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# **Frontier Cambodia Environmental Research**

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## **Report 2**

# **FOREST RESEARCH METHODOLOGY**

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**Frontier Cambodia**

**2003**

## **Suggested citation**

Frontier Cambodia (2003) Beharrell, NK & Fanning, E. Wickramasinghe, L. (Eds) **Forest Biodiversity Methodology Manual**. Frontier Cambodia Environmental Research Report 2. Society for Environmental Exploration, UK

The Frontier -Cambodia Environmental Research Report Series is published by:

**The Society for Environmental Exploration**  
**50-52 Rivington Street,**  
**London, EC2A 3QP**  
**United Kingdom**

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**ISSN 1748-4952 (Print)**  
**ISSN 1748-4960 (Online)**  
**ISSN 1748-510X (CD-ROM)**

Ó **Society for Environmental Exploration 2003**

### **Frontier-Cambodia**

Frontier-Cambodia has been conducting biological conservation surveys, environmental education and socio-economic studies across Cambodia in partnership with the Ministry of Environment since January 2004. The broad-ranging research techniques employed by Frontier-Cambodia enable researchers to discover and map a huge variety of wildlife including small and large mammals, birds, reptiles, amphibians, butterflies, and vegetation types.

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The Ministry of Environment is responsible for management and protection of all national parks in Cambodia. The DNCP works with various organisations to ensure Cambodia's natural resources are preserved for present and future generations.

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## 1. INTRODUCTION

Cambodia in Southeast Indochina, is geographically situated to the North East of the Gulf of Thailand. The greater part of Cambodia comprises the plain of the lower Mekong valley, with the western slopes of the Annamite Chain to the east, and the isolated highlands of the Elephant and Cardamom mountains in the west (Bugna, 2002). Cambodia's two dominant topographical features are the Mekong River and the Tonlé Sap Lake. The Mekong River rises in Tibet flowing through Cambodia and via southern Vietnam to the South China Sea. During the wet season, flooding which occurs annually, results in rich sediment being deposited making the area around the Mekong very fertile for agricultural production.

The forests of Cambodia consist of a number of forest types (Baltzer et al. 2001); wet evergreen (EF), semi-evergreen (SEF), mixed deciduous (MDF), deciduous dipterocarp (DDF) and savannah woodland (SW). Once predominantly covered by forest, the coverage has been greatly reduced from 70% to 50% during the mid-1990s due to rapid and uncontrolled logging within the region. To the Southwest of the country virgin rainforest grow to the seaward slopes of the mountains. Higher elevations support pine forests and the coastal strip includes both evergreen and Mangrove forests. Towards the east grassland and deciduous forests dominate the highlands.

The first national park was set up in 1925 protecting the forests around Angkor. The system of national parks was destroyed by the civil war, and only re-introduced in 1993 when 23 areas were designed as national parks covering 33,000 sq km. The most important national parks in Cambodia are Bokor on the South coast, Ream which includes a marine reserve, Kirirom southwest of Phnom Penh and Virachay along the Lao and Vietnamese border. Ream National Park (Preah Sihanouk National Park) is situated within the Krong Preah Sihanouk Province and covers an area of 21,000 ha (15,000 ha secondary lowland and mangrove forest, 6,000 ha marine).

Cambodia's forest and wetland habitats support a wide diversity of flora and fauna, many of which are endangered. Mammals under threat in Cambodia include the Asian elephant *Elephas maximus*, Asian golden cat *Catopuma temminckii*, the tiger *Panthera tigris*, Asiatic wild dog *Cuon alpinus*, black finless porpoise *Neophocaena phocaenoides* and the black gibbon *Hylobates concolor* amongst others. A large number of rare birds are also found in Cambodia attracted by the vast water resources. Endangered reptiles include the green turtle *Chelonia mydas*, hawksbill turtle *Eretmochelys imbricata*, Reticulated python *Python reticulatus* and Siamese crocodile *Crocodylus siamensis*.

## 2. AIMS

The Frontier-Cambodia Forest Research Programme (FC FRP) has four major aims;

- To conduct baseline biodiversity research in selected forest areas of Cambodia.
- To provide information on the biological value and conservation importance of selected forest areas, to assist the development and implementation of management plans for these sites;
- To conduct socio-economic surveys within local communities, in order to assess current threats to, and benefits derived from, the forest area;
- To develop a system of long term monitoring of the biodiversity status of selected forest areas in Cambodia.

## 3. SURVEY OBJECTIVES

Each research element provides information on biodiversity values and human influences on selected forest areas of Cambodia. With the assistance from Cambodian institutions Ministry of Environment (MoE) and the Ministry of Agriculture Forest and Fisheries (MAFF), foreign Research Assistants (RAs), and permanent FC FRP staff. Several aspects of biodiversity and the socio-economic situation of communities in and around the forest area are studied.

Specifically, each survey conducted would typically include the following research elements;

### **Systematic fauna trap site: standard trap nights and times searches**

- **Mammal survey**, Collection of small mammals (rodents) by trapping, and bats by mist-netting of roost sites and feeding areas. Also, observation of large mammal species to produce a list of mammals found in the reserve.
- **Amphibian and reptile collection**; bucket-pitfall trapping and opportunistic collection of amphibians and reptiles.
- **Bird survey**, observation of the bird species throughout the different habitats represented in the reserve, to produce as comprehensive a list for the area.
- **Butterfly survey**, a comparison of butterfly faunas of differing habitats within the reserve, using transect methods. Also, opportunistic collection of butterfly species in order to produce as complete as possible a species list for the reserve.

### **Other**

- **GPS ground truthing**; recording features and locations of the vegetation boundaries/ areas with the forest area that can be fed into GIS systems for mapping.
- **Vegetation analysis**; the mapping (by observation) of different vegetation types within the reserve; detailed study of 4-5 different vegetation types using forest plots (50m x 50m) and transects (60m x 10m).
- **Socio-economic survey**, collection of data on the lifestyles of people inhabiting and using the forest area, by interview and questionnaire. Also, interview with local government and

forestry and fisheries officials, in order to build up as complete a picture as possible of the use of forest resources, current and potential threats to the biodiversity of the reserve.

## 4. TRAP SITE PROTOCOL OVERVIEW (FAUNA)

Frontier trap sites have been conducted to a particular formula since 1989. A variety of taxa are surveyed during trap sites, mammals, amphibians, reptiles and butterflies are the main groups.

It is important that trap sites are located in representative habitats within the forest area to be surveyed. Thus at the on set of surveying a new forest area, provisional trap site locations can be identified using maps. Each trap site location needs to be verified, (site visit conducted via a reconnaissance “recce” trip). Ideally sites should be at a range of altitudes and aspects, dependent upon the habitat site.

For example a forest area is 12,000 ha and covers lowland forest (<850m asl), sub-montane forest (850-1250m asl) and swamp forest. The forest area has been degraded in some areas, was selectively logged (10 years previously) and some forest areas remain “undisturbed”.

One year will be spent working within this forest area, 4 expedition phases. A maximum of 5 trap sites can be conducted in one phase, an optimum number is 4, giving time of educational and communities activities and a few days off! Thus 16 trap sites would be an ideal number to carry out within this forest reserve.

This area presents three main habitats:

HABITAT	DISTURBANCE
A Lowland forest	i) degraded
B sub-montane forest	ii) selectively logged
C. Swamp forest	iii) undisturbed

The above represents 9 trap site options initially: A i), A ii), A iii); B i), B ii), B iii); C i), C ii), C iii). The remaining 7 can be variations on a range of i) and ii). If the majority of the forest area (50%) is **lowland forest, undisturbed** (A iii), a representative number of trap sites (8) should be conducted at locations within the forest area.

**Systematic surveys methods** are conducted at each trap sites. The number of trapping nights should remain the same for comparative purposes throughout.

Trap site surveys are associated with the bucket pitfall trap lines. Each trap sites consists of 3 **bucket pitfall lines (trap lines)** of 11 buckets each. Each bucket line should be 50 or 100m in length with buckets arranged 5 or 10m apart respectively. The bucket pitfall lines should be located in representative micro-habitats within the trap site location. *For further detail refer to section 6.*

**Sherman live traps** can be used to more specifically trap small mammals. These can be used in a variety of ways dependent on the number owned by the project. NOTE: these traps are expensive and are generally only purchased for contracted pieces of work. Snaps traps used to be used! *For further detail refer to section 5.* A set of 100 Sherman live traps can used in association with the bucket pitfall lines. These can be used in a grid system 10m x 10m distribution to gain trap revealed movement or location around the bucket lines, 33, 33 34 respectively, placed a minimum of 2m apart around the line.

**Canopy traps** should be deployed to catch butterflies along each trap line, a minimum of 2 per line, and checked daily.

**Sweep netting** for butterflies should be conducted daily along each trap line for standard man hours (effort), ideally 2 people, 2 hours per day at peak activity (10am –12 noon). *For further detail refer to section 8*

**Timed searches** for amphibians should be conducted, a standard number of man hours per site.

**Mist netting for bats** should be conducted at each trap site, a standard number of mist net hours per site, over the widest possible time range.

**Bird transect and or point count** work over a standardised period can be conducted to produce comparative data for the later trap sites of the phase.

The first trap site per phase should be located close to the base camp within a representative habitat. This trap site should be used as “on the job training” for research assistants. Thus theory is being put into practise after a series of lectures and simulated training sessions. The data collected from the first trap site should still remain valid in terms of data accuracy and species identification. However, it is advised that this data set is not used for comparative purposes with other data sets (trap sites), as the effort will be greater than subsequent trap sites, as personnel are trained.

## 5. MAMMALS

### 5.1 Introduction

#### 5.1.1 CAMBODIA

Larger mammals are one of the most well studied faunal groups of Cambodia. Large mammals of this region include the Asian Elephant *Elephas maximus*, Tiger *Panthera tigris*, Javan rhinoceros *Rhinoceros sondaicus*, Pileated gibbon *Hylobates pileatus* amongst others. The smaller mammals of Cambodia have received very little attention with the exception of the recent study carried out by Flora and Fauna International (Daltry and Momberg, 2000). The findings of this study resulted in a preliminary species inventory of the rodents and insectivores of the Cardamom Mountains, which included a separate bat survey. The amount of bat work undertaken in Cambodia has been sparse. Daltry and Momberg (2000) carried out preliminary survey work in the Cardamom Mountains resulting in eight new records for Cambodia. Previously, 22 species of bat were recorded in Cambodia (Corbet and Hill, 1992) but relatively little is known about the status and distribution of many of these. The bat species diversity of the surrounding countries are considerably higher than the recorded 22 species in Cambodia, which implies that the actual species count may well be higher.

To date 47 species of mammal have been included on the IUCN Red List (IUCN, 2001), listed as critically endangered, endangered and vulnerable, with some species having insufficient data to classify them.

#### 5.1.2 GENERAL BACKGROUND

Mammals constitute an essential part of the Cambodian fauna and are found in most habitats. Bats are one of the most diverse groups of small mammals, and are generally understudied. Small mammals are relatively easy to catch, handle, and identify. They have short life spans and changes in species diversity, density, and community composition over time are relatively easy to detect.

Small mammals are important parts of all ecosystems they are found in because they are central to the food-chain, feeding on vegetation and invertebrates and being predated upon by larger mammals, reptiles and birds. They often function as seed dispersers and are therefore important for plant regeneration.

Small mammals can be used as an ecological indicator group. Data from repeated surveys could indicate the general state of an area and thereby contribute to the management of these areas. Mammals are threatened by many different factors. Habitats and features important to many mammals are being cleared or degraded or fragmented, leading to total loss of populations, or resulting in small non-viable populations. Humans often heavily hunt mammals for food, skins and for the pet-trade, which further threaten the existence of some species and populations.

### 5.2 Aims

The aims of the FC FRP mammal survey are to produce as comprehensive as possible a list of large and small mammals for the reserve studied, and assess their conservation value. In particular, it aims to study the lesser-known groups (rodents, shrews and bats), and species which are known to be endangered at a national or international level (IUCN, 2001).

## 5.3 Methods

Four methods are used in the mammal survey;

- Trapping of small mammal species using live-traps (direct - bucket pitfall and sherman traps).
- Bat-netting (direct - mist nets)
- Opportunistic observation large and small mammal species
- Indirect observation: tracks and signs.

*NOTE: All RAs working with mammals for SEE in Cambodia should have undergone a course of rabies inoculations. Gloves are also essential equipment when handling any mammal.*

### 5.3.1 SMALL MAMMAL TRAPPING

#### 5.3.1.1 Pitfall traps

Refer to section 6 for details.

#### 5.3.1.2 Sherman traps

Sherman traps (H.B. Sherman traps, Inc. USA) are aluminium box traps designed for live trapping of a range of small mammals. The traps can be baited with various types of food (e.g. coconut with peanut butter, banana, or fish), depending on the target species. As Sherman traps are relatively small (standard size - 23 x 9 x 7.5 cm) they will only catch animals of a limited size. Large Sherman traps or mesh traps can be used to sample for example small carnivores.

#### Procedure

**Orientation:** For the purpose of assessing the diversity in an area, the traps available should either be placed in transect lines traversing as many different habitats as possible, a grid system or be spaced out in an unstructured manner at suitable spots.

Suitable spots for placing the traps are where there is a high chance of catching the target species. Terrestrial mammals often nest and forage in places with a dense under-storey, along fallen and rotting logs and near obvious food sources such as fruiting trees. If Sherman traps are used in conjunction with pitfall traps they should not be placed too near the pitfall bucket line.

For the capture of arboreal species, the traps can be fastened with tape or wire to a suitable stem or branch at the required height.

**How Sherman traps work:** The traps contain a trigger plate on which the bait is placed. The trap must be set carefully to ensure that the trigger is sensitive. When an animal enters the trap, the body weight on the trigger plate releases the door, which closes behind it. The trap should be placed as stable (an animal will not “step into a trap”) and horizontal as possible (no more than a 30 degree angle), to prevent the trap wobbling, which may keep the animal from entering. The entrance should be either level or pointing slightly downwards, as animals prefer to run up into a trap rather than down into one.

**When to check them and what to do:** Most target species are nocturnal and the traps are baited and set at dusk. Depending on the season and weather, the traps should be checked early in the morning. As the trap material is metal they heat up quickly and animals may overheat if they are left for too long may starve (have a high metabolism) if left in the traps too long without sufficient food.

- If the door to the trap is closed, and there is an animal in the trap, open the door carefully inside a clear plastic zip-lock bag. Gently shake the animal into the bag. Remove the trap and quickly close the bag. With the animal now in the bag it is possible to identify it, keep it as a specimen or mark it and release it.
- If the bait is missing, but no animal has been caught, test the trigger. It may be that ants removed the bait, or it may be that the trigger has stuck. If the trigger has stuck, it will be necessary to re-sensitise the trigger (gently and carefully bend the trigger lever).
- It is advisable to wash the traps regularly to prevent old bait, animal droppings or plant material falling underneath the trigger plate and blocking the moving parts. Furthermore, the scent of earlier trapped animals remains in the trap and may prevent other animals from being attracted and trapped.
- If the bait is untouched it should be removed and replaced with fresh bait for the next trapping session.
- After checking the traps they should all be closed. If the traps are left open during the day, animals may enter and suffer from overheating during the day. If the traps are left open for trapping of diurnal species they should be checked regularly according to the weather.
- If the animal is not to be kept, always release it at the point of capture.

#### **5.3.1.3 Mesh traps**

Mesh Traps, either locally or commercially made, e.g. Tomahawk traps (Tomahawk Live Trap Co. USA) are large wire-mesh traps. They consist of a box containing a hook-trigger upon which chosen bait is placed. The traps can be used either for terrestrial or arboreal species as they easily can be tied or nailed to a branch. The larger size of these traps allows trapping of large insectivore and small carnivore species.

An animal entering the trap will move the baited hook, triggering the door to spring shut. A trapped animal can be easily seen inside the trap. It can be removed by hand (while wearing thick gloves) and marked, released or kept as a specimen.

When setting the trap, make sure the entrance is clear and that the trigger and door can move freely.

The trapping procedure is the same as for Sherman trapping.

#### **5.3.1.4 Capture-mark-recapture**

In order to assess the abundance, density and home range a capture-mark-recapture study is necessary. Marking the animals allows recognition of individuals and records their movements. There are several ways of marking animals, both permanently and temporary.

An easy and effective temporary method for marking animals is a fur clip marking method with various combinations for individual recognition, *see the appendix for example of fur clip method*. All captured animals are given a unique mark, which enable the identification of individuals. Sometimes animals have natural markings (e.g. scars or parts missing), that can be used for recognition.

If an individual is caught a number of times at different trap locations, its home range and core area can be measured. Measuring and weighing individuals can record changes over a period of time (e.g. for pregnant females or sub-adults).

If aspects like community dynamics, life cycles and breeding seasons over time are the aim of the survey, permanent marking techniques should be applied.

### 5.3.2 BAT WORK

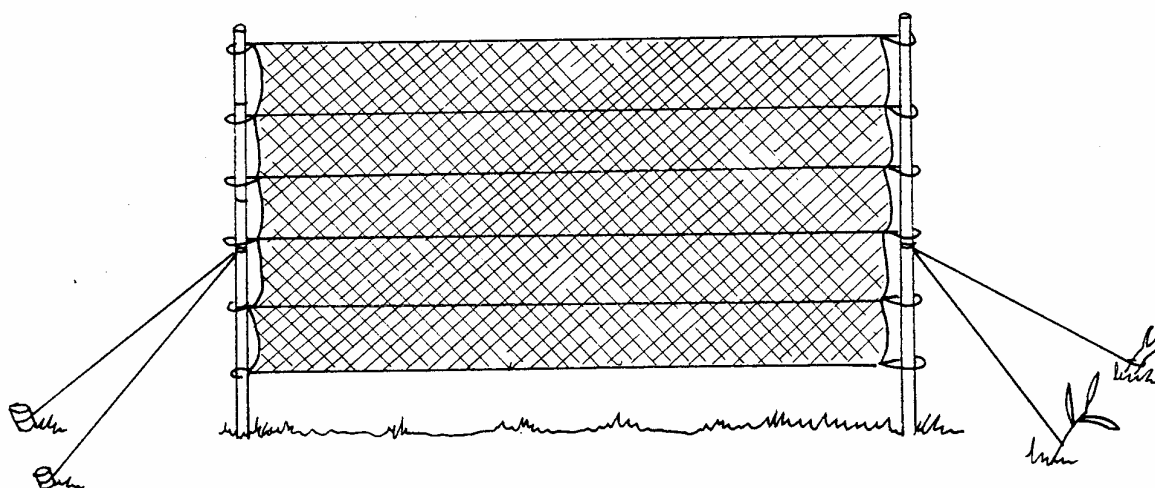
#### 5.3.2.1 Mist netting

##### Procedure

**Orientation:** Bat netting is carried out using mist nets, at bat feeding grounds and roosts. Netting of cave roosts produces larger catches than netting in forest or over streams, but both should be carried out in order to sample as large a range of species as possible. Bat netting in the open forest should be carried out at potential bat 'flyways'; near or over streams or pools, and along paths within the forest. The unit of sampling is net-metre-hours (length of net used in metres x hours for which nets are set up).

Nets should be in place well before dark; bats will fly from around 1700hrs on, although the busiest periods ('rush hours') in roost sites are likely to be around 1830-1930hrs, and early in the morning from 0500hr onwards. At open sites, avoid opening the nets too early as birds are likely to be caught in them.

Before the net is erected, obstructing vegetation and rocks should be removed from the site. Two bamboo poles of 2.5-3m length are needed: the net loops at one end of the net should be threaded over one of the poles (which should be held clear of the ground). The net should then be slowly unwound, ensuring that it does not touch the ground, and the loops at the other end of the net threaded onto the second pole. The uppermost loops should be secured to the poles using string. The poles can then be erected and should be held upright with guy-lines to pegs in the ground (if in the open), trees (if in forest), or rocks (in caves) (see Fig.1). The net's horizontal strings should be as taut as possible; however, vertically, the net panels should be looser; if they are too taut, bats will 'bounce off' the net instead of being caught.



**Figure 1:** Illustration of a mist net

The net should be attended throughout the night, and all bats caught should be removed as quickly as possible. Those at the net should always have a pair of gloves and several cotton bat bags for

holding bats. To remove the bat from the net, it is important to know which direction the animal was flying when it entered, and work from this side to bring it out backwards. The bat should be held firmly but gently in one (gloved) hand, and the other hand used to untangle the animal. The feet should be freed first, and hooked onto the glove to prevent them becoming entangled in the net again. When the lower part of the body is freed, the wings can be released, and finally the head.

The times of capture, and, if at a cave roost, direction of movement (in/out) should be noted and the bat should be placed in a bat bag (preferably one to a bag) which is then securely tied. Measurements should be taken of every individual caught.

**What do to when a bat is caught:** When a bat gets caught in the net, immediately untangle it; if left, it may get severely entangled and injure itself. When removing an individual from the net first find out from which side it flew in, then remove it from the same side. Hold the body gently but firmly with one hand (thumb under the chin to prevent it from biting, but be careful as small species are easily strangled) while gently untangling it from the net (normally feet and wings first) with the other hand. A fine crochet hook is sometimes helpful for untangling.

If the individual is to be kept, place it in a breathable cloth bag (individually numbered and firmly tied up) and leave it hanging in the bag until there is time to examine the specimen. Try and keep all individuals in separate bags as they may injure each other if kept together. Do not leave specimens overnight. Small species easily die from starvation and stress, so handle them quickly and gently. Always wear gloves when handling bats; they are vicious biters and may carry rabies. If an individual is to be released, either hang it from a branch (fruit bats) or gently throw them into the air.

**How to disassemble a mist net:** At the end of the bat netting session, the nets should be taken down carefully and folded away (see Fig. 2). If they are damp, they should be dried before storage and repairs made with black thread.

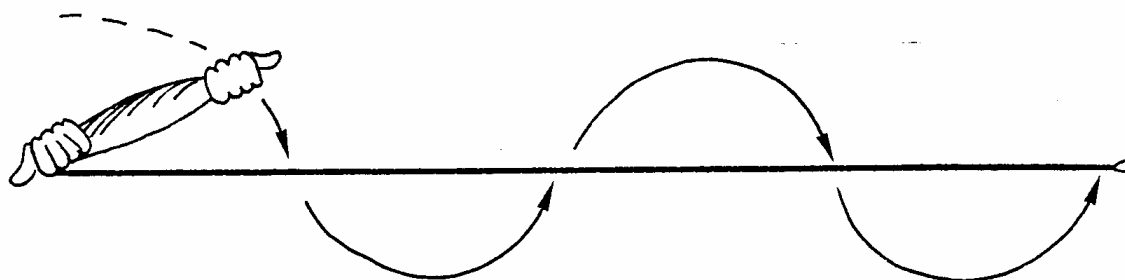


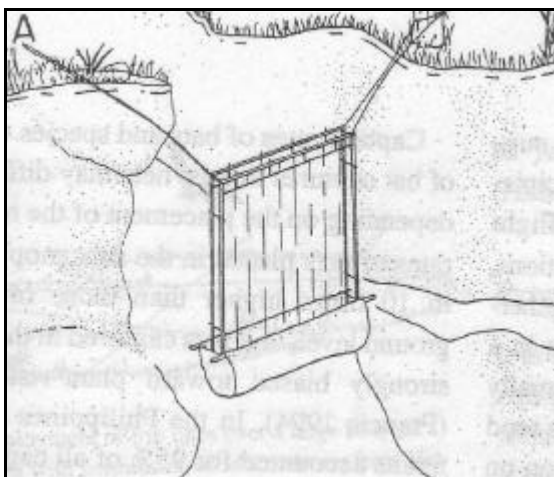
Figure 2. Folding the bat net.

### 5.3.2.2 Harp Trapping

#### Procedure

Harp traps are square or rectangular metal frames (of varying sizes, but normally 1 to two square metres) crossed by a series of vertical wires or string. A cloth or plastic capture bag is attached underneath. The trap can be placed on legs and used for ground trapping but can also be suspended by ropes in the canopy.

The wires are barely detectable by the bats, which fly into them and fall down into the capture bag. Once in the bag, the bats will rarely escape and can easily be collected.



**Figure 3.** Harp trap suspended by ropes (from Wilson et al 1996).

Harp traps are good for catching larger species of bats, and bats that fly high in the canopy. They are also ideal for trapping around roosts where there are a large number of bats, as it is much easier and faster to collect individuals from the bag than untangling them from a mist net. They can be set in the openings of caves or hollow trees that function as roosts, and around buildings inhabited by bats. Placing the traps in clearings in the vegetation often gives the best results as the bats are channelled into the trap.

Harp traps are relatively heavy and awkward to carry around, so it is a good idea to identify a good trap location before bringing the traps. It takes a minimum of two people to set up the trap.

Using harp traps in conjunction with mist nets is a good combination, ensuring a high probability of catching most of the species that are present.

### 5.3.3 DIRECT MAMMAL OBSERVATION (opportunistic)

Mammal observation methods are similar to those of the bird survey. However, mammals are usually shyer than birds and greater precautions must be taken to avoid disturbing them; it is essential to work in small groups, avoid brightly coloured clothing, and walk quietly if mammals are to be observed directly. Certain synanthropic species (eg, some rats and mongooses) or very common forest species (some squirrels) may be seen close to human habitation and from well-used tracks, but primates and commonly hunted large mammals are more likely to be seen from little-used forest trails, or from hides overlooking undisturbed forest areas.

In addition to direct observation, tracks and signs and calls provide evidence of mammal presence in an area. Species which are rarely seen, but leave distinctive signs, include the bears, Wild dogs, and cats.

Interviews with local people can also be used to determine the presence of certain species; however, the results of such interviews should be treated with caution; they do not always reflect the current status of mammals. The presence of hunting trophies, eg, horns and skins, in houses can also be used as evidence of the past presence of animals in an area.

### 5.3.4 INDIRECT MAMMAL OBSERVATION

#### 5.3.4.1 Large mammal tracking: Line transects

Recording the tracks and dung of large mammals is used rather than direct observations of animals for a number of reasons:

- Large mammals are difficult to see in forest habitats
- Aerial surveys provide broad distribution and abundance data, but are unsuitable for certain antelope species, which favour woodlands
- Some aerial surveys misidentify similarly sized antelopes
- Indirect surveys allow the careful consideration of each observation.
- Indirect observations allow field surveys to be conducted throughout the day and are not restricted to periods of peak animal activity. This is an important consideration when conducting field surveys within a limited time.

Counting of tracks and dung is also less intrusive and requires very little and inexpensive equipment. Frontier-Tanzania studies have shown that track and dung counts are a reliable method for determining large mammal distributions because they are not affected by differing detection of signs between habitats. However, bear in mind that tracks are more easily made in the wet season when the ground is soft and that the decomposition rate of dung will differ according to weather conditions and therefore neither method is accurate as a means of determining length of stay. The tracking procedure is outlined below:

**A pair of 100m transects** (in opposite directions) marked with a 100m rope labelled at 20m intervals is walked out by four research assistants and two game guards, two assistants and one game guard per transect. If two extra assistants are available they can each record the data on data sheets (data sheet book) so that the others are free to concentrate on searching for signs and tracks. The direction of the transects is decided by throwing a stick overhead taking the bearing of the direction of the stick, and following this bearing.

**Recording signs:** One research assistant walks on one side of the transect line and one on the other. They look for all large mammal signs, tracks and dung. The width of the search area can vary for each survey but is normally two or three metres from the line. The game guards are experienced in dung and track identification and will confirm the species indicated by the sign. The distance of the sign from the transect needs to be confirmed when those outside a certain width are being discounted. The transect should be walked from the end to the beginning as two other people will be going from start to end recording vegetation.

Data should be recorded for each 20m section, thus all the tracks and dung signs in the last section (100m to 80m) will be recorded first, then those in section 80 to 60m and so on. There are a total of five sections in which to record data. If a track of one species has already been recorded for a 20m section, it need not be recorded again. This means that a presence index of tracks is recorded with the highest total for each species being five (present in every 20m section) and the lowest 0, (absent in all sections). For dung, all piles are recorded throughout all transect sections. Data is recorded on standardised data sheets, and summarised each day on completion of fieldwork.

#### 5.3.4.2 Large mammal tracking: Sand transects

Where permanent study sites are established the technique of searching for large mammal tracks and signs along sand transects can be used. This method is preferable to randomly placed large mammal tracking transects because the tracks and signs are easily seen (not obscured by vegetation) and temporal information about animal use of the area is more accurate, to within 24 hours. However, this method is not suitable for surveying large areas of land due to the expense

and effort of constructing the sand transects is. The procedure for constructing the sand transects is given below:

### **Procedure**

- A 100 metre long rope is strung out, taking care to follow exactly along a pre-determined compass bearing. The vegetation along the 100 metres is then cleared to a width of 1m.
- The 100 x 1 metre transect is then covered with one inch of sand (approximately one 10kg bucket of sand / 1m<sup>2</sup>; therefore 400m will require 4 tons of sand).
- Each day at the same time over a 10-night period, two observers and one trained game scout will walk along this stretch of sand recording the spores of large mammals (Appendix 6.11). Each spore recorded will be identified to species. The sand will be raked each day after the line has been walked.

## **5.4 Identification**

Identification of larger mammals can be carried out using the *Preliminary identification manual for Mammals of South Vietnam* (Van Peenen, 1969), *Mammals of Thailand* (Lekagul and McNeeley, 1971) and the more comprehensive *Mammals of the Indomalayan Region* (Corbet and Hill, 1992). The latter book also has the most useful coverage of bats, although the illustrations and key in *Mammals of Thailand* can also be helpful.

## **5.5 Data recording and specimen collection**

Refer to the Frontier-Cambodia ***Data sheet book*** and ***Specimen preservation manual***.

## 6. AMPHIBIANS AND REPTILES (Herptofauna)

### 6.1 Introduction

The IUCN Species Red List for Cambodia lists a total of 17 reptile species which are threatened. Four of which are critically endangered, five listed as vulnerable and the rest listed as endangered. The aim of the herptile study carried out by CFRP is to complete a list of amphibians and reptiles observed in the area over the study period, in order to add to the existing data on the fauna of the study area.

### 6.2 Aims

The aims of the FC FRP herptofauna survey are to produce as comprehensive as possible a list of amphibians and reptiles for the forest area, and assess their conservation value with particular reference to species which IUCN Red-listed (threatened) at a national or international level (IUCN, 2001).

### 6.3 Methods

Both reptiles and amphibians can be caught in bucket pitfall traps, through opportunistic observation and times searches.

#### 6.3.1 BUCKET PITFALL TRAPPING

Pitfall traps are a cheap and effective method to sample reptile, amphibian and small mammal populations in an area. This allows an assessment to be made of the biodiversity of an area with minimum effort and collects large numbers of live specimens.

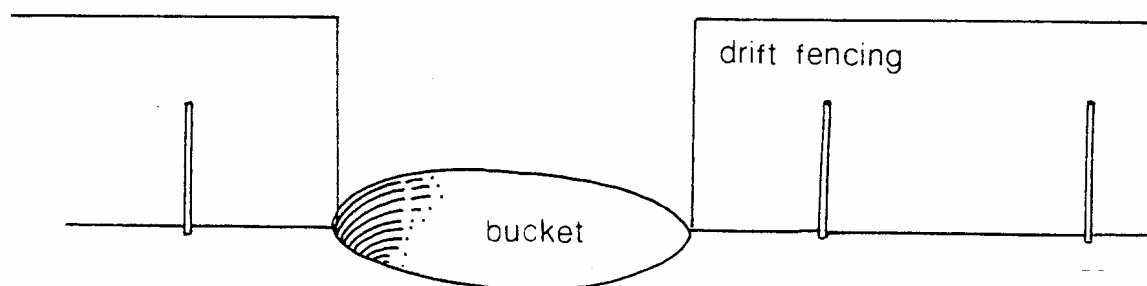
The pitfall traps are 11 buckets (20 to 40 litres) sunk into the ground at 10m intervals along a 100m-long drift fence (commonly called bucket lines). Three, bucket lines are typically set up at each trapsite within representative micro-habitats.

A drift fence is used to channel animals that are moving through the forest into the buckets. This method favours the capture of small terrestrial animals that cannot climb out of buckets. It is particularly successful with fossorial species such as burrowing skinks and blind snakes, but will also collect small terrestrial reptiles, some ground dwelling frogs and small rodents and shrews. The species caught will depend on a number of factors including habitat, altitude, association to water, and season.

#### Procedure

**Site selection** will depend on the objectives of the study, but the area of habitat to be studied must be continuous for at least 100m and be relatively free of ground vegetation to minimise environmental disturbance.

**Before starting the bucket line**, cut the plastic to the correct size. Remove the handles from the buckets and place holes in the buckets to prevent water collecting. These should be no more than 3mm in diameter to prevent the escape of small specimens.



**Figure 4.** Detail of bucket pitfall arrangement

**To assemble the bucket line**, dig the buckets into the ground at 10m intervals along the chosen site. Make sure the lip of the bucket is level or below ground level to allow animals to fall in. Fill in any gaps around the bucket with earth. Unroll the plastic sheeting and lay it along the ground next to the buckets. Starting from one end, secure the top 60cm of the plastic onto sticks fixed vertically into the ground, and bury the bottom 10cm into the ground so that the plastic runs vertically along the bucket line for 100m. The drift fence should run vertically through the middle of the buckets with no opportunity for animals to crawl underneath. Slits should be made in the plastic (ground-side) at each side of the bucket. This allows the plastic to be buried to make a seamless finish. Finally, remove any debris that has fallen into the buckets and make the area as natural looking as possible, so as not to scare the animals away. Place a numbered tag near the bucket for accurate data recording.

**Check the bucket line** for the presence of animals early in the morning (minimum) and during the day (when time allows) to reduce predation of trapped animals. Buckets should be checked more frequently if they are located in strong sunlight or a wet area, to prevent unnecessary fatalities. Remove any debris in the bucket. All animals targeted by the study found in the buckets should be carefully collected in a specimen pot, labelled (bucket line, bucket number and specimen no./code) and taken to camp for identification.

**When dis-assembling the drift fence**, untie the string, collect the sticks, remove the tags and roll up the plastic. Pull the buckets out and fill in the holes.

### Tips

- Collect sticks that are already dead. The sticks can be used for many trapsites.
- Pay particular attention to soil and plastic around the buckets to make a continuous seam from which animals cannot escape.
- Tie the plastic with a tight bow (shoelace knot) or quick release knot; it will ease the drift fence dis-assembly.
- Tie the plastic with no sagging, otherwise specimens could climb over the sheeting.
- During dis-assembly, roll the plastic from one end only. This way, you will end up with the plastic sheeting in one single neat, tight roll.
- The plastic can be re-used. If the plastic has been used before, line the buckets up with the slits in the plastic made from the previous buckets. Always keep the previous slits in the plastic facing the ground; they can be buried, keeping the top of the plastic sheeting undamaged.
- Make sure every animal is taken back to camp and its identification confirmed before returning it to the place of capture. Different species may look very similar, and will often require identification using appropriate field-guides.
- When checking the buckets, beware of dangerous animals such as snakes and scorpions.
- When leaving the site, try to leave the area in as undisturbed a state as possible by filling in the holes made by buckets, removing litter and redistributing leaf litter.

### 6.3.2 TURTLE TRAPPING

Turtles can be collected in a variety of water courses, and are generally caught using mesh traps measuring 98 x 24 cm. They also feature a 1-2 metre net extension cord to prevent turtles from drowning when the water level is high. 8 to 10 traps should be placed, at approximately equal distances apart, in areas of shallow water. They should be secured to a tree or a other solid structure. The traps can be baited with fish, placed in a pierced plastic bag, or banana, securely fastened to the inside of the net so as not be available to animals on the outside. Traps are best checked every 24 hours and re-baited after 48 hours. Turtles caught have to be measured and weighed and identified using Stuart et al's 2001 guide.

Specimens are not to be taken, however a numbering code can be assigned to the turtles' carapace scutes.

### 6.3.3 OPPORTUNISTIC COLLECTION

Amphibians can be collected in streams and ponds at night using torches, particularly during the breeding season, when examples of tadpoles should also be collected. This activity will supplement the other capture methods within each site and throughout the forest area to compile more complete inventory lists.

While moving through the area the survey team collect any of these vertebrates encountered, especially those which are rare or associated with specific microhabitats, usually by hand. The sampling intensity is variable. Reptile specimens observed should be collected and killed (for snakes, by a sharp blow with a stick).

### 6.3.4 TIMED SEARCHES

This method will document a representative sample of the amphibian diversity of an area with reference to different habitat types (trap sites). In addition to capturing amphibians in the pitfall traps, amphibian timed searches are carried out.

Likely microhabitats within the site are systematically searched for amphibians in the evenings.

The sampling intensity at each site is ten person-hours (four searchers x 30 minutes of searching per evening x five evenings, after adequate training).

#### Procedure

- A team of four people are required.
- The team searches likely microhabitats including the base of reeds, rivers, lakes and pools, around rocks, and in vegetation up to 1m high for treefrogs.
- Amphibians are located by their calls with torches.
- The search continues for 30 minutes and specimens are collected in plastic zip-lock bags.
- The 30 minute searches are carried out at various times throughout the evening.

## 6.4 Identification

Very few field identification books exist for Cambodian amphibians and reptiles specifically. Much of the fauna of Cambodia is also found in neighbouring Vietnam and so the following books can be

used for the field identification of snakes; *A field guide to the snakes of South Vietnam* (Campden-Main, 1970), and *The Snakes of Thailand and their husbandry* (Cox, 1991).

## **6.5 Data recording and specimen collection**

Refer to the Frontier-Cambodia ***Data sheet book*** and ***Specimen preservation manual***.

## 7. BIRD SURVEY

### 7.1 Introduction

The birds of Indochina have been studied since the French colonial period (see, for example, Delacour, 1929; Delacour *et al.*, 1928; Delacour and Jabouille, 1929), and, as a result, they are better studied than many other animal groups. However, new species and subspecies are still being described (Eames *et al.*, 1994).

Around 491 bird species have been recorded in Cambodia prior to January 2000, although many more species have been indicated here in unpublished sources. The majority of these surveys were carried out along the Mekong and around the Tonl Sap region. Thirty five bird species found in Cambodia are on the IUCN Red list (2001) listed as vulnerable endangered or critically endangered, in addition Birdlife International have also compiled a list of 39 species which are globally threatened or globally near threatened (Birdlife International 2000). The greatest threat to Cambodias birds is from hunting for food. The water birds around the Tonl Sap region are particularly at risk from egg and chick collection (Smith 2001).

### 7.2 Aims

The aim of the FC FRP bird survey is to produce (by observation) as extensive as possible a inventory list of birds for the forest area under investigation. Bird diversity is often regarded as a good measure of overall biodiversity in an area (Government of Socialist Republic of Vietnam, 1994). While this may not always be the case, it is true that identification works and ecological data are almost always more complete for birds than most other groups of organisms. Birds are also relatively easy to identify in the field, unlike many plant and insect groups where there are a large number of very similar species and field identification guides for the region are few.

### 7.3 Methods

There are 3 simple ways in which birds can systematically be recorded within a given area. In addition to this, one always benefits from opportunistic, casual observations that are recorded separately, but may provide further essential information of bird diversity.

#### 7.3.1 LINE TRANSECTS – Timed or distance

This method:

- assesses relative abundance of bird species and diversity;
- uses actual number of birds detected for calculations;
- can produce indices of number of birds per unit length;
- good to conduct in open habitats.

#### Procedure

Walk approximately 1km/h for closed forest or 2km/h for open forest / woodland. The area covered is the length of transect x width covered.

Use simple categories to record information, such as:

Distance -	Near	Far
	<50m	>50m
		open forest / woodland
	<25m	>25m
		closed forest

Height seen at: Above 3m, below 3m

Behavioural: Feeding, singing, etc

Individuals: Number, age, sex

Descriptive notes : Any distinctive markings/colour of plumage, eye, leg, tail shape / length, song, etc.

Using already cut and marked transect lines, you can record data in to 50m sections with accurate details of location within the forest area. Thus, it maybe more feasible within the systematic Frontier-Tanzania FRP methodology to do distance transects, whilst obviously also recording start and finish times.

Line transect data could also be used to extrapolate information for a **Timed-species count** (must then add to data sheet, identified by sight or sound, and time seen to know which 10 minute fixed time band they must be allocated).

### 7.3.2 TIMED-SPECIES COUNTS

This method:

- Assesses relative indices of abundance, based on the assumption that you will see the most common birds first.
- Good for canopy and mid-level bird species.
- Produces a species list with a count made each time the species is first positively identified by sight or sound (indicate which). This is repeated 15-20 times within the area and a cumulative score given for each species with the higher mean score indicating greater observation frequency.

If 60 minutes is the fixed time period, this is then broken in to 10 minute bands with birds species seen in the first 10 minutes given a score of 6, bird species recorded in the second 10 minutes, allocated a score of 5, etc.

1 <sup>st</sup> 10 minutes	6
2 <sup>nd</sup> 10 minutes	5
3 <sup>rd</sup> 10 minutes	4
↓            ↓	
6 <sup>th</sup> 10 minutes	1
Not recorded in that count	0

Further information can be recorded, such as using the distance and height bands (see line transects).

### 7.3.3 POINTS COUNTS

This is a good method when monitoring changes to species diversity or abundance. However, a problem with this technique is that it samples a smaller area thus few birds tend to be recorded. There should be at least 50 'points' within the study area and each point should be visited at the same times each day.

When at the fixed point, one should allow 3 minutes before conducting the 5 minute recording period, as the birds need time to settle after potential disturbance by the observers presence. The points should be approximately 300m apart. Along our 50m marked transect lines, a yellow tag could be used to indicate 300m mark. Distance and band counts can be used to gain more information (see line transects), as well as the direction in which the birds is seen or heard.

Bird observation is carried out throughout the habitats represented in the reserve. Two basic observation methods give good results;

- watching from a hide for a prolonged period;
- moving relatively rapidly (but quietly) along forest tracks, in order to observe shy forest species (Lekagul and Round, 1991).

Hides can be placed at points with a good view of the forest canopy; however, new species are as likely to be observed in the vegetation close to the hide itself, provided that the observers remain quiet within the hide. Observation is best carried out in the early morning (0600-0900hr), and towards dusk (after around 1600hr), although many species are active throughout the day. Binoculars are used to aid identification, and a telescope is also useful when viewing from a hide. A portable tape recorder or notepad should be used to make notes and observations as soon after a sighting as possible.

## 7.4 Identification

The two main identification guides for Cambodian birds are *Birds of Thailand* (Lekagul and Round, 1991), and the more comprehensive (although less well illustrated) *Birds of South-East Asia* (King *et al*, 1975). The *Birds of Hong Kong and South China* (Viney *et al.*, 1994) is also useful and well illustrated, although covering fewer species. Another useful book is *A Field Guide to the Birds of Borneo, Sumatra, Java and Bali* (Mackinnon 1993). Nomenclature should follow that given in the *Annotated checklist of the birds of the Oriental region* (Inskipp *et al.*, 1996).

Identification is carried out in the field, or upon return to camp (if adequate field notes have been taken), using the guides listed. Several species can also be easily recognised by their calls, and this is particularly the case with the owls (Strigidae), which are often difficult to observe directly. The calls are well described in *Birds of Thailand* (Lekagul and Round, 1991).

Certain small birds such as warblers can often be attracted by making a high-pitched 'pishing' sound which imitates bird alarm calls (Lekagul and Round, 1991). Some species, including the pittas, can be 'called' by imitating their own call, where this is known.

Birds in tropical forest environments often travel in mixed-species flocks; warblers and medium-sized insectivores such as the minivets are regularly observed in such flocks. When mixed flocks are seen, an effort should be made to identify all the species present and estimate the numbers of each one, as well as observing the behaviour of the flock.

## 7.5 Data recording

Refer to the Frontier-Cambodia **Data sheet book**.

## 8. LEPIDOPTERA (Butterflies and moths)

### 8.1 Introduction

Although there are over 27,000 described species from the Oriental region, the Lepidoptera of Cambodia are relatively little studied. Moths in particular snout moths, have been the subject of recent work in the Cardamom Mountains carried out by Flora and Fauna International (Daltry and Momberg 2000). The data they obtained from the hill evergreen forest area revealed that the site was comparable in terms of diversity with the rain forests of Malaysia, a well-known biodiversity hot spot (Daltry and Momberg 2000).

As with work on other insects, the seasonal nature of many of Cambodia's forests means that it is usually impossible to sample the entire butterfly or moth fauna of an area over a short period (or even over a single year; Monastyrskii, *pers. comm.*). Flight periods of many species are short and can vary between different locations. However, Hebert (1980) found that moth communities of *montane* rainforest in New Guinea appeared to be a-seasonal, with adults of all species flying all year. In certain restricted circumstances, therefore, it may be possible to collect a representative sample of the entire fauna in a relatively short period of fieldwork.

### 8.2 Aims

The aim of the FC FRP lepidoptera survey is to produce (by observation) as extensive as possible a inventory list of butterflies and moths for the forest area under investigation.

### 8.3 Methodology: Butterflies

Butterfly fieldwork involves both qualitative (collection) and quantitative (systematic sampling, transects) methods; preferably, both should be utilised as this ensures a more comprehensive collection of the butterflies of an area is made.

#### 8.3.1 QUANTITATIVE METHODS

##### 8.3.1.1 Systematic sampling at Trap Sites

**Sweep nets** and canopy traps are used at trap-sites for a standard time and frequency.

Sweep nets are used at peak activity 10 am 12 noon, daily for the duration of the trap site (typically 10 days) with standard man hours effort, across all the trap sites within a forest area.

**Canopy traps** are set up at a range of heights along the bucket pitfall trap lines (to be representative of the micro-habitats). A standard number are deployed along each line and at each trap site within the forest area, a minimum of 6 per trap site. Canopy traps are baited with well-rotted banana. For more in-depth details refer to the following section (8.3.1.2 Butterfly transects).

##### 8.3.1.2 Butterfly transects

Quantitative butterfly survey can be used to observe the change in butterfly activity over time, and/or differences in butterfly faunas of different habitats. Transect methods were developed by Pollard (1975, 1977), in order to observe seasonal variation in populations of British butterflies. However, if several transects are set up, this method can be used to compare butterfly faunas of different sites.

At least three transects should be set up, each in a different habitat type. The transects are each 1 kilometer long, and can be marked with barrier tape (at intervals of 100m). In addition to barrier tape (which may be removed by local people), at least the beginning and end points of the transect should be marked more permanently (eg, by knife marks on trees).

The transects should preferably follow paths or tracks, as they need to be walked regularly, and those carrying out the transect work must be able to concentrate on the butterfly fauna rather than trying to follow a difficult path.

Each transect is walked by observers at least once a week (if possible, twice), in order to amass as much data as possible. It is usually impractical to walk all three transects at the same time, which would control for natural variation in weather conditions. However, if each of the transects is walked on the same day of each week, this provides some control for weather variability. The transects can be carried out in all but heavy rain, although slight variations in temperature, wind or precipitation can influence butterfly activity; weather conditions (temperature, cloud cover, humidity, rain) should be noted at the start of each transect. Diurnal variation in butterfly activity is also great; the transects should always be walked at the same time of day. This time will vary according to the season; in summer, there is a noticeable decrease in butterfly activity towards noon, but this effect is less pronounced in the cooler seasons.

At least two people (preferably three) are needed to walk the butterfly transect; one acts as the observer, and others as recorder and catcher. The observer walks slowly along the transect, noting every butterfly which enters an imaginary 10 x 10 x 10m box immediately in front of him. New and unknown butterflies should be caught and specimens taken for identification. Each transect will usually take around one hour to complete. The temptation to linger at 'butterfly-rich' areas, such as streambeds, should be avoided, as this will tend to bias results.

After completion of the transect, a list can be produced showing the number of individuals of each butterfly species observed. Since it is not possible to identify all taxa in the field, it is important that voucher specimens of every taxon observed are taken, so that these can later be named. Where a species is not known, it is usually possible to assign it to a family, and each 'morpho-species' should be assigned a name or code (i.e., Satyridae 1) to distinguish it from others of its family.

It is important that the observers involved in carrying out the butterfly transect work are able to distinguish at least the butterfly families involved, and has a good knowledge of the existing collection of butterflies from the site.

### **8.3.2. NON-QUANTITATIVE COLLECTION METHODS (Opportunistic)**

Butterflies should be collected, using a sweep net, in as many habitat types as possible throughout the area under study. Although early-successional habitats often support the greatest range of butterfly species (see Hill *et al.*, 1996), forest faunas are most likely to include rarer, restricted-range taxa (Spitzer *et al.*, in press).

Certain groups are particularly difficult to catch; for example, the HesperIIDae (Skippers), which are small and extremely fast-moving. It is particularly important to make a representative collection of these groups. Many butterflies will return to a perch or feeding site after they have been disturbed (some of the HesperIIDae and Satyridae, for example, are territorial, aggressively defending an area against intruders). If they are disturbed by an unsuccessful attempt to catch them, they are likely to return in time.

A specimen should be caught in a single, rapid sweep of the net, which is followed by a twisting motion to fold over the end of the net and trap the butterfly there.

Killing should be carried out by either pinching the underside of the thorax behind the head, or using a killing jar containing cotton wool charged with ethyl acetate. If the latter method is used, it is important that the concentration of ethyl acetate in the jar is sufficiently strong to quickly kill the insect; however, excessive liquid in the jar damages specimens. Specimens should be removed from the jar soon after killing in order to prevent them becoming too damp. Butterfly specimens should be handled as little as possible (to avoid damage to the wings). When handling is necessary, watchmakers forceps (fine point) should be used.

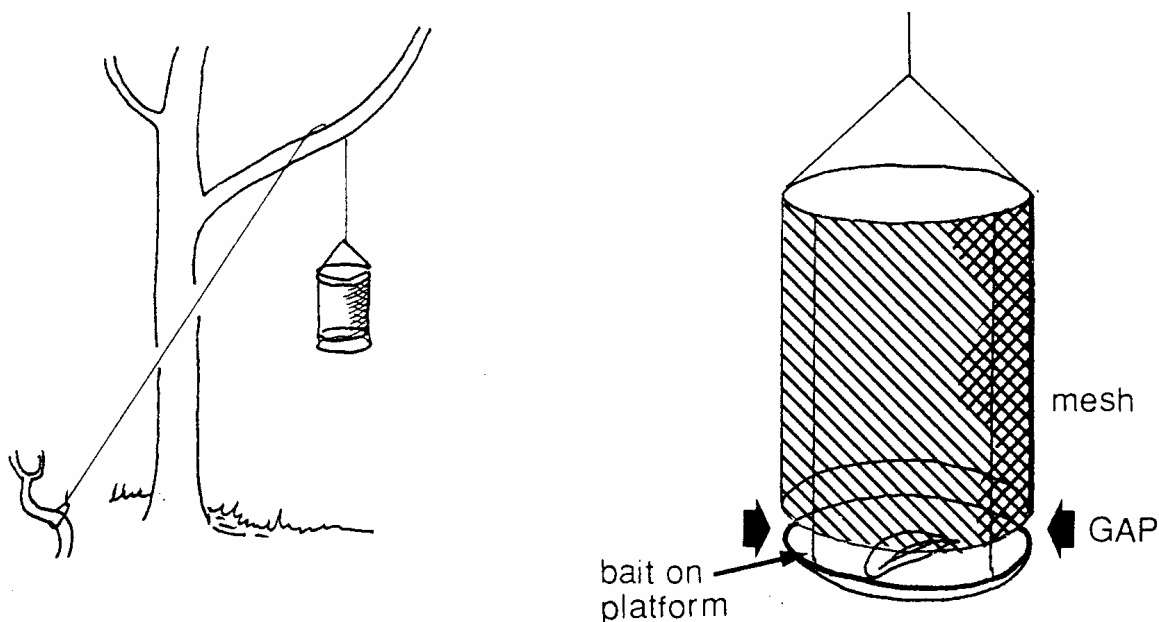


Figure 5. Typical location of a butterfly canopy trap.

## 8.4 Methodology: Moths

### 8.4.1 TRAPPING METHODS

Moth trapping should be carried out on dry, fairly calm nights. The catch will vary with the weather; moonless nights after rain are optimal. Light trapping may be carried out using a mercury vapour lamp behind a large white sheet, and/or the collapsible Heath trap. In either case, a generator or reliable car or motorbike battery is needed for power. The first method requires constant presence in order to collect specimens. The Heath trap, on the other hand, can be left overnight once it has been set up. The mercury vapour bulb/sheet method has several advantages over the Heath trap, which was designed for temperate conditions. These are;

- It is possible to collect one group preferentially (for example, hawkmoths or silkmths, which are the easiest families to identify). The heath trap collects all groups indiscriminately, although because of its small size it is most effective at trapping smaller moths.
- The flight times of the moths collected can be noted (most species exhibit a peak of activity for part of the night, and this will vary between species).
- A proportion of the moths caught in the Heath traps are likely to escape before the morning.

Another important advantage is that equipment left overnight in the forest may be stolen (especially when it is as obvious as a light-trap). When the Heath trap is used, it should be carefully placed away from thoroughfares etc.

Placing of the lamp will also influence the nature of the catch. If carried out in a clearing, it will be more visible than within the forest, and the catch will be larger. This should be borne in mind if trapping is being used to determine differences in the moth fauna of different habitats. Flight periods also differ between moth species, and all-night trapping sessions will give the best range of species. However, if heavy rain occurs the equipment should be retrieved and brought under cover.

Current procedure for sheet trapping involves allowing habituation to the light for 5 minutes, followed by a 1 hour observation / capture session. During this time all moths observed over 1 cm in body length are recorded. For any new morphotypes observed notes on body length, wing span, and appearance are taken, along with a photograph.

## 8.5 Identification

There are no official identification works on Cambodian butterflies, however Frontier-Cambodia have produced a butterfly guide to South-West Cambodia based on 3 years of specimens collected – this is ever expanding. Monastyrskii (2002) is a recent publication of common Vietnamese butterflies and utilises much Frontier-Vietnam data. A useful field guide to butterflies of Thailand exists; *A Field Guide to the Butterflies of Thailand* (Lekagul *et al.*, 1977; now out of print). For more detailed identification, works include Pinratana (1979-92), D'Abrera (1982-86), and Corbet and Pendlebury (1978).

## 8.6 Data recording and specimen collection

Refer to the Frontier-Cambodia ***Data sheet book*** and ***Specimen preservation manual***.

## 9. GROUND TRUTHING SURVEY: Guidance

### 9.1 Introduction

The Global Positioning System has developed into an efficient GIS data collection technology which allows for users to compile their own data sets directly from the field as part of 'ground truthing'. Ground-truth surveys are essential components for the determination of accuracy assessment for classified satellite imagery.

In conducting a field survey, researchers must have a basic understanding of the study area such as its physical characteristics, location, framing pattern, local agricultural products, main occupations, and its socio-economic status. This basic knowledge provides fundamental ideas for identifying entities appeared on the imageries and thus, ease the interpretation process during the ground truth survey.

### 9.2 Aims

The aim of ground truthing is to collect basic information from physical realm to identify land use or land cover. This information can be used to increase the accuracy of satellite image interpretation and land-use mapping.

### 9.3 Methods

- Prior to beginning the journey, decide on the route to be taken and mark (GPS coordinate) this and the turnaround point on a topography map.
- On-route, record GPS waypoints at regular intervals e.g. every 300-500m travelled and at natural vantage points.
- At each of the recorded waypoints, grade the vegetation according to the categories provided (below) and provide observational / descriptive notes. For each observation, this should include a compass bearing, distance and extent of the vegetation types encountered.
- Specific waypoints should also be made to mark the location of miscellaneous features (details below).
- General observational notes should also be made for the areas on-route between the waypoints.

## 9.3.1 VEGETATION CLASSIFICATION FOR GROUND TRUTHING

Category	Description
<b>Forest : Good quality</b>	i) Tall stature (25-40m); ii) Upper canopy dominance of semi to fully mature tree individuals, medium to large sized individuals frequent; iii) Buttress roots relatively common; iv) More or less continuously closed canopy conditions (>90% cover); v) Possibly, presence of distinct strata within canopy structure; vi) Variation in the age classes of tree species present; vii) Absence of bamboo/ banana and/or other locally distributed pioneer (light demanding) species; viii) Low density of plants in field layer (therefore generally easier to move around) with relative dominance of woody species; ix) Few signs of human disturbance (stumps & cut timber etc).
<b>Forest : Average quality</b>	i) Reduced stature (ambient height 20-30m); ii) Lesser no. of mature (large sized) trees; iii) Buttress roots on only juvenile individuals or non-commercial species ie. strangling fig ( <i>Ficus</i> sp.); iv) Canopy incomplete (60-100%) with % cover unevenly distributed; v) Stratification within the canopy layers is simplified or indistinct; vi) Possibly, a tendency towards a similar age class of tree individuals present; vii) Pioneer and light loving species increasingly frequent. viii) Greater vegetation density within field layer; ix) Signs of past disturbance.
<b>Forest : Degraded</b>	i) Low ambient stature (c. 10-20m); ii) Non-commercial species present the only mature individuals; iii) Buttress roots very infrequent; iv) In one extreme, may have a very open upper canopy comprised of scattered mature individuals and a dense field layer <u>or</u> , have a closed canopy of very low height and also a dense field layer ; v) Stratification completely absent or layers disjunct; vi) Pioneer species dominant in all layers (bamboo and banana may be frequent); vii) Numerous signs of disturbance in the form of stumps and felled timber (old and/or recently cut).
<b>Scrub</b>	Open, transitional habitat between pasture and forest with a dense mixture of herbs ie. banana, climbing species, young pioneer sapling and scattered tree species.
<b>Pasture land</b>	Open grassland with perhaps minimal cover from isolated trees. May be fallow (temporarily disused) or actively grazed. Land disused for longer periods may have dense herbaceous cover eg. <i>Eupatorium odoratum</i> (Asteraceae).
<b>Arable land</b>	Wet : Paddy-field Rice. Dry : Generally concerns monocultures of terrestrial species and includes crops such as Maize, Cassava, Hill Rice, Peanut, Tea etc.

### 9.3.2 MISCELLANEOUS FEATURES

Category	Notes
<b>Boundaries</b>	Vegetation types & land use types.
<b>Waterbodies</b>	Lakes/ ponds, rivers/ streams. Notes should include : size and orientation.
<b>Infrastructure</b>	Roads, Trails & Paths, Bridges etc. Notes should include : forks & orientation.
<b>Habitation</b>	Villages, Hamlets, Small-holdings, Forest guard stations & posts, Temporary dwellings i.e. lean-tos etc. Notes should include : name, physical description (size / materials etc) and whether in active use.
<b>Forest Use</b>	Animal traps, Signs of logging and non-timber forest product (NTFP) collection. Notes should include : type and number of traps and (if trap-line) orientation, and other general notes.
<b>Faunal Activity</b>	Direct sightings & indirect sightings (spoor). Description should include : species ID; notes of remains, dung, footprints and any other signs of presence and use.

### 9.4 Data recording

Refer to the Frontier-Cambodia **Data sheet book**.

## 10. VEGETATION STUDY

### 10.1 Introduction

Although no comprehensive survey of the flora of this region has been carried out recently, the Cambodian flora is undoubtedly rich in endemic forms. Dy Phon Cambodia's only plant taxonomist described the flora of the Southwest region but was unable to estimate the number of endemic species found here (Dy Phon 1970, 1971). Partial analyses of the floral and faunal composition, rarity and endemism show that the mountains of Southwest Cambodia form a biodiversity hotspot (IUCN 1995).

Due to the pressure of human populations on Cambodia's forests, disturbance of natural vegetation is often severe, with a variety of secondary forest formations being found in addition to less disturbed primary forests. Even within protected areas, a patchwork of differing vegetation types is found, and the overall aims of the vegetation study carried out by SEE in Cambodian reserves are to assess the extent and distribution of different forest types, and the degree to which natural forests have been degraded by human activity.

### 10.2 Aims

The aims of the vegetation surveys carried out by FC FRP are:

- To observe and map major vegetation types within specified areas;
- To measure and plot the trees within each major forest type and record species composition information.

### 10.3 Methods

For each forest area, work is carried out in each of several sites, at which work is carried out on the woody vegetation (in plots and transects), and herbaceous flora.

#### 10.3.1 SELECTION OF STUDY SITES

Study sites are not randomly selected, but should be strategically selected so as to represent the extent of vegetation types in the reserve area. The choice of study sites should be carried out using maps, taking into account the main environmental factors influencing forests (particularly altitude and aspect) and human disturbance.

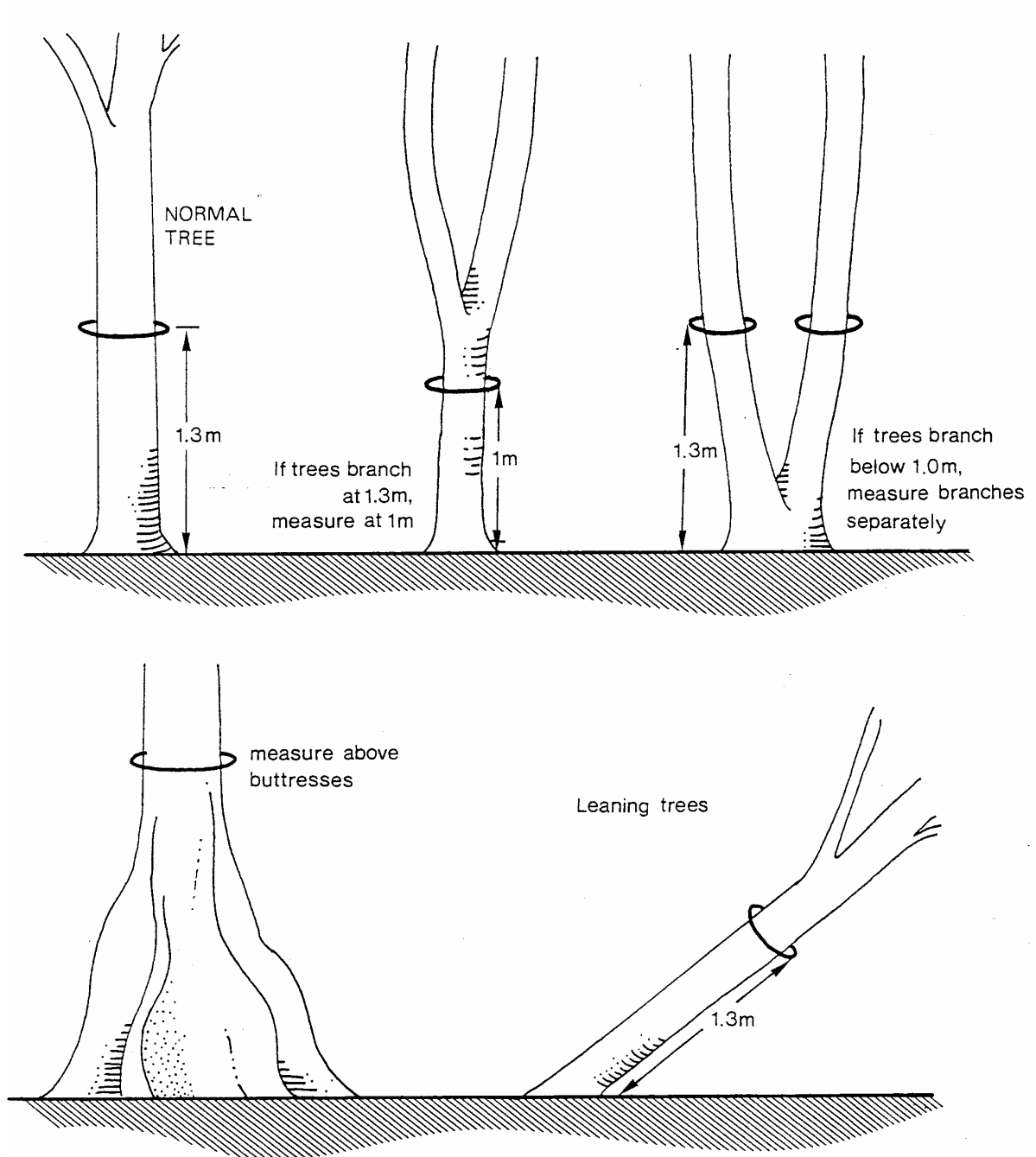
The project capacity for sampling should be taken into account and sampling effort split between the major forest types in proportion to the extent of each forest type in the area.

#### 10.3.2 VEGETATION PLOTS

The forest plot is studied in order to demonstrate the stocking density (number of trees per hectare), family composition of the forest in the areas studied.

A 50m x 50m, or 50m x 20m, square is marked out using red-and-white barrier tape. An origin point should first be chosen, and each side of 50m laid out by a team of 2 or 3 people using a compass bearing in order to ensure a straight line and a 90° angle at each corner point. The family and the Diameter at Breast Height (DBH) are recorded for every tree in the plot. Trees are defined as a woody plants 4.5m or more high (used as a minimum size for trees recorded in forest transects by Ashton and Hall, 1992).

DBH measurements are taken at a height of 1.3m above the ground. For sloping, or buttressed trees, DBH measurements are adapted as shown in Figure 1. For multi-stemmed trees, each stem over 4.5m in height is treated as a separate tree.



**Figure 6.** DBH measurements for atypical trees.

When a tree has been identified, it is marked by making a nick in the bark with a sharp blade.

### 10.3.3 GROUND FLORA

The aim of the ground flora survey is to gather comparative data on the diversity and nature of shrub- and herb-layers in the different forest types studied.

Herbs, shrubs and trees under 4.5m tall are sampled in 2m x 2m quadrats within the forest plot. Twenty such quadrats are studied, covering a total of 80m<sup>2</sup> (5% of the total plot area). The quadrats should follow a diagonal line through the plot.

Within each quadrat, all herb, shrub and sapling species should be identified. The number of individuals and the approximate percentage cover of the quadrat should be noted for each species, in addition to the total percentage cover of the quadrat (and therefore, percentage of bare ground not covered by ground layer vegetation). Each species observed in the ground layers should be assigned to a broad ecological group (tree seedlings, shrubs, herbs, climbers, or palms), to allow comparison of the floral characteristics of the sites studied.

*Tree seedlings* are small (<4.5m tall) examples of woody species in which mature individuals exceed 4.5m tall. They often form the majority of plants in the field layer.

*Shrubs* are woody, multi-stemmed species and treelets that generally flower and set seed at less than 4.5m.

*Herbs* rarely form compact rosette plants in tropical forests (Richards, 1976), and their stems are sometimes woody, making them difficult to distinguish from the shrubs. Richards (1976) classifies as herbs those species (generally non-woody) which do not exceed about 2m or more.

*Climbers* may be woody (eg, *Tetrastigma* spp.) or herbaceous (eg, *Lygodium* spp.). All are characterised by stems which are not self-supporting, and a scrambling habit.

*Palms* are all members of the family *Arecaceae*. Some palm species may also act as climbers (for example, the rattan palms *Calamus* spp.).

### 10.3.4 FOREST TRANSECTS

Forest transects are carried out in order to produce a diagrammatic representation of a cross-section of forest at the plot site (see Ashton and Hall, 1992, for examples of forest transect diagrams).

Sites for forest transects are chosen alongside, or partially within, the forest plot area. It may be preferable to position the transect just outside the plot area so that both can be carried out simultaneously. The transect is 60 x 10m (an adaptation of Ashton and Hall's 64 x 8m profile method). It is marked by laying a long (60m) fabric measuring tape on a straight line; this forms the central long axis of the transect area. On sloping ground, the line of the tape should not follow the contour (a line perpendicular to the contour will better reflect the variety of microhabitats at different points on the slope). This central axis remains in place while the transect data is collected.

One side of the central axis is defined as positive, and the other negative; data is collected for those trees on the positive side first, then the negative. Work starts at the origin and proceeds along the 60m axis in a direction arbitrarily defined as North.

Each tree within the transect (5m on either side of the central tape) is labelled with a plastic number tag placed in a notch in the bark (it is important that these remain in place until all transect data has been collected).

For each tree, the following data are collected; position on the x axis (60m), position on the y-axis (between +5m and -5m), DBH, canopy extent (in the North and South directions), and

measurements of tree height (see Figure 2). The tree should be identified, and a sketch made to facilitate the production of the transect diagram. A forest transect data sheet is shown in Figure 3.

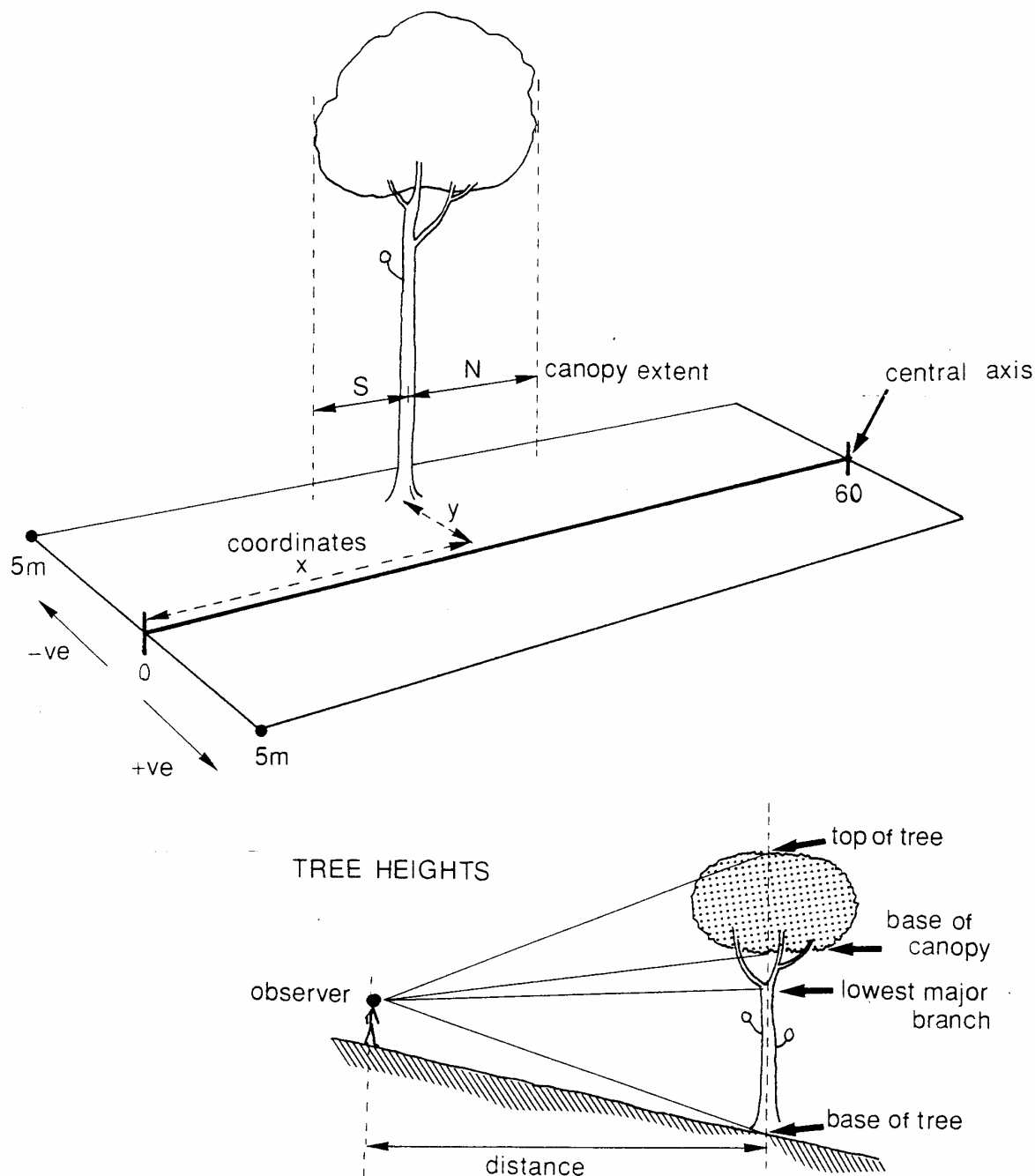


Figure 7. Data recorded for each tree within the forest transect.

### 10.3.4.1 Canopy extents

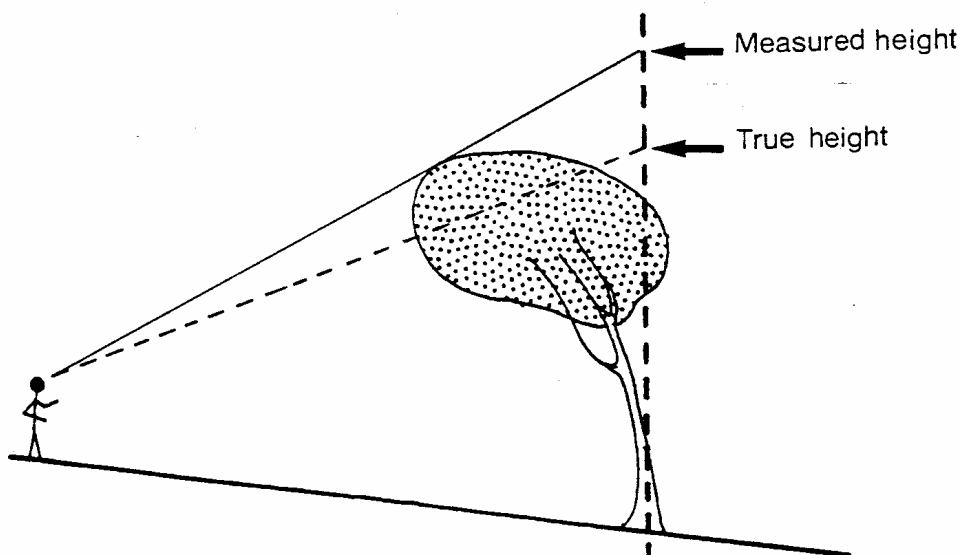
These are measured by standing beneath the tree, and looking vertically upward into the canopy. The extent of the canopy can usually be seen by identifying the foliage type. The furthest extent of the canopy in the North and South directions is found, and the distance from the centre point of the trunk to each of these points measured.

### 10.3.4.2 Tree height measurements

Measurements for the calculation of tree heights are taken using a clinometer. The observer stands at a point well away from the tree (at least 10m horizontal distance from the trunk for small trees, increasing to 20m for larger trees), and *above* the base of the trunk if the transect is on a slope.

Using the clinometer, angles are measured to the base of the tree, lowest significant branch (excluding small twigs), base of canopy, and top of canopy (see Figure 2). It is important to record whether the angles are negative (observer is above the point being measured) or positive (observer is below the point being measured). The horizontal distance from the observer to the base of the tree is recorded.

Care must be taken where the tree bends towards the observer; this could cause too great an angle to be recorded (Figure 4). In such cases, the observer should measure to a point above the central upright axis of the tree, or move to a more convenient viewing position where the distortion is less extreme.



**Figure 8.** Distortion caused by a bend in the canopy of a tree.

After these measurements have been taken for each tree in the transect, the angle of slope of the ground should be taken by measuring between two sighting poles of equal length, at 10m distances along the 60m axis.

### 10.3.5 AD LIB BOTANICAL COLLECTIONS

Botanical specimens are collected throughout each phase, both within the forest plot/transect sites and throughout the reserve. It is important that habitats in which forest transects are not carried out, such as high-altitude forests and non-forest habitats, are represented in these samples.

During the summer wet season, dry preservation of botanical specimens may be difficult, and at this time of year it may be preferable to preserve the pressed specimens with ethanol, as described in *The Herbarium Handbook* (Bridson and Forman, 1992).

## 10.4 Disturbance transects (forest resource use assessment)

The aim of this survey component is to assess the level of human disturbance with reference to pole cutting and timber extraction.

### 10.4.1 SYSTEMATIC TRANSECTS ACROSS A RESERVE

The sampling unit is the disturbance transect. The disturbance transects can be carried out with reference to the 450m x 900m grid system or similar dimensions dependent upon project capacity and size of forest area to be surveyed. The level of both pole cutting and timber extraction are assessed. For the purposes of this survey, poles are defined as all trees with straight stems at least 2m in length and with 5 -15cm dbh. Timber trees are defined as all trees with straight stems at least 3 m in length and exceeding 15cm dbh. The level of disturbance is assessed in terms of the number of poles and timber which are cut or left standing in a 10m strip (5m either side of the transect line). The disturbance transect is sub-divided into 50m sections and data is recorded separately for each section.

Disturbance is recorded along all transect lines at 900m (or xxxm) intervals. The point at which each transect intersects the surveyed boundary of each forest reserve is carefully measured to the closest numbered boundary demarcation point, so that the procedure can be precisely repeated in the future for monitoring levels of disturbance.

#### Procedure

A team of three people (minimum) is required; two observers and one recorder. The team starts at the beginning of the transect line in the 450m x 900m grid system (i.e. at the forest boundary). Five metres either side of the transect line are investigated for cut standing and naturally fallen poles and timber. One observer describes one side of the transect, the second observer describes the other side of the transect, and the recorder notes down all observations made. The disturbance transects are sub-divided into 50m sections, and records are taken separately for each section.

Every cut tree stump and cut pole is measured by the observers within the disturbance transect. DBH is measured at the standard height of 1.3m above the ground using a calibrated DBH tape. The diameter of cut trees and poles is measured at the point of the cut.

Fallen tree trunks or branches are not counted. This reduces possible duplicate counts as one does not count a trunk then further along the transect count the base from which it came.

Each transect line is surveyed from forest boundary to forest boundary for disturbance. Opportunistic notes on other human disturbance seen along the transect are made, such as traps, pitsaws, cleared areas or evidence of fire.

### 10.4.2 LOCATION SPECIFIC TRANSECTS WITHIN A RESERVE

Signs of human resource use (or 'disturbance') will be recorded along a 4m wide 200m transect. Such signs include the number of cut poles (5-15cm dbh) and timbers ( $\geq$  15cm dbh), fire, charcoal production, cultivation and pitsawing.

Transects will start in representative habitats and follow a bearing selected by throwing a stick and seeing which way it points. Two transects will be surveyed near to each main work site (trap site/vegetation plot). These transects can double as those to survey signs of animals.

Follow the above description for the procedure.

## 10.5 Data processing and presentation

### 10.5.1 VEGETATION PLOTS

In order to evaluate the relative importance of different plant species and families in the sample plot, two measures may be used; the *number of individual trees*, and the *basal area of wood*.

The *number of individuals* gives greater weight to families represented by many, small trees. The understorey and lower canopy contain a greater number of trees than the emergent layer, which is made up of few, scattered trees.

The *basal area of wood* is a more useful measure as it gives greater weight to larger individuals. Using DBH data, the basal area of wood can be calculated for each tree within the plot (assuming that each trunk is cylindrical, and given that area of a circle =  $\pi r^2$ ). From these figures, it is easy to arrive at a total basal area of wood within the plot (and per hectare), and to calculate the basal area of wood for each plant family.

The basal area can be used in conjunction with height data (height of stem below major fork) to calculate the volume of standing wood in the plot. This measure is particularly of interest to foresters considering the exploitation of timber.

### 10.5.2 GROUND FLORA

Using data gathered in the ground flora survey, it is possible to arrive at a mean percentage cover for the quadrats studied in each plot. Cover in the ground layer is rarely continuous, and tends to be lower where there is deep shade at the forest floor (for example, dense regenerating forest). When used in conjunction with other evidence (such as observations of stumps and other evidence of felling), percentage cover can therefore provide information on the recent history of the vegetation.

The absolute number of species observed can be taken as a measure of diversity. The proportion of the flora at each site in the growth form/ecological groups identified may vary greatly between different forest sites, depending on their history and existing physical and vegetation characteristics of each site.

### 10.5.3 FOREST TRANSECTS

The angles taken for each tree height (see Figure 3 above) can be converted to distances using trigonometry (since  $\tan \sigma = \text{length of opposite} / \text{length of adjacent}$ , for any right-angled triangle, then tree height = distance from tree  $\times \tan \sigma$ ).

Using the measurements for each tree, in combination with the field sketches, the forest transect is drawn to scale. First, the underlying slope is drawn, and each tree is then sketched in. Those trees with the highest positive value of  $y$  (+5m) should be drawn in first, those with the greatest negative value (-5m) last. All trees should be labelled with their number, so that they can later be identified.

### 10.6 Data recording

Refer to the Frontier-Nicaragua *Data sheet book*.

## **11. SOCIO-ECONOMIC STUDY**

### **11.1 Introduction**

The resident human populations have several implications for the future well being of an area of biological importance. There is often conflict between the land-uses of these populations and those of management of protected areas. The impact of human populations is mainly due to their lifestyle and it is this, together with an assessment of their impacts, which need to be investigated and monitored.

### **11.2 Aims**

The aims of the socio-economic survey carried out by FC FRP are to study the agriculture, aquaculture, welfare and economy of local inhabitants, and their impact on the forest and marine systems. The data gathered in this survey can be used to assess the anthropogenic threats to the biodiversity of an area, and evaluate the effectiveness of current management strategies. In addition, socio-economic data are essential to the formulation of future management plans for protected areas.

### **11.3 Methods**

The surveys are carried out using Rapid Rural Appraisal tools (Grandstaff and Messerschmidt, 1995), and have been adapted and developed by the field team themselves using works contained in the bibliography. The views of all the authorities involved in the management of a reserve are collected, along with data from each village. Villages of different ethnic groups are visited for the purpose of comparison.

Several techniques are used, depending on the source of information being surveyed. These are summarised below.

#### **11.3.1 INTERVIEWS WITH MANAGEMENT OFFICIALS**

The hierarchical structure of local government is such that many levels are involved with the management of an area. These can include Province, District, and Subdistricts. Depending on the specifics of an area, all, or some of the representatives from these groups will be approached for interview. These take the form of semi-structured interviews and occur throughout the phase. Interview frequency and structure depend on the nature and amount of the information required; information concerning demography, land tenure and economic activity are sought. Permission to carry out further interviews with other members of the community is also provided by these groups.

#### **11.3.2 SEMI-STRUCTURED INTERVIEWS: Community Leaders**

By using informal interview techniques leaders of communities will provide information about the demographic characteristics of the village, its economic activity and medicinal practices; and accompany the interview team during its visits to other families in the village.

#### **11.3.3 SEMI-STRUCTURED INTERVIEWS: Family Heads**

The interview team spends up to three days in a village collecting information from the heads of family.

The number of interviews is restricted by time so a representative cross-section of families is taken (on the basis of wealth; usually identified by the village leader). The interviews are to establish the lifestyles; agricultural techniques and characteristics; and health and education of each family.

Questions concerning the use of the forest resources (apart from the amount of firewood collected) have been omitted from the questions because official, rather than factual, answers are given; merely raising these issues can sometimes lead to a feeling of hostility towards the interview team. This is felt not only from the family head being interviewed at the time but also from others that may be later included in the survey (an interview is generally an open affair). Evidence of anthropogenic disturbance of forest can be gathered during the vegetation survey.

An example of the questions used is given below (data sheet). Although fairly formal in appearance, the questions generally trigger open-ended discussions about each subject. It is the responsibility of the team to ensure that the data on the interview sheet are obtained.

#### **11.3.4 OBSERVATION AND MAPPING**

Observations provide an invaluable source of information and patterns of agriculture, etc are usually identified. These are usually confirmed during interviews. Different land-uses within the area are mapped to establish the level of disturbance caused by agricultural clearances, logging, etc. It is these methods, rather than interviews alone, which are relied upon to provide a picture of the level of impact of human populations.

### **11.4 Results**

At the end of each day, and at the end of each interview stage, the results should be collated. Discussions follow about the success, reliability of interviews, qualitative and quantitative analysis, and conclusions. The team leader is ultimately responsible for deciding whether personal bias or thoughts on a subject are present in any of the teams' data, analysis or conclusions.

Analysis of the data involves grouping the data into one of three categories: assets, consumption and expenditure. Each of these are converted to monetary values using local prices.

- *Assets* include those data that add to the wealth of the family. These include the house (suitably adjusted to take account of its age); small industry and commercial interests; livestock kept at the time of questioning; and the yearly production of rice, corn or other crops; etc.
- *Consumption* figures cover the quantity of food eaten by the family in one year.
- *Expenditure* figures include money spent on education; health; fuel; fertiliser and pesticide; etc.

The figures from each village are averaged and used for comparison. The figures cannot be compared against each other, for example using expenditure and consumption against assets to calculate savings, as the data is based on different time scales and is not comprehensive enough to be accurate. This could be done if the livestock kept at the time of interview could be replaced by the quantities of livestock kept over the year.

In addition, the data reveal other interesting patterns such as the level of education received; the importance and success of the use of fertilisers and pesticides; family size; etc.

The results can be used to formulate recommendations or conclusions that are thought to benefit the area whilst at the same time not compromising the culture or development of the human populations.

## 11.5 Data recording

Refer to the Frontier-Cambodia *Data sheet book*.

## **12. TOURISM**

### **12.1 Introduction**

Tourism is fast becoming a feature of many of the areas studied, and should not be ignored. Tourism develops rapidly, and often uncontrollably, so it is important that management strategies and plans should take account before the area's resources are adversely affected.

The aims of the studies depend on the level to which tourism has developed. They can range from identifying the potential for tourism in an area (MacKinnon *et al.*, 1986), to assessing the levels of impact caused by existing tourism. Ultimately, the aims should concern the effects of tourism on the conservation value of the area.

### **12.2 Methodology**

Interviews, observations and mapping are carried out in a similar way to, and often in conjunction with, the socio-economic techniques. The questions, adapted and developed by the team, are based on previous work (see bibliography). In addition, the profile and views of tourists can be obtained using formal questionnaires; again using questions adapted and developed by the team using previous work. For these, both open-ended and closed questions are used; and are open to qualitative and quantitative analysis.

### **12.3 Results**

The data are analysed to determine the impacts of tourism on the environment, socio-culture and local economy. These impacts are well documented (Ceballos-Lascurain, 1996; MacKinnon *et al.*, 1986), and recommendations based on methods to minimise deleterious impacts can be given. The development of tourism in a sustainable way is the ideal and over-riding priority of these recommendations.

It must be stressed that tourism is not viewed unfavourably by the field team. Tourism can be important to an area in terms of development and also (if well planned) in aiding conservation.

## 13. FISHERIES

### 13.1 Introduction and Aim

The fishery component aims to collect data at regular intervals and from a range of villages in order to provide useful information for management bodies/ authorities (National Park, District Council). The differences in catch size and composition from different fishing methods, seasons and villages will assist management recommendations, hopefully leading to an improvement in the long-term viability of the particular fishery under investigation.

### 13.2 Objectives

- To select a range of fishing villages that are accessible throughout the year to act as permanent monitoring sites.
- To intercept samples of the landed catches for measurement and classification according to gear type used (traps, lines, nets or other), market destination and fishing location.
- To describe the fishery by measuring the length and weight of all identified fish and to provide first year statistics from the four monitoring sites.
- To compile catch per unit effort results for the fishery.
- To train host country personnel (Fisheries Officers) in the above techniques and to fully integrate them in a monitoring programme.

### 13.3 Methods

#### 13.3.1 FISHERIES MONITORING

A standardised period of time should be spent in a fishing villages/ catch landing site, once relationships with the community have been built up.

As each catch is landed, and with the consent of the fishermen, the team should examine the fish prior to them being sold to fishmongers or cleaned and separated for transport to market.

#### 13.3.2 Catch information

A Fisheries Officer/ host country personnel interview the fishermen and record the following information:

- number of hours spent fishing
- location on the river of the fishing activity
- number of fishermen
- number of boats
- method used (line, net or trap)
- net length
- net mesh size
- net colour
- number of hooks per fishing line
- hook size
- type of bait
- part of the river (edge, middle whole)
- fishing depth (surface, middle, bottom)
- fishermen tribe
- likely destination of catch

### 13.3.3 Fish processing

All the fish need to be identified to species in each catch and then measure *standard fork length* (from tail-fork to the front of the head) and weigh the fish. Fish should be identified by host country personnel and available literature. Two teams should operate consecutively when a large catch is processed. Large catches of very small fish need to be weighed in batches to reduce the processing time.

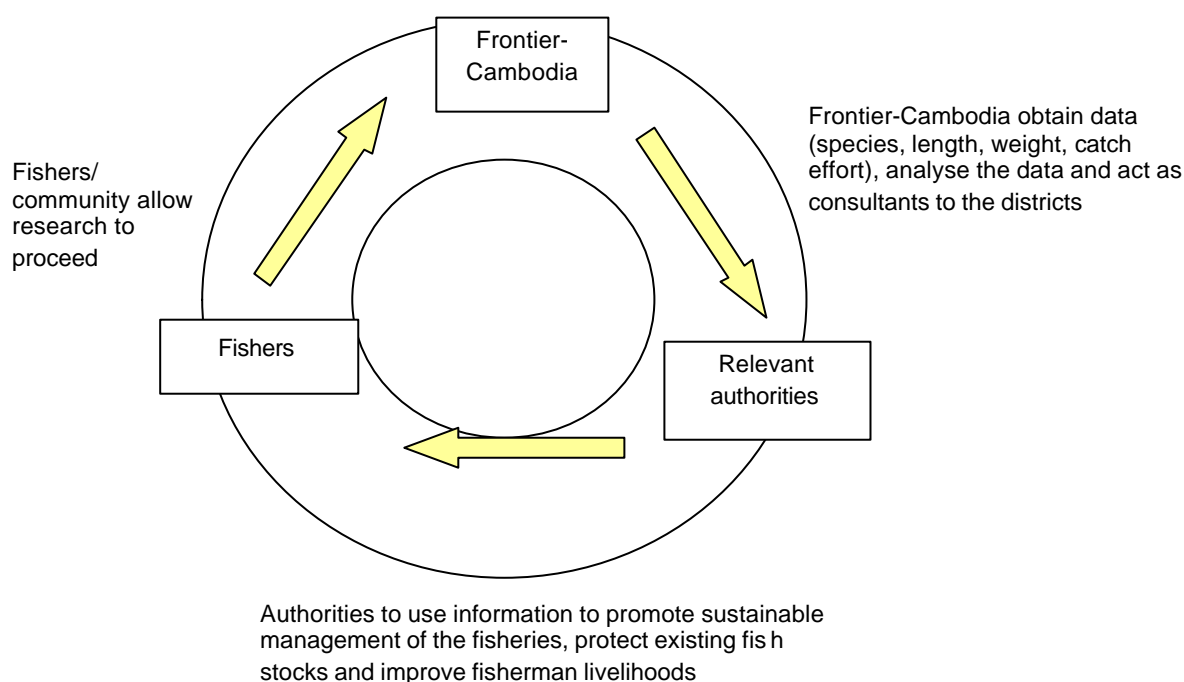
## 13.4 Feedback to fishing communities

Feedback on the fisheries data collection can be achieved using two complimentary approaches.

### 13.4.1. Fishing communities

With the help of counterparts fishermen can be invited to attend 'feedback' sessions in their village. The aims of the meetings are to:

- 1) Explain how the data collected will benefit the fishermen in the long term. Give simplified statistics on the previous phase's fishing trip.
- 2) Explain the relationship between Frontier and partners.



- 3) To provide fishermen with the opportunity to give feedback on the fisheries programme.
- 4) To thank the fishing communities for their hospitality and co-operation.

### 13.4.2. Management authorities

Quarterly meetings can be held between Frontier-Cambodia staff and management authorities. At these meetings the results of recent research are to be presented and the forthcoming work discussed.

## 13.5 Inputting fish data

The fish data collected will undergo quite analysis in Excel. In order to make this a relatively simple task it is essential that the data are inputted in the correct format.

In the field monitoring data will be collated on the basis of each individual 'catch'. It will include the weights, lengths and identifications of all the fish, in addition to the practical details of the catch (the time taken, the methods used etc).

In order to input this data into the computer the format must be changed. The following is a simple guide.

**Give each catch a code.** Be careful to give different codes to different catches from the same boat. The codes are important because they will allow us to analyse specific catches. Do not use numbers in the codes as the computer will think they are part of the analysis.

All of the fish data must be entered by species. Each species is inputted onto a different sheet. The format for the initial spreadsheets is as follows:

Species	Weight	Length	Catch code
<i>Oreochromis nilotica</i>	50	21	MIKA
<i>Oreochromis nilotica</i>	70	30	MIKB
<i>Oreochromis nilotica</i>	52	22	MIKC
<i>Oreochromis nilotica</i>	25	10	MIKA

Now you need to sort all the weight data in ascending order. Block the entire weight column, go to **data** and click **sort**

Now block both sets of weight and length data. Go to tools, data analysis, regression. Input the y range as the range of length data cells, and the x range as the range of weight data cells. Input in the format **\$C\$2:\$C\$15**

In the same window click the following boxes:

**Labels, Confidence limits (95%), New worksheet, Residuals, Line fit plots.**

You now have your weight length table and the regression statistics.

To input the correct title for the graphs and the axis simply click on the existing text, delete and input. To get your best fit line, click on the points of the graph. A window will appear. Choose **automatic** and select a suitable colour. You now have your line.

To extrapolate any missing weight data input the following equation, with the relevant values into the weight column:

$$x = (y-c)/m$$

where x = weight; y = length, c = intercept (labelled coefficient in regression data), m = the value below the intercept on the graph.

## 14. REFERENCES

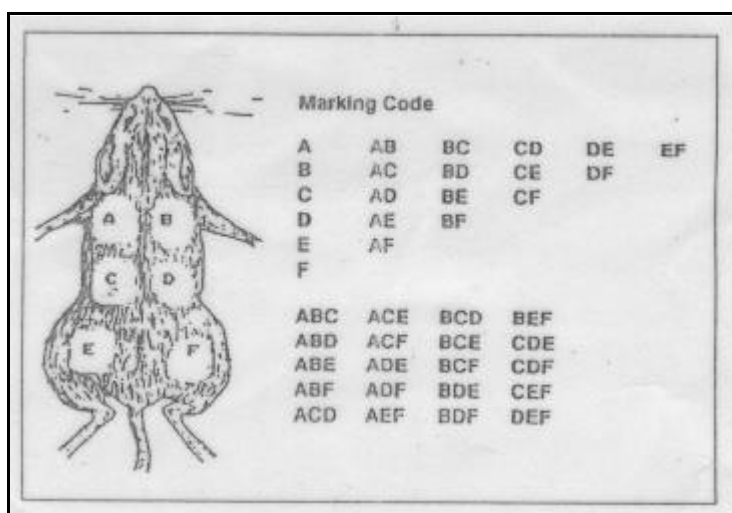
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## Appendix 1

### Marking, measuring and sexing small mammals: fur clip marking method.

A cheap and easy way of temporarily marking small mammals is cutting the fur, giving each individual a unique code. Cutting the fur will give a mark that will remain visible from three to eight weeks, depending on the species and age. Young individuals re-grow fur faster than adults. The mark can be applied to the animal while gently holding it by the scruff of the neck. With the use of mesh traps the animals can be marked without handling, while they are still sitting in the trap. This method causes minimal harm and stress to the animals.



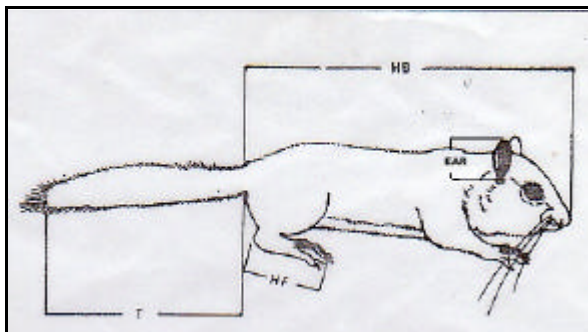
**Figure 9.** Fur clip method for small mammals. A combination of the marks gives a total of 41 unique marks for each species.

Using the letter system showed in figure 4, each individual of each species can be given an unique mark, with a total of 41 combinations. If there are many individuals of one species, the system can be applied for each sex. For example there can be both a female AB and a male AB of the species X in a trapping area, giving the possibility of 82 combinations for one species.

When cutting the fur, cut as small an area as possible so that it does not affect the thermoregulation. If the survey is continuing for more than three weeks, be sure to cut the underfur, otherwise the fur may grow out and the mark disappear too quickly.

### Measuring small mammals

When surveying small mammals there are standardised methods for measuring specimens. This is to make identification easy and to ensure comparable data.



HB= Head-body, T= tail, HF= hindfoot.

**Figure 10.** Measuring small mammal dimensions.

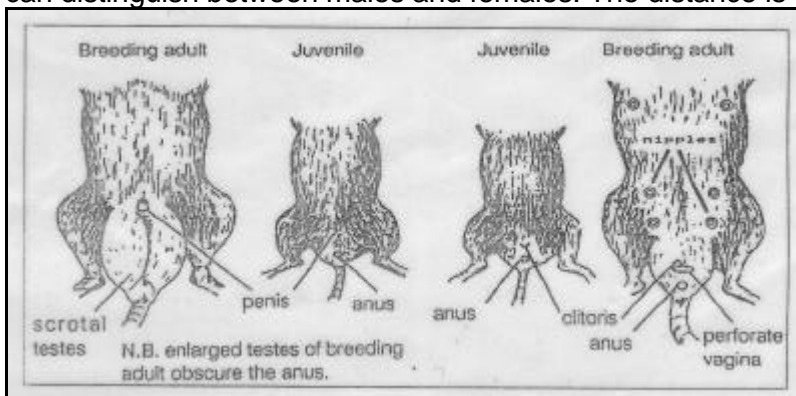
### Points to remember

- The most important measurements for field identifications are the head-body, tail, hind foot and ear.
- The head-body is the length of the animal from the tip of the nose (without whiskers) to the anus. Measure the animal when it is in a natural position.
- The tail is measured from the anus to the tip of the tail (not including hairs).
- The hind foot is measured from the back of the heel to the tip of the longest toe (without the claw).
- The ear is measured from the tip diagonally across to the bottom, the longest stretch.
- Measuring is preferably done when the animal is either held in the hand, under anaesthetic, or dead. If in a mesh trap the animal will move around and the measurements will not be precise.
- The smallest measurements (hind foot and ear) should be precise, so callipers must be used.

### Sexing small mammals

Sexually dimorphic characters such as genitalia, body size, pelage, scent glands and behaviour can normally be used to distinguish between male and female mammals

Sexing small mammals is often difficult, as sexual characteristics can be hard to identify. In juveniles and non-breeding adult rodents, the distance between anus and the penis or vagina can distinguish between males and females. The distance is longer in males than in females.



**Figure 11.** Sexual characteristics in adult and juvenile males (left) and females (right) rodents.

In females, the nipples are not very distinct but can often still be seen. Depending on the species, the females usually have between three and five pairs of nipples. One or two pairs

can sometimes be located between the front legs, and a pair far behind, between the hind legs (***be aware that males of some species have visible nipples - always look for other characteristics as well***).

When the males are in breeding season, the testes are often enlarged in the scrotal sac and are easily identified.

Pregnant females have a swollen abdomen (are heavier) and have visible nipples. When the female is lactating, the nipples are large and have a ring of bare skin around them, and the vagina is perforated.

Sexing insectivore species such as shrews is often problematic. The penis is not visible externally and only protrudes from the cloaca during erection. Pressing the sides of the cloaca can physically evert the penis.

## Appendix 2

### Small mammals – more advanced work

#### Grid trapping

For more advanced ecological surveys, such as estimating the abundance (total number of animals), density (number per unit area), and/or home range and community structure, a different trap set-up is required.

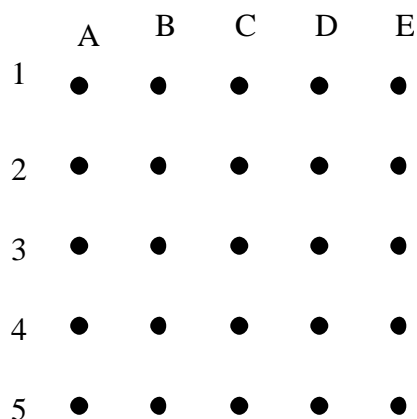
At least one hundred Sherman and/or mesh traps are essential for such a survey. The traps should be set up in a quadratic grid configuration, *see figure 1*.

The spacing of the traps depends on the size of the traps (and hence the target species) and the complexity of the habitat. If Sherman traps are used for trapping of small species, the distance should be 510 metres between the traps. If larger mesh traps are used, the distance should be 15-20 metres.

For the production of reliable and comparable data the distances in the grid should carefully be measured out with the use of compass and tape measure. A grid consisting of at least 10x10 trap arrays is recommended as this covers a relatively large area and will retrieve the most results.

It is recommended to place two traps at every trapping station, which will avoid the saturation of traps with “trap-happy” individuals or species. The traps should be placed within two metres from the exact point, partly to produce precise data and partly to ease locating the traps when checking them.

If trapping of arboreal species is essential to the survey, traps should be placed in the trees (at varying heights) at all or every second trapping station.

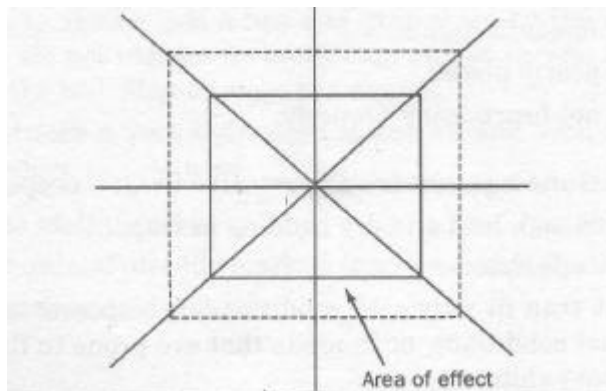


**Figure 12.** Grid configuration. Each dot represents a trapping station. Labelling the rows with letters and numbers gives each trapping station a unique reference code (e.g. C2).

Trapping should continue until less than 10% of the captures are unmarked (see section capture-mark-recapture) individuals (normally 10-14 days), this ensures that the majority of individuals are identified.

After grid trapping, all traps should be closed and the site should be left undisturbed for a recovery period of minimum 4 days. Then traps can be re-arranged and opened to form 8

“assessment lines” radiating from the centre of the former grid and extending beyond its border to estimate the area of effect, see *figure 2*.



**Figure 13.** Trapping grid with area of effect.

Area bordered by a permanent line is the former grid-trapping area. Eight assessment lines transverse the area.

Animals marked on the grid and then later captured on varying distances along the assessment lines provide information on the effective sample area of the grid. This is the area used for density estimates.

Refer Wilson *et. al* (1996) and Rabinowitz (1997) for detailed descriptions of grid trapping and assessment lines.

### **Assessment lines and density estimates** (from Rabinowitz, A. R. 1997)

Estimates of density can only be made if there is some way to determine movements of the target species away from the capture area. The purpose of assessment lines is to determine how far away the animals are coming in from, and thus get a better idea of the true trapping area - called the Area of Effect. The proportion of new to previous marked animals of any one species along these lines determines the area of effect, which can then be used for density estimates.

Assessment lines are generally placed at acute angles to the census line and trapping is conducted for a short period of time. The angle depends upon the expected area of effect, and the spacing of the trap stations on the assessment lines. Assessment lines must be arranged so that they do not modify the capture rates on other lines nearby. Trap spacing depends upon the estimates or known movements of the dominant species (a spacing of one 1/6 the average diameter of the home range has been suggested). For most small mammal species a trap spacing of 15 to 20 metres is used, with assessment lines at approximately 45° angle to the census lines.

### **Data analysis**

1. Determine the width of the extension outside of the actual trapping configuration ( $W_A$ ) by examining the assessment line capture data visually or graphically. See *figure 1*. Remember that area of effect varies not only between species but may have to be calculated separately for different sexes of species.
2. Determine area of effect (A) or the real extent of the trapping area that goes beyond the area of your grid.

3. Determine the number of animals caught within the area of effect ( $N_A$ ), which is the number of animals caught within your configuration adjusted to include animals within all of A.
4. Determine the true species density based on the figures from steps two and three.

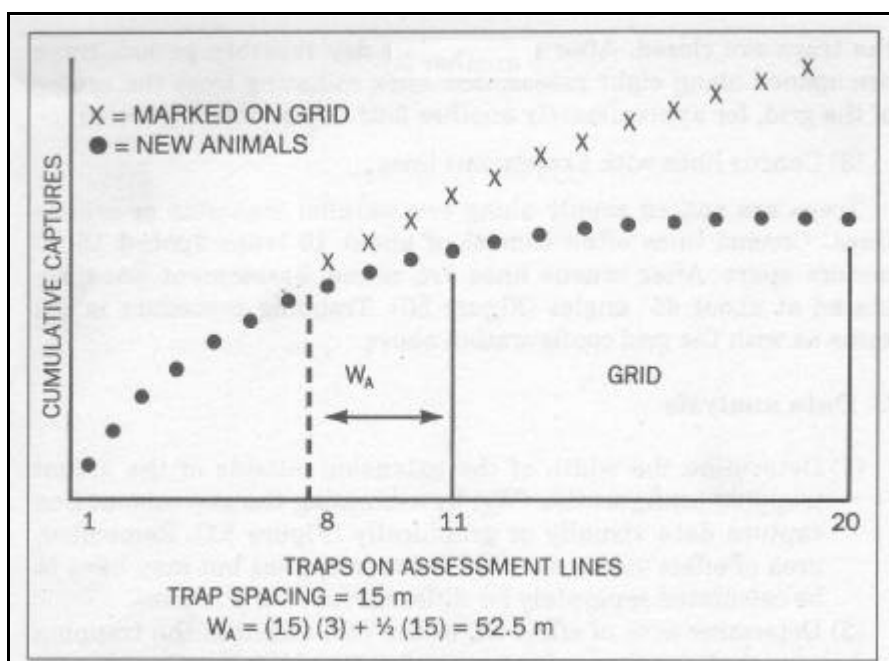
### Determining $W_A$

$W_A$  = width of the extension outside of the actual trapping configuration which is determined by the movement of animals away from the trapping configuration. To determine this width, use the distance from the grid to the midpoint between the two trap stations where the break in slope occurs between you and marked animals, as seen graphically. See figure 1.

### Determining A

$$A = W_G^2 + 4W_G W_A + \pi W_A^2$$

$W_G$  = Width of grid



**Figure 14.** Determination of  $W_A$  from animals marked on grid to new animals. The distance from the grid to the midpoint between the two trap stations where the break in slope occurs between new and marked animals is the width ( $W_A$ ).

### Determining $N_A$

Proportion of animals removed (sampled) from Area of effect:

$$R_P = M/T$$

M = Number of animals caught in the area of effect that had already been marked on the grid

T = Total animals (marked and unmarked) caught on the assessment lines, within the area of effect

$$N_A = N_G / R_P$$

$N_G$  = Total number of animals captured and marked during grid trapping

$R_G$  = Ratio of marked to total animals in area of effect

**Determining species density**

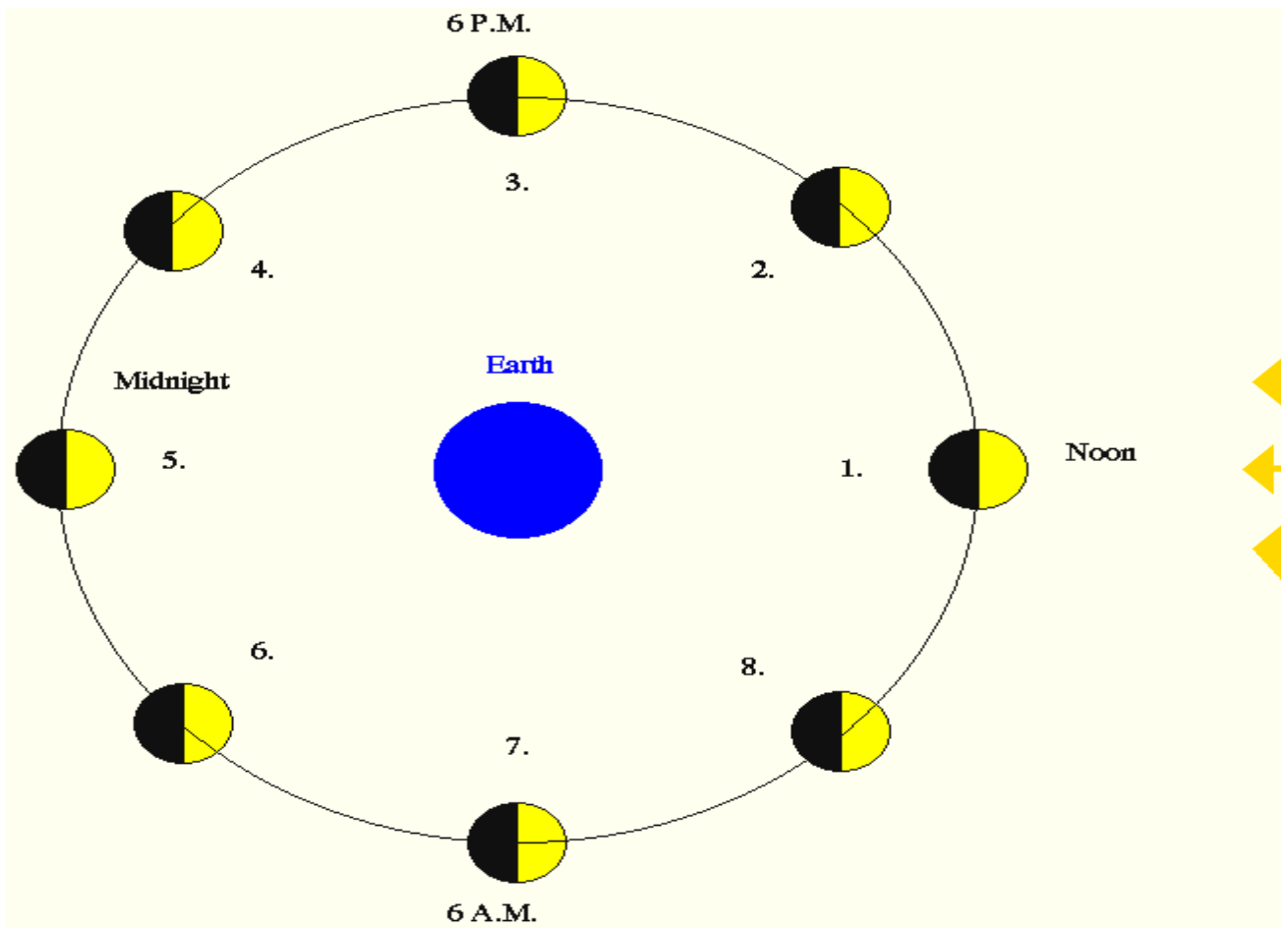
$$D = N_A / A$$

$N_A$  = Adjusted number of animals captured

$A$  = Area of effect

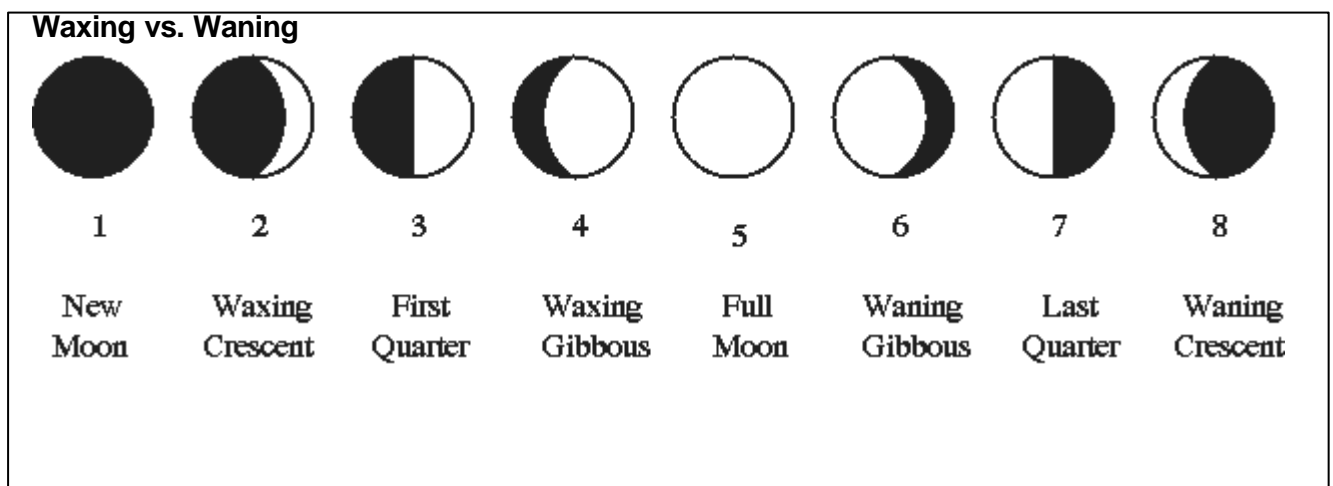
APPENDIX 3: Figure 15: Phases of the moon

## Phases of the Moon



The Moon appears to go through phases. In other words, the amount of the Moon that we can see changes over time in a cyclic period that repeats itself approximately once a month. (The actual period of this cycle is approximately 29.5 Earth days.) The cause of these phases is the relative positions of the Sun, Earth, and Moon. As seen in the diagram, if the Sun is located off to the right of the picture, the Earth and Moon are illuminated as shown (the white areas being the lighted areas). Notice that no matter what phase the Moon is in, HALF of it is ALWAYS lit by the Sun. (Which half is always lit? The half that is facing the Sun.) The reason that we do not always see a Moon which is half lit is because of our position relative to the Moon and the Sun. As the Moon moves in its orbit, different portions of it appear (to us!) to be lit up as we look at it from Earth. This is why we see lunar phases.

For example, if the Moon is at position 1 in the diagram, the half of it that is lit by the sun is facing away from us, so we do not see the moon at all. This is called a new Moon. When the Moon is at position 3, we see half of the half of the Moon that is lit up. We call this a quarter Moon. The important point is that the moon doesn't change, nor does the amount of the Moon which is lit by the Sun. The only thing that changes is the position of the Moon relative to us and the Sun. This change in position causes the phases.



**Figure 16:** Moon waxing and waning

The diagram above shows what the different phases of the Moon would look like as seen from Earth (note that the numbers below each phase correspond to the different positions of the Moon as seen in the first diagram). It appears that the Moon repeats certain phases: there are two crescent, gibbous, and half phases each month (each cycle). These phases are not exactly identical, however. Look closely at the diagram. You will notice that during phases 1 through 5, the amount of lighted area increases over time from right to left. When this occurs, the Moon is said to be waxing. During phases 5 through 8, the amount of light area decreases (or the darkened area increases) from right to left. When this occurs, the Moon is said to be waning. Therefore you can tell if the Moon is waxing or waning based on whether the right side of the Moon is dark or light. (Of course, this only works in the Northern Hemisphere. In the Southern Hemisphere the effect is just the opposite!) Astronomers use this to distinguish between the repeated phases of the moon by referring to the waxing or waning crescent, gibbous, and half phases.

### Telling Time

The phase of the Moon can tell you the time of day. For example, because a full Moon is seen when the Moon is on the opposite side of the Earth from the Sun, an observer on the Earth will see the Moon rise just as the Sun sets. The next day, the Moon will rise

approximately one hour later (because the Moon will have moved farther along on its orbit). This means that a waning half Moon will rise at midnight, a new moon at dawn, etc...

### **Phases of Other Planets**

Another interesting point about phases is that they are not restricted to the Moon. We can observe phases of Venus and Mercury as well. (We do not observe phases of the outer planets because their orbits lie outside the orbit of the Earth and therefore they can never be between the Sun and the Earth.) There are two differences between the phases of the Moon and the phases of Venus and Mercury, however. The first is that we do not see all of the phases of Venus and Mercury. Think for example about the full phase. This occurs when the Sun lights the side of the Moon which faces the Earth (i.e., when the half of the Moon that is lit IS the side of the Moon which faces the Earth). Clearly Venus and Mercury cannot be on the opposite side of the Earth from the Sun because their orbits lie inside the orbit of the Earth. Therefore, for the Sun to light the half of Venus or Mercury which faces the Earth, these planets would have to be on the other side of the Sun from the Earth. In order to see this phase for these planets, we would have to be able to look through the Sun (which we can't). The second difference is that Venus and Mercury appear to change size as they cycle through their phases. (Actually, only Venus is really close enough to the Earth for this to be noticeable.) The reason for the apparent change in size is that the distance between the Earth and Venus changes as they orbit the Sun. So, Venus looks smaller when it is in its crescent phase than when it is in its gibbous phase.