



# **Biodiversity monitoring Vwaza Marsh Wildlife Reserve Malawi**

## **Manual & Field Guide**

# Contents

---

Logistics pages	3
-----------------	---

---

Day to day plan	4
-----------------	---

---

General field safety procedure	5
--------------------------------	---

---

Maps	6
------	---

---

---

LWT data collection protocols	10
-------------------------------	----

---

Primate behavioural observations	11
----------------------------------	----

---

Elephant dung collection and seed analysis	15
--	----

---

Elephant herd sightings and group observations	17
--	----

---

Elephant individual identification	19
------------------------------------	----

---

Elephant ID guide	20
-------------------	----

---

Large mammal transects	29
------------------------	----

---

Hippo count transects	33
-----------------------	----

---

Camera trapping	34
-----------------	----

---

---

CRA data collection protocols	36
-------------------------------	----

---



# LOGISTICS PAGES

## DAY TO DAY PLAN

	Morning	Afternoon	Evening
Sun	Meet in Lilongwe, travel to Vwaza	Arrival, orientation, introductions, risk assessment	
Mon	Intro to projects, field safety, map orientation	Distance practice, game drive	
Tue	Elephant project training, elephant safety, elephant ID, camera trapping, primate behavioural observations	Bat ecology & ID training, entomology, bat survey techniques	Bat survey
Wed	Research work		Bat survey
Thu	Research work		Bat survey
Fri	Day off (local village market visit and other activities optional)		BE presentation
Sat	Research work		Bat survey
Sun	Research work		Bat survey
Mon	Research work		Bat survey
Tue	Research work		Bat survey
Wed	Research work		Bat survey
Thu	Research work		Sundowners
Fri	Depart Vwaza	Arrive Lilongwe	

### General timings

05:30	Breakfast (for those doing transects)
06:00	Leave for walking or driving transects
07:00	Breakfast (for those not on transect)
09:00	Field work
10:00	Late breakfast and coffee for those back from transects
13:00	Lunch and daily review at camp
15:00	Field work
16:00	Leave for bat survey
18:00	Dinner (those on bat survey will eat when they return)

**Remember to stay flexible as things are likely to change**



## GENERAL FIELD SAFETY PROCEDURE

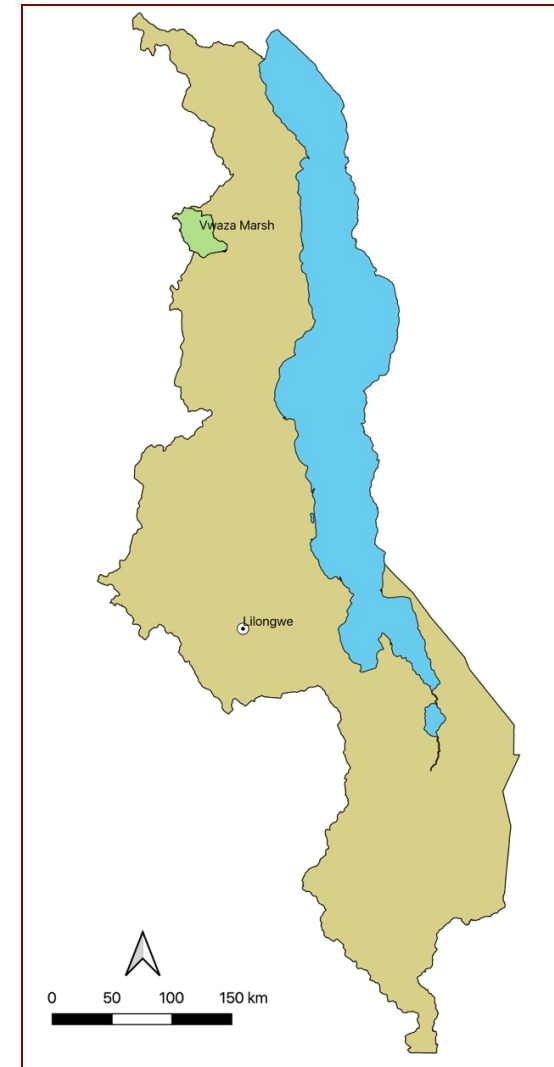
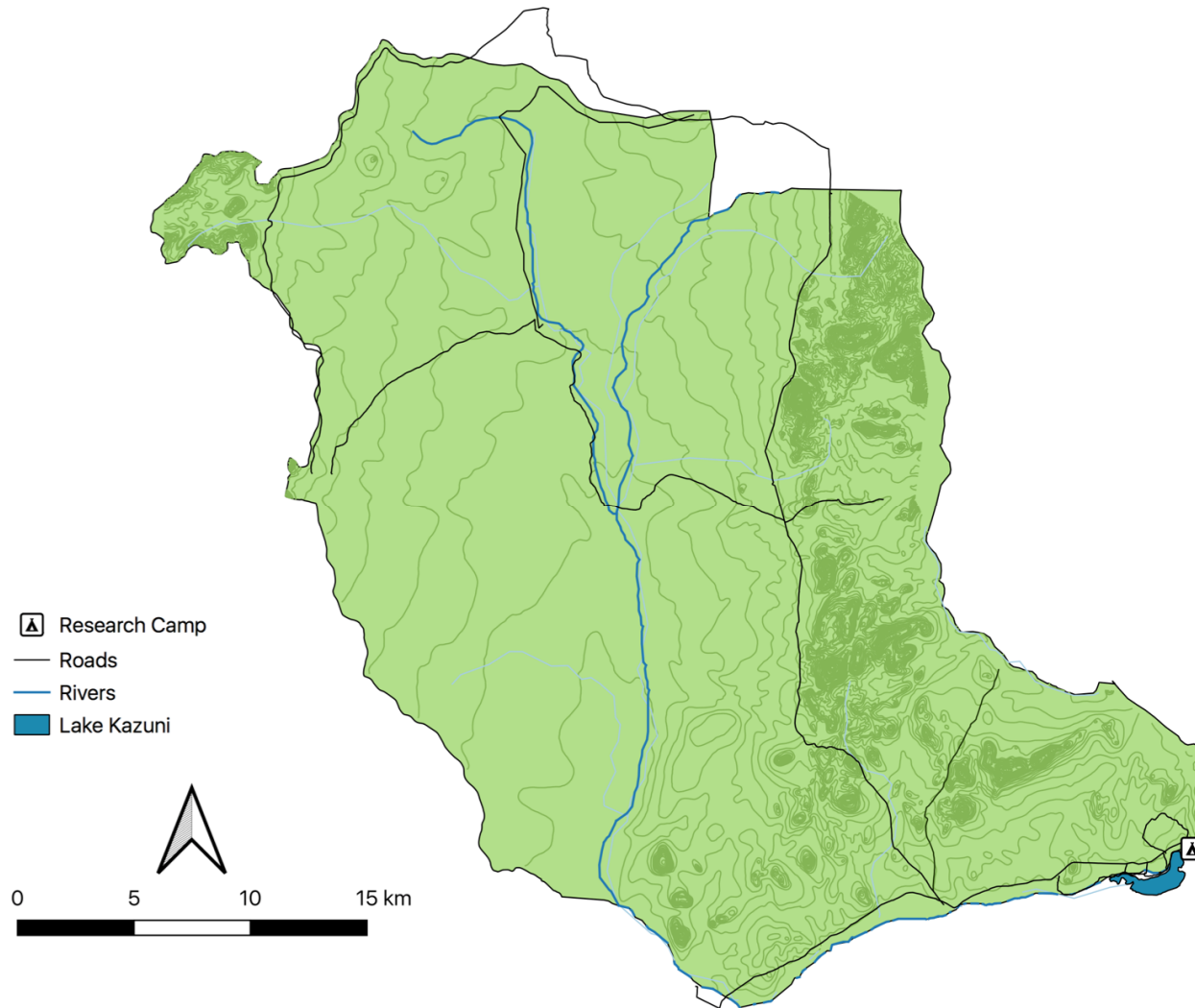
1. Always fill in the log book when leaving base so that we know what you are doing where and when you intend to return.
2. Always carry in each group (a) this sheet, (b) the mobile phone sheet, (c) at least one mobile phone, (d) a radio. Make sure devices are switched on, fully charged and loaded with airtime.
3. Stick to your route and return time. If you are going to be late, call staff or someone else who will adapt your return time. You may have to relay that message across the study site until someone at base gets it and can adapt the logbook.
4. If you are more than an hour over your return time, we will send search parties out to look for you (the first place we will head for is the route you have specified on the logbook). Please make sure you are back in time or send a message if you are delayed so that no unnecessary searches are initiated.

**If you have an accident/emergency**, those able to should administer first aid. If you are in a functioning vehicle, take the casualty back to the nearest location below immediately. Try to contact staff on the way so that they can get in touch with the emergency services as necessary. If you do not have a functioning vehicle or are on foot, but have mobile phone or radio coverage, try to contact staff or anyone else you can raise and ask for assistance (you may have to ask them to go for help or relay the message). If this is not possible, stay put, help the casualty to the best of your ability and have 1-2 fit people climb the nearest hill/mountain top and establish contact, or return to base. If you are unable to contact anyone, then it will be up to you to carry out an assessment. It is essential that you do this as calmly as possible and decide the best course of action, which will not make the situation worse. In most cases this will mean you will stay put, as this gives us the best chance to find you quickly (one reason to stick to your route always and fill in the logbook), but extreme situations may require extreme measures. You should never leave a casualty alone and make sure they are kept warm and/or in the shade and comfortable. Make sure you have a GPS location for the casualty.

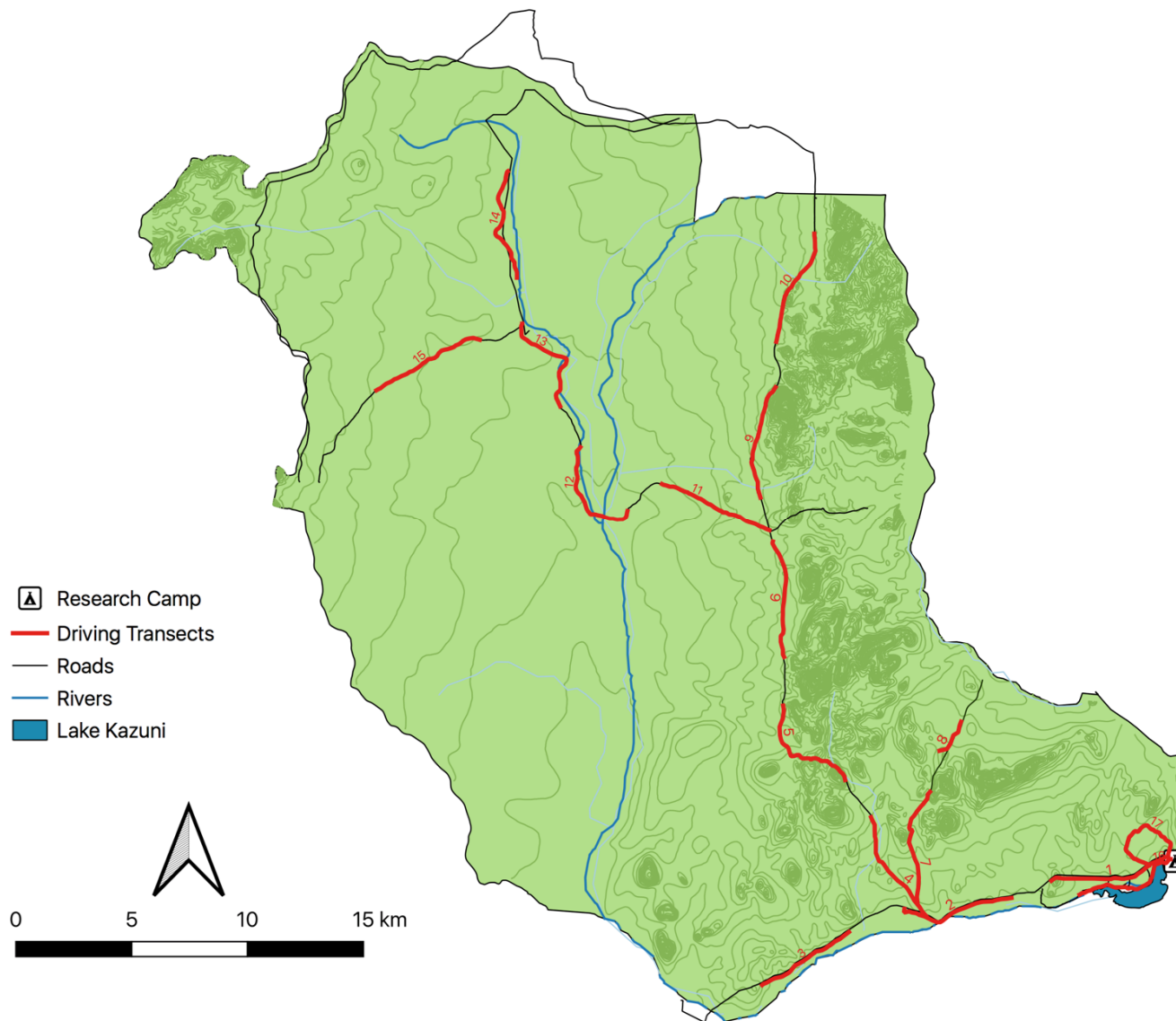
### Numbers

Expedition leader – Malika Fettak	+265 (0)992896982
Research manager – Mandy Harwood	+265 (0)997070756
Emergency services	+265 (0)888189072 (ambulance)

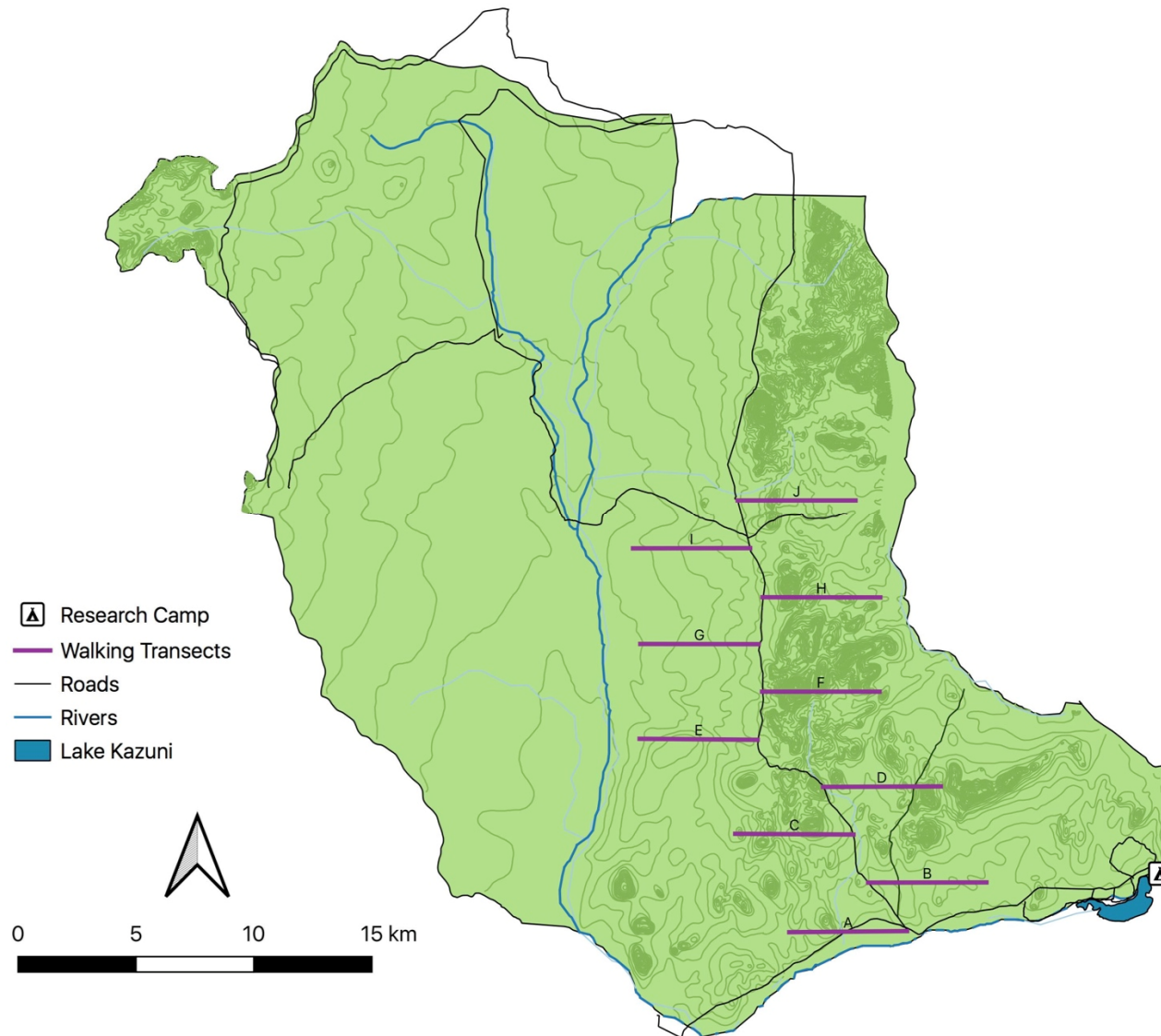
## MAPS



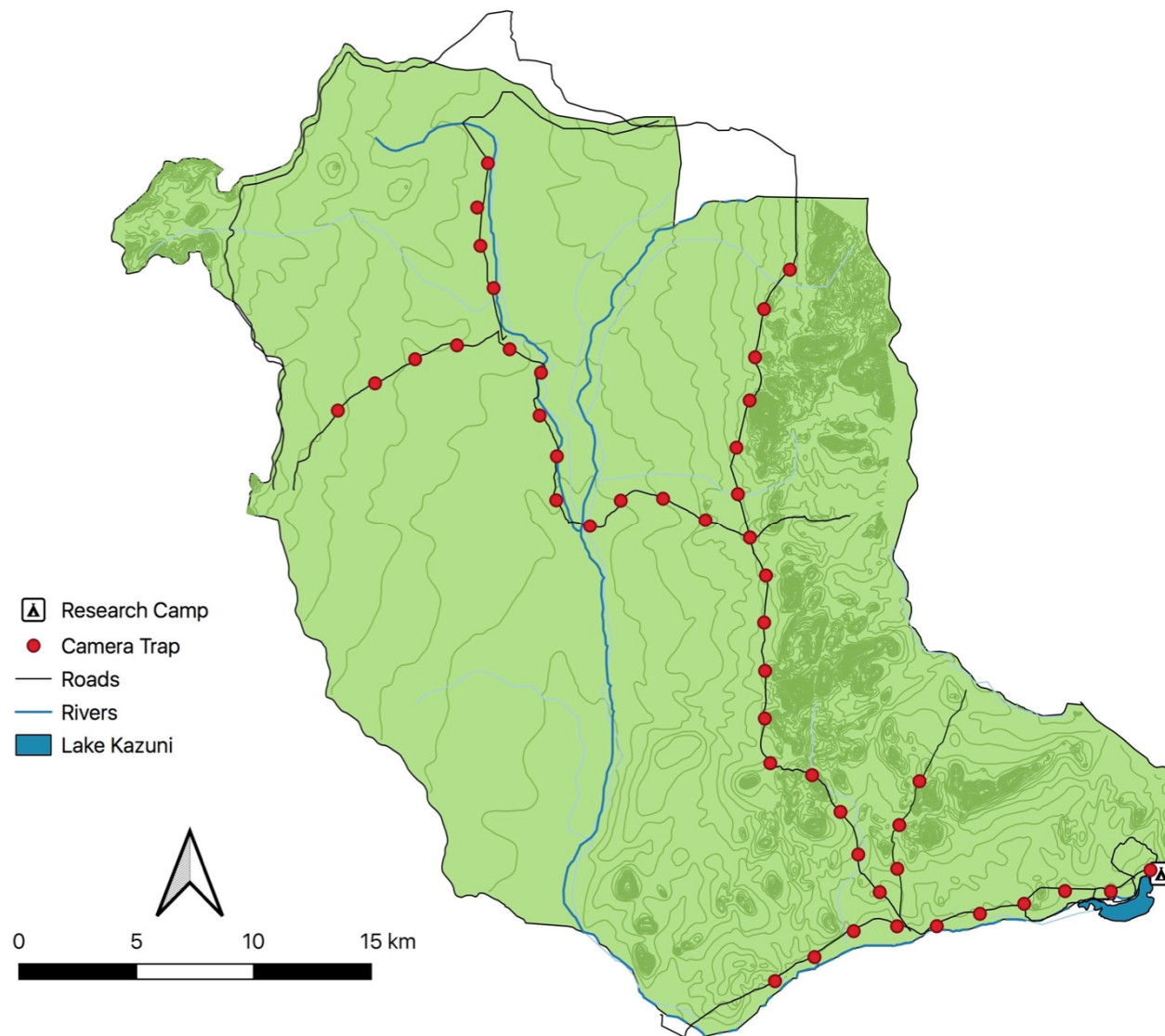
Vwaza Marsh Wildlife Reserve and its location in Malawi



Driving transects



Walking transects



Camera trap placement



# **DATA COLLECTION PROTOCOLS**

# PRIMATE BEHAVIOURAL OBSERVATIONS

The Lilongwe Wildlife Trust conducts primate release program in Vwaza Marsh. Extensive behavioural, health, and spatial data are collected both pre-release at the Lilongwe Wildlife Centre, and post-release in the field to assess the welfare of released primates. Behavioural data is determined using LWT's primate ethogram (an ethogram is a catalogue or list of all the different behaviours or activities observed in an animal). Adult monkeys are fitted with VHF radio collars that we track to find and follow the troop. You will learn how to use the telemetry equipment and tracking in the field.

## Daily census

When you find the monkeys, first record the situational data and the GPS location. Then take a census of the troop to make sure all individuals are present and accounted for. If you do not see an individual, wait until the end of your observation time as he/she might just be on the periphery of the group. If he/she is not seen for a whole day, or a few days, then we can mark that individual as missing. Each individual is identified using unique combinations of coloured eartags.

## Time of day

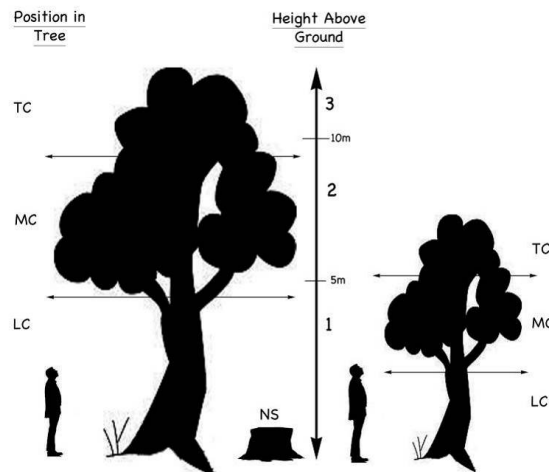
- Each individual is observed at least once per week in each of our 4 time blocks.

Time Block	Time of Day
1	6:00 – 9:00
2	9:00 – 12:00
3	12:00 – 15:00
4	15:00 – 18:00

## Instantaneous focal sampling

Behavioural data are collected using individual focal sampling. One individual is observed at a time for 20-minutes.

- Observe one individual for 20 consecutive minutes.
- Use a stopwatch or interval timer beep set to alert you of each minute mark.
- On each minute, record the exact behaviour the individual is demonstrating at that exact moment.
- Sometimes you will see two behaviours occurring at once (e.g. foraging and locomote), and you can record both on the data sheet (e.g. FO/L).
- ALL of the behaviours that are described on the ethogram can be recorded during instantaneous focal sampling.
- For every observation you record the animal's position in the canopy. These are ground (G), man-made structure (MM), natural structure (NS) (e.g. tree stump), lower canopy (LC), mid canopy (MC), and top canopy (TC). These measurements are dependent on the specific tree that the monkey is in. When you look at the tree, divide it visually into three equal parts, and that will be your LC, MC and TC. Additionally for position in the canopy, you record (in meters) the individual's position above the ground. This is categorized into a 1-4 scale (see ethogram for details). We use a combination of tree position and height above ground to indicate position in the canopy (e.g. LC1 or TC3).



- For observations that include the behaviour “Feeding”, you record what kind of food the individual is feeding on under Food Type. See list of foods and their recording codes on the ethogram.
- For observations that include an interaction with another individual, (e.g. grooming, playing, threatening), include that individual's ID under Association.
- If you cannot see your animal during the time of observation, you mark the behaviour as Out of Sight (OS).
- You must have a minimum of 7/20 behavioural observations (i.e. not OS) for a successful sampling.

### Continuous focal sampling

- Stress, dominance, and social behaviours are recorded continuously. These are recorded simultaneously (within the same 20-min focal period) with the instantaneous sampling on the same focal individual.
- During the focal, if the focal animal demonstrates any stress, dominance, or social behaviours any time within the 20-mins (e.g. not dependent on the minute interval beep), you record them under the continuous section as occurring between the interval minutes (e.g. between minutes 1-2, 2-3, etc).
- If the behaviour is shown on an interval minute, then you automatically also include it under continuous as having occurred both before and after the interval minute (e.g. if the animal is grooming on minute 6, then you also record G+ under mins 5-6 and mins 6-7).
- You record some behaviours EVERY time they occur (e.g. scratching) and some only once if they occur within that minute (e.g. grooming).

### Scan sampling – Proximities

- During each focal, three proximity scans are conducted to measure which individuals are close to the focal animal
- On the 0, 10, and 20 minute of the focal, you scan the troop and measure based on visual approximation how far each individual is from your focal animal.
- Categories are less than 1m, 1-5m, 5-10m, and more than 10m.
- The proximity scan can be classified as Out of Sight (OS) if 1) the focal individual is out of sight during the proximity minute, or 2) no other animals are visible to the observer on that proximity minute. You cannot guestimate they might be more than 10m if you definitely cannot see them.
- Aim to capture the whole troop in each scan.



## Ethogram codes

	CODE	BEHAVIOUR DESCRIPTION	Cat.
1	G-	Grooming – Taking care of the fur of another individual, by pushing aside its fur and inspecting for foreign objects (dirt/insects). Also includes taking care of another animals' teeth or skin ( <i>record other individual(s)+ record as duration behaviour for continuous</i> )	Social
2	G+	Getting groomed – The focal animal is groomed (as described above) by another individual ( <i>record other individual(s)+ record as duration behaviour for continuous</i> )	
3	PR-	Presenting – Presenting itself (either the body or hind quarters) to another primate. Inviting them for social contact, such as grooming or mounting ( <i>record other individual(s)</i> )	
4	PR+	Being presented – Being presented to by another individual ( <i>record other individual(s)</i> )	
5	C	Contact - Individuals touching in a non-aggressive way, such as nosing or cuddling, but not grooming or playing ( <i>record other individual(s)</i> )	
6	CL	Clinging – Clinging to another individual while being carried, specifically for infants	
7	N	Nursing young – Mother breast feeding an infant	
8	SU	Suckling – Feeding from the mother, specifically for infants/juveniles	
9	PL	Playing – All types of interactions between two or more animals using the relaxed open mouth play face (mouth is half or wide open, teeth are covered by lips or at least the upper incisors are showing) Interactions such as touch, pull, push, hit, chase, bite and hug ( <i>record other individual(s)+ record as duration behaviour for continuous</i> )	
10	MA	Mating – A male mounting a female, or a female is mounted by a male, with actual penetration. Often accompanied by a copulation call ( <i>record other individual</i> )	
11	MO	Mounting – The focal animal mounts another individual or is mounted by another individual. Either male/female without penetration, male/male or female/female ( <i>record other individual</i> )	
12	FE	Feeding – The actual act of eating, food is touching the lips or is in the mouth in combination with chewing ( <i>list food type</i> )	Feed
13	FO	Foraging – Looking for food to eat. Includes turning rocks or other objects upside down and pushing away objects on the floor/sand.	
14	L	Locomotion - Any movement to get from one place to another, such as walking running and jumping. In any direction possible direction on the ground, in the trees or on buildings.	Other
15	R	Resting – Sitting or laying down without any activity, and low levels of awareness of the environment. The eyes may be open or closed, but generally the head is down.	
16	V	Vigilance - Any level of observation or awareness of their environment. This includes sitting in a tree or on the ground, with head up eyes open looking. Not only for extreme vigilance	
17	PA	Predator Avoidance – Any form of predator avoidance behaviour, this includes alarm calls or responding to alarms calls and hiding into the trees ( <i>record details on additional data sheet</i> )	
18	O	Other – Any other behaviour not defined in the descriptions of the behaviours mentioned ( <i>describe types of 'other' behaviour on data sheet</i> )	
19	OS	Out of Sight – The focal animal is partly or completely invisible, i.e. when behaviour could be missed because of lack of sight.	Dominance
20	A+	Aggression - Physical aggression with a (potentially) damaging action, including biting, slapping, grabbing and hair pulling. Usually occurs with mouth-open and teeth exposed ( <i>record other individual(s)+ record as point behaviour + outcome conflict for continuous</i> )	
21	A-	Receive aggression - Receiving physical aggression ( <i>record other individual(s)+ record as point behaviour + outcome conflict for continuous</i> )	
22	TH+	Threat: Non-physical aggression towards another individual, such as chasing with and open-mouth facial expression and teeth exposed. Often accompanied by vocalisations. Also includes threatening other individuals (with raised eyebrows, mouth is open like an 'o', teeth are covered), head-bobbing (short movements with head and/or shoulders) towards other animals whilst staring, lunging, and display behaviours (shaking trees, bushes or other objects) ( <i>record other individual(s)+ record as point behaviour + outcome conflict for continuous</i> )	
23	TH-	Receive threat – Receiving threat as described above ( <i>record other individual(s) (record other individual(s)+ record as point behaviour + outcome conflict for continuous</i> )	
24	MP+	Making place - Another animal moves away when the focal animal approaches (closer than 2m) or after being threatened by the focal animal ( <i>record other individual(s)+ record as point</i>	

25	MP-	Making place - Focal animal moves away when other animal approaches (closer than 2m) or after being threatened by the other animal ( <i>record other individual(s)+ record as point behaviour + outcome conflict for continuous</i> )	Stress
26	SC	Scratching - A single scratch or repetitive movement of scratching the body with hand or feet ( <i>record as point behaviour for continuous</i> )	
27	SG	Self-Grooming - The focal animal grooms itself by pushing aside its fur and inspecting for foreign objects (dirt/insects). Includes taking care of its own skin, teeth and fur. ( <i>record as duration behaviour for continuous</i> )	
28	YA	Yawning - The focal animal yawns, opening mouth and showing teeth ( <i>record as point behaviour for continuous</i> )	
29	SM	Self mutilation – The focal animal exposes a (potentially) damaging action to its own body. This includes hair pulling, self-hitting or biting ( <i>record as duration behaviour for continuous</i> )	
30	PC	Pacing and other abnormal behaviour- Moving in a stereotyped pattern, unrelated to stimuli of the immediate environment. Including repetitive walking up and down (score when the animal walks back and forth at least twice), and other motor stereotypes ( <i>record as duration behaviour for continuous</i> )	
31	PH	Positive social (affiliative) behaviour towards humans. This includes coming to the fence to sit/stand next to the observer/other people around, lip-smacking towards people, or trying to reach out for any human contact ( <i>record as point behaviour for continuous</i> )	Human
31	AH	Agonistic behaviour towards humans. This includes all threatening behaviours described above ( <i>record as point behaviour for continuous</i> )	

Food Types and Codes		P – Pods	FR – Fruit	TB – Tree Bark
BU - Buds	E – Eggs	G – Grass	I – Insects	FL - Flowers
YL – Young leaves	ML – Mature leaves	M – Mushrooms	URF – Unripe Fruit	O - Other
RE - Reptile	RO – Roots	S – Seeds	PF - Provisioned Food	UK - Unknown
MK – Milk (infant suckling only)		GUM– Gum		

Position in Canopy	Use a combination of letter and number codes to indicate position and height from ground
TC – Top of Canopy	
MC – Middle of Canopy	1 – less than 5m from ground
LC – Lower Canopy	2 – 5-10 meters from ground
G – on Ground	3 – 10-20 meters from ground
MM – on Manmade structure	4 – more than 20 meters from ground
NS – on elevated Natural Structure, such as tree trunks, and termite or ant hills	

Weather	SU – Sunny	C – Cloudy/Overcast (not rain)
W – Windy	LR – Light Rain	HR – Heavy Rain
Temperature	H - Hot	
W – Warm	C - Cold	



# ELEPHANT DUNG COLLECTION AND SEED ANALYSIS

Part of LWT's Elephants for Landscape project is dung analysis of the elephants in Vwaza. This gives us information on both the diets of the elephants, as well as an estimation of the age classes of the population.

## Dung collection

- We collect dung opportunistically at least twice per week, or when we know elephants have been in an area for an extended period of time.
- Wear gloves while handling dung.
- Samples are collected from fresh dung piles only (<12 hours after deposition with no signs of insect deterioration, and no evident deformations owing to impact with the ground or evident decay over time).
- Take the GPS coordinates of the dung pile.
- Record the number of total boli in the dung pile before collecting three of the most intact ones.
- Place in plastic bag. Make sure to write on the plastic bag the dung sample number.

## Dung analysis

- Measure the diameter of three boli from each dung pile in order to relate to the age of the elephant (see Table 1). Measure the long and short axes of the elliptical ends of the bolus and then take the mean of those two measures to get the diameter.



- Break up the whole of the dung pile and search thoroughly for seeds. Wear gloves.
- Place seeds into a labeled pot as you find them. These pots should be labeled referencing the number of your dung sample.
- Once the whole dung has been sorted, make up a solution of 1 part Dettol, 10 parts water. The solution should be cloudy and opaque.
- Pour solution into the seed pot and gently massage each seed to remove organic matter.
- The seeds should be removed from the solution using tweezers and placed into a clean dry pot that is numbered with the seed sample number.
- Use the sieve to ensure no seeds are left in the solution.
- Leave the seeds to completely dry. Ensure they are out of reach of baboons. Take caution on windy days that the pots do not blow away.

## Seed analysis

- Once dry, count all seeds found within the droppings.
- Photograph each seed next to a ruler on a white background. Same species seeds from the same dung sample can be photographed together.
- Measure the length and width of each seed.
- Weigh each seed.
- Enter these data and the photo number into the Master datasheet.
- Place seeds into a plastic bag, which should be labeled with the date, GPS of the dung location, and dung sample number.
- Identify the seed from the 'Trees of Southern Africa' book and from our reference collection.
- If the seed is unknown, then refer to the 'Unknown seeds' photo album on the elephant project laptop. If the seed is the same species as one of these seeds, then enter it in the species column, e.g. unknown12, unknown46.
- Calculate the percentage of occurrence of each item within the dung pile as well as the percentage occurrence of each item within the whole of the sampling.

**Table 1.** Age classifications for elephants based on dung boli diameter (adapted from Morris et al. 2005 and Jachmann and Bell 1984).

Age Class	Age	Bolus mean diameter (cm)	
		Males	Females
Calf	1	6.4	6.4
	2	7.9	7.9
Juvenile	3	8.6	8.6
	4	9.3	9.3
	5	9.9	9.9
	6	10.4	10.4
	7	10.9	10.9
	8	11.3	11.3
	9	11.6	11.6
	10	11.9	11.9
Sub-adult	11	12.2	12.2
	12	12.5	12.5
	13	12.7	12.7
	14	13.1	13.1
Adult	15	13.4	13.3
	16	13.7	13.5
	17	13.9	13.7
	18	14.1	13.8
	19	14.3	14.0
	20	14.5	14.1
	21	14.6	14.2
	22	15.0	14.3
	23	15.1	14.4
	24	15.3	14.5
	25	15.5	14.5
	>25	18.5	15.0

# ELEPHANT HERD SIGHTINGS AND GROUP OBSERVATIONS

## Group and individual observations and ID

During these data collection sessions, we focus on more detailed group composition and individual identification data, whereas the transect data (see below) gives us more population estimates and habitat use. These data must be detailed and accurate. It is always better to get less, but accurate data than a large amount of vague data. These methods were developed as a joint project with Elephants for Africa.

### Research sessions from vehicle

- We drive along selected routes looking for groups of elephants.
- When we find a group, we observe them until we have accurate data.
- Elephants seen away from the lake are often moving through a habitat, which can make data collection more difficult, but we can then be sure that the individuals seen in the group are choosing to associate with each other.
- Before starting the research session by vehicle, record the date, time, start GPS, and situational data on the data sheet.
- We try to drive alongside the elephants, but at a distance that does not push them or interfere with their behaviour, but which will allow you to take pictures of them from each side. If they are uncomfortable with our presence, back off or leave them to move on.

### Research sessions from camp / the lakeshore

The water resource in front of camp is utilised by elephant throughout the year for drinking, swimming, playing and to cover themselves with mud and sand. This means that large numbers of elephants congregate at this resource, but that does not mean that they would choose to associate with one another in the absence of those resources. We therefore conduct research sessions at the lake to increase our sample size, but we must be very careful that the groups we record are those that arrive at the lake and leave together, not short-term interactions brought on by resource availability. To guarantee this, we must only record data on groups that arrive at the lake after the researchers, not on those already interacting there.

- Before starting your research session, record the date, time, and other situational data on the datasheet. We work in pairs, with one person focused on observing the elephants and one recording the data.
- Only record groups that have arrived at the lake after you have.
- Focus on one group at a time and record the group composition data first, including ages and sexes (consult the How to Age and Sex Elephants sheet for reference)
- Then take photographs of each individual (see below).
- Once you are satisfied that you have good data from all individuals in that group, move on to the next group.
- When many elephants arrive, it can get confusing and the quality of the data that you are collecting will deteriorate. Try to remain focused and organized.
- Each elephant group you observe should be assigned a letter for that day starting with A (note that the next day, you will start with A again).
- Each individual you observe will be labeled with B for bull or F for female, followed by a number in the order of which you observe them (e.g. B1).
- Make sure you are still a safe distance away from the animals when observing or photographing them.

## **Herd sightings and group composition**

- To reduce confusion when distinguishing between elephants, assign each group a letter per day (not per sighting; i.e the next day you will start at A again), and each individual a number per day (not per sighting), e.g. individual 1 from group A.
- Each individual you observe will be labeled with B for bull or F for female followed by a number in the order of which you observe them (e.g. B1).
- It is best to have a few people assisting on identifying the elephants and filling in the datasheet, as you will need to keep track of individuals who are often moving.
- We record:
  - Group size
  - Group Size Confidence Level (on a scale from 1-3, with 1 = you are 100% certain that all elephants in the group were seen, 2 = you are 50% certain, and 3 = you are not certain at all that all members were seen).
  - Group leader – the elephant who is in front when walking anywhere (If identifiable)
  - Habitat: Woodland (W), Grassland (G), Dambo (D), or Floodplain (FP).
  - GPS coordinates and the perpendicular distance to the centre of the group. Remember that the coordinates you record are your location, not that of the elephants, so you will need to determine the perpendicular distance from yourself to the centre of the group.
  - Compass angle: this is the angle of the group in its relation to true North.
  - Number of adults, subadults, juveniles, and infants, and number of adult males and adult females.
  - ID photo numbers of each individual. Quality of data is more important than quantity, so focus on one elephant at a time.

# ELEPHANT INDIVIDUAL IDENTIFICATION

## ID photographs and descriptions

This project is conducted in partnership with Elephants for Africa (EfA), an NGO based in the UK with extensive fieldwork conducted in Botswana. EfA has been identifying individual elephants in Botswana since 2002, based on differences in ear and tusk morphology. These recognisable individuals form the foundation of our research, allowing us to collect long-term data on interactions and associations between individuals.



We use photos of the notches and holes on the ears, in combination with the shape and size of the tusks to individually identify elephants. Identification is easiest done through photographs. When taking photographs of elephants, be sure to take detailed photos of their ears, face-on, and full body. When back at camp, look through the photos carefully for identifying characteristics.

- Record both ears and both tusks. Take a photo of each side profile and one head-on of each individual, as well as a full body photograph.
- Optimise the light conditions for the highest clarity of details (no back-lighting, in sunlight if possible).
- Avoid taking photos of elephants when they are partly wet. If the ear is completely wet or completely dry then it can work, but the patterns on the ear from water drops can hide the actual details.
- Take as many photographs as you need.
- Make sure that you make a note of which photo numbers refer to which elephants at the time of capture, rather than having to go through hundreds of photos during data entry, when you may not recall which elephant is which.
- When switching between individuals, take a few frames of the ground.
- If, when you review the photos, they are not clear enough, record that elephant as unidentifiable.
- Data from these sheets are used to supplement the ID identification data on the Group Composition and ID Data Sheets, and should be used to amend those data.
- When back in camp, look through established IDs to see if it is an elephant that has been seen before. If it is, then change the letter you gave it in the field to its official ID number, e.g. B32 (B for Bull) or F104 (F for female). If it is new, then create a new ID code in the database
- Distinguishing characteristics include detailed information about the ears, tusks, tails and general appearance of each elephant, physical condition, and musth status of males
- Photos are stored on the elephant project computer in specified folders by date, group, and individual.
- We also draw ourselves the individual ear characteristics and record individual descriptives on the Elephant ID Descriptives Data Sheet following the standard terminology.
- Compare photos to the ID books of elephants



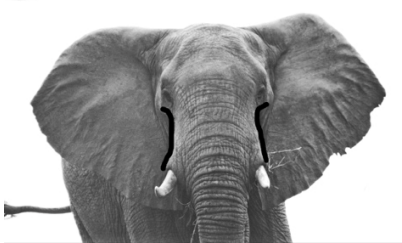
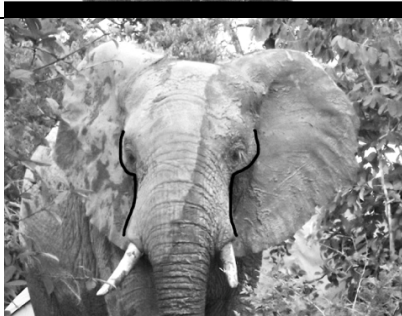
## ELEPHANT ID GUIDE



- Focus on the general body shape, the shape of the head, and the thickness of the tusks and genitalia.
- Males have more massive and rounded foreheads, and thicker, more conical tusks.
- Females have smaller, more pointed or square foreheads, and more slender tusks. Adult females have two breasts between their front legs.
- Males tend to carry their heads higher than their shoulders, and their abdomens slope downward from their forelegs to hind legs.
- Females tend to carry their heads lower and their abdomens are more curved.
- In males, the penis shaft bulges out below the tail and curves forward.
- In females, the genitalia look like a funnel with the vulva opening pointing downward.



## Male elephant age classes

Class	Height (cm)	Age (yrs)	Description	
1	204- 228	10-15	Male head shape more noticeable; tusk circumference and shoulder height greater than females of the same age.	
2	229- 243	16- 20	At about 17yrs male reach same height as largest adult female over 40yrs.	
3	244- 275	21-25	Taller than most females, but head still slender and narrow compared to older males.	
4	276- 296	26- 35	Head shape changes to an hourglass shape. Head breadth and height increases with age.	
5	>297	36+	Very big, tower over largest female by three feet or more at shoulder, neck thick, tusk circumference at lip strikingly greater than younger males and all females.	

## Female elephant age classes (10+ years)

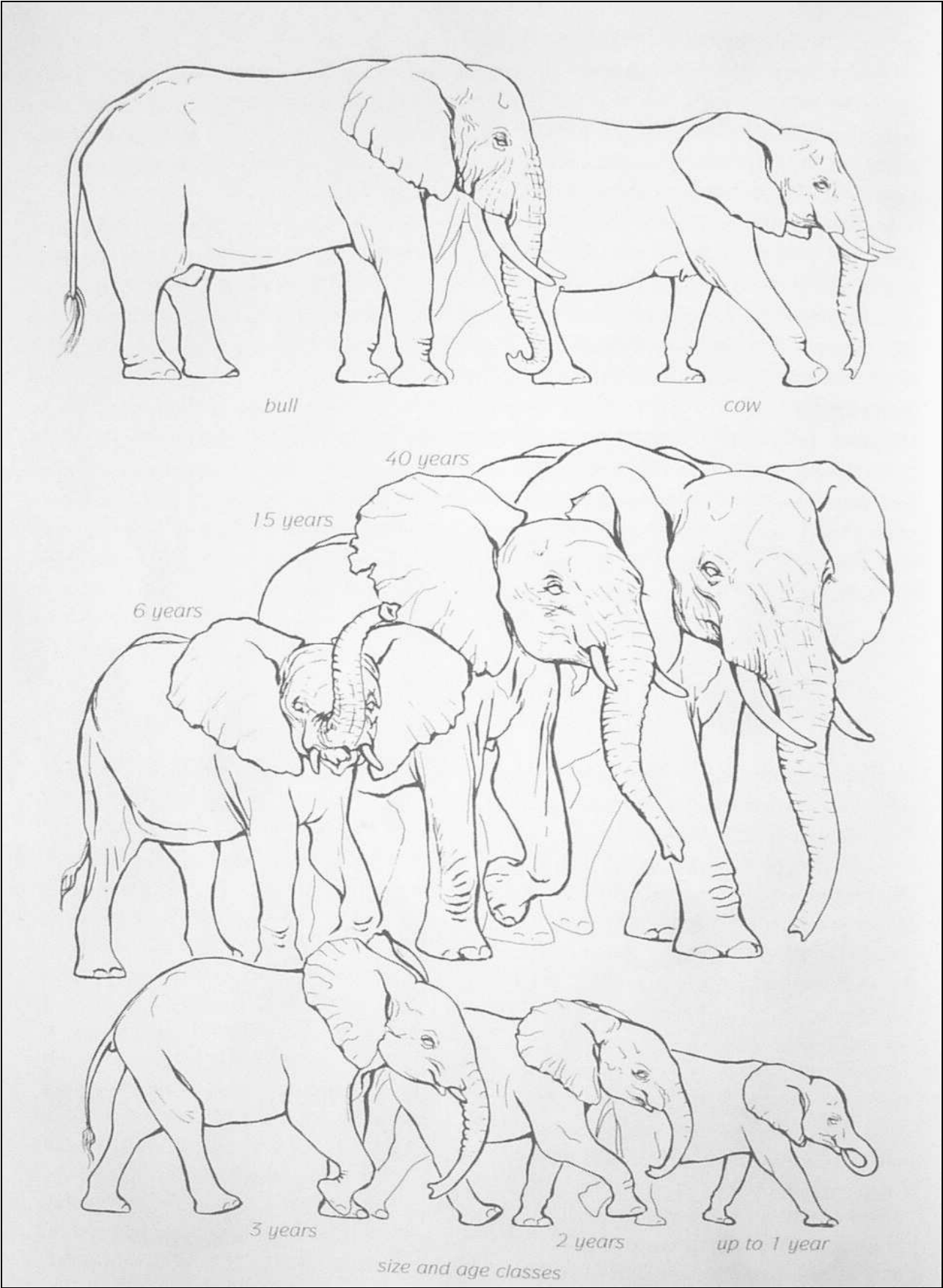
Class	Age (yrs)	Description
1	10-15	Thin tusks, probably still splayed rather than convergent; more square in body shape than older females who are rectangular.
2	15-20	Tusks begin to take on their adult configuration that is convergent, straight, or asymmetrical with one higher than the other.
3	20-35	Circumference of tusks at base distinctly bigger than teenaged females.
4	35-50	Tusks marginally thicker; back has lengthened so that animal appears long in body.
5	50+	Hollow above the eyes, ears held lower, longer back length, sometimes long tusks.

**0-10 years old age classification (male and female)**

(Calf sizes are relative to an adult female 25-45 years old with a shoulder height of about 250cm)

Class	Age	Shoulder height	Development
1	Newborn	Top of shoulders reach lower wrinkles below mother's 'elbow'; can easily walk beneath her.	Thin, stiff-legged; sometimes part of umbilical cord attached; whites of eyes often red; backs of ears bright pink; often hairy on head and back.
2	2-3 weeks	Same as above.	Walking well; more filled out in body; backs of ears non longer pink; trunk is short and slender but exploring, picking up sticks.
3	3-4 months	Reaches to below point of mother's elbow.	More rounded, fatter; begins trying to feed on grass; spends time away from mother; plays with other calves.
4	8-9 months	Reaches elbow; can still pass under mother but probably scraping.	Feeding adeptly and continuously for long stretches; capable of drinking with trunk.
5	1 year	Shoulder taller than breast level of mother, reaching to wrinkles above elbow.	Head and ears look in proportion to each other and body.
6	1-2 years	Top of shoulder midway between elbow and junction of leg with torso, the 'armpit' of mother.	Trunk looks more in proportion; tusks of male calves may show beyond lip from 18 months on.
7	2-3 years	Reaches mother's armpit.	Tusks of most calves and many female calves will show; mother may show signs of trying to wean calf.
8	3-4 years	Top of shoulder above mother's armpit; back almost level with anal flap and reach lower quarter of mother's ear.	Almost all calves will show at least 5-7cm of tusks; most calves still suckling, but some may be weaned.
9	4-5 years	Reaches mothers' anal flap or above.	Tusks are 15-18cm long; has probably stopped suckling and may have a younger sibling.
10	5-6 years	Appears to be about one-quarter the size of an adult female; back almost level with middle of mother's ear.	Tusks are about 15-18cm long; differences in male and female behaviour become more pronounced: female calves allomother younger calves; male calves seek out other males for sparring.
11	6-7 years	Shoulder and back height above base of mother's tail and above middle of ear.	Tusks begin to splay out in both males and females; sexual differences discernible: males have thicker tusks and heavier bodies.
12	7-8 years	Back level with adult female's eye and well above base of tail.	Tusks are usually splayed by now; no longer looks calf-like, but more like a small adult.
13	8-9 years	Overall size in height and length over half an adult female.	Tusks are about 25-30cm.
14	9-10 years	Overall size almost three quarters of an adult female.	Male are larger than females of same age and spend more time on periphery of family; females are more integrated in family.

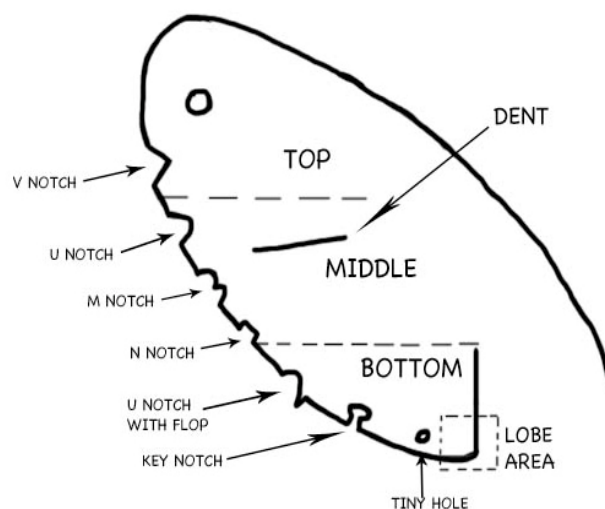
Elephant age and sex



## Elephant individual ID standard terms

### Ears

CHARACTERISTIC	SHAPE	SIZE / DEFINITION
Slit		
	U	Large
	V	
	M	Small
	N	
Flop		Piece of skin hanging down
Dent		
	Round	Large
	Bean	
	Triangle	Tiny
	Oval	
Floppy		Ear flops over at the top
Tatty		Ear edge too tatty to draw it all
Pink pigmentation on back of ear		



### Tusks

Broken		Chipped		Splayed	
Groove		Chiseled		Convergent	
Shorter		Straight		Straight	

### TAIL

Short Hair
Kink
No hair
No tail
Incomplete tail
Most hair on one side

### OTHER

Scar
Lump
Pink markings on penis
Other

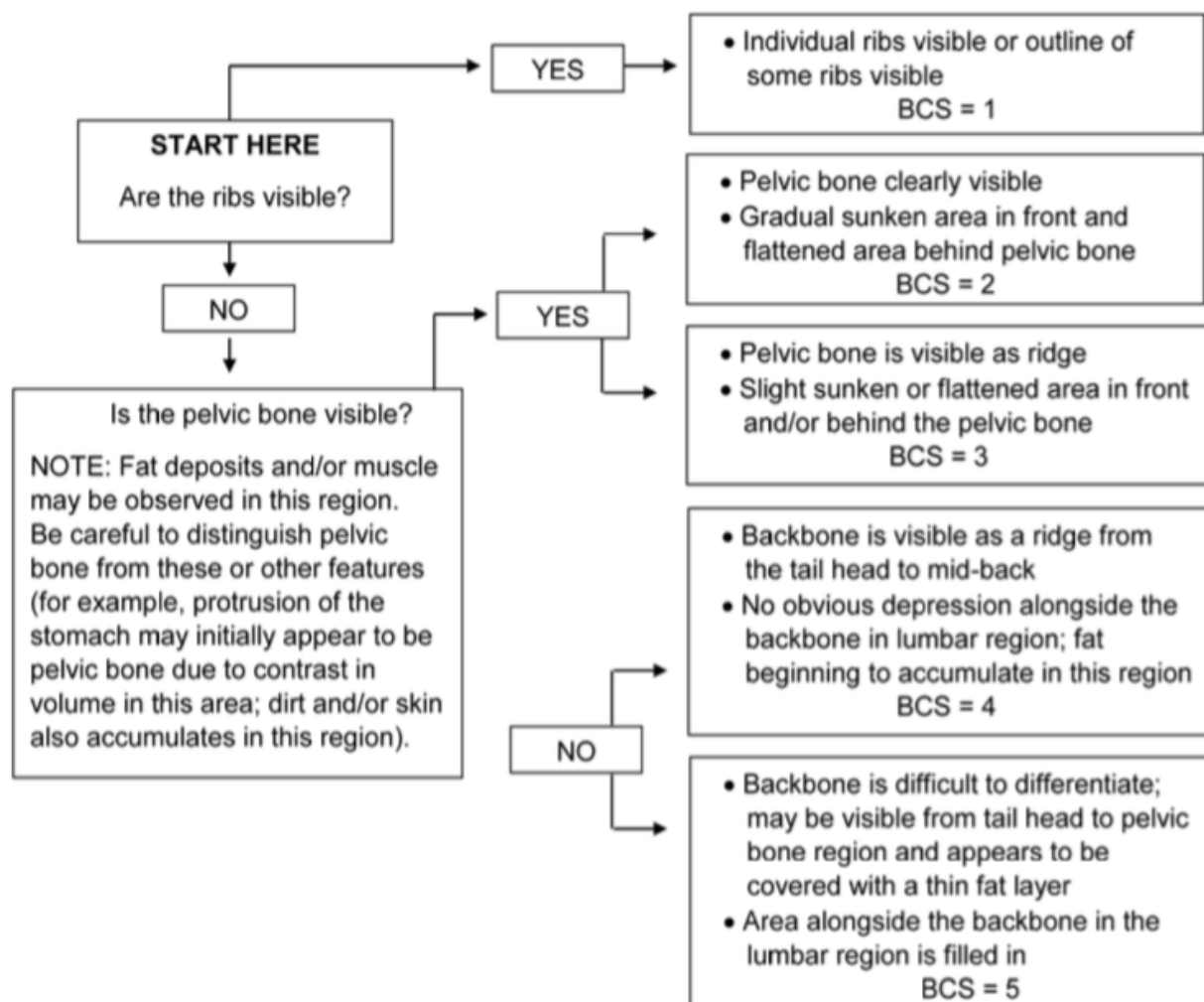
### Code

### Physical Condition

1	Emacipated: Very very thin
2	Very thin. Shoulder blades, pelvic bone visible
3	Thin. Shoulder blades, pelvic bone and backbone are visible
4	Good. Slight sinking in front of pelvic bone
5	Fat. No sign of shoulder blade or pelvic bones or backbone protruding and fat hangs from the body


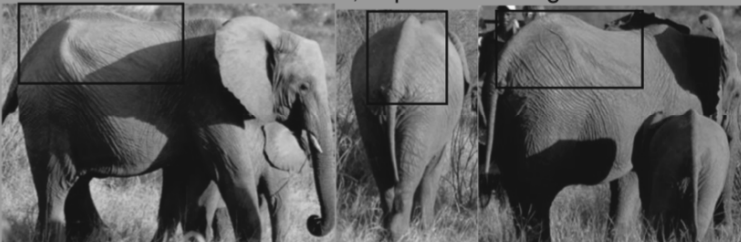

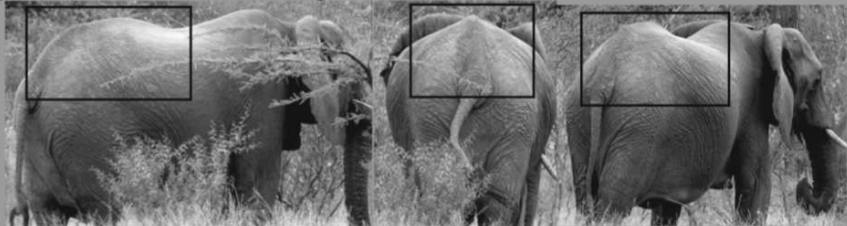
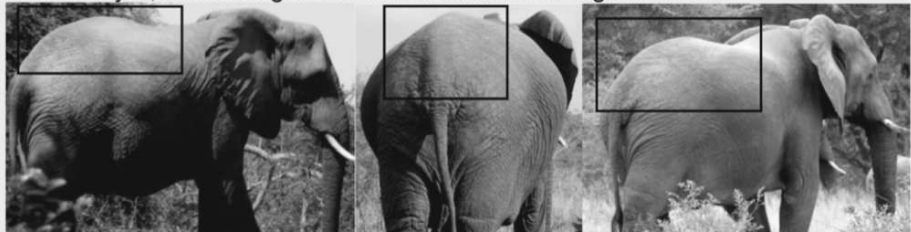
## Elephant body condition criteria

Code	Physical condition
1	Emacipated: Very very thin.
2	Very thin. Shoulder blades, pelvic bone visible.
3	Thin. Shoulder blades, pelvic bone and backbone are visible.
4	Good. Slight sinking in front of pelvic bone.
5	Fat. No sign of shoulder blade or pelvic bones or backbone protruding and fat hangs from the body.



**Figure 4. Body condition scoring flow chart for female African elephants.**

doi:10.1371/journal.pone.0093802.g004

BCS	Description and example photographs
1	<p><b>Ribs:</b> Clearly visible</p> <p><b>Pelvic Bone:</b> Protrudes, deep depression in front and depression or flattened area behind pelvic bone</p> <p><b>Backbone:</b> Prominent from tail head to shoulders, deep depression alongside backbone in lumbar region</p> 
2	<p><b>Ribs:</b> Not visible and appear to be covered by a very thin fat layer</p> <p><b>Pelvic Bone:</b> Clearly visible, gradual sunken area in front and flattened area behind pelvic bone</p> <p><b>Backbone:</b> Clearly visible from tail head to mid-back, depression alongside backbone in lumbar region</p> 
3	<p><b>Ribs:</b> Not visible</p> <p><b>Pelvic Bone:</b> Visible as a ridge, entire pelvic bone may not be visible, slight sunken or flattened area in front and/or behind pelvic bone</p> <p><b>Backbone:</b> Visible from tail head to mid-back, sloping alongside backbone in lumbar region</p> 
4	<p><b>Ribs:</b> Not visible</p> <p><b>Pelvic Bone:</b> Not visible</p> <p><b>Backbone:</b> Visible as ridge from tail head to mid-back, no obvious depression and fat beginning to accumulate alongside backbone in lumbar region</p> 
5	<p><b>Ribs:</b> Not visible</p> <p><b>Pelvic Bone:</b> Not visible</p> <p><b>Backbone:</b> Difficult to differentiate, may be visible from tail head to pelvic bone region and appears to be covered with a thin fat layer; area alongside backbone in lumbar region filled in</p> 

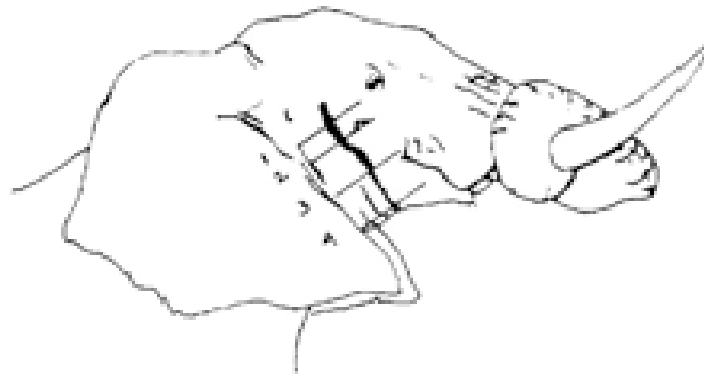


Fig. 1. Illustration of the amount of secretion from the temporal glands. See text for explanation.

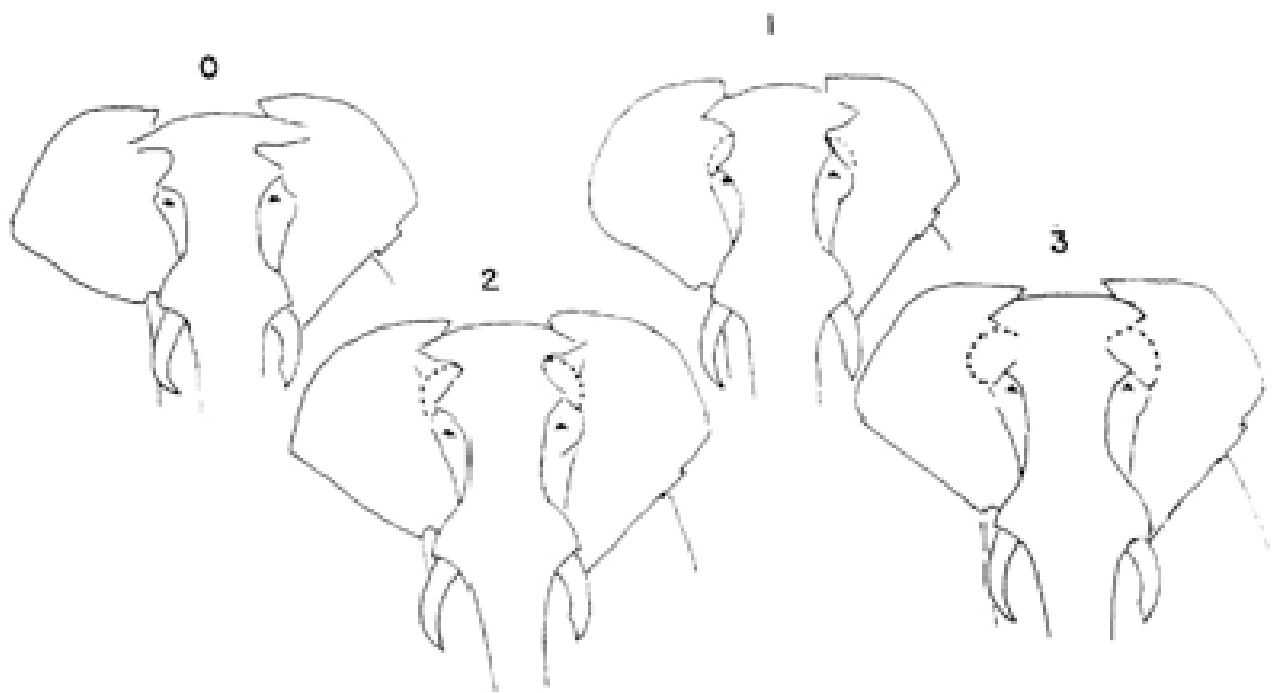


Fig. 2. Illustration of the degree of temporal swelling during musth. See text for explanation.



### **Signs of musth in reproductively active bulls**

Musth walk: Head is carried high with chin tucked in and an overall swaggering gate.

Temporal gland secretion (1): Gland secretes an oily fluid which runs down the cheek to the chin and eventually leaves stained streaks. Musth males often rub the glands against trees. (Note that temporal gland secretions alone are not a reliable indicator of musth – they can also indicate stress or excitement in non-musth elephants; look for co-occurrence with other signs.)

Swollen temporal gland (2): Glands are at least the size of an orange at the peak of musth. Musth males often drape their trunks over the tusks to relieve pressure on the glands.

Frequent urine dribbling: Occurs during full musth, with penis kept inside sheath so urine sprays the hind legs. Sheath eventually stained yellow-green and legs have dark streaks running down.

Strong smell: Musth has a distinct, strong smell that is easily discernible to humans.

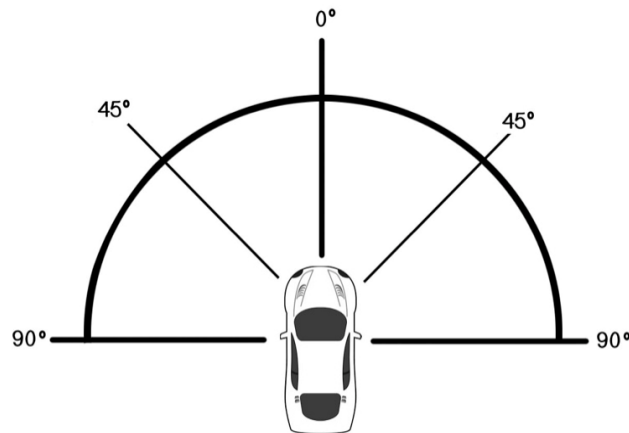


# LARGE MAMMAL TRANSECTS

Large Mammal Transects use distance sampling to estimate population distribution and density. They can also give us estimates of prey availability for carnivores and preferred habitat for various species. These can be both walked and driven in the bush, but the principles are the same. You travel along a line and count all large mammals you observe.

## Driven transects

- Each transect is 5 km in length. There are 2 km between transects.
- All large mammals are recorded during the transect, from which we will extract species-specific data.
- From inside the car, stop and record all large mammals you see from both sides of the vehicle, from 90 degrees to either side to the front of the car.



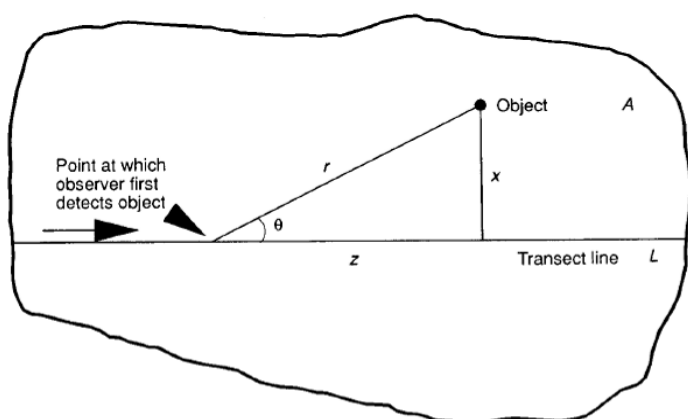
- There is no need to ID individual elephants during transects, but if someone does take pictures these should then be analyzed later.
- Encountering elephants in the vehicle:
  - Slow down as soon as you see elephants.
  - We do not switch off the engine in case we need to retreat.
  - Scan the area for the entire herd; remember that they can be behind you or hiding in the bushes.
  - Look for females and young; remember they get angry and scared when separated and are more likely to charge.
  - Give the elephants space to move off the road before driving past them.
  - Drive away slowly and quietly if they show any threat behaviour.
  - Never drive or park between members of the herd, or block their desired travel route.
  - Speak quietly.
  - No flash photography.
  - No sudden movements inside the car – stay calm, quiet and safe!
  - Bear in mind that suddenly the car may need to move suddenly. Remain seated with all your kit in your bag, not strewn all over the car.

## Walking transects

- Each transect is 5 km in length
- We walk in the order of scout, pace-setter and navigator, citizen scientist, staff member.
- You walk in a straight line no faster than 2 km/hr.
- No talking, noise making, smoking, listening to music or wearing headphones.
- Particular care needs to be taken when sighting elephants.
- There is no need to ID individual elephants during transects.

## What to record

- Direct sightings only are recorded on the transect.
- Any and all individuals and groups of large mammals are counted, measured and recorded.
- When an animal is sighted, observers stop walking and wait silently. Check for all other group members and make sure you are all standing bunched together and not spread out when on foot.
- Recordings are made as quickly as possible to collect correct data before the individuals or the group moves, and quietly so as not to disturb or influence their behaviour and position.
- We record
  - Time of observation
  - Meters from the start of the transect
  - GPS location
  - Habitat: woodland (W), grassland (G), dambo (D), floodplain (FP)
  - Species
  - Side of transect: Record if animals observed are on the left side (L) or right side (R) of the transect line
  - Distance from the observer on the transect line to the first animal sighted (in meters) using the range finder (AO – animal to observer)
  - The angle from the observer on the transect line to the same animal (AT – angle from transect)
  - Compass angle: this is the angle of the animal in its relation to true North
  - The total number of animals sighted
  - The number of adult males sighted
  - The number of adult females sighted
  - The number of juveniles and infants sighted
- We consider individuals to be in a separate group (and therefore a separate sighting and record on the data sheet) when distance from the last animal seen in the previous sighting is 25 m along the transect from the next sighting.



Basic measurements that can be taken in line transect surveys. Here an area of size  $A$  is sampled by a single line of length  $L$ . If sighting distances  $r$  are to be taken in the field, one should also measure the sighting angle  $\theta$ , to allow analysis of perpendicular distance  $x$ , calculated as  $x = r \cdot \sin(\theta)$ . The distance of the object from the observer parallel to the transect at the moment of detection is  $z = r \cdot \cos(\theta)$  (from Buckland et al, 2001).

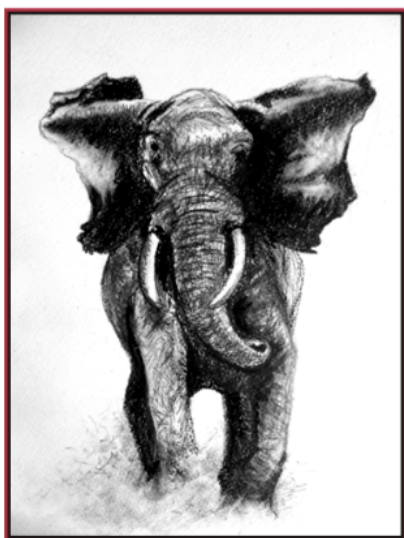
## Encountering elephants on foot

- It is very important that you are quiet, stay close to the rest of the group and be very vigilant of your surroundings.
- Look to assess whether the herd is spread, what direction they are heading and where you are in relation to where they are trying to go.

- Look for females and young; remember they get angry and scared when separated and are more likely to charge.
- Do not make any sudden movements, do not take photos, and do not speak loudly.
- Bunch together with all other members of the group, DO NOT spread out; now is not the time to go for a pee!
- Make sure everyone in the group is present.
- Check to see if you are upwind or downwind of the elephants (downwind is always better).
- Watch the behaviour of the elephant(s); look out for the key behavioural warning signs (rocking front foot, flapping ears, etc – see below)
- Bear in mind we may get mock (hopefully not real) charges, in which case the scout will likely fire a warning shot. During a mock charge, the elephant is warning you to leave his/her personal space. In this event, you may have to run, throwing your bags as you go to distract the elephants, and may need to make for a tree to hide behind or climb.
- DO NOT PANIC
- ALWAYS follow the advice of scout and staff

### Elephant charges

- Warning/mock charge: Rushing towards person(s) or vehicle(s), then the elephant stops abruptly, standing tall with ears spread, kicking dust with a fore foot and possibly swinging the trunk towards the opponent or vehicle. May be accompanied by trumpeting or air-blasting. Warning charges can often transition into real charges and should be taken very seriously. In response to a mock charge, leave the area you are occupying immediately, quietly and quickly.
- Real charge: Rushing towards person(s) or vehicle(s) with ears not fully spread (for greater speed). Trunk usually tightly curled up, head held low, and tusks pointing towards opponent. A real charge is fast, abrupt and silent, so pay attention and respond to early warnings before the elephants feel the need to charge. In response to a real charge: DO NOT RUN. You will not be able to outrun a charging elephant. Instead, hold your ground, making yourself big, arms up and shout at the elephant to stop.



Elephant mock charge



Elephant standing tall

## Key elephant behaviours to look out for

Signs of uneasiness or apprehension – the elephant is deciding on a flight-or-fight response

- Chin slightly up and ears slightly spread: Usually occurs when they notice a potential threat.
- Plucking at vegetation without feeding: Vegetation may be slapped against the body.
- Foot swing: One front foot is raised and tentatively swung back and forth.
- Touching own face: The elephant touches its own face with its trunk.
- Trunk twisting: the trunk tip is twisted back and forth.
- Tail twisting: the tail is swung vigorously or held at right angles to the body and arched.

Threat displays of annoyance and aggression – retreat

- Ear spread: Faces an opponent and spreads the ears out 90 degrees from the body (not to be confused with slow, gentle ear flapping which relaxed elephants do to keep cool).
- Standing tall: Lifts head high to look taller, chin is raised so elephant looks down at adversary.
- Serious threat: Tusks point towards opponent with ears spread; more serious than standing tall.
- Trumpeting or air-blast: Trunk is used to audibly blast air with a gush, or to blow with a loud pop.
- Head shaking: An abrupt and vigorous jerking of the head so the ears flap and crack.
- Trunk swing forward: Swinging or tossing the trunk towards the opponent.
- Throwing dust, branches, or objects: Objects thrown in the direction of the threat or opponent.
- Bush bashing: Tossing the head and tusks through vegetation to demonstrate strength.
- Tree pushing: Used as a show of strength (can also be done to feed on roots or leaves in which case it is not a threat behaviour).
- Tusking ground: Bending or kneeling down, pushing the trunk into ground or uprooting vegetation. Commonly used by males as a signal of aggression.
- Ear fold: Lower half of the ear forced under and backwards, a horizontal ridge appears across the ear.

# HIPPO COUNT TRANSECTS

LWT is conducting a hippo population census concurrently with the elephant and large mammal surveys. This will allow us to keep long-term records of population trends across seasons, years, and anthropogenic pressures, to inform population management for DNPW.

## Transects

- Transects are walked along the entire lakeshore (5km).
- Upon sighting a hippo or pod, we stop perpendicular (90°) to the animal/pod and record
  - Time of sighting
  - Meters travelled along the transect (check GPS)
  - GPS of observer
  - The perpendicular distance of the observer to the centre of the pod
  - The compass angle of the pod in relation to true North
  - Total count of hippos in the pod. Spend at least 5 minutes at each pod to allow for submerged hippos to surface and be included in the count
  - Record the age classes of each hippo (if identifiable)
  - Number of animals in the water.
  - Number of animals on the shore
  - If a hippo is out of the water / on the shore, record the distance of the hippo to the nearest water's edge.

# CAMERA TRAPPING

## Pre-deployment

- Ensure each camera trap has enough battery life for its intended time in the field (if you are not planning on changing batteries whilst the camera is in the field).
- Check each camera trap has an SD card and that the SD card is working before deployment.
- Check date and time signatures are correct. Note: If you take out the batteries on some models, this will reset the time and date.
- If your camera traps are labeled (e.g. LWT1) and the camera trap has a Station ID function, then make sure all labels correspond with the Station ID on the camera.
- Check that all cameras are set to the same parameters and that the chosen parameters are the right choice for your chosen animal (e.g. a large time delay between photos will be no good if you are trying to capture images of a large troop or herd of animals).

## Choosing a camera trap site

- Select sites that your target species are known to use (e.g. for large carnivores most roads and tracks are heavily used whilst the opposite is true for ungulates). Where possible, confirm the presence of your target species through tracks, scat, calls, etc.
- Try to determine the travel path of the target animal – Pick a site where the target animal's travel path is limited to the area that can be photographed by the cameras.
- Try to avoid sites with lots of vegetation and moving branches/grass. Whilst this can be cut back, it is always best to avoid disturbing a site as much as possible. The more vegetation there is, the higher the chance that it will falsely trigger the camera. Over days this can lead to thousands of images to go through and use up battery life very quickly.
- Try to avoid areas of excessive sunlight. Passive camera traps will be affected by the ambient temperature and may not trigger when an animal walks past.
- Once you have selected a site, clear any vegetation that is likely to trigger the camera (large blades of grass, branches over the sensor). If you are in an area where seasonal burning is carried out, make a small fire break around your camera to ensure the camera is safe from fire.
- If you are looking to identify individuals (e.g. leopard, hyaena), then make sure your camera traps face **directly** on to the trail you are focusing on. Poorly chosen sites or poor setting will result in unusable images for your study.
- Camera stations should be at least 2 km apart.



Camera trap images showing good (left) and bad (right) camera trap placement for individual identification.

## Deploying camera traps

- Cameras should be set back at least two meters from the nearest point where a target animal might travel across the sensor. This allows for clear, focused pictures and a large enough field of detection from the sensor. The longer the target animal is in the detection zone, the less chance of missing a photograph.
- Depending on your target animal, set the camera trap sensor to the appropriate height. A good rule of thumb is human waist height for general use.
- Use freshly cut sticks and branches to help prop up and secure the camera to the tree trunk or other anchor. A well-placed twig placed between the camera housing and the tree trunk can help adjust the angle in which the sensor is pointed (always use live wood to brace cameras and adjust camera angles, since dead wood is too brittle).
- Test the aim of both cameras by crossing in front of them. Do this on both the edges and the middle of the path. Most camera trap brands come equipped with an indicator light that will light up when the camera's sensor detects you. Approximate a target animal by walking in a crouch and then walking in a more relaxed fashion. Make sure that every conceivable angle at which the target animal can pass in front of the camera is tested and that in each instance a photograph is triggered.
- Before arming your camera, double-check all your parameters and time/date. Make sure you have an SD card in the camera and that it is not set to lock.
- Once you are finished setting up your site **we record** on the datasheets:
  - The camera and SD card ID.
  - Date and time that you are setting the camera.
  - The battery life.
  - The location (e.g. road name) and GPS coordinates of the camera.
  - Parameters et: Photo speed, camera make and model, and flash type (black, infrared, or white).
- Finally, make sure you arm the camera before leaving the site; it can be easier to forget than you think! Always do this last or you will end up using battery life and SD card memory while setting up your site.

## Checking camera traps

- Camera traps should not go longer than two weeks without being checked. This allows a reasonable number of photos to be collected without disturbing the site regularly.
- Camera traps can either be checked remotely in the field using a laptop or by swapping SD cards in the field. If you are swapping SD cards in the field, ensure that you know which SD card came from which camera.
- Use every camera trap check to ensure the parameters and time/date are still correct and swap batteries if needed.
- If you are checking camera traps in the field using a laptop, then use this opportunity to change anything about the camera positioning from the images downloaded (height, distance to path etc.).
- Make sure you organize your photos on the laptop when you remove them from the cameras into folders labeled with each Camera ID.

## Analyzing camera trap images

- All images are stored on the project laptop in designated folders
- First we must go through and delete all photos that do not have an animal (or person) in them (i.e. photos of grass and shadows).
- Then the images are uploaded into the program Wild.ID.
- Once there, you must go through each image and identify the species of animal captured



# DATA COLLECTION PROTOCOLS

It is CRA policy not to make its data collection protocols available online, but only as hardcopies in the field. Protocols for vegetation surveys, bat trapping and surveys, insect surveys and processing will be provided at base.