

Where the RSO has not flown within 9 months, a minimum of two hours of training must be allocated at the beginning of the survey, flying full practice transects.

2.3.4 Ground coordinators

The ground coordinator's position may often be taken as a 'second hat' by one of the crew, often the FSO. It is extremely important that the duties outlined here are followed, whether someone is appointed to the GC position or whether it is done by another crewmember.

The GC:

- briefs the pilot and crew on the day's survey plan;
- uploads GPS points to the FSO and pilot GPSs;
- downloads track and point data from the GPSs on return;
- receives and checks the FSO data;
- stands by and assists the RSOs with transcription of their data;
- assists with camp logistics and planning for aircraft fuelling.

2.3.5 Training

Time must be allocated before the survey for training and familiarisation. At a minimum, even when staff members are experienced and have had aerial survey experience within 12 months:

- Review of all species in the area, and discussion about habitats and movement patterns;
- Two-hour flight session with open microphones, spotting and discussing the sightings and observations made.
- Practice with cameras during that flight session and confirmation by senior officer that photographs are properly taken, and no groups >20 animals missed.
- Review of training slides with animal numbers for practice in counting groups.

- Testing by senior officer with slides: estimation & species recognition. Species recognition must be 100%, and estimation of groups within +/- 20%.

Where RSOs have not had experience in aerial survey:

- Training in counting groups and identifying species in the target area, ½ day minimum.
- 3 x 2.5 hour flight sessions, practicing calibration (1 session) and spotting techniques (2 sessions).
- Testing by senior officer, as above.

2.4 Fieldwork

2.4.1 Calibration

Calibrating the aircraft is one of the most crucial aspects of an SRF, and the most problematic to get right. Calibration does three things:

- Allows calculation of a regression of flying height and strip width, so that any observation's strip area and thus density of observations can be known;
- Confirms correct operation of the radar altimeter;
- Checks elements of observer consistency and ability.

The process of calibration involves:

1. Setting up a line of markers on the ground at known intervals, which will be counted from the air;
2. Affixing streamers (stiff rods) to the struts of the aircraft so that they are clearly visible to the rear seat observer, not blocked by the wheel, and approximately the correct position for a 150m strip width;
3. The aircraft flying repeated passes over the line of markers at heights from 250 to 450 feet above the ground, while recording the height from the radar altimeter and the number of markers seen by RSOs;
4. Analysis and verification of the RSO strip widths and radar altimeter function.

The instructions here refer to setting up an aircraft and airstrip for a target strip width of 150 metres on each side at a target flying height of 350 feet a.g.l. See the website for calculation of different target strip widths and for different flying heights; other strip widths in use in SRF include 180-200m and target heights of 300 or 400 feet.

Tip

To calculate the ratio for calibration at different heights and strip widths:

$$\text{ratio} = \frac{(\text{Target flying height (metres)})}{(\text{Target strip width (metres)})}$$

For example, at our usual flying height of 350 feet (divide by 3.28 = 106.7m):

$$\text{ratio} = \frac{150\text{m}}{106.7\text{m}} = 1.406$$

Caution!

If the calibration is made incorrectly, the ENTIRE survey will give the wrong results! This includes errors in the setup of markers or streamers, in the radar altimeter, or any movement or change in the observer positions. There are several ways in which this can happen:

1. Radar altimeter does not function correctly, and is not verified;
2. Observers do not correctly report or count markers during overflight;
3. FSO does not record correct radar altimeter height during pass over airfield;
4. Streamers get moved after calibration;
5. Observers change position after calibration.

Nos. 1 -3 are errors that get made during the calibration flight; 4 & 5 can be made any time. If calibration regressions and numbers are done incorrectly or used incorrectly, this will also ruin the calculations.

2.4.1.1 Setting up the markers

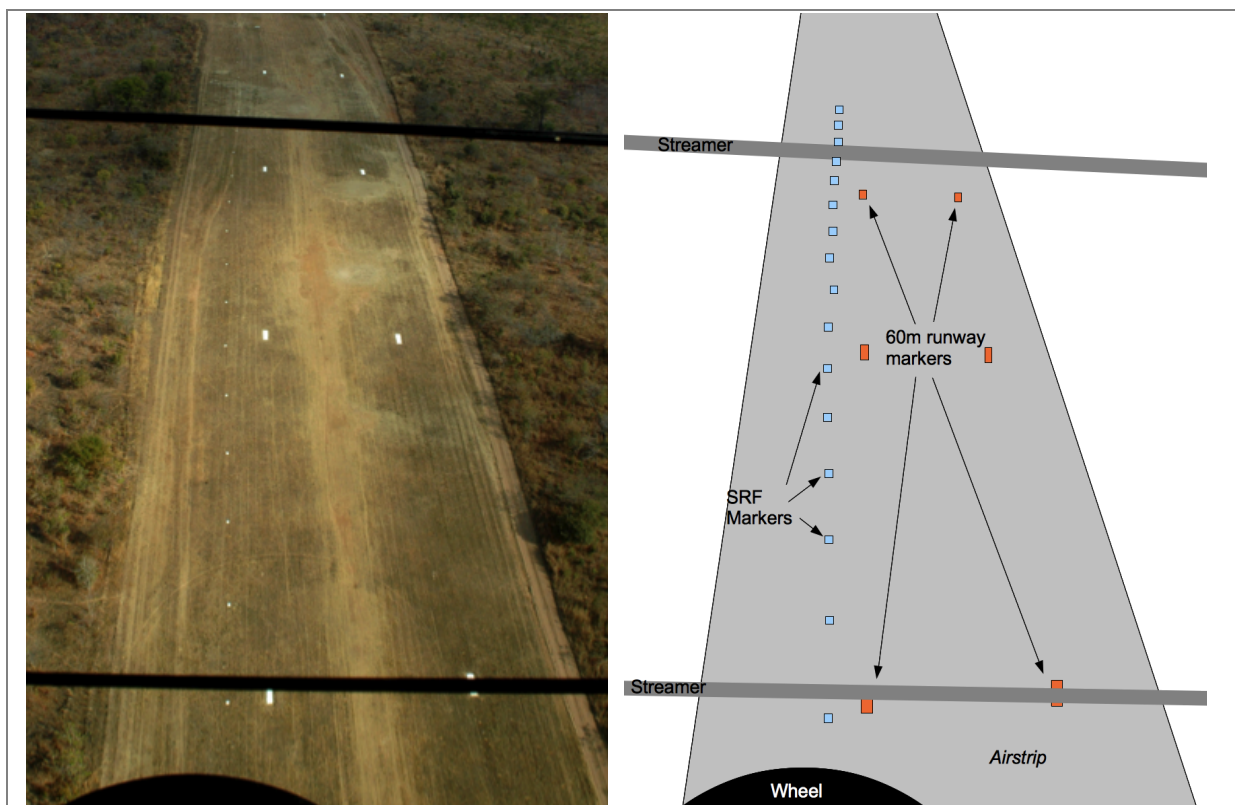


Figure X. A line of highly-visible markers is laid out at a defined interval along a straight line clearly visible from the air.

Requirements:

Suitable level area to place markers: Ideally each survey area should have its own set of markers, which are checked and renewed for each survey; this is often the local airstrip.

- Level ground with no more than 2-3° of slope;
- No trees or other cover close to marker positions - the markers must be visible from the air from any direction of approach.

Markers: Markers are simply objects that can be easily seen from the air, and should be of a suitable size and colour to stand out from half a kilometre. Markers should be a minimum of 50cm x 50cm in size.

- Permanent markers may be laid out parallel to runways or roads, and are usually cement blocks or large stones, painted white. These should be checked and renewed by survey staff on foot before every calibration.
- Temporary markers that have been successfully used include white-painted 3mm plywood sheets (50cm x 50cm), sets of white plastic bags weighted down with rocks and earth, or plastic buckets.

Length and spacing:

- A 1 kilometre line of markers is adequate, allowing each observer (left and right) to make simultaneous observations;

- 20 m spacing (50 markers over 1 km) is a good distance, giving 7-8 markers to count at the target strip width of 150m, a relatively easy number to count.

Materials Required

- Streamer units - parallel rods affixed to the wing strut by clamps.
- Screwdriver & wrenches for tightening & adjusting clamps;
- 10m tape measure;
- Electrical tape;
- Knife for trimming thin lines of electrical tape;
- Small builder's spirit level
- Spreadsheet or stats package

2.4.1.2 Setting up the aircraft

The aircraft is set up in the same angle that it will be in the air, and level ground chosen.

1. Position the aircraft on level ground in 'flight attitude', with the nose low. In most Cessnas, this will mean that the upper door frame is perfectly horizontal (use the builder's level).
2. Ensure that the ground to either side of the aircraft, to a distance of 4 metres, is also level.

Small changes in the level of the ground can have large consequences for the calibration, leading to strip widths that are larger or smaller than expected, and/or very different between the observers.

Tips & tricks

- Putting the aircraft into flight attitude can be done by digging a hole for the nose wheel or putting the nose wheel just off the edge of the tarmac on a runway.
- Confirming the level of the ground is easily checked by bringing your eye down to ground level and looking along a line parallel with the wings – the ground should be completely flat, neither rising nor falling along the line.

2.4.1.3 Setting up the streamers

Parallel rods are affixed to the wing struts of the aircraft at an approximate position for a 150m strip width for a single observer on each side.

Instructions:

1. Position the streamers on the wing strut of the aircraft – the clamps should be tightened enough so that they can still be moved (slid up and down the strut).
2. The RSO takes position in aircraft, in a comfortable position which he/she expects to keep for the duration of the survey. The RSO will indicate the correct position of the streamers from his/her perspective, from this single position.

The RSO should check that the position feels comfortable even at the end of the calibration; if you find yourself in a different position that feels more natural, and the streamer positions seem to have changed, it is worth re-starting the ground calibration measurements, instead of forcing yourself to sit in an uncomfortable position for days of survey.

Depending on the height of the observer and the aircraft configuration, the observer may not see the tire! In that case the streamer should be lined up with the bottom of the window.

3. Position the lower streamer as far down as possible without including the wheel of the aircraft within the strip (diagram to the right). From the perspective of the RSO, the streamer should just barely touch the top of the wheel.

This step lets the strip start as close as possible to the aircraft without being blocked by the wheel; the closer the animals within the strip, the better chance we have to see them.



4. Measure the exact height of the RSO's eye (C) from the ground directly beneath their position, in meters. (e.g., 1.35m).
5. Multiply the height of the observer's eye by 1.406 to obtain the length that should be measured on the ground (D).

Note: this "magic number" is only applicable when target flying height is 350 feet above ground (B) and target strip width is 150 metres (A), the suggested height for UWA surveys. If different, see appendix # for calculation of a different ratio.

Ex: $1.35 \text{ (eye ht.)} * 1.406 = 1.90 \text{ m (measured width on ground)}$

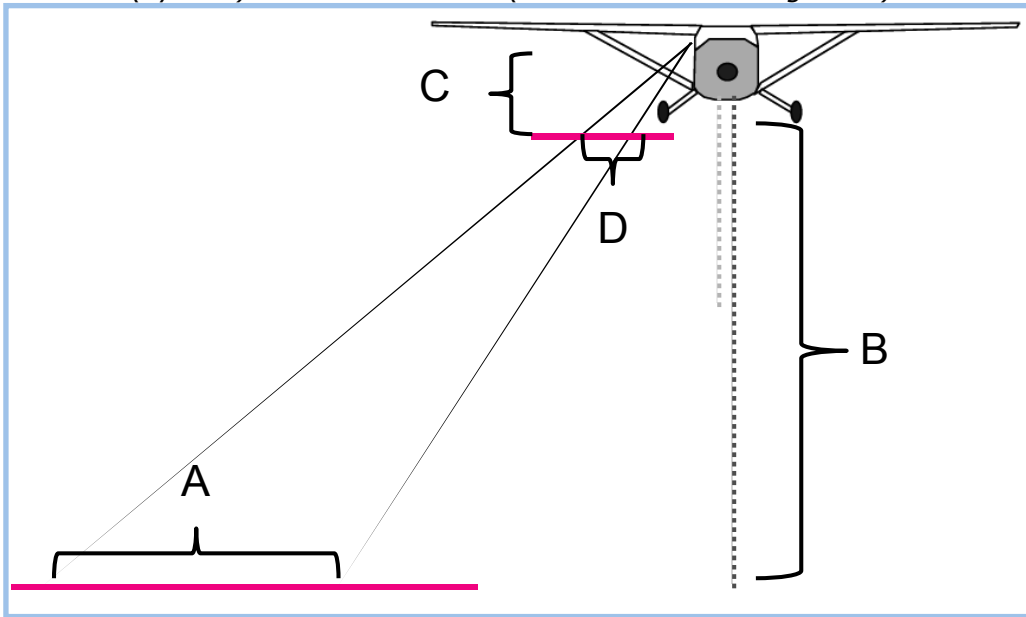


Figure 8: Measurement distances used to calibrate the aircraft.

B=height above ground (usually 350ft) and A is strip width (usually 150 metres).

- Place a thin, easily-visible object (i.e. a red pen or pencil) on the ground in line with the observer's eye, the streamer, and the top of the wheel.

The RSO should help to place the pencil so that from their perspective, the pencil lines up exactly with the wheel and lower streamer.

7. Lay the tape measure on the ground, with the "0" mark exactly at the pencil, and the tape measure extending perpendicularly from the aircraft. Measure the distance D and place a second pencil or mark at that point.

- Now have the RSO direct you as you move the upper or outer streamer so that it lines up with the second mark on the ground.

Note that in the first case you line up the pencil with the streamer, while in the second you line up the streamer with the pencil.

Do not remove the ground marks until you have finished tightening and confirming the streamers!

9. Cut two very thin strips of masking or electrical tape ~ 5 cm long. Have the RSO place these strips on the inside of the window. The first should line up with both the lower streamer and the pencil, the second with the upper streamer and the second pencil.

These strips are important because they let the RSO check their head position as he/she counts - the tape and streamers should line up as he/she counts.

10. Confirm with the RSO that both streamers are lined up, and tighten them into place.

After tightening, have the RSO check the position of the streamers again – the streamers may move as they get tightened, and require repeated adjustment.

11. Check to make sure (1) streamers don't wiggle (aside from their natural flex) and (2) that the streamers are parallel with each other and with the ground.

12. Mark the position of the streamers on the wing strut using pencil or electrical tape. This allows the crew to check and adjust the position of the

streamers before each flight (see the note on post-service calibration checks).

13. If camera mounts are available for the windows, fit them at this point and move them into position to be able to see both the ground marks and streamers in test photos (see section 2.4.2.1).
14. Repeat for the other side.

Tips & tricks

- To check that streamers are parallel, use the tape measure to measure the distance between them first near the clamps and then near the rod tips - they should be the same.
- The observer relaxes into his/her position and looks at tape and streamers, confirms position. DO NOT BE AFRAID TO REDO EVERYTHING if it looks strange!

2.4.1.4 Overflights

The aircraft makes passes at various heights above the airstrip. Crew record the pressure and radar altimeters and RSOs count the numbers of markers visible in their field of view.

Calibration involves flying several passes perpendicularly over an airstrip at known altitude, and recording the number of ground markers (i.e., strip width) that each RSO sees.

The aircraft will make four passes at each of several heights – 250, 350 and 450 feet a.g.l. – a minimum of twelve passes. An additional pass will be necessary each time an RSO is unable to give a good count (e.g., if the markers end within the RSO's observation strip). Immediately after the calibration flight, the FSO will give the calibration sheet to the monitoring ecologist, who will check for any observer problems.

The team should choose a time when the winds are low, and must choose a time when there is no crosswind as the aircraft crosses the markers. Winds and turbulence make it very difficult to maintain a given height and keep the wings level, and a crosswind leads to the aircraft crabbing at an angle across the markers, which increases strip width.

Requirements:

- Calibration form
- GPS
- Excel or suitable stats package.
- airsickness bags.

General instructions:

- All crew take their positions and RSOs confirm that their streamers appear to be normal.
- If the markers are at the same airstrip as the aircraft is based, the FSO should set the altimeter on his/her side to an even number just as the aircraft takes off.
- The pilot will make one or two practice passes to confirm the proper approach and target altitude across the airstrip.
- The FSO will help the pilot to keep track of the number of passes at each height. Four passes should be made at each height – 250, 350 and 450 feet a.g.l.
- As the aircraft comes up on the line of markers, the pilot or FSO will call out "ready to count!"; as the aircraft passes directly over the markers:
 - The FSO records the pressure altimeter reading and the radar altimeter reading;
 - The RSOs count the number of visible markers, and call the numbers out to the FSO when requested.

- Any crewmember may declare a 'no count' if they see problems with the aircraft diving or climbing, passing at an angle to the markers, or wings rolling, or any other reason.
- Once twelve successful counts have been made on each side without error, the aircraft may return to base.

Pilot:

1. Make passes over the airstrip at the target altitude; confirm with the FSO the target height for each pass.
2. Alert the FSO and RSOs as you approach the airstrip. When the plane is directly over airstrip, you or the FSO should call "NOW".
3. As the aircraft crosses, keep the wings of the aircraft as level as possible; rolling the aircraft causes huge changes in the perspective of the RSOs.
4. When you get close to the markers, fly a constant height, and do not chase the target height on the radar altimeter – it is not necessary to be exact, and far more important to maintain level flight and not pitch up or down.

FSO:

1. When the plane is directly over the airstrip (your or the pilot should call "NOW" at this point), read the pressure altimeter and radar altimeter readings and record on your data sheet (each reading recorded to nearest ten feet).
2. Request the number of markers from first one, then the other RSO – it is worthwhile alternating the RSO whom you request numbers from. State the person's name or position loudly and get their response – "LEFT?" or "RIGHT?".
3. If you suspect the aircraft was rolling, or diving or climbing strongly, or that your aircraft crossed the line of markers at an angle, loudly state "NO COUNT" and record X marks instead of markers, and make a note.
4. If one or both RSOs indicate that they had trouble counting, similarly record an X in their or both columns.

RSO:

1. When the plane is directly perpendicular to the line of markers (pilot should call "NOW" just before this point), count the number of markers you see between the rods, and take a photograph if possible.
2. If you are unsure about the number of markers that were there, say "NO COUNT" – this could be because it's difficult to see them (you need practice), or the aircraft is rolling (re-fly required).
3. If the line of markers seems to end before the end of the upper rod, say "NO COUNT - END OF MARKERS" and make sure the FSO records this; the pilot will need to re-fly ensuring he/she is directly over the centre of the markers so that you have enough on your side.

Tips & tricks

- **Pilot: Use the radar altimeter and pressure altimeter together to make reaching target heights easier.** The radar altimeter varies quickly with small changes in terrain under the aircraft and it is easy to try to 'chase the numbers' and end up diving or climbing strongly as you cross the airstrip. Use the radar altimeter to get to approximately the target height as you cross the airstrip on the practice runs, and record the pressure altimeter at that moment. Then, use that pressure altimeter reading to make the passes over the airstrip.
- **Airsickness:** it is really common to feel airsick during calibration, particularly your first time. FSOs should not turn their heads to talk to the RSOs – instead, concentrate on quickly writing and then looking directly out the front of the plane again. RSOs and FSOs should keep an eye on the horizon during turns and minimise their head movements. Even if you feel sick during calibration, most people never feel it again on regular flights.
- **Weather:** it is best to do calibration in the early morning when winds and turbulence are low.

2.4.1.5 Calibration calculation

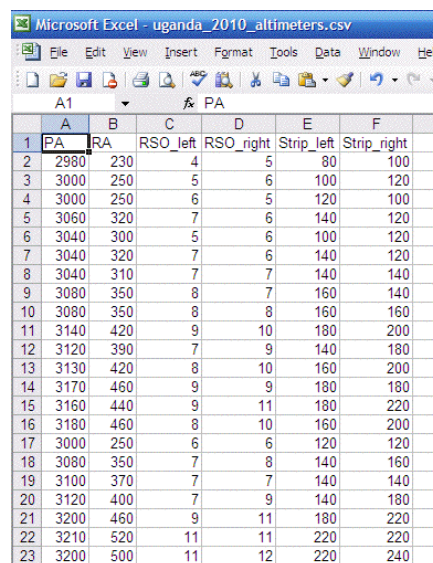
Data are entered into a spreadsheet or stats package. For each observer, the observed strip width is regressed against flying height, and consistency of parameters checked. If necessary, the calibration is re-flown.

Microsoft Excel, OpenOffice.org, R or any number of analysis programmes may be used; in the event of a complete technology failure, graph paper may be used.

Here we use an example from an Excel (version 2003); there is also a spreadsheet designed for the purpose of this manual, available at countinganimals.underdiverwaterman.com.

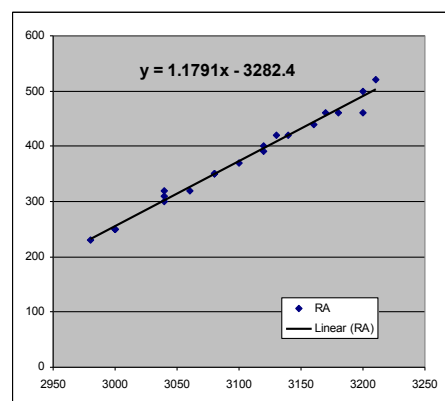
Instructions:

- Enter the form data into four columns on the spreadsheet:
 - PA = Pressure altimeter reading
 - RA = Radar altimeter reading
 - RSO_left = markers seen, left
 - RSO_right = markers seen, right
- Add two more columns for strip width, and calculate:
 - Strip_left = RSO_left * 20
 - Strip_right = RSO_right * 20
- Plot the radar altimeter vs. pressure altimeter graph:
 - Select the PA and RA data, from the upper left (PA) to lower right (final reading of RA in that column).
 - Select **Insert: Chart** from the menu. Select "**xy**" chart from the window that appears, and make sure you select the subtype on the right hand side that has only dots, no lines. Click **Finish**. Your chart will appear in the window.
Check: the bottom (X) axis of the chart should be PA (pressure) and the left (Y) axis should be RA. If not, make sure your columns are the right way around and try again.
 - Right-click on one of the points on the graph, and select **Add trendline ...**. On the "Type" tab select linear; on the "Options" tab select "**Display equation on chart**", then **OK**.
 - The equation gives you: **y = slope x + intercept** – i.e. in the example opposite, slope = 1.18 and intercept = -3,282.
 - The plot should be very linear, with the plotted points following the trend line closely.
 - The slope should be between 0.95 and 1.05. Outside of this range, the



	A	B	C	D	E	F
	PA	RA	RSO_left	RSO_right	Strip_left	Strip_right
2	2980	230	4	5	80	100
3	3000	250	5	6	100	120
4	3000	250	6	5	120	100
5	3060	320	7	6	140	120
6	3040	300	5	6	100	120
7	3040	320	7	6	140	120
8	3040	310	7	7	140	140
9	3080	350	8	7	160	140
10	3080	350	8	8	160	160
11	3140	420	9	10	180	200
12	3120	390	7	9	140	180
13	3130	420	8	10	160	200
14	3170	460	9	9	180	180
15	3160	440	9	11	180	220
16	3180	460	8	10	160	200
17	3000	250	6	6	120	120
18	3080	350	7	8	140	160
19	3100	370	7	7	140	140
20	3120	400	7	9	140	180
21	3200	460	9	11	180	220
22	3210	520	11	11	220	220
23	3200	500	11	12	220	240

Figure 9: Example calibration data entry.



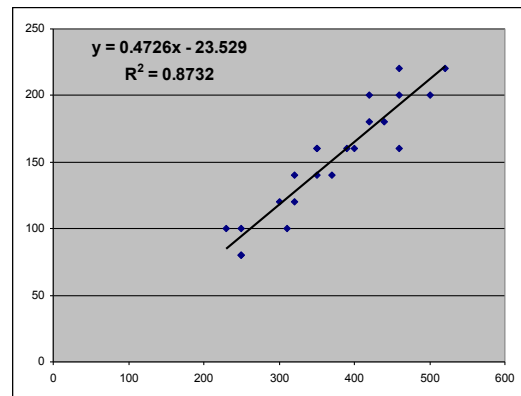
aircraft must return for avionics service before it can be used.

In the example above, the slope is 1.179 and the radar altimeter is malfunctioning.

4. Plot the observed strip widths versus height above ground:
 - a. Select first the RA data, then press Control and select the Strip_left data.
 - b. Select **Insert: Chart** from the menu. Select "xy" chart from the window that appears, and make sure the you select the subtype on the right hand side that has only dots, no lines. Click **Finish**. Your chart will appear in the window.

Check: the bottom (X) axis of the chart should be RA (Radar) and the left (Y) axis should be Strip_left. If not, make sure your columns are the right way around and try again.

- c. Right-click on one of the points on the graph, and select **Add trendline** On the "Type" tab select linear; on the "Options" tab select "**Display equation on chart**" and "**Display R squared on chart**", then OK.
- d. The equation gives you: **y = slope x + intercept** – i.e. in the example opposite, slope = 0.4726 and intercept = -23.539.



Check what the strip width would be at 350 feet:

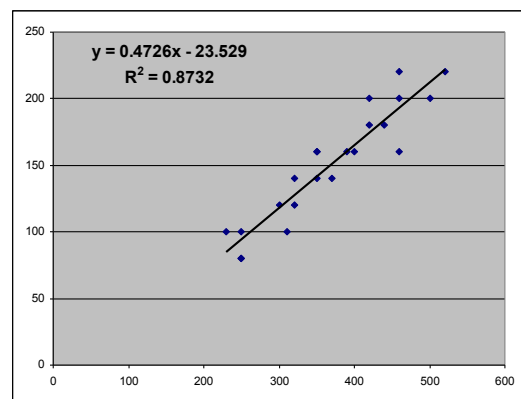
Strip Width = 350 x SLOPE + Intercept, e.g.

Strip Width = 350 x 0.4726 - 23.539 = 141.871m

If this 'nominal' strip width is < 130m or > 180m, you should reset the streamers and re-fly the calibration.

Why? A strip width too low gives us too small a sample to base our data on; a strip width too wide means the observer can't reliably search it and will miss observations.

- e. The R^2 ("r squared") value indicates how reliably the observer was able to count markers – it should be > 0.85. In the example here it is 0.87, which is acceptable. If the R^2 value is < 0.8, the observer must re-fly.
- f. If the intercept is < -30 or > +30, re-fly. (If the intercept is < -20 or > +20 this would imply that the strip width at 0 feet (ground level) is larger than the distance between the markers, which is impossible; +/- 30 is considered still acceptable, as errors in reading and variations in flying typically lead to errors of this size)



Tips & tricks

- Radar altimeters often give faulty readings above 450 feet, sometimes as little as 400. If your graph stops being linear above 400, delete those points with RA > 400 and redo the radar altimeter graph and your strip width graph. This is permissible but the pilot must be cautioned to fly at the target height of 350 feet, and the FSO must keep an eye on this; this aircraft should also be given areas of level terrain in the event of a multi-plane survey.
- If the slope of the RA / PA graph is < 0.95 or > 1.05, the altimeter is probably faulty, and must be checked on next service. While it is possible to develop a correction factor for faulty readings where the graph is constant (as in the example above, slope = 1.18 but the graph is perfectly straight), the tendency is for the correction factor to vary depending on humidity and temperature, which are beyond your control!
- It may be necessary for observers to fly two or three calibration flights before they get a good calibration.

2.4.2 Transect flights & crew duties

Transects are flown by the crew, recording actual flight paths and animals observed. Data are transcribed and checked upon return to base. Regular briefings allow for aircraft logistical planning.

2.4.2.1 Preparation

Before survey departure and before daily flights equipment and supplies must be checked.

2.4.2.1.1 Aircraft

The pilot is responsible for the fuelling and maintenance of the aircraft, and this is beyond the scope of this manual. However, it is the duty of the senior officer / ground coordinator to keep track of remaining hours until maintenance, and the remaining fuel stocks, together with the pilot. This should be part of the daily briefings.

Tip

- Headphones are a requirement for aircraft for good communication between the crewmembers and for hearing protection. Headsets should be worn at all times, and it is advised that during training and familiarisation the RSOs make their recordings on their tape recorders and into the microphones.
- In areas where there is a high density of wildlife, RSOs may need to put down their microphones on their headphones because of interference from hearing all the other observations – however, in a low to medium density area it is often very helpful to be kept alert by hearing the other announcements, and it is reassuring to the FSO and pilot who are also keeping an eye on the alertness of RSOs.

2.4.2.1.2 Cameras

Setting up a camera properly for survey work is a vital part of an accurate survey. For all cameras:

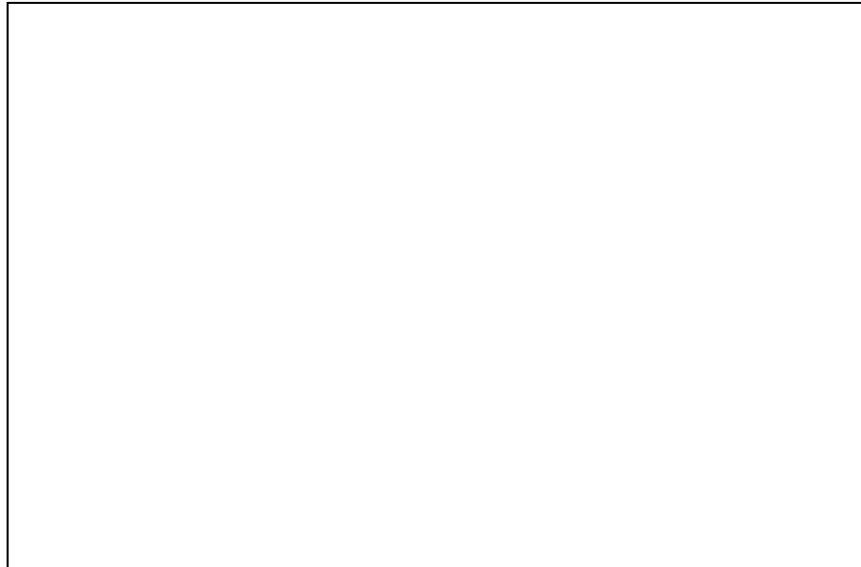
1. Turn on and test operation – is it working normally?
2. The focus should be taped on infinity, and the focus set to manual focus.
3. Check the remaining battery life. If the indicator shows less than full charge, replace with a fresh battery.

A camera battery's charge level is deceptive. They stay at full charge for a long time and then, when the first bar of charge disappears, the rest of the charge goes quickly!

4. Check the memory remaining: there should be at least 100 photos available on the memory card. If not, it has probably not been erased; confirm that the photos were saved and format the memory card.

If you have window mounting units available, these need to be set up and cameras properly attached before each flight. The initial setup must be done during the calibration.

The camera mounts pictured here are “Stickypod Dash Mounts” (www.stickypod.com), which have proved to be very effective. There are other designs but most likely a suction-cup based unit with jointed arms like this will be most useful.



The cameras are placed in a good position, with a known ‘target area’, and cable releases attached. This allows the observer to simply press a button when a group of animals is in view, and be confident that the photograph was taken, with minimal disturbance to his/her observation of the strip.

The ideal position for the camera is one in which it has exactly the same field of view as the observer; this is unfortunately impossible, as the observer’s head and the camera can’t occupy the same position! However, during calibration setup a good approximation can be made that gives almost exactly the right field of view.

Depending on the aircraft, there may be space behind or in front of the observer to place the camera. The best position is probably in front of the observer, with a view perpendicular to the aircraft.

Instructions:

1. Hold the camera in a position that is close to the observer’s head (they should be seated and helping with this) but that does not block their view.
2. Take test photographs of the streamers, and, using the photographs, move the camera to line up the streamers and the ground marks.
3. Once you have determined this ideal position for the camera, attach the camera mount to the window. Attach the camera and move the jointed arms until you have found the position from 2 above.
4. Tighten the screws or locking units and take more test pictures: is it in the correct place? Redo 3 if not.
5. Tap the camera firmly with one finger to make it wobble – it should not twist or otherwise move from position. If it does, repeat 3-4 but tighten everything more firmly.
6. Attach the cable release to the camera port.

7. Have the observer sit normally and practice taking photos, to get an idea of the 'target area' where he/she should trigger the camera.
 - a. This target area will be slightly different in the air, but is still a good approximation.
 - b. Move objects into the field of view of the camera to show the foremost and rearmost edges of the camera view – the observer can look at these to get an idea of where the ideal zone is.

Tips

- Setting the lens to focus on infinity: the easiest way to do this is to first leave the lens on 'autofocus', and then focus (or take a picture) at an object at least 200m away (approximately the distance of observations from the aircraft). Use electrical tape on the focus ring, gently pressing it in place, then switch the camera/lens to manual focus.
- Read the manual for the camera – they are all different, and understanding how to quickly check all these parameters is really important, and can save you much aggravation. *Know your equipment.*
- Attaching camera mounts to the Cessna window requires that you press hard on the window – have someone press on the outside of the window at the same time, to avoid popping the window out of the frame!
- Loop or tie the cable around the camera mount – if the cable is pulled hard it will then pull on the mount, not the plug on the camera itself!

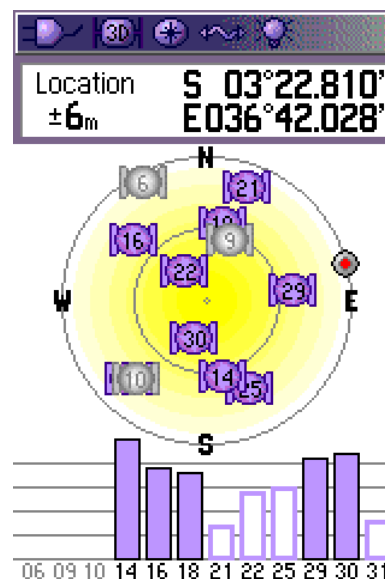
Caution!

- **The RSO's attention must be on the strip at all times during actual transect flights.** It is very worthwhile checking the field of view of the camera during training and test flights – the RSO should take photos and then look at the image on the camera back to confirm that the camera is taking pictures of the same area, and then adjust his/her technique appropriately. However, this experimentation must be done by the beginning of survey work, and the RSO must not check photos once transect work begins.

2.4.2.1.3 GPS

The pilot GPS will no doubt be set up to the individual preference of the pilot; the FSO GPS should be set up in a consistent manner for the use of the FSO. Check:

- Battery level: this is not as tricky as camera battery levels, but you should not start with a quarter charge or less.
- Transects: are these uploaded correctly? Zoom out until you can see the transects and subunit lines or points on the map, and confirm that they seem to be the correct distance away.
- Is the GPS getting a position correctly? The GPS should be turned on and a position verified before you enter the aircraft (see example to the right, from a Garmin GPSMap60).



Tips

- Practice removing and replacing the GPS batteries until you can do it almost without looking. *Know your equipment.*

2.4.2.1.4 Survival kit

A minimum set of survival supplies and equipment must be carried on the aircraft, under the seats or in the rear cargo area (not in a luggage pod under the aircraft, as this is often destroyed even in a survivable emergency landing).

- 2 litres of water per person;
- First aid kit with bandages, painkillers, tape;
- Energy bars or biscuits;
- Matches or firestarters;
- Survival blankets.

2.4.2.1.5 Forms

The FSO should have one form for each planned transect, plus spares, and a clipboard.

2.4.2.2 Flight standards

There are important standards for flying transects which must be followed.

Time of day: Survey flying is usually conducted in two flights each day, morning and evening. No counting is permitted between 11:00 a.m. and 3:00 p.m., because animals tend to seek shelter under trees at these times and therefore are less visible.

Weather: No counting is permitted in bad weather – there are safety concerns, and it affects the behaviour and visibility of animals. Scattered light rain is not considered a problem. A crosswind > 20 knots is grounds for cancelling a flight. In a strong crosswind the strip width will be increased by an unknown amount, which cannot be reliably corrected for.

Length of flights: Transects should last no more than 45 minutes. If they last longer, transects should be broken at a recorded GPS point or geographic

subunit in order to prevent observer fatigue – take five minutes to circle, stretch, have sweets and biscuits! Be sure to record breaking point carefully on the GPS so that the remainder of the transect can be flown accurately at a later time!

Session length: Counting sessions should last not more than 3 hours. The ability of any observer to concentrate on counting is reduced after 3 hours and only gets worse!

2.4.2.3 Flight procedure

1. Crew boards and confirms equipment and status:
 - a. RSO tape recorders have sufficient battery and tapes;
 - b. Cameras have sufficient battery and memory;
 - c. FSO has GPS, spare batteries and forms;
 - d. Pilot has transect points uploaded to GPS.
2. The pilot takes off and flies to the transect area.
 - a. FSO records takeoff time.
 - b. FSO announces, and RSOs record: date, survey, session, e.g. "*Kidepo National Park, 10 August 2010, morning session*".
3. Transects are flown:
 - a. Approaching the transect, the FSO announces the transect number to the RSOs, e.g. "*TRANSECT TWENTY*". RSOs record this in their voice recorders.
 - b. At the beginning of the transect, the FSO begins to call subunits: "*Subunit One*", and this is recorded by RSOs in the voice recorder.
 - c. For each subunit the FSO announces the number: "*TWO*", "*THREE*", etc., and this is recorded by RSOs.
 - d. From the beginning of transects, RSOs record animal observations.
 - i. For each observation, they record the species code (twice) and estimated group size, and any pictures taken, e.g. "*Elephant elephant five*", "*Zebra zebra fifty two, two frames*".
 - ii. If groups are greater than ten, photographs should be taken.
 - e. At the end of the transect, the FSO announces "*END OF TRANSECT*" and RSOs record this.

2.4.2.4 Postflight procedure

After parking the aircraft, equipment and data forms are taken with the crew back to the field base, and the ground coordinator ensures that data are properly taken care of:

1. Ground coordinator takes charge of:
 - a. Pilot and FSO GPSs
 - b. Camera memory cards
2. GC provides forms to RSOs and checks that they are situated well away from distractions to fill forms.
3. RSOs transcribe their tapes onto paper forms
4. GC downloads data from GPSs and cameras.
5. FSO checks and submits data forms to GC;

6. RSOs submit data forms to GC;
7. GC checks FSO and RSO forms;
8. Flight paths and waypoints are mapped and cross-checked with recorded transect numbers.
9. GC debriefs pilot and crew, and makes plan for afternoon flights.

2.4.3 Pilot

The duties listed here are in addition to normal preflight checks.

2.4.3.1 Preflight

1. Confirm transect map and briefing with ground coordinator & FSO;
2. Confirm your GPS is uploaded with transect endpoints & route;

2.4.3.2 During flight

1. Navigate to the starting area of the session. Announce the time en route to the crew.
2. Note the session starting time: you should not exceed 3.5 hours of actual transect flying, and return to base when time is up.
3. Confirm (announce) upcoming transects at least 1 minute prior to the first one, and ensure that FSO and RSOs are on the job.
4. Confirm that the FSO correctly announces the beginning of the transect ("Subunit one!") and the end of transect ("End of transect!").
5. Confirm that trainee FSOs are recording data correctly from time to time, and watch for dozing observers especially on long, hot flights!

2.4.3.3 Postflight

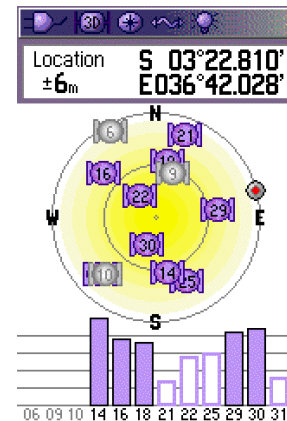
1. Submit GPS to ground coordinator for download.
2. Debriefing:
 - a. Update number of hours remaining to maintenance;
 - b. Review remaining transects in block and make plan for next session.
 - c. Review fueling issues.
 - d. Set time with crew for next session and make sure everyone is aware (people often drift off or oversleep before afternoon sessions!).

2.4.4 FSO Duties

2.4.4.1 Preflight:

1. Confirm transect map and briefing with ground coordinator & pilot;
2. Confirm GPS loaded with subunits, transect endpoints & route;

3. Check that you have enough FSO forms (typically one per transect), pencils and clipboard;
4. Extra batteries and tape recorder.
5. Turn on GPS and confirm it receives satellites (see the screenshot on the right).



2.4.4.2 During flight:

1. Confirm upcoming transects with pilot;
2. Announce upcoming transects: "Next transect is transect one hundred and twenty – one two zero". You should do this one minute or so before the transect is reached.
3. The beginning of the transect will appear on the GPS. Announce beginning of transect: "Subunit One".
 - e. Write time START, to the nearest second;
 - f. Confirm correct waypoint, and mark a new waypoint if a non-planned point is used.
 - g. Write radar altimeter height.
4. The beginning of each subunit is marked on the GPS as a point or a grid line. When it is reached:
 - h. Announce the number: "TWO", "THREE", etc.
 - i. Write down the radar altimeter height about every 30-45 seconds – at least once for each subunit and not more than three: e.g. 350, 320, 380.
 - j. During the subunit, write down additional observations as required by protocol (presence of human activities, fire, etc.).
5. Announce "END OF TRANSECT" on the final point, or if the pilot chooses to call end of transect early.
 - k. Write time END.
 - l. Take a GPS point if a non-planned point is chosen, and write this on the form.

2.4.4.3 Post flight:

1. Fill in all metadata blanks on data sheet (date, initials, aircraft, survey).
2. If there are actual data missing, point it out to the ground coordinator ('vital data' (see below) you cannot get after the flight, or it is difficult to get; 'important data' can be sometimes missed (radar altimeter) or found elsewhere (e.g. GPS log).

2.4.4.4 Data to Collect

Vital data:

- GPS start and end points
- Changes to planned transect – take new GPS points if there are any changes due to terrain or other issues.

- Cultivation, habitation, villages, tin sheets (of any kind, whether housing or storage or other structures), as per survey protocol.

Important data:

- Time start and end, to the nearest second.
- Radar altimeter heights to the nearest ten feet.

Optional

- Poacher's camps, dead elephants, unusual sightings -> Take a waypoint!
- Any other observations – fires, other illegal activities.

2.4.5 RSO Duties

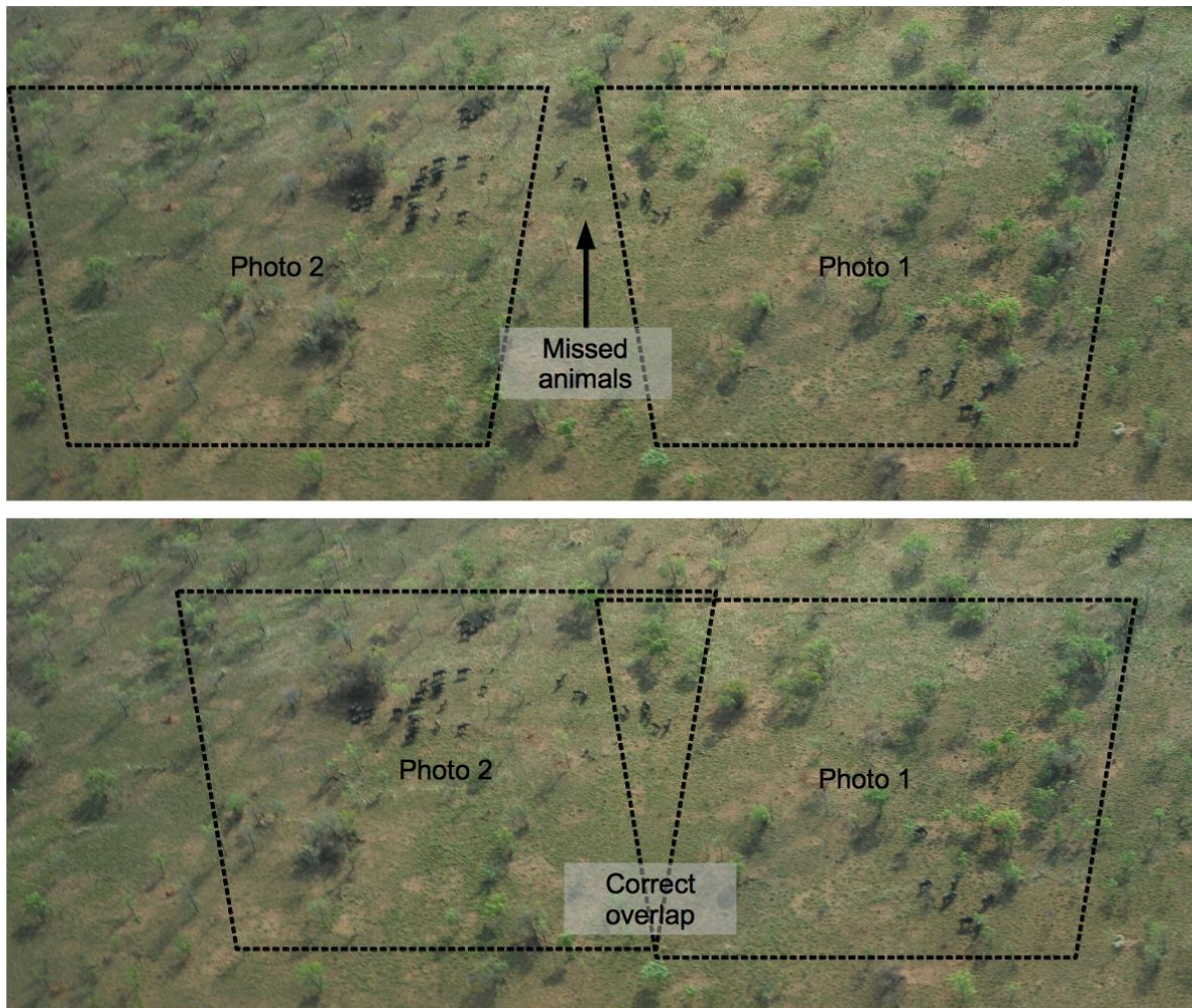
2.4.5.1 Preflight:

1. Check operation of tape recorder. Record date and session information, and play it back.
2. Confirm spare batteries.
3. Check the position of the streamers and tape – do they line up? Does anything appear to have moved? If so, inform the ground coordinator.
4. Take a test photo and ensure proper operation of camera and cable release – is the field of view correct?
5. Review the species in the area from your code sheet and with the other crew – any surprises likely?

2.4.5.2 During flight

1. Sit comfortably, ensure that the inside tape is lined up with the streamers.
2. Record all information given to you by the FSO: transect number, subunit number, end of transect.
3. Scan both forwards and backwards; many species will stay immobile until the plane has passed.
4. Count, and photograph, in the target area perpendicular to the aircraft.
5. Record the observations on your handheld tape recorder:
 - m. State the species name twice;
 - n. State the estimated number;
 - o. If photos are taken, indicate the number and the word "Frames".
 - p. E.g. "Zebra zebra five", or "Elephant elephant twenty, two frames".

State the species code twice because you may delay a little bit in recording, and speak too early – ending up with a number but no idea which species it was!
6. If you do not have mounted cameras: be ready to take photos but keep the camera on your lap or your arm will become fatigued.
7. For large herds, you will need to take several pictures in a row to ensure you photograph everything. Photos must be overlapping so that we know we have the entire herd. Don't be afraid to take extra pictures – with practice you will learn the correct spacing and be able to correctly overlap with a minimum of photos, but in the beginning take extra.



Tips

- Play with the tape recorders (know your equipment!) until you are familiar with every aspect of their operation. We normally use old-style tape recorders because they have large buttons that are easy to press, and easy to feel that they have been pressed, even in a noisy, bumpy aircraft; get used to how it feels even without looking at its operation.
- The easiest way to use most recorders is to press RECORD and then use the PAUSE on/off switch to start and stop recording.

2.4.5.3 Post-flight:

1. Return your camera to the ground coordinator. Immediately inform him/her if you took pictures of animals on transects!
2. You will fill in the data sheets for RSO data – fill in initials, survey name, date and seat position.
3. Choose a place where you will not be distracted by anyone, including your neighbouring RSO who will also be listening to their tapes. You must immediately start this work – you may have a cup of tea or a soda, but not eat.

This is not to be cruel ... you have a chance of catching mistakes, and remembering actual numbers / species, immediately after the flight. If you wait, nap, eat, get distracted, this is no longer the case.

4. Play back your tape recorder.
5. Fill in transect number and each subunit as you hear it:
 - a. If you miss a subunit (i.e. '5' follows '3'), write an X for the missing subunit (i.e. for '4').
 - b. If the subunit is empty of animals, write a dash (-).
6. If a subunit has observations, fill in the species code and number of animals estimated.
 - a. Immediately confirm species codes if you come across something not on the code sheet. Do NOT invent your own codes!
7. If you took pictures, indicate the number of frames by putting a square box around the number.
 - a. Count these pictures with the ground coordinator after the session.
8. Submit your forms to the GC.

2.4.5.4 RSO Observational Method

Observing is not something that can be done casually, though it seems very straightforward. Basic skills include species identification and ability to estimate groups and operate a camera; the observer also needs to cultivate a method for scanning forward and back from the primary engagement area, and to not be distracted from counting and observing in the perpendicular target area.

Basic rules:

- Count and record all the animal observations that appear within the sampling strip.
- Photograph groups greater than 10 and record the number of frames taken.
- Do not record animals that run **into** the strip next to the aircraft; likewise, you may include animals that have just moved out of the strip in response to the aircraft, though you must be very sure that this was the case.

Scanning

While the basic rule is to count and photograph animals at the closest point of approach, right next to the aircraft, you need to be looking forwards and backwards:

- Animals are often spotted before the aircraft comes up on them, and (particularly for large herds that need photographing) you can get ready to count and photograph the group;
 - Some animals freeze as the aircraft passes, making them more difficult to see, and then move after you have passed – if you scan behind you regularly, or use your peripheral vision, you will pick these animals up
- Inexperienced observers, as a result, usually miss kudu and bushbuck, who are very good at sneaking around the back of trees as you pass. After a few days of experience you will begin to see far more of these cryptic animals.*

How do we deal with this? Each observer develops their own scanning technique, but some tips can help.

Whatever you do, you must scan all areas of the strip and should spend an equal amount of time on each area. Using a crisscrossing scan in each field of view, starting at top left, moving to the right, then down to the left, then right again, works very well for this and forces you to scan the entire field (see the illustration below).

Get in the habit of scanning three separate fields:

- Next to the aircraft;
- Forward of the aircraft;
- Immediately behind you – this can be a quicker scan, as normally you will pick up movement from animals like kudu and bushbuck that flee after you have passed.

You should spend most of your time scanning perpendicular to you and forward, and occasionally look behind you. Think “side – forward – side – forward – side – behind”.

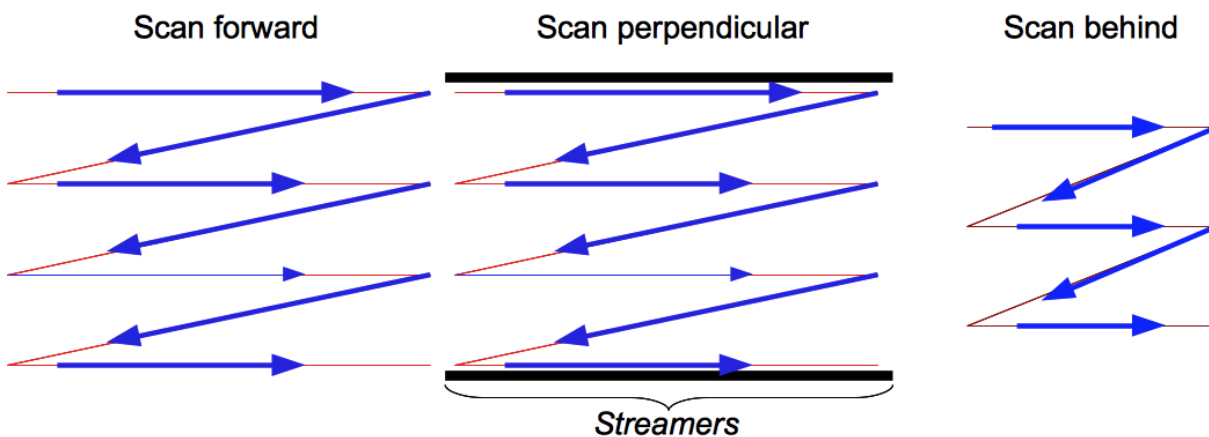


Figure 10: Scanning technique.

Searching the whole field

It can be extremely easy to miss animals, even right in the middle of your field of view. Using the scan technique above is really helpful, but we need to spend special attention on some areas.

- **Shadows:** when there are areas of shadow in the field of view, it is necessary to spend extra time searching those areas – give them a second look.
- **Scattered groups:** when you see a group of animals, the immediate tendency is to focus on them, get a good count ... and at this same time you risk missing the five animals on the other edge of your field of view! Get a good look at the animals out in the open that you first saw, but then make sure you scan the rest of the field. This is where the scanning technique above is particularly helpful – especially spotting the animals early, in front of the aircraft.

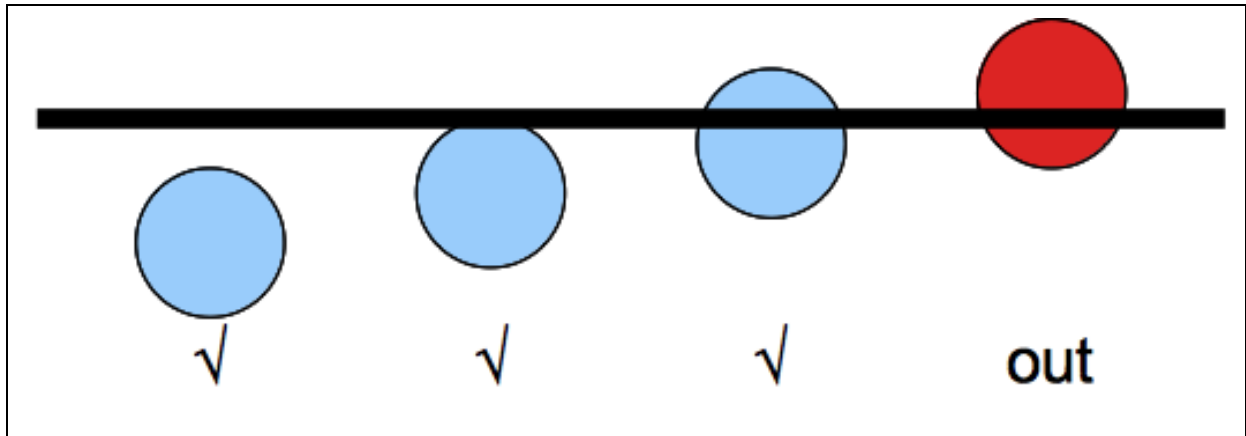
In or out?

If animals were more considerate of the researcher, they would stay completely still and either be clearly in or out of the strip. Probably the most difficult aspect

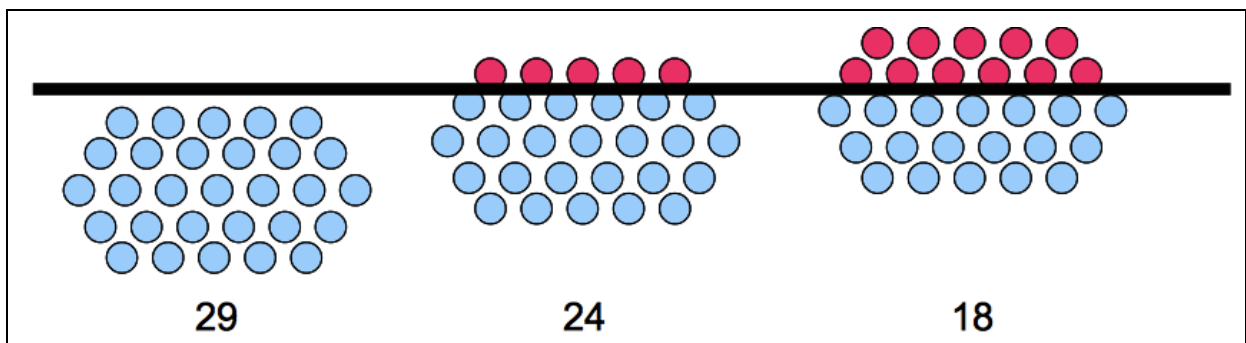
of counting is determining whether a certain group, or individual, should be counted or not.

It is important to make a quick judgement about whether an animal or part of a group was in or out of the strip, and stick to that judgement – do not spend too much time trying to decide, focussed on one problematic group.

The following diagrams illustrate some of the possibilities and issues:



Individual animals are counted as in if they are more than halfway inside the strip.



Count the number of animals in a group that are inside the strip. Make an estimate, and take a photograph.

Figure 11: In or out of the strip - what to count.

2.4.6 Ground Coordinator

This position may be taken by the FSO, but ideally this is done by a senior officer who is responsible and diligent about data quality, and has the technical background to download, upload and organise data. The GC should be familiar with all stages of the survey, from planning to survey flights to the health and morale of the team. The GC must know all the processes involved by all crew.

2.4.6.1 Pre-flight

1. Upload GPSs:
 - a. Pilot: route with transect beginning and end points;

- b. FSO: route with transect and subunit points.
- c. Confirm that old tracks have been saved.
- 2. Brief pilot and crew on session plan, and provide equipment
 - a. GPS units;
 - b. Check spare batteries for RSO / FSO;
 - c. Confirm FSO forms / clipboard;

2.4.6.2 Post-flight

1. Remove camera cards, and check battery level. Take battery if showing even slight drop.
2. Receive pilot and FSO GPS (it may be worthwhile only taking the pilot GPS at the end of the day).
3. Download GPS data:
 - a. Save to at least two file formats on your computer: GPX and ESRI shapefile (.SHP).
 - b. Naming convention: **YYYY-MM-DD [AIRCRAFT] [Position] [Keywords] .gpx**, e.g. **2010-11-05 5HCFA FSO Kidepo.gpx**
A naming convention like this must be applied diligently to all digital data – and it will save you hours of frustration in the future! In this way you know when each file was made, from which GPS it came (FSO GPS) and some keywords to describe it.
 - c. Map the data to confirm you have recorded the correct information!
 - d. For the FSO GPS only: Copy the old track data to GPS memory (if available) and erase the old track. BEFORE you erase, confirm that you have GPX and SHP files saved for track and points!
4. Download camera data.
 - a. Make a folder for each observer's data, and use a similar naming convention as above: **YYYY-MM-DD [AIRCRAFT] [Position] [SESSION AM/PM]**, e.g. **2010-11-05 5HCFA RSO AM** – this tells you which aircraft, position and session the data came from.
 - b. Download the data from the card to the folder.
 - c. If there were no photos taken, make a README.txt file and make a note that no photos were actually taken.
 - d. Confirm that the photos are in the directory, then erase the card; alternatively, with very large memory cards, there is no need to do this on a daily basis.
5. Receive and check FSO data, and get the FSO to correct errors:
 - a. Count the number of forms, and compare to flown transects.
 - b. Are all metadata filled in?
 - c. Are sheets readable?
 - d. Are there changes to transect start/end points? Ensure these are written down properly.
6. Receive and check RSO data:
 - a. Count the number of forms, and compare to flown transects.
 - b. Are codes correct?

- c. Metadata filled in?
- d. Photos taken and indicated in form?
- 7. Punch and file FSO and RSO forms.
- 8. Back up the downloaded data.
- 9. If time permits, count photographs immediately with RSO.
- 10. Debrief pilot and crew:
 - a. Review the transect map – what has been done to now? What is remaining?
 - b. Plan the next session, and confirm the time to meet to go to the airstrip again.

Tips

- GPX is an excellent backup for GPS data, as it is an open-source standard and readable by most GIS packages. It keeps all the data from a GPS: waypoints, tracks and routes (see the Appendices for links).
- You can take the camera and attach a USB cable to it directly, but it is almost always a lot faster and more reliable to remove the data card and use a card reader.

2.4.6.3 Other duties

Depending on schedule, the number of aircraft involved, and logistical issues, there are number of other jobs the GC can do.

Data entry: starting data entry early is extremely valuable. It is often possible to correct errors (poorly written data, for example) immediately after a flight.

Counting photographs: this needs to be done as soon as possible, and is valuable for a number of reasons:

- Problems with photographic technique can be picked up immediately;
- It can still be difficult to see animals even in a good photo, and the RSO can help you pick them out soon after the flight – this is not possible a week later!

2.5 Analysis

The following analysis instructions are based on using SRF_UWA_0.1.xlsx, which is available on the Counting Animals temporary website:

<http://www.countinganimals.underdiverwaterman.com>.

There are several software tools for analysis of sample count data using the Jolly II method outlined in Norton-Griffiths (1978), and this is just one example. You will find other tools on the website, and are encouraged to play with them all! You can also work it out on paper, and in fact you must do this at least once to really understand the steps involved.

Regardless of the tool used, the following steps apply (with variable names indicated as per Jolly II calculations (Norton-Griffiths 1978), where:

N	Number of sample units in the population (how many non-overlapping transects <u>could</u> you have flown?) = baseline / average strip width.
n	Number of samples (transects) actually flown;
Z	Area of the entire census zone.
z_i	Area of transect 'i'.
y_i	Number of a certain species counted in transect 'i'.
\hat{R}	Overall density of that animal species = sum of all observations in all transects / sum of area of all transects.

1. Transect length, width and thus area are calculated and summed together ("Survey Area" = "Z")
2. Strip area is calculated for each transect, based on flying height per subunit or the average flying height per transect ("Strip Area" = "z");
3. Number of observations for each species are tallied by transect (y);
4. Overall density is calculated:

$$\hat{R} = \frac{\sum y_i}{\sum z_i}$$

5. Variance of observations is calculated:

$$s_y^2 = \frac{1}{n-1} \times (\sum y_i^2 - \frac{(\sum y_i)^2}{n})$$

6. Variance of sample areas is calculated:

$$s_z^2 = \frac{1}{n-1} \times (\sum z_i^2 - \frac{(\sum z_i)^2}{n})$$

7. Covariance between observations and sample areas is calculated:

$$s_{zy} = \frac{1}{n-1} \times (\sum zy - \frac{\sum z \times \sum y}{n})$$

8. Population estimate is calculated:

$$\hat{Y} = \hat{R} \times Z$$

9. Population variance is calculated:

$$\text{var}\hat{Y} = \frac{N(N-n)}{n} \times (s_y^2 - 2 \times \hat{R} \times s_{zy} + \hat{R}^2 \times s_z^2)$$

10. Standard error:

$$SE(\hat{Y}) = \sqrt{\text{var}\hat{Y}}$$

11. Confidence limits for \hat{Y} : look up 't' at n-1 degrees of freedom at a given α :

$$\pm t \times SE(\hat{Y})$$

2.5.1 Data entry

This guide assumes that you are familiar with Excel spreadsheets: opening tabs, entering data, saving. Spreadsheet tab names, variables and Excel commands are all here indicated in monospace bold type; commands or menu selections are indicated in order of the commands as you select them, e.g. **EDIT:PASTE SPECIAL:VALUES** to indicate that you select the **EDIT** menu, then **PASTE SPECIAL**, then **VALUES**. In this and other sheets, green shading indicates data you should fill in.

This sheet is designed with variable names and tables. This allows Excel to reference and calculate other sheets more easily and/or for us humans to read and remember references. For example, in the **Calibration** tab the slope for the left observer is called **SlopeLeft**, and this is what is referred to in equations instead of "E4". Any equation that uses **SlopeLeft** will return the number in that cell, e.g. 0.363 in the example.

Caution!

It is crucial to enter data carefully: when typing in cells, make sure you use the same transect number (or label), species codes, etc. Don't type spaces when entering data or Excel may think you're putting in a text label instead of a number, and so on.

To delete rows in a table, select the whole row (or set of rows) by clicking and/or dragging in the row numbers on the left side, then right-clicking and selecting **Delete**.

0. Open the calculation spreadsheet (**UWA_calc_0.1.xlsx**).

In the beginning it is probably worth opening up the example spreadsheet (UWA_example_calc_0.1.xlsx) and looking at the example tables to familiarise yourself with the process.

1. Check **SPECIES CODES** (the first tab).

- a. Confirm that these codes are correct for the survey you're entering, and that the common names are filled in properly.

The codes used during the survey should match your organisation's master list of species codes. If the codes used in the field are different, you must

make a clear note in both the paper documents and the calculation sheets, indicating the codes used.

2. Enter calibration data in the **Calibration** tab (this should already be done in the field):
 - a. Enter the metadata: survey name, aircraft, crew names, etc.
 - b. Enter the target information: ideal strip width, flying height, distance between markers.
 - c. Enter the pressure, radar and marker values for left and right observers in the green shaded area. "Target" height doesn't matter but, if written on your sheet, is worth recording.
 - d. As you fill in the data the graphs and regression variables will fill in automatically.
 - e. When the data are entered, check the graphs and values as per the instructions in the "Calibration" section of this manual.
 - f. Values that are out of range in the calibration will be automatically highlighted in red – i.e. the radar altimeter reading of 1.18 in the example. RECALIBRATE if there are problems here!
 - g. Check that the Slope and Intercept values are filled in next to each observer's name.
3. Enter all the FSO data in the FSO tab – each row is for a single subunit, and you enter data under the columns highlighted in green:
 - a. Transect number, subunit number, one to three radar altimeter readings.
 - b. Mean height, strip widths (left, right, total) and areas are filled in automatically.
4. Enter the RSO data in the RSO tab:

Each row is for a single observation of a single species. You will have repeated rows with the same subunit and transect and/or species codes for multiple observations within a single subunit.

- a. You enter all columns in this case: observer initials or name, transect, subunit, species code as per the species list, the estimate, how many pictures were taken, how many were counted from the photos.
- b. Correct Count uses the estimate column unless there is a photo count, in which case it uses the photo.

If there were problems with the photo count, then do not fill in the "photo estimate" column. Change the 'estimate' column if you need to make corrections, but make sure you note this in the comments and on the paper form.

Tip

- There is an example spreadsheet available showing the calculations, based on Queen Elizabeth National Park survey data from 2010. It is on the website with this manual.

2.5.2 Population Estimates

1. Update all of the calculations in the spreadsheet and check:
 - a. Press **Control-Alt-F5**. This updates all of the calculations and tables in the spreadsheet.
 - b. Open up the **Area and Subunits** tab: this is a transect-by-transect summary of all the data from the FSO table.
 - i. Are all the transects indicated in the "row labels" column? Are there any duplicates? Any "blanks" row? Any missing?
 - ii. Do the numbers of subunits look correct?
 - iii. Are there any errors in the Grand Total row?
 - iv. If necessary, go back and check the FSO table, deleting partially-filled rows and correcting errors.
 - c. Open the **Observation Table** tab: this is a transect-by-transect summary of all the observations made in the RSO table.
 - i. Check if all the transects are listed correctly, as above.
 - ii. Check the species codes – do they all make sense? Watch out especially for columns that look the same – "WB" and "WB " would indicate that one species code was entered with a space in the name and recognised by the computer as a different species.
 - iii. Look at the numbers – anything crazy in there?
 - d. Press **Control-Alt-F5** again and recheck before you go to the next step.
2. The **Jolly** tab shows the calculations based on these other tabs.
 - a. Check that all the transects are listed on the left side.
 - b. Look at the strip and transect areas look normal.
 - c. Any errors in the table? Any errors in the table?
3. The **Results** tab shows a more nicely formatted table with the proper species names indicated.
 - a. Have a hard look at the numbers here: do they make sense?
 - b. Copy and paste this table (ignoring the #NA rows at the bottom) into Word.

2.5.3 Mapping (for UWA)

Grid cells and transects are laid out for Queen Elizabeth National Park, the savanna parts of Kibale National park, Kidepo Valley National Park, Lake Mburo

National Park and Murchison Falls National Park. Accordingly, instructions are given here for mapping using the grid cell system for those survey areas.

The UWA grid system uses a 2.5 x 2.5 km grid cells for most of its parks but a 5 x 5 km cell for Murchison Falls– each is the length and width of a single subunit. These instructions use ArcGIS 9.x instead of QGIS as this is part of the standard mapping method in UWA.

The density of a grid cell on the map is calculated simply by the number of individuals of a given species seen in that cell, divided by the area of the strip in that cell.

Tips

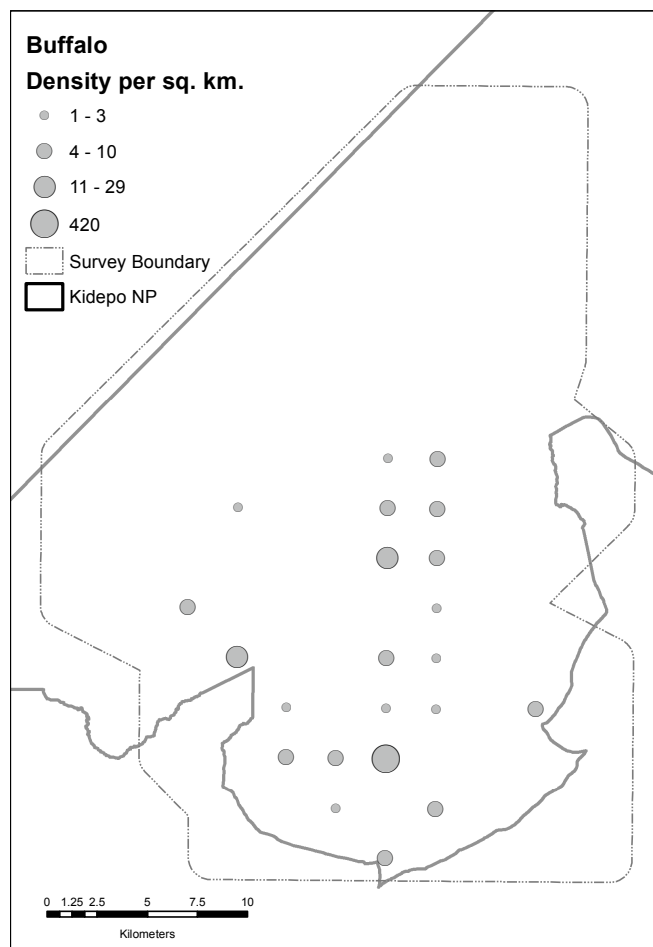
- The method shown here uses a 'Transect-Subunit' (TRSU) relational system – each observation is identified by a number made from the transect and subunit it came from. E.g. subunit 5 in transect 20 becomes TRSU 2005.
- The area of each subunit is calculated in the FSO table from the average height above ground in each subunit and the calibration regression:

$$\text{Strip width} = \text{average height} * \text{Slope} + \text{Intercept}$$
- A pivottable summarises the FSO data by TRSU and species, and the density of each species seen in each TRSU may be calculated by dividing the number observed by the area.

You will need the UWA calculation spreadsheet and a master list of the grid cells in the survey region. An example is shown below – the actual grid cell co-ordinates will need to be determined by your survey zone at the time and filled in. This example data comes from QENP 2010.

1. Open the UWA Calc spreadsheet with the calculated data (from 2.5.1)
2. On the **FSO** tab, Fill in the "Lat" and "Lon" rows of the table based on the starting and end points of the transects and your master list of cells.
3. The **Mapping1** tab has a pivottable summarising the RSO data by subunit. Update it:
 - a. It should be updated, but if not press **Control-Alt-F5**. This updates all of the calculations and tables in the spreadsheet.
 - b. To the left of the pivottable are three rows that look up data from the FSO and RSO data, giving latitude, longitude and strip area. The first row is filled in but needs to be copied (drag down) to the bottom next to the end of the pivottable (see the example spreadsheet if necessary).
4. Create a new table using the pivottable, area and species data:
 - a. Select the pivottable from the "**Lon**" column label to the lower right corner, and **copy**.
 - b. Move to the **Mapping2** tab. Paste only the values into the upper left corner: **Edit: Paste Special: Values**.
 - c. Change the column headed **Row Labels** to **TRSU**. (ArcGIS won't accept variables with spaces in the name).
 - d. Save the spreadsheet (**control-S**).
 - e. Save the sheet as a text file so that ArcGIS may read it: **File: Save As** then select Comma Separated Values (csv) as the file type.
5. Create the density map layer in ArcGIS

- a. Click the **Add Data** button;
 - b. Select the CSV file created in the previous steps and add it; it will now appear as a table in the contents.
 - c. Right-click on the new table and select "**Display XY data ...**".
 - d. The next dialog will have automatically selected Lat and Lon as Y and X coordinates, but confirm that this is correct. Click **OK**. You now have a layer of points for each subunit.
 - e. Right-click the new point layer and select **Properties**, then the **Symbology** tab.
 - f. Select **Quantities** then **Graduated Symbols** on the left of the window.
 - g. For the species you want to map, select its code from the "**Value**" field (i.e. EL for elephant).
 - h. Under "**Normalisation**" select "**StripArea**": this will divide all the observations by the area of the strip in that subunit.
 - i. Click on the **Template** button on the right and change the base symbol to a hollow circle: select the **Circle 2** symbol from the list and change the colour to "**no color**".
 - j. Change the symbol sizes to range from 6 to 24.
 - k. Click **OK**. You now have a density map (in animals per km²) for that species.
6. For the remaining species, copy and modify this layer:
- a. Right-click and **copy** the first layer.
 - b. Right-click and **paste**.
 - c. Right-click and modify **properties**.
 - d. Change the **Value** field to match the next species.
 - e. Change the **Classes** field from 3 to 4 then back to 3 – this updates the classification (there may be a better way of doing this).
 - f. Click **OK** then be sure to change the name of the layer to match the species.

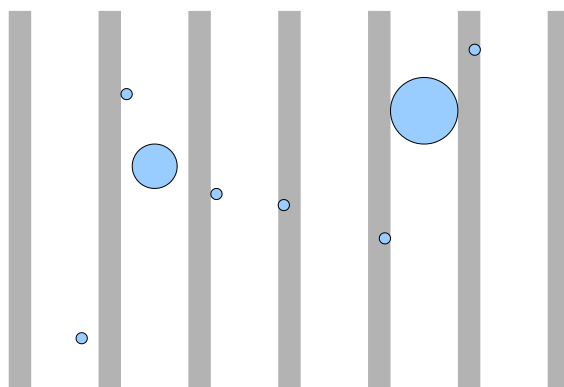


3 Total Counts

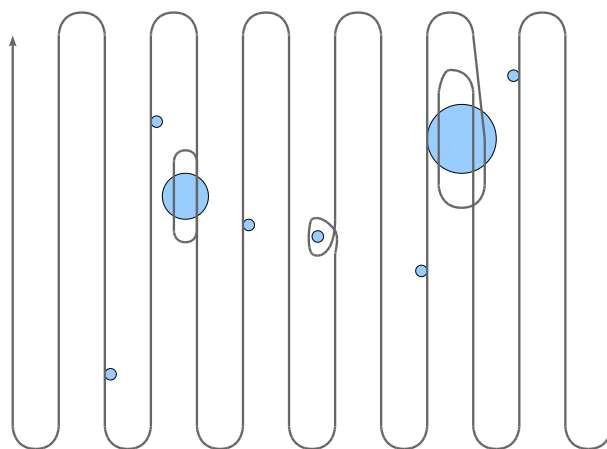
Total Counts are a complete census technique. In contrast to a sample count, which looks at parts of a population and estimates the total population size, a total count (TC) attempts to count all the individuals and groups in a population. In a TC the aim is to visually search the entire survey area, and to do this as quickly as possible to reduce the effect of animal movement.

As you can imagine, searching for and counting all the individuals in an area is far more intensive than taking a sample: it is a more expensive technique (often over 5 times more expensive than a sample count of the same area).

Total counts are typically used for special target species which are less effectively counted in SRF. Elephant and buffalo are the most commonly total-counted species, as they are highly aggregated/clumped and SRF estimates tend to have extremely wide confidence intervals because of this clumping. SRF relies on the assumption that the distribution of animals in between transects is the same, or similar to, the distribution in the sample strip (see Figure 1). If animals are highly aggregated, the tendency is for some transects to have very high counts and others to have low or none – this leads to very poor confidence in our results: what would have happened to the SRF estimate below if one of the two large groups had actually been in a transect?¹



In comparison, a total count follows a tighter flight pattern (example below) and groups are all counted; those spotted further away from the flight line, or larger groups, are circled and counted:



¹ The estimate would have been greatly increased – three small groups were actually within transects, but just one larger group would probably have increased the observations by twenty times or more – e.g. estimate of 30 vs. estimate of 500.

Caution!

Because total counts assume that the entire population is counted, they are often given great weight in reports and in analysis of trends. Total counts, however, are still estimates and we must treat them as such. There are other sources of bias and error that may make the estimate unreliable, and in particular we must remember that aerial surveys may miss large proportions of the populations of some species, and there are often substantial undercounts made in even lightly wooded habitats.

3.1 Procedure:

The general process may be summarised as follows:

1. Aircraft proceeds to start line of search area.
2. Crew begins spotting for target species.
3. When a sighting is made:
 - a. it is announced by the spotter (usually RSO), indicating distance, direction and estimate, e.g. "Elephant left, 200 metres, estimate 12".
 - b. FSO records the GPS position, direction, distance and estimate, and repeats back the data;
 - c. If the estimate is uncertain or > 20 animals the aircraft returns for photography:
 - i. The pilot makes a pass to the left of the group, or circles it;
 - ii. FSO makes a new waypoint and updates the form;
 - iii. Photographs are taken;
 - iv. Aircraft returns to the flight line.
 - d. Crew are all actively involved in keeping accurate track of groups and areas counted:
 - i. Possible duplicate observations are noted in flight;
 - ii. Possible missed observations on the previous flight line are checked.
4. After the block is counted, data are downloaded from the GPS and cameras, and photographic data counted immediately.
5. Data are mapped and checked for duplicate observations.
6. Flight lines are mapped to ensure complete coverage.
7. Once duplicates are removed, totals are produced for entire survey region.

3.2 Bias in TC

Careful attention to technique is important to reduce bias in total counts. The table below discusses some major sources of bias (after Jachmann, 2001), and briefly mentions the solutions to each.

<p>Double counting occurs when individuals are counted more than once. This may happen in several ways.</p> <ul style="list-style-type: none"> • Groups may move from one area to the next after being counted, and not recognised as being the same group. • Groups or individuals may fuse or split by the next pass, and thus seem like an uncounted group or groups. 	<p><i>The team must count each block as quickly and efficiently as possible, to reduce the chance of movement between passes over an area.</i></p> <p><i>Careful attention to previous sightings (numbers, demographic details, etc.), will allow you to identify movements, fusion and fission of groups.</i></p> <p><i>Pay attention to the behaviour of groups – it is often possible to predict fusion or fission of groups from their behaviour as you fly by, and you can watch for it on the next flight line.</i></p>
<p>Improper coverage of survey area:</p> <ul style="list-style-type: none"> • When the aircraft does not cover the entire survey area, or • When flight lines are too far apart to ensure complete observation of all the area between them. 	<p><i>The pilot and FSO must watch the GPS live map to ensure that the complete lengths of flight lines are used.</i></p> <p><i>Keep an eye on the range of vision you have on each flight line – if there are areas that you haven't been able to see, such as a valley or dense vegetation, request an overflight of that area.</i></p>
<p>Visual estimation of herds:</p> <ul style="list-style-type: none"> • As with SRF, estimation of herds by eye can lead to serious inaccuracies; • Vegetation may obscure part of the herd. 	<p><i>Cameras are vital for counting large groups greater than 20 animals.</i></p> <p><i>Flying and photographic technique can reduce the effect of vegetation by providing observers and cameras good views of a group on fly-bys.</i></p>
<p>Visibility & sighting probability bias:</p> <ul style="list-style-type: none"> • Regardless of flying technique, vegetation and terrain may obscure visibility. • The smaller a group of animals, the less likely it is to be spotted 	<p><i>Aircraft (and pilots) that can fly slow and low will minimise this. The aircraft should fly low enough to see individuals, and slow enough to give the crew enough time to search the field of view.</i></p> <p><i>Alternative methods such as double-counting (Jachmann 2001) can allow for estimation of missed groups and individuals.</i></p>

3.3 Survey Design

As with SRF counts, flight plans are made for the survey area – in contrast to SRF, these flight plans are guidelines for searching the area and ensuring complete coverage.

Divide the survey area into counting blocks using features such as roads, rivers, and hills.

- It is suggested to use watersheds as the boundaries for survey blocks as this will increase the probability that elephant and buffalo are towards the centre of the block, along the watercourses, and reduce the chance that large numbers of animals will move to the next block in between block counts.
- Other block boundaries that help block animal movement may be useful: major roads or major rivers (which are big enough to block or restrict animal movement), or terrain features (escarpments).

Set up a grid of lines in each block to be used as a route by the pilot:

- The spacing between lines is dependent on the visibility in the habitat, and planning them may require reconnaissance flights, habitat maps and working with wardens and scouts who have knowledge of the area.
 - 500m spacing (i.e. 250m searched either side of aircraft) may be used in dense woodland;
 - 1 km spacing is more typical in lightly wooded habitat;
 - Up to 3km spacing may be used in completely open, flat terrain.
- The grid of lines should extend beyond the block boundaries for each flight – in other words, you should re-search these boundary areas. (Duplicate observations may be removed during flight or post-processing)

3.4 Crew

Experience and diligence are extremely important in proper conduction of any scientific enterprise, and this is no exception. Consistency of method is vital for accuracy and for analysis of long-term trends, and each member of the crew must meet certain standards.

Selection of experienced and capable staff is vital – it is important for the entire crew to function well together and for the data produced to be reliable and properly recorded. In particular, good communication between the crew is important for proper recording of sightings in total counts and for elimination of duplicate observations.

Pilots must be able to fly the transect plan with good height and speed control, RSOs must be able to recognise the target species and make good estimates, have good vision and endurance, and FSOs must be able to quickly record observations from the RSOs and keep spatial track of observations and the aircraft flight path.

However, it is also important to balance the need for experienced staff with the need to give experience to junior staff, and to involve the ecological staff of a given protected area in surveys. Accordingly it may be necessary to allocate extra time for training, both on the ground and in the air.

Most of the requirements for crew are similar to those for SRF, but comments are made below for special requirements.

3.4.1 Pilot

Experience as per SRF.

Pilots in total counts must be able to make proper passes along a herd, and have practice in choosing a point and navigating back to it (this is far more difficult than you may realise, even with the help of a GPS). They must also be able to circle tightly around a group but safely without bringing the plane close to the stalling point.

3.4.2 Front Seat Observer

Front observers require more experience than with SRF.

- In total counts the FSO needs to be totally familiar with the use of the GPS – instantly able to take waypoints and find the map navigation pages.
- In addition to recording data and waypoints, the FSO works with the pilot to navigate and ensure total coverage of the survey area, and must thus have good spatial orientation skills.

3.4.3 Rear Seat Observers

RSOs should have similar experience to SRF. In addition:

- They must have a minimum of 4 hours of training specifically for total count methods.
- They must be good at estimating distances from the aircraft, to decide which observations are to be included in the current flight line and to record the distance to individual observations.

3.4.4 Training

As with SRF, time must be allocated before the survey for training and familiarisation. At a minimum, even when staff members are experienced and have had aerial survey experience within 12 months:

- Review of target species in the survey;
- Two-hour flight session, spotting and discussing the sightings and observations made, as per normal total count method.
- Practice with cameras during that flight session and confirmation by senior officer that photographs are properly taken, and no groups >20 animals missed.
- Review of training slides with animal numbers for practice in counting groups.

- Testing by senior officer with slides: estimation & species recognition. Species recognition must be 100%, and estimation of groups within +/- 20%.

Where RSOs have not had experience in aerial survey:

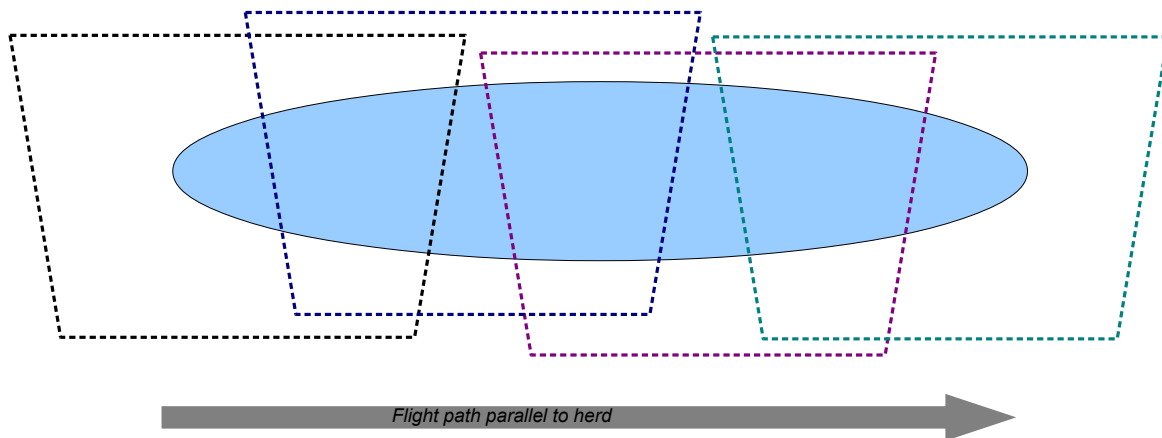
- Training in counting groups and identifying species in the target area, ½ day minimum – as per SRF.
- 2 x 2.5 hour flight sessions, practicing total count method (2 sessions).
- Testing by senior officer, as above.

3.5 Fieldwork

3.5.1 Flying technique

Flying a total count is more flexible than in SRF – height may vary depending on terrain and habitat, and flight lines are only guidelines to ensure complete coverage. As emphasized previously, the method is adapted to the specific conditions of animal distribution and visibility in the habitat, but the following applies:

- Height should be between 500 and 600 feet a.g.l.
- Ground speed should not exceed 100 knots; use up to 20 degrees flaps on downwind legs (with caution).
- Flight lines are guidelines, and you may depart from them as much as necessary to look at denser vegetation or any area which needs to be searched closely. Use the route or planned lines to ensure that you do cover the whole area, though!
 - Patches of denser vegetation will need special attention. A spiral flight path is often used to cover a woodland patch, or closer parallel flight lines selected by careful attention to the GPS map in flight.
 - Hills or valleys will obscure visibility, and you will need to likewise return for an overflight of hidden areas.
- Photographing a large herd requires that you make a straight pass, not a curved or circling one; if you circle, it becomes very difficult to ensure overlap of all photos.



Photographing a herd: example of 4 overlapping photos ensuring complete coverage.

Figure 12: Total count photographic pass.

3.5.2 Crew Duties

In contrast with SRF, the whole crew may be involved in searching and counting the area. Good communication is vital – due to the risk of bias of missing or double-counting, the crew must all pay close attention to the nature of the wildlife distribution they are seeing, tracking individual groups and remembering what they've seen before and discussing it to cross-check.

Having several people watching a survey area reduces the chances of missing animals, but it brings with it an increased chance of double-counting a group.

Pilot

The pilot's main job is to navigate the flight lines and track coverage of the survey area. Review the section on flying technique.

The pilot may also be involved in spotting animals, but only where this does not interfere with safety and good navigation. The pilot may scan forward of the aircraft to spot animals which may pass directly underneath the aircraft.

FSO

The FSO tracks the flight on the GPS or map, and records data on wildlife sightings.

The FSO is often involved in spotting animals, but this is secondary to recording data. A regular part of the FSO 'scan' should include the area in front of the aircraft, to see if animals are going to pass directly underneath.

The FSO should remind the crew in each block of the flight line spacing so that they have an approximate idea of the distance to search from the aircraft: i.e. 500m from the aircraft in a 1km spacing area, or 375m from the aircraft in a 750m spacing.

RSO

RSOs are primarily responsible for spotting animals, and communicating observations to the pilot and FSO.

- The main area to be searched is the area halfway to the next flight line – i.e. if spacing is 1 km, you search an area 500m to each side of the aircraft.

Ensure that observations close to this boundary area are recorded in one or the other flight line – it is better to count a bit further beyond the line and then remove the observation from the next flight line, than to miss it altogether when it moves.

- Observations are clearly announced: e.g. “Buffalo left two hundred metres, estimate fifty”.
- RSOs take photographs of larger groups using handheld cameras. This should not be done casually – only take a photo, or series of photos, if you are sure to get the entire group. If there is any doubt, just ask the pilot to return: e.g. “Elephants right two hundred metres, we need to overfly them”.

3.5.3 Pre-flight

Pilot and FSO GPSs are pre-loaded with flight lines. Old tracks may be deleted but usually it is better to leave them in place so that the pilot may see previous flights clearly.

Aircraft is checked:

- Seating positions are OK and comfortable.
- Canopy and all windows are well cleaned.

The FSO checks:

- Enough forms for the session; three or four should be more than enough.
- Pencils and erasers close to hand.
- GPS with flight lines, confirmed to be working correctly.
- Extra batteries for the GPS, even if you have a 12V cable connection!

The RSOs check their cameras:

- Are the battery indicators completely full? The batteries should be freshly recharged, and spares should be on hand.
- Lenses are taped at infinity.
- Zoom settings are taped at 28 or 35mm (this is optional).
- Shutter release is tested and correct exposure is confirmed.
- Exposure settings are correct for the camera: aperture priority, smallest aperture number (i.e. 2.8, 5.6 or so).

3.5.4 Post-flight

GPSs are downloaded and flight lines mapped immediately, and compared for overlap with previous sessions.

Photos are downloaded and the image numbers are correlated with individual observations.

- This is most easily done by comparing the time of GPS waypoints with the time stamp on the photographs.

- Sets of photographs can be determined by how close the time stamp of individual photographs are together. Typically we take pictures within 5 seconds of each other if they are of the same group of animals.

Prepare a map showing GPS tracks and waypoints.

1. Download GPS track and waypoint files as a single GPX file (suggested to do this in GPS Babel).
2. Open QGIS and load the project file if you already have tracks mapped.
3. Click "Add vector layer", then Browse and select your GPX file (you may have to change the file type to GPX in the lower right of the dialog before GPX files show up). Select Open then Open again.
4. Each GPX file contains information on tracks, waypoints, routes, and individual route and track points. Select 'waypoints' and then press control and click 'tracks'. Click OK.

Review the sightings and check for duplicates. Look at the waypoints and the tracks, and look for groups that have the same number (or close to it – i.e. have a close look at groups that are close by and are 20 and 22, or 50 and 49 in size). Some pointers (from TWCM 1995):

1. Was the observation by the same or different planes?
Two similar groups recorded by the same plane on the same day are considered to represent two different groups. It is assumed that the crew of one plane would recognise a herd it had seen before, and be aware of where it had flown before.
2. Check the time between observations and proximity of the sighting – how much could the herd have moved?
3. Similarity in composition of the group – slight differences might be expected between photographs, but not large ones. Examine the photos to see if quality of photo might account for difference in number of animals counted. In particular, distant photos tend to give lower counts than close ones.)
4. Sequence of observations and possible confusion. Look at the sequence of counts and the flight path. You might assume that the crew would not count the same group twice one right after the other, but that it might double-count it if it had flown off and done several other groups in the meantime.

Caution!

- The time stamp of a photograph is the time the photograph was taken according to the camera's internal clock, which is not necessarily the time indicated as the 'creation date' or 'modification date' in the file list in Windows Explorer.
- It is possible to add another column to a Windows Explorer window to show the photo date and time correctly. Change the folder view to show 'details' (not list or icon view), then right-click on the column headings. One of the options will be 'date taken' – select that.

3.6 Analysis

Analysis of a total count is relatively easy compared to SRF, but careful attention is needed in the initial processing after flights to remove duplicates.

1. Review possible duplicates as per the previous section.
2. Record each observation in order in a spreadsheet:
 - a. Aircraft
 - b. Date
 - c. Time
 - d. Observation number
 - e. Group size
 - f. Type (bull / family)
 - g. Administrative area
3. Tally up the total observations per admin area, and for the total area.

Part of your analysis is the process of elimination of duplicates. You must keep a record of how you did this – keep the duplicate observations in a separate sheet as part of the record.

You should report in your methods the duplicates removed and the reasons for each.

4 Bibliography

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- Jolly, GM. 1969. Sampling methods for aerial censuses of wildlife populations. East African Agricultural and Forestry Journal, no. 1969: 46 - 49.
- Norton-Griffiths, Mike. 1978. Counting Animals. Nairobi: African Wildlife Foundation.
- WCS. 2008. Aerial survey of the Luangwa Valley. WCS Flight Programme.

5 Appendices

5.1 Post-service calibration

After the aircraft returns from service, the streamers may have moved, and the calibration should be checked by the crew. Since the streamer position is so critical, we need to ensure that the target strip width on each side is still OK.

1. Check the position of the streamer mounts on the strut :
 - a. Still in place relative to the tape / pen mark?
 - b. Seat the observers. Do observers feel they are OK?
 - i. Bottom tape in window lines up with tire;
 - ii. Top tape / streamer seem normal.
2. If you suspect they have moved:
 - a. As with calibration, position marks on the ground for the bottom and top streamers.
 - b. Measure the distance between these marks.
 - c. Distance for observers should be the same as during calibration (consult your notes). WRITE DOWN THE MEASUREMENTS YOU FIND.
 - o Right: _____
 - o Left: _____
3. If you have to reset the streamers, repeat the normal calibration steps, but using the above numbers:
 - a. bottom streamer touching tire;
 - b. measure left and right distances as per original calibration;
 - c. position the top streamer to fit that distance.
4. **RECORD what you did – even if you find that the streamers were OK!**

5.2 Appendix B: Online Resources

At the time of writing, the analysis and budgeting tools and the PDF forms are online at a temporary site:

<http://www.countinganimals.chi-tanzania.com>

This site will link to the final website location when it moves. These files are also provided on CD/DVD with the bound version of this manual.

Aerial survey methods, like all of science, are constantly under development. The tools here will be updated and modified from time to time. It is recommended that you join the mailing list for these aerial survey methods at:

<http://groups.google.com/africanwildlifesurvey>

When tools are updated, or techniques are under discussion, they will be announced on this mailing list and on the main website.

5.2.1 GIS software

Most organisations use ArcGIS as their main GIS platform. However, a free alternative to ArcGIS is available: QGIS. While at the time of writing QGIS does not have the full range of features available, it can certainly do the majority of the mapping and GPS data management required in the field and for preliminary reporting.

<http://www.QGIS.org>

QGIS plugins are varied and extend the capacity of the programme dramatically. Set up QGIS while you have a network connection (see 2.2.4.5 for instructions).

- The "Openlayers" plugin will let you download the Google Physical layer and other layers (only while online!); this is a great background for transect planning, as it shows elevation relief, roads and towns.
- The fTools plugin has a large set of useful tools for geoprocessing and field survey.
- GDAL tools let you work with a large number of raster-based tools.

5.2.2 GPS data upload / download

Upload and download of GPS data may be done with freeware applications such as GPSTabel, DNRGarmin or QGIS, or with commercial applications such as GPSUtility.

- GPSTabel is free software for Windows, Linux and OSX, and is highlighted in this manual. It allows for upload and download of GPS data in a huge variety of formats

www.gpsbabel.org/

- QGIS requires that you activate the "GPS" plugin; this should be a default part of the installation, and can be activated under the "Plugins" menu. The interface only allows for download of EITHER track, waypoint or route information each time, so three downloads or uploads would be required

to transfer these datasets; the GPSTools software lets you download or upload all data at the same time and is more convenient.

www.qgis.org/

- DNRGarmin is free software for Windows, from the Minnesota Department of Natural Resources, and functions similarly to GPSTools.

www.dnr.state.mn.us/mis/gis/tools/arctools/extensions/DNRGarmin/DNRGarmin.html

- GPSTools is commercial software (\$30) but well worth the money. It allows for download and upload of GPS data in the same way as GPSTools, but also allows for editing and display of track and waypoint data in an advanced editor. Tracks may be split, combined, renamed, and individual segments saved as shapefiles. Routes may be planned on-screen and time and distance estimated. Scanned maps may be georeferenced and downloaded data overlaid on the scan.

www.gpsu.co.uk/

5.2.3 Office software

All of the tools described here are available in both Microsoft Office and OpenOffice.org formats. OpenOffice.org (OOo) is a superb, free alternative to Microsoft Office:

www.OpenOffice.org

5.2.4 GIS Data

Your organisation should already have a good library of geographic data for planning and reporting on field projects. Other sources include:

- Digital Elevation Models (DEM) – terrain maps, showing elevation and slope. These may be downloaded from a number of sites, including:
 - Main NASA site: asterweb.jpl.nasa.gov/
- Administrative boundaries showing country, regions and districts:
 - Digital Chart of the World (DCW): www.maproom.psu.edu/dcw/
- Rivers and water bodies:
 - DCW, as above.
- Protected area boundaries:
 - World Database on Protected areas: www.wdpa.org

5.2.5 Geotagging software

Geotagging is the process of adding geographical metadata to your images. This may be done at the time the photograph is taken, with a connected GPS, or by correlating a GPS track (i.e. the GPX file) with images.

Tips & Tricks

- If you're going to geotag your photos with software, make sure the GPS is running the entire time you are taking photos.
- Try to synchronise the time on the camera with the time on the GPS – this is how the software figures out where the camera was!
- The first photo you should take should be of the time and date on the GPS screen – that way you can compare the image time/date with the 'correct' GPS time/date and figure out the correction factor (more than ten seconds is a real problem for accuracy).

5.2.5.1 Free packages for geotagging:

- <http://geotag.sourceforge.net>
- <http://www.geosetter.de/en/>

5.3 Example transect & flight maps

As an example, the two maps below show the transect plan and actual flight lines (downloaded from GPS) from a survey in Zambia (WCS 2008).

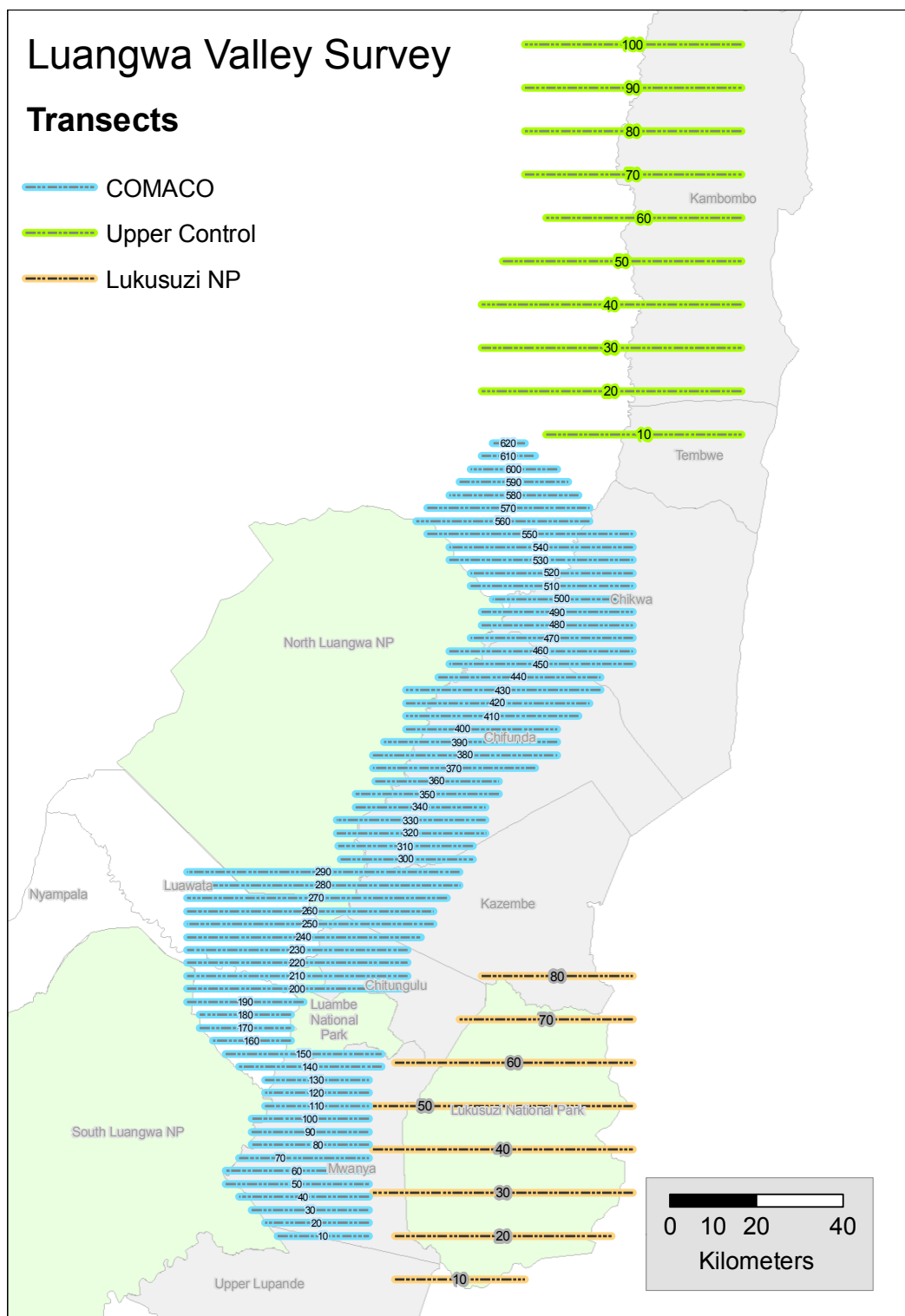


Figure 13: Transect lines, Luangwa Valley 2008.

This is an example of a stratified survey: high-density areas (blue lines) were flown at a higher intensity than the other two zones, and estimates were produced separately.

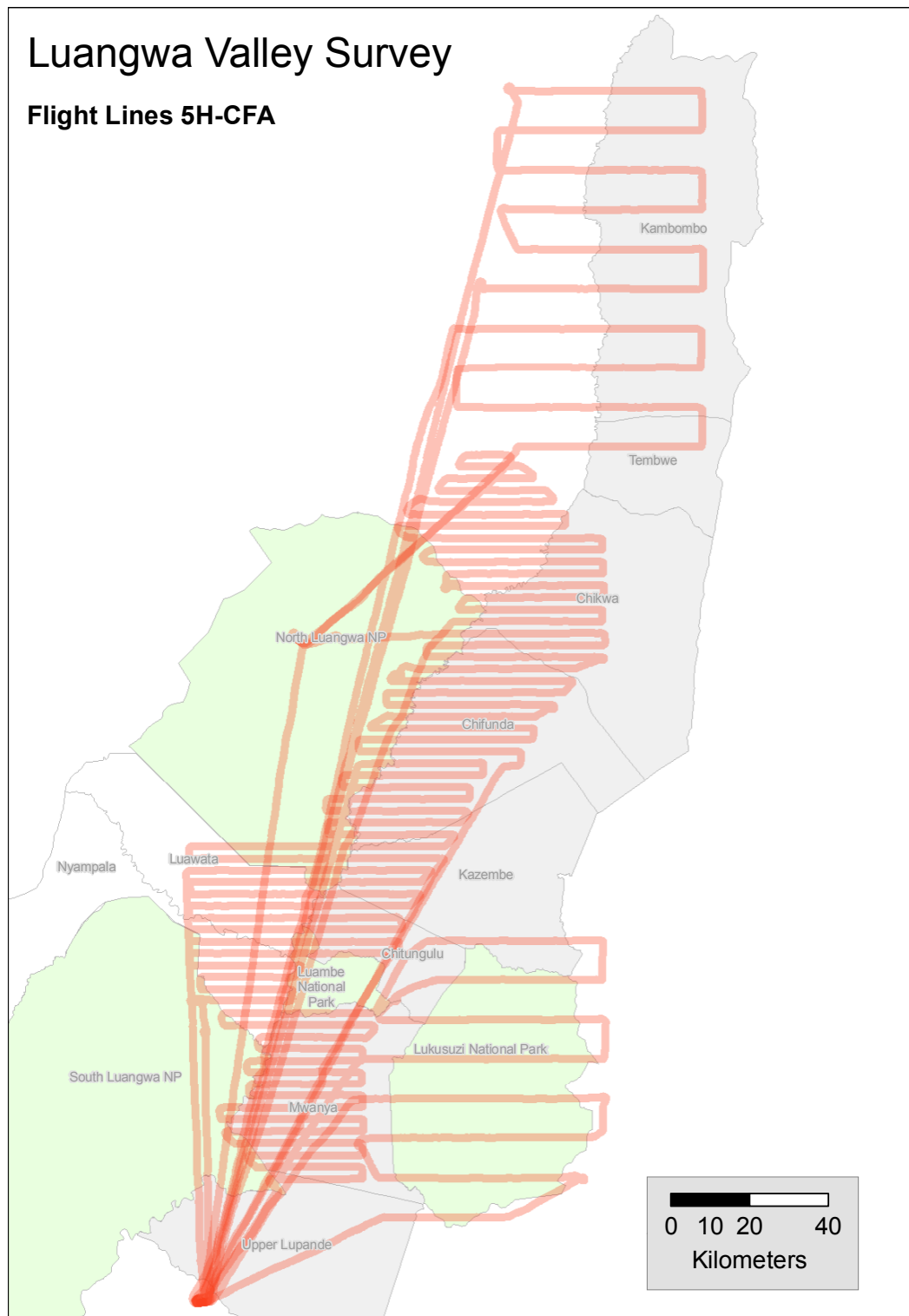


Figure 14: Actual flight paths, Luangwa Valley 2008.

Note the two field bases in use: one in the south where most of the flight lines converge, and one in the north with close access to some of the northern transects.

5.4 Counting Photographs

With digital photography, it has become far easier to immediately process photographic data – it can, and should, be done immediately after the survey flight.

The process: download from the camera to a folder on the computer; geo-reference photographs if required; allocate frame numbers to individual observations based on sequence/time and the number of frames indicated by RSOs, and write the frame numbers on the data sheet; open the photograph in a graphic package such as Photoshop or GIMP; enhance the photo as necessary; count the number of animals seen and place dots on each as part of the counting process; save the counted (dotted) picture in the same folder as the original.

Downloading

This is dependent on the model of camera. Typically, however:

1. Connect the camera (or card) to the computer with a USB cable;
2. Open the folder on the camera to see the images;
3. Select the set of images from the camera folder (it may help to change the view to “details” and sort by date – then, select the set of photos from the appropriate start time to the end) and ‘copy’.
4. Create a folder for the photographs – suggested format YEAR-MONTH-DAY SESSION AIRCRAFT POSITION, i.e. “2011-03-20 AM 5H-CFA Right”, and paste the photographs into that folder.

Georeference: this is optional. Use the GPS track and the photographs to determine the approximate GPS location of each photograph. There are numerous software packages for this and you will need to consult the directions for the package you are using.

Allocate photographs to their observations

5. Open the spreadsheet with your observations listed.
6. For each observation where the RSO or FSO indicates a photo was taken, look at the number of frames and then indicate the frame numbers (i.e. DSC_1002 or whatever filename is used):
 - a. If there is a waypoint indicated, check the time of the waypoint and match this to the time taken;
 - b. If there is no waypoint, use the sequence of images and the start/stop time of each transect to determine the correct images.
7. Briefly examine each photograph to see if it belongs with the others in its set, and if the species is correct.

Enhance and count photos

1. Open the photograph in Adobe Photoshop or GIMP
2. Apply ‘auto levels’ settings (**Ctrl-Shift-L** in Photoshop and GIMP)
3. For multiple images of the same herd, identify zones to count
 - a. Open all images for the set;
 - b. Examine each image and find the parts of the herd that are the clearest in each photo, or most central.

- c. Using a brush or pencil tool, draw zones around the set of animals that you will count in each photo – then review to ensure you have the complete herd covered, photo by photo!
4. Count:
 - a. Select the 'brush' tool and a contrasting colour (red or green depending on background), and place a dot on the back of each animal that you count.
 - b. As you finish each group of animals, circle them with the brush tool and write the total of each group inside the circle.
5. **File: Save As** and add the words "COUNTED" to the filename, saving it back to the same folder as the original!
6. Total the number from each photograph and update your spreadsheet.

5.5 Setting up a camera for fieldwork

Setting up a camera for aerial photography is substantially different to setting it up for regular photography: you are concerned only with photos of objects at a distance, and for shutter speeds to be fast enough to avoid any motion blur from a moving aircraft.

The cameras used in most field science applications these days are digital. The minimum standards are:

- 6 megapixels or better (almost all cameras will have 10 megapixel resolution or better);
- Lens capable of fixed focus, 28 or 35 mm fixed focal length is best, but a zoom (i.e. 18-50mm) is acceptable. The exact fixed focal length will depend on the type of sensor in the camera – most cameras will need a 28mm lens to get a wide enough angle to cover the streamers plus a small margin.
- SLR model with instant response when the shutter is released – many cheaper cameras (point-and-shoot types) do not do this, and there is a delay between pressing the shutter release and the taking of the photo; even a quarter-second delay is enough to miss a shot.

The instructions here are generic, and the specific method to set up the camera will depend on the model you have.

1. Set the lens to fixed focus and zoom
 - a. If the lens is a zoom lens, choose a zoom level that you will be using in the air – probably around 28 or 35 mm. Tape the zoom ring on the lens so that it cannot be moved easily.
 - b. With the camera on autofocus, point the lens at a distant object (at least 200m away) and lightly press the shutter release to make it focus.
 - c. Tape the focus ring in place.
 - d. Change the camera setting to manual focus.
2. Set the ISO (speed) rating to 400.
3. Set the mode to aperture priority and set the aperture number to the smallest number available – i.e. 2.8 or 3.6, but NOT 22 or 32 (the wrong side of the scale!). This means that the camera will use the fastest shutter speed possible with the lens set to 'wide open'.

4. Ensure that the 'quality' setting is at its highest. This (depending on camera model) will be called "best" or "fine" or "superfine" ... this requires that you read the manual to make sure you have the right setting!
5. Set the date and time to the local time – check the GPS readings. Do this BEFORE you start the survey!
6. Take a photograph of a GPS that is showing the current time – this will be a record of the exact difference between the GPS time and the internal clock of the camera; this is used to georeference photographs later. This photo should be stored with the digital pictures as part of the permanent record.

Tips

- Use plain electrical tape to tape the zoom and focus rings on the lens – this should already be part of your kit. Electrical tape usually can be placed and removed with a minimum of trouble and it leaves little residue. Duct tape does not – it has much stronger glue which makes it difficult to remove!
- Take test photos during your training flights and review them on a laptop after landing – do not trust the appearance of the photos on the camera screen!

5.6 Management of GPS route and waypoint in the field

On a daily or per-session basis, data are uploaded and downloaded from GPSs and saved. Before flights, the pilot GPS should have the transect and route information uploaded, and the FSO GPS should have transect and subunit information. After the flight, track and waypoint data are downloaded from each GPS and saved. Old track data are kept on an archive on the GPS, and old block data are deleted when a new block is started.

The following are general instructions for a typical survey where block data are organised into sets for pilot and FSO GPSs:

5.6.1 Introduction

Each block has its own set of waypoints and routes for navigation.

- The pilot's GPS (g296) will need the waypoints for the transect endpoints; the FSO GPS will need the full set of subunits and endpoints.
- Both GPS's will need the same route loaded; it is OK if only the pilot GPS has the route, though.

5.6.2 Erase previous block data:

5.6.2.1 Pilot GPS

This is usually a Garmin 296 or equivalent.

Erase only waypoints and routes, not the track:

1. Turn on / enter simulator
2. [Menu] [Menu] then select Points
3. [Menu], select Delete by Symbol
4. Select City (Medium) then [Enter] then select OK to delete waypoints.
5. It will ask you if want to delete route points as well – OK

Use GPS Utility to transfer the blocks:

1. Attach GPS and start GPS Utility
2. Load the block endpoints: "BLOCK transects.txt" (e.g. Ngoma transects.txt)
3. Confirm on the map – waypoints and route OK?
4. Upload to GPS – waypoints & routes only.
5. Check on GPS map page.
6. Turn GPS off.

5.6.2.2 Garmin 60Csx

Erase waypoints, routes & track:

1. Turn on GPS, turn off reception to save battery (**Menu** at first satellite page then **Use with GPS off**;
2. [Menu] [Menu] then select Tracks
3. Select Clear, [Enter] and confirm [Enter].

4. [Find], select Waypoints then [Enter].
5. [Menu], select Delete [Enter].
6. Select City (Medium)
7. Confirm (Yes) [Enter].

Use GPS Utility or GPSBabel to transfer the blocks:

1. Attach GPS and start the application;
2. Load the block endpoints: "BLOCK subunits.gpx"
3. If using GPS Utility, confirm on the map page – waypoints and route look OK?
4. Upload to GPS – waypoints & routes only.

5.7 Forms & Checklists

The forms listed here are all available for download in PDF format on the “Counting Animals” website.

5.7.1 Master Equipment Checklist

The following list is a general checklist for aerial surveys. (The 'calibration' section is only required for SRF).

Calibration kit:

- Streamer / rod kits for aircraft. Confirm left and right clamps – they are different!
- Small builder's level.
- Screwdrivers x 2 (flat head and Phillips).
- Pliers.
- Electrical tape – red and black.
- 10m measuring tape for rod distance and eye height.
- 50m measuring tape for markers.

Survey kit

- forms for FSO, RSO.
- Pencils and erasers for data entry.
- Tape recorders: two per aircraft, with one spare.

GPS units

- Pilot: will probably provide but CHECK before leaving base!
- FSO
- One spare for each survey.
- 2 x data cables for download.

Batteries

- Sufficient AA or, ideally, rechargeable units, for an entire survey. GPS60Csx handhelds can go through a set of alkaline batteries in a day – but TEST this at home because battery quality and GPS power drain varies considerably!

Emergency kit for aircraft + first aid.

Photographic kit for each plane:

- Cameras (2/plane) w/ 28 or 35mm fixed lenses.
- Battery chargers for cameras.
- Cable releases – two per plane, plus two spare (these are easily damaged).
- Stickypod mounting kits.

Airsickness bags

Crew instruction sheets for FSO, RSO and pilot:

- print out this manual for trainees, or the relevant sections for experienced staff.

Office kit:

- Data forms: this depends on the length of the transects, but typically 1 FSO sheet per transect and 2 RSO.
- Clipboards: one per plane.
- Box file to file survey data as it is filled in.
- Pencils
- Erasers
- Sharpeners

Topographic map of the entire survey region.

5.7.2 UWA Forms

The following pages are the FSO and RSO forms used by the Uganda Wildlife Authority in their survey programme.

FSO DATA SHEET

Aircraft:	FSO:	Survey:
	Pilot:	Date:

[illegible]

RSO DATA SHEET

Aircraft:	RSO Position: <i>R / L</i>	Survey:
	Initials:	Date:

[illegible]