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Chapters

Cover Photographs by Sun Visal

INTRODUCTION

This report forms the basis of a wide monitoring protocol for the core areas of the Tonle Sap Great Lake. Of the three Core Areas, Prek Toal has received the most intensive and extended conservation attention. The area has therefore been selected as a model for which protocols will be designed, tested, revised. The protocols can then be adapted for the other core areas and additional sites of conservation significance.

The majority of this report concentrates on the large waterbird colonies of Prek Toal for a number of reasons:

1. Waterbirds represent by far the most important component of the lake's biodiversity, in terms of global conservation significance.
2. The lake represents the last major breeding site in the world for some species, making the colonies globally irreplaceable.
3. Monitoring of these colonies can have a direct and clearly defined influence on adaptive management practices.
4. The monitoring of the waterbirds is inextricably linked with the protection of the core area. The permanent presence of rangers trained to perform both protection and monitoring make it more cost-efficient and therefore more sustainable. Additionally it reduces further the gap between scientific monitoring and direct conservation impact.
5. The waterbird colonies themselves are excellent conservation surrogates for many other species; thus the monitoring provides an efficient protective umbrella for other components of the lake's biodiversity.

However, other species have also been identified for potential monitoring where they meet the following requirements:

- They are of national (see upcoming prakas on the National List of Endangered Species) regional (see WWF Ecoregion Review 2004) or global conservation significance (see IUCN Red Data Book 2006)

OR

- Trends in the population or distribution of the species can be demonstrably linked to a specific environmental threat, beyond that affecting just the species itself.

AND

- The effort (man-power, training, cost) to gather a sufficient quantity and quality of data, repeatedly over time, is proportionate to both the resources available for monitoring AND to other monitoring priorities.

AND

- Sufficient long-term technical advisory capacity is available to analyse, interpret, and adapt monitoring protocols and data generated.

To date, crocodiles, watersnakes and Bengal Floricans meet these criteria and protocols are presented for these species.

CHAPTER 1:

LARGE WATERBIRD MONITORING PROTOCOLS FOR THE CORE CONSERVATION AREAS OF THE TONLE SAP GREAT LAKE

Tom Clements, Sun Visal

Introduction

Prek Toal is one of three core areas of the Tonle Sap Biosphere Reserve, the largest lake in South-east Asia and one of the world's most productive fisheries. The Prek Toal bird colonies are the only remaining breeding site in South-east Asia for two Globally Threatened species – Spot-billed Pelican *Pelecanus philippensis* and Milky Stork *Mycteria cinerea* – and the largest remaining site for five more Globally Threatened or Near-threatened species – Oriental Darter *Anhinga melanogaster*, Lesser Adjutant *Leptoptilus javanicus*, Greater Adjutant *Leptoptilus dubius*, Black-headed Ibis *Threskiornis melanocephalus* and Painted Stork *Mycteria leucocephala*. In total, these species number in excess of 5,000 breeding pairs, together with several thousand more pairs of other species (e.g. cormorants and Asian Openbills *Anastomus oscitans*). The uniqueness and importance of the site justifies a dedicated monitoring and counting programme, both in order to obtain accurate population estimates (e.g. the proportion of the global population present) and to monitor the success of current conservation interventions and the possible impact of threats across the species' dispersing range.

The conservation of the Prek Toal core area is managed by the Ministry of Environment of the Royal Government of Cambodia. Depending upon the season, up to 25 rangers are patrolling the forest, mainly working at semi-permanent vantage platforms ('*rien*') located at the top of trees. Nesting birds are counted from the same platforms. Between 2001/02 and 2002/03 nesting birds were counted from 11 platforms, from which at least part of the colony could be seen. Although this method provided some approximate population sizes there was no estimate of the percentage of the colony that could be seen from the platforms, or the area that was counted more than once. The ranger platform-based counts did, however, prove to be an **extremely efficient** method to protect and manage the colony – leading to an almost complete cessation of egg and chick collection incidences.

Monitoring the number of birds in the breeding colony serves a number of purposes:

1. It allows the significance of the Prek Toal colonies to be assessed – i.e. they contain *x*% of the Global population of each species.
2. It allows trends in species populations to be followed over time.
3. Monitoring reports are indicators of threats to the birds, both at Prek Toal and throughout their range. For most species, Prek Toal is the only major breeding colony in Southeast Asia. Assuming that the colonies at Prek Toal are protected, decreasing population numbers would be indicative of increasing threats elsewhere in the species' dispersing range. For example, a reduction in feeding habitat for pelicans might result in a decreasing population at Prek Toal, even if the birds at Prek Toal were breeding successfully.
4. The large waterbirds are good *indicators* of other threats to the Prek Toal core area – e.g. decreasing food availability, increasing pollution, habitat destruction.
5. Monitoring of the large waterbirds is linked to management of Prek Toal as it involves the same staff. Therefore obtaining accurate population counts is indicative of effective colony management.

1. Counting birds at Prek Toal

1.1. Situation

Monitoring of the Prek Toal bird colonies requires the estimation of two parameters:

1. Accurate population numbers. This will provide information on the significance of the Prek Toal colonies (*x*% of the world's population).
2. Calculation of population trends over time, in order to evaluate the success of conservation activities.

Three types of bird colonies exist at Prek Toal:

1. 'Black' colonies – cormorants, darters and Lesser Adjutants. These start the earliest, in August, with the Lesser Adjutants fledging last in March. Peak counts are obtained in December-January. The darters and cormorants nest very densely on <100 trees, whilst the Lesser Adjutants nest sparsely on >50 trees.

2. 'Black-and-White' colonies – storks, pelicans and Greater Adjutants. The pelicans return in November with the storks returning soon after. Most chicks fledge in late May, with a peak count in March or early April. This is the largest of the colonies, numbering in excess of 300 trees.

3. Ibis colonies – Black-headed Ibis arrive in January and nest in the scrub around the stork/pelican colony. This makes the nests almost impossible to see, hence counts are practically impossible.

The current counting method involves the use of observation platforms, from which some of the trees that comprise the colony can be seen. It is possible, also, that there are small satellite colonies out of sight of the platforms, but they do not significantly affect the colony counts obtained. In the wet season and early dry season (until early January) the 'black' colonies are accessible by boat; during this period it is possible to make a detailed count of each occupied tree. In the later dry season counts can only be made from platforms, as the area is extremely difficult to access. It is only possible to count an unknown proportion of the colonies from the platforms. This makes estimating the population of later nesters – pelicans, storks, adjutants and ibis – particularly challenging.

1.2. Estimation: the concept

Ideally a population can be counted with absolute accuracy, and this is sufficient to understand trends in population size. However for wildlife this is possible only in a small number of cases. At Prek Toal it may be possible to obtain absolute counts for some species in the 'black' colonies, which are accessible by boat. For most of the other species, which are of highest conservation concern, absolute counts are impossible due to incomplete visibility: not all nesting pairs on each tree can be seen and not all colony trees are visible from a platform.

For species that cannot be accurately counted within the entire study area the population must be obtained through estimation – sampling a proportion of the population and extrapolating the estimated density over the entire area. This is analogous to sampling primate populations through transect counts, and extrapolating these to give an area density. Within the sampling area the detectability of the species must be assessed – i.e. the proportion of individuals that can be counted. Finally, observer error needs to be measured, for example by conducting

multiple independent counts of the same birds in a short period of time.

At Prek Toal, the appropriate sampling unit is a colony nesting tree and the dependent variable is either the number of adults, chicks or nests on the tree. Of these, the number of nests (hatched and being incubated combined) is the most stable. The number of adults present continually fluctuates through the day and depends seasonally on the nesting stage. Chicks are generally easy to identify when small but can become progressively more difficult to count. In order to estimate observer error, and natural variation in the number of adults and chicks, independent counts should be taken at the peak of the breeding period.

The variance of the population estimate will be dependent on the variance in the number of nests on each tree and inter-observer variability. This takes the form of a confidence interval: e.g. the 95% confidence interval of the darter colony population size is 450-550 pairs, meaning that we are 95% sure that the true population size lies between these limits. The confidence interval also allows us to detect significant changes in population size (those greater than would be expected by chance).

Accurate counts will only be possible for a proportion of occupied nesting trees. For large colonies or species with large populations, it is to be expected that random changes in the colony shape will logically result in a different proportion being visible from the fixed-location platform in different years. This proportion therefore has to be recalculated annually in order to estimate the population size. In addition, some trees may be visible and counted from more than one platform: these trees need to be identified and estimates adjusted accordingly.

The following key factors therefore need to be calculated in order to estimate the population size for a species:

- the average density of nests, chicks and adults on visible trees
- observer variability, through independent counts of the same visible trees
- counts need to be adjusted to account for duplicate counting of the same trees
- the overall size of the colony (number of occupied trees)

This will be achieved through the following standard methods:

1. **Tree counts** from fixed platforms of visible trees
2. **Tree marking and mapping** in order to calculate the number of visible trees, to obtain independent counts by different observers of these trees, and to identify trees that are counted from more than one platform
3. **Aerial surveys** to estimate the overall extent of the colonies

2. Platform Tree Counts

2.1. Observation Platforms (*rien*)

The bird colonies are located using boat surveys, particularly from August to January. Aerial surveys should be used during the early dry season (January-February) to identify satellite colonies. Once a colony has been discovered, the rangers choose a nearby tree on which to build the observation platform (*rien* in Khmer). The platform serves two main purposes: to count the nesting birds, and to monitor the colony and protect it from poaching and disturbance. It should be built in a tall tree that has good views of the colony and is easy to access in the dry season, i.e. a tree that is close to a river that the rangers can access throughout the year. The platform should be built sufficiently close to the colony in order to count the birds accurately, but not too close to limit disturbance.

Platforms should located on the top of the tree and have a bamboo viewing platform, supported by wooden poles, and accessed by a wooden ladder. The construction should be strong enough to support at least two people, and must be robust enough that it does not move or shake in strong wind or waves. The material cost is usually about 50 $US.

2.2. Colony demarcation

During the wet season, particularly October-November, when the water level is high, boats can freely access every part of the core area and create large amounts of disturbance to the birds. To protect the birds and limit disturbance the colonies should be demarcated using string and signs, in order to warn people to stay away. The colony boundaries are usually set 400-500 metres from the trees at the edge of the colony. The string used is a bright colour (e.g. red or yellow) that the fisherman can see well. For the 'Black' colony (darter and cormorant species), which start to nest when the water level is high, both string and signs are used. For the 'Black and White' colony, which nests when the water level has started to drop, only signs are used along the main waterways and roads. Signs can also help counting the birds, by showing the colony boundary and distinguishing groups of trees that should be counted from different platforms.

2.3. Data Sheets

Datasheets are model forms to record field data. Three types of datasheets are used for colony counts:

(1) Daily colony count datasheet (Appendix 3)

(2) Tree datasheet, which follows the same format as (1)

(3) Weekly summary datasheet (Appendix 5)

Pre-formatted datasheets help the recorder to:

- Collect all the required data (i.e. form headings ensure recorders don't forget data); and
- Follow the correct method for data collection.

Furthermore, the use of the same datasheets by different teams, at different sites and times makes sure that data is provided in the same format, i.e. they standardise data collection and quality.

2.3.1. Daily count datasheet (Appendix 3)

The daily count datasheet is completed by the ranger observation team at least twice a week from each platform. This is the most important datasheet because it gives detailed information on the colony population and its evolution during the breeding season. It provides the basic data that is analysed to estimate the population size. The datasheets are returned to the station when the ranger teams rotate. This ensures that counts by different teams are **independent** – i.e. the newly arriving team does not know how many birds the previous team counted on each tree. The tree datasheet (2) maintains a running log

of the occupied trees in the colony (but not the number of birds), to assist the new team.

The usual situation in Prek Toal is to have a large colony with many trees and several breeding species on each tree. Sometimes there are up to 200 trees. Therefore several datasheets are required for a single count.

2.3.2. Tree datasheet (Appendix 3)

The tree datasheet follows exactly the same format as the daily count datasheet, but serves a different purpose. It is used to help the rangers to monitor the location of occupied trees and the bird species that are nesting there. The species present are recorded using a ✓, rather than writing the number of birds. This record is kept at the platform, so that when the teams rotate the new team knows the location of occupied trees, and which species are present.

2.3.3. The weekly summary datasheet (Appendix 5)

This datasheet summarizes the daily counts on a weekly basis for each colony. The rangers should return this datasheet to the Prek Toal Environmental Station when the teams rotate. It is given to the Ranger Coordinator, who uses it to calculate the maximum monthly totals.

2.4. Counting procedure

The colony counts are either done by boat (using binoculars) or from platforms (using a telescope). Boat-based counts provide accurate data in a short period of time from all nesting trees, regardless of distance from the platform. They also allow counts of invisible trees (i.e. trees that cannot be seen from the platform). However these counts are only possible when the water levels are high (from August to December), when only the Oriental Darters are breeding. Therefore platform-based counts must be used for the remaining species, which nest when water levels are low.

In order to collect scientifically rigorous data, which can be analysed to obtain a population estimate, it is essential that standardised counting protocols are followed by the rangers. This allows data collected by different teams from different platforms in different years to be combined and compared. To improve the accuracy of the counts, rangers are trained annually and throughout the season both on the counting methodology and the use of the equipment. Training takes place both in the field and at the Environment Station.

Ranger teams count the trees in order from the platform, tree by tree. Counts always start at the same tree and proceed in the same direction from each platform. They must measure the direction of each tree, estimate the distance to the tree from the platform, identify the tree species, give the tree a number and estimate the percentage of the tree that can be seen from the platform. One ranger team comprises two people, one as the observer and the other as the recorder. The recorder is responsible for completing the datasheet (Appendix 3), whilst the observer uses the telescope to count the number of birds on each tree.

2.4.1. Preparation for the count

Rangers must choose the right time to count the colony, i.e. when the visibility and weather are favourable and the sun is behind the platform. Counts are not conducted when it is raining, windy or it is difficult to see the trees.

The following equipment is required:

- Daily count datasheet;
- Tree datasheet,
- Watch;
- Pen and corrector;
- Compass;
- Telescope.

Observers need to complete the information on the top of the datasheet:

- Colony site: the name of the site or the name of platform
- Date: day-month-year.
- Time start/finish: hours-minutes, AM or PM
- Name of observer & recorder: who is looking and who is writing.
- Weather: prevailing weather conditions.
- Observation material: telescope, binoculars or naked eye.
- GPS coordinates: UTM East and UTM North.

2.4.2. Making the count

The following information is recorded for each tree:

- Tree number: the number of the nesting tree, indicating if the tree has already been marked.
- Tree species: species of the tree being counted.
- Direction: measured with a compass and written in degrees.
- Distance: estimate of the distance from the platform to nesting tree in metres.
- Visibility: a percentage score of the tree that is visible from the platform.

One line on the datasheet is completed for each tree in the colony. On each tree, one species is counted at a time, first the adult birds, then the chicks, the nests with chicks and finally the nests without chicks (parents incubating eggs). These numbers are placed in the correct species column, indicated by the picture on the datasheet. Only visible bird species are counted, focusing on the key species: Oriental Darter, Greater Adjutant, Lesser Adjutant, Painted Stork, Milky Stock and Asian Openbill, but including other species where present. Black-headed Ibis cannot be counted from the platforms because it nests in the scrub.

2.4.3. Writing conventions

A convention is a code proposed to simplify writing and that, once it is stated, can be used all the time. The advantage of a convention is that the data are presented in a short, homogeneous form. However, to apply it correctly the observer must understand clearly what it means and respect the writing code. For the colony counts, the following convention is used:

When using the convention, it is important that the rangers clearly record the separating marks (slash, bracket and plus sign) between each number to avoid confusion.

Other codes are also be used when, due to poor visibility, it is difficult to make an accurate count of the birds and/or nests:

- + : when the observer thinks that more birds are present than were actually counted, e.g. 20+ means that 20 individuals were counted, but the recorder thinks that more birds were present.
- ? : when the number is unknown, i.e. neither accurate counts nor estimates are possible. For example: '12 / 0 (?)' means that 12 adults were present but the number of nests is unknown.
- A question mark can also be used in other columns on the datasheet when the observer is unclear. For example, a '?' in the tree species column means that the observer could not identify the tree, or writing 'Daem Reang?' would mean that it is probably that tree species but the observer is not completely sure.
- [ ] : numbers are placed between square brackets when species identification is uncertain.
- The last column of the data sheet is to write additional information or an explanation of when + or ? or [ ] signs were used. For example, "Tree partly hidden from view" or "very far" or "heat haze" or "against the sun".

After completing the colony count the rangers must:

- write the total for each species at the bottom of the page;
- add the total of each page for each species to give the platform total;

this is written at the end of the last page (below the 'Total line" of the table).

2.5. Timing of the colony counts

Although the Oriental Darters arrive early (in August), most species arrive much later. Counts are taken throughout the breeding season. However, only data collected during the 6 week period when the species' colony is at its maximum size are used for population estimation and monitoring. During this time the rangers need to take extra special care to collect the data accurately.

Species	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Darter												
Pelican												
Greater Adjutant												
Lesser Adjutant												
Painted Stork												
Milky Stork												
Asian Openbill												
Legend		Breeding season				Peak counts						

2.6. Ranger management

2.6.1. Team organization

Currently, there are 25 conservation rangers in total. They are divided into six groups of four people each for fieldwork. One group is responsible for one to two platforms. In each group, one pair works at the platforms whilst the other rests in the village. The teams rotate weekly during the wet season and early dry season (September to February), when access is easy and every two weeks in the late dry season (March to June), when access is difficult. Sometimes it can take two days walk to reach the platforms in May and June when water levels are very low.

Twelve of the rangers are former bird and egg collectors. They are all illiterate but have extensive knowledge of the Prek Toal core area. Each former collector is paired with a literate ranger for fieldwork – the literate ranger working as the recorded and the collector as the observer.

Before departing for work in the core area the rangers are required to come to the Prek Toal Environmental Station to meet the team coordinator and receive instructions about new activities. These meetings also help to exchange information and ideas within the team about the status of the colonies and how to improve the monitoring and protection. After the meeting all field equipment is checked, and the rangers depart to the forest.

2.6.2. Ranger training

To build the teams' capacity, all the rangers receive technical training every month and one or two lessons on general knowledge. The training is conducted in Prek Toal Environmental Station, with one day allocated for training rangers who are in the village and another day allocated for the teams that have just returned from the forest. Both literate and illiterate rangers join the training. The literate rangers sometimes need to assist the illiterate rangers to understand the questions and write answers.

The Rangers are trained in nine lessons:

- *Using maps, compass and GPS;*
- *Reptile and herp survey technique;*
- *Large waterbird colonies of Prek Toal;*
- *Field Data collection: colony counts and the weekly summary report;*
- *Colony Tree mapping;*
- *Environmental issues of the Tonle Sap;*
- *Ranger's role and responsibility;*
- *Waterbird identification and counting;*
- *Cambodian Wildlife Law.*

During the training, documents are distributed to the rangers.

To strengthen the teams' capacity, the ranger coordinator and project officer should visit the rangers at the platforms at least twice a month and conduct brief trainings, especially focusing on technical work. During these field visits checks are made on the quality of the rangers' data collection.
A meeting is held every month to discuss the monitoring and protection of the bird colonies. During this meeting technical issues regarding the colony counts are discussed, and advice is given to the rangers on how to resolve technical and practical problems encountered.

Tree Marking and Mapping

2.7. Tree Marking

Tree marking and mapping is conducted by boat during the wet season following the breeding season (August-November), and is completed before the pelicans return (November). At this time of year the colony is effectively unoccupied. Tree marking and mapping is necessary in order to calculate the number of visible trees seen from the platforms in the previous season, and to resolve problems of multiple counting of the same tree (where it occurs). By marking the trees it is also possible to improve the quality of the platform-based counts, as trees are uniquely identified by a large visible zinc number. Finally, since the tree marking surveys take place by boat when water levels are high it is possible to map trees that were occupied but were invisible from the platform. This helps to estimate the true size of the colony.

In summary, the major objectives are:

- To uniquely mark trees with large visible numbers to reduce errors and confusions on the part of the rangers during platform-based counts;
- To individually map nesting trees exactly, using GPS;
- To determine how many nesting trees were visible from each platform;
- To determine how many trees were counted from more than one platform; and
- To determine how many trees were occupied but were invisible from the platforms.

Equipment:

- Tree marking data sheet (Appendix 4)
- Tree datasheet from the previous breeding season
- GPS
- Radios (one for each team)
- Telescope
- Numbered zinc plates
- Numbered lead plaques
- Nail
- Wooden Poles
- Spray Paint
- Hammer
- Cleaver

At least two ranger teams work on the tree marking. One team is based in the platform with the previous season's datasheets and the telescope. Their task is to assign the correct number to each tree. The other team (or teams) use a boat to paddle to each tree and attach the correct tree number. Trees are marked in the same order as they appear on the tree datasheet from the previous season. The team on the platform uses the compass to measure the bearing to each tree, taken from the datasheet, and to guide the paddleboat team to the correct tree. The paddleboat team often hold a pole with a white flag so that the platform team can easily follow their progress. Teams communicate by hand-held radio.

When the correct nesting tree is located, the paddleboat ranger team are required to complete the tree marking datasheet (Appendix 4). This includes the tree number, species, GPS waypoint number and the UTM easting and northing. Where possible, the paddleboat team attach a numbered zinc plate to the tree in the correct direction so that the number can be easily read from the platform. The number on the zinc plate should be the same as that assigned to the tree during the previous season. If the ranger team cannot

attach a zinc plate then a lead plaque is instead attached, again with the correct tree number and platform (e.g. P8-145).

If the rangers find a tree with old nests present that was hidden from the platform they are required to complete the tree marking datasheet and attach a lead plaque following the identification code 001, 002, 003, etc... These lead plaques are distinguishable from the platform-numbered trees because the platform number is missing. The assigned lead plaque number is recorded on the tree datasheet. These are invisible trees.

Sometimes the rangers will arrive at a tree that already has a zinc plate or lead plaque belonging to another platform. In this case they attach a second zinc plate facing to the second platform from which it was counted. They also record on the tree marking datasheet the other numbers present on the tree, and the platforms these numbers are associated with.

Every year the rangers must also check all trees previously marked with a zinc plate in order to replace lost or damaged marks. These trees are located using the GPS coordinates obtained during the previous tree marking season. If they discover that the zinc has been lost a new plate is put with the same number. Sometimes the plate is present but is obscured by new vegetation growth; in this case the rangers clear away the new vegetation and check with the platform team by radio that the number is now visible.

For the Oriental Darter colonies it is impossible to mark the trees because the birds return very early in the season (August), before the Tonle Sap water level has risen sufficiently to allow boat access. For these colonies the rangers use a 1000-metre rangefinder to measure the distance and a compass to measure the bearing from the platform to the trees when the birds are counted. This allows the nesting trees to be accurately mapped. Sometimes nesting trees are located beyond the 1000 metre capacity of the rangefinder, in which case the trees are recorded as being >1000m distant.

2.8. Colony Maps

2.8.1. Tonle Sap Digital Orthophoto Maps

The Tonle Sap Digital Orthophoto Maps are used as the basic underlying layer for all colony mapping. The orthophotos were produced by the PASCO-FINNMAP consortium under contract to the Department of Fisheries (DOF) of the Ministry of Agriculture, Forestry and Fisheries (MAFF) as part of the Tonle Sap Environmental Management Project (TSEMP). The contract was delivered in February 2006, although the images were obtained in January 2005.

The Orthophotos exist at two scales. The first is a 1:5,000 colour digital orthophoto series obtained from 1:25,000 scale aerial photography, covering the whole Tonle Sap Biosphere Reserve area (accuracy ±1.20 metres). The second is a 1:2,500 colour digital series obtained from 1:12,000 scale aerial photography, covering the three core areas, including Prek Toal (accuracy ±0.60 metres). The images exist in Universal Transverse Mercator (UTM) Projection – Zone 48, using the WGS84 map datum. A Digital Terrain Model (DTM) was also obtained. The 1:2,500 orthophotos are recommended as the base map for Prek Toal.

2.8.2. Individual Tree Mapping

The locations of all emergent trees at Prek Toal have been digitised from the 1:2,500 orthophotos, and each has been given a unique number. This approximates to the total availability of nesting habitat.

The master tree list can be compared each year using GIS to the individually mapped and marked trees. A visual inspection can resolve discrepancies – i.e. where the same tree was mapped more than once, or where the same tree was counted from more than one platform. From this two outputs can be calculated (see Map 1):

1. A best estimate of the total number of trees occupied by the colony in that year, both trees that were visible and trees that were invisible from the platforms. This estimate will be revised further in years where aerial surveys were also conducted (see below).
2. An adjusted estimate of the total number of trees that were occupied and counted from the platforms (i.e. that were visible). This estimate is adjusted because the effect of double- or triple-counted trees has been removed.

For visible trees the platform-tree distance can be calculated in GIS. Since platform counts are likely to get progressively less accurate with distance from the platform, only data from visible trees closer than 500 metres are used in population estimation calculations.

3. Aerial Surveys

Aerial surveys were conducted in 2005 and 2006 in order to estimate the extent of the colony – the number of occupied trees – and it is recommended that this is continued in future years. The survey must be conducted at the end of March or beginning of April (before Khmer New Year), when the colony is at its maximum extent. Only a single flight of less than 5 hours (approximately $2,000) is required, assuming that the weather conditions are appropriate and there are no technical malfunctions. Flights in 2005 and 2006 were conducted using the Cessna aircraft flown by Mission Aviation Fellowship Cambodia.

3.1. Technical Setup

The entire flight data collection is designed to be controlled by a laptop computer. This automates data collection, reducing the possibility of human error and loss of data.

A Nikon D70 digital camera is used to obtain the photographs at 3008 × 2000 pixels. The camera is controlled using the Nikon Capture 4 software on the laptop computer. This allows the camera clock to be synchronised with the laptop's clock – which should be set to Greenwich Mean Time. Photographs are taken using the time-lapse photography option in the Nikon Capture 4 software, using a delay of 8 seconds (s) between pictures. This means that it is only necessary to start the camera at the beginning of the transect and pause it at the end – with photographs being taken continuously along the transect. The software automatically copies the photographs to a designated directory on the laptop computer, so that disk space is not a limiting factor (i.e. there is no need to change the digital camera card). Photographs can be viewed shortly after they were taken on the laptop screen to ensure that data of sufficient quality is obtained.

A Garmin 12 XL GPS is used to obtain latitude and longitude co-ordinates, using the WGS84 map datum. The GPS can also be controlled from the laptop using the GPS Utility software. The 'Track Real Time Position' is used to plot the aircraft's position every second. This GPS track needs to be saved regularly as the data are later used to reference the photographs. The Position Console (in GPS Utility) and a map displaying the flight plan allow the flight's progress to be continuously monitored.

Before the flight a photograph of a GPS clock needs to be taken by the Nikon D70 digital camera in order to allow later synchronisation.

3.2. Flight Plan

The flight plan (see Map 2) assumes that the aircraft would be flying at 2,500 feet (763 metres), at a speed of 150km/hr. Based upon surveys in 2005 and 2006 this is an appropriate altitude given the risk of low elevation cloud during the survey period. At this altitude, with a camera focal length of 35mm, the photographs would measure 516 × 340 metres with a pixel size of 17 × 17 cm. The photographs need to be timed to ensure a minimum of 30% overlap between sequential pictures. Consequently the time-lapse photography is set to 8s, or every 333 metres flown (assuming a speed of 150km/hr), an overlap of 55% in the photograph length. Similarly, flight transects were placed 250 metres apart, an overlap of 36% in the photograph width. This ensures that a complete over-lapping sequence of photographs is obtained.

The choice of focal length and altitude are particularly important as these determine the photograph size, whilst the flight speed and time-lapse setting determine the frequency of photographs along the transect. Flying at a lower altitude, or increasing the focal length will reduce the photograph size and increase the pixel size. Generally, flying below 2,000 feet (610 metres) or increasing the focal length beyond 45mm should be avoided as photographs will then no longer overlap.

With a spacing of 250 metres, 28 transects are required in order to cover the main nesting colonies (see Map 2). The total length of the survey transects is 240.2km. A further four transects, totalling 6km, are also required to cover a satellite colony of Lesser Adjutants and cormorants. Given that the aircraft requires a minimum of 1km to turn after completing a transect, the flight plan assumes an average turning width of 1.5-2km. Accordingly the complete flight plan requires 9-10 loops over the colonies. Appendix 1 gives the co-ordinates of each transect start and end point and the order in which they should be flown.

A total of 700-800 digital photographs will be taken during one flight.

3.3. Immediate post-flight data processing

There are two outputs from the flight:

1. A complete GPS-tracklog of the flight, with latitude/longitude points taken every 1-3 seconds.
2. The set of digital photographs taken by the Nikon D70, each of which will be stamped with the date and time it was taken.

The central coordinates of each photograph can be obtained by matching its time-stamp with the GPS tracklog. There are several software programs that can be used to do this, including PixPoint for ArcGIS, by Red Hen Systems, and GPS-Photo Link. The process could also be done manually – although this would be time consuming.

PixPoint requires a very particular import file, the format of which is given in Appendix 2. In the future, an easier to use program should be found, or automating the production of this import file.

PixPoint will produce a JPEG-worldfile (extension .jpgw) for each photograph that contains the coordinate of the central point. These files can be read by any GIS program.

The following simple information should then be obtained from each photograph: presence of birds, % cloud, presence of rivers (the latter helps to check geo-referencing).

Only photographs containing birds need to be chosen for analysis.

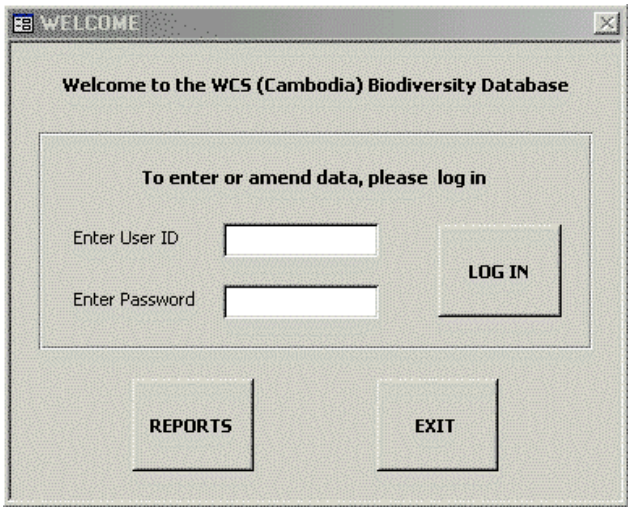
3.4. Analysing the Photographs

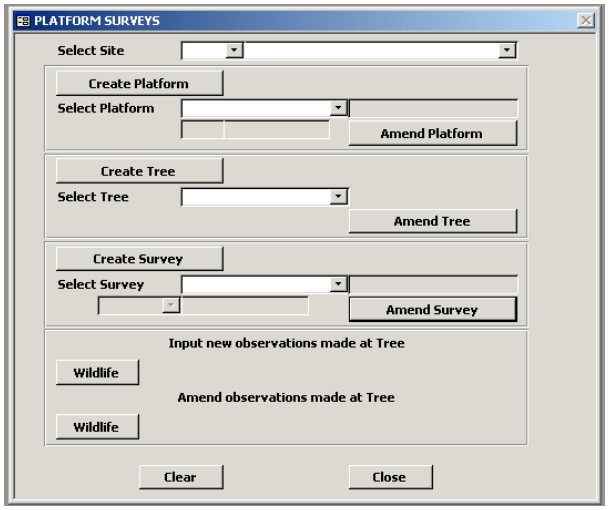
Photographs with evidence of nesting birds are analysed to identify the extent of the colony in that year – i.e. the number of occupied trees. This can be achieved through a visual inspection of the photographs, and matching them with the master tree database obtained from the orthophotos. Alternatively, the photographs can be geo-referenced by a GIS specialist, using the orthophotos as a basemap. The geo-referenced photos can be more easily compared to the master tree list to identify which trees are occupied. The final output by either method is the total number of occupied trees in that year.

4. Data Storage

4.1. Tree Count Data

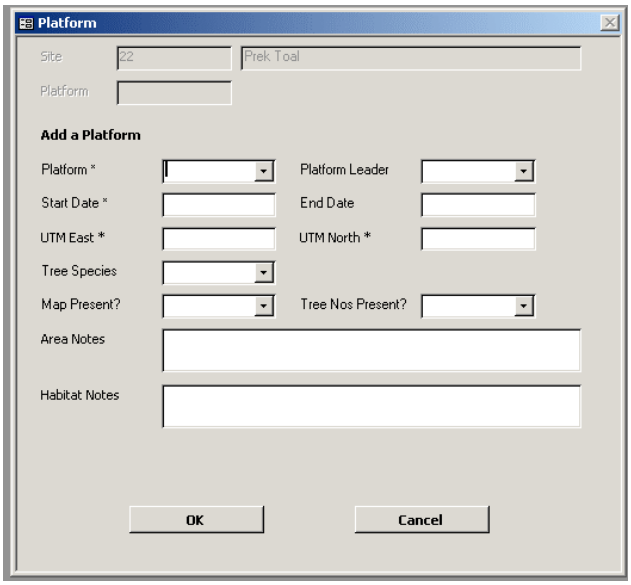
A Microsoft Access database has been designed by WCS to store data on the platform tree counts. It currently contains a complete record of all data from 2001-6 for 'black' colonies and 2003-6 for 'black and white' colonies. These total 2,878 counts, 4,056 trees and 145,425 species records. A reporting facility still needs to be designed for the database.

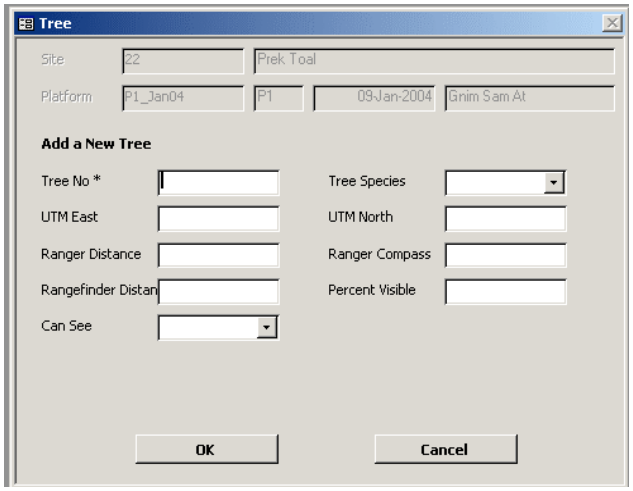




The database has simple on-screen forms for inputting data on the platforms, the nesting trees, counts made from the platforms and the species seen on the trees.

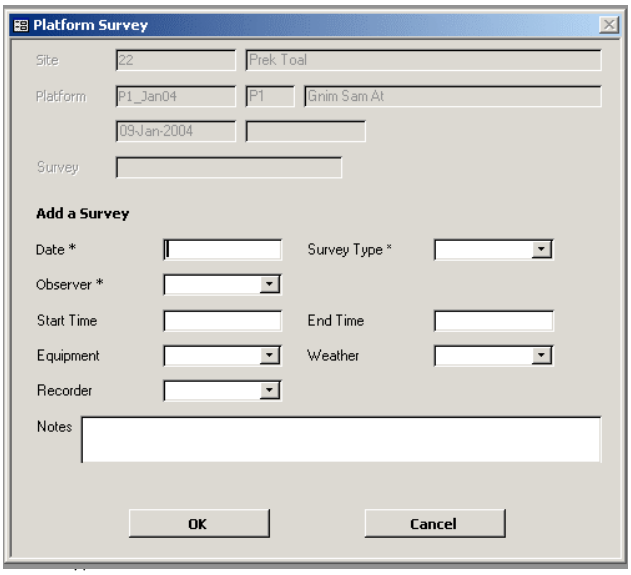
Platform input screen.

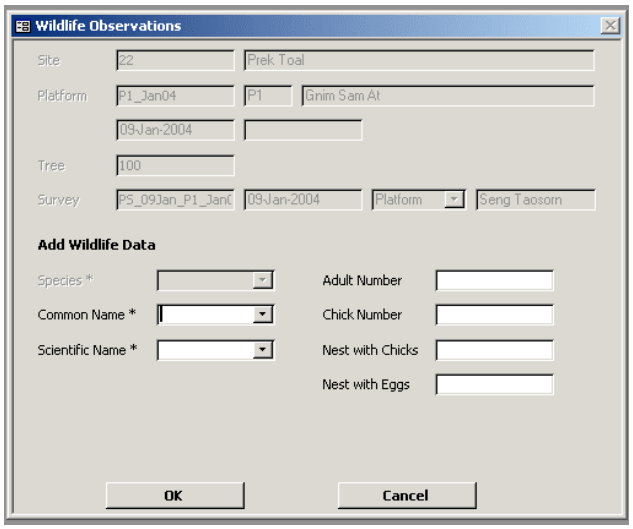




Tree input screen.

Survey/count input screen.





Wildlife observations input screen.

4.2. Photographs

The annual aerial survey photographs, together with the TSEMP orthophotos should be stored on a dedicated external storage disk, which is regularly backed up.

5. Wider Implications

Prek Toal is the focal centre of large waterbird populations in Cambodia, and throughout the region. It should not, however, be viewed in isolation. The species that breed at Prek Toal rely on wet season and early dry season feeding grounds, such as the Tonle Sap Biosphere Reserve (e.g. Boeng Tonle Chmar, Kompong Thom), Ang Trapeang Thmor, the Mekong, Northern Plains and further afield (e.g. in Thailand, Vietnam or Laos). For example, the entire Southeast Asian population of Spot-billed Pelican *Pelecanus philippensis* breeds at Prek Toal, but ranges as far as southern Thailand during the wet season. Monitoring at Prek Toal therefore provides information not only on the success of conservation interventions at the breeding colonies, but also potential impacts on the populations elsewhere. For example a decline in pelican populations at Prek Toal, despite continued breeding success, would be indicative of threats at feeding grounds. Consequently monitoring at Prek Toal represents an efficient method to follow trends in populations of several wide-ranging Globally Threatened species, which would be difficult to monitor anywhere else.

Data from Prek Toal should be combined centrally with results from feeding site counts (both in Cambodia and potentially in other regional countries). Key locations include Boeng Tonle Chmar, the Kompong Thom grasslands, Ang Trapeang Thmor and pelican feeding sites in Thailand. Results from Kompong Thom (in July/August) and Ang Trapeang Thmor (in Nov/Dec) have proved important in understanding seasonal movements of Greater Adjutants, Black-headed Ibises and the pelicans. Ideally future biological research would provide data on movements (e.g. by using satellite tags) to understand the seasonal linkages between the various key wetland habitats.

Appendix 1: Flight Plan

All co-ordinates are given in Longitude/Latitude, using the WGS84 map datum.

Flight Order	Transect Number	Start / End	Longitude	Latitude
1	28	End Transect	103.6741	13.1426
2	28	Start Transect	103.6521	13.1861
3	20	Start Transect	103.6356	13.1781
4	20	End Transect	103.6657	13.1186
5	12	End Transect	103.6551	13.0985
6	12	Start Transect	103.6191	13.1701
7	3	End Transect	103.6004	13.1611
8	3	Start Transect	103.6380	13.0868
9	11	Start Transect	103.6522	13.0988
10	11	End Transect	103.6170	13.1691
11	19	End Transect	103.6335	13.1771
12	19	Start Transect	103.6627	13.1198
13	27	Start Transect	103.6725	13.1407
14	27	End Transect	103.6501	13.1851
15	21	End Transect	103.6377	13.1791
16	21	Start Transect	103.6680	13.1192
17	13	Start Transect	103.6573	13.0991
18	13	End Transect	103.6211	13.1711
19	5	End Transect	103.6046	13.1631
20	5	Start Transect	103.6421	13.0888
21	10	End Transect	103.6500	13.0980
22	10	Start Transect	103.6149	13.1681
23	18	Start Transect	103.6315	13.1761
24	18	End Transect	103.6574	13.1252
25	26	End Transect	103.6703	13.1399
26	26	Start Transect	103.6480	13.1841
27	17	End Transect	103.6294	13.1751
28	17	Start Transect	103.6554	13.1241
29	9	Start Transect	103.6487	13.0963
30	9	End Transect	103.6129	13.1671
31	2	Start Transect	103.5984	13.1601
32	2	End Transect	103.6359	13.0858
33	16	End Transect	103.6532	13.1232
34	16	Start Transect	103.6273	13.1741
35	24	Start Transect	103.6439	13.1821
36	24	End Transect	103.6789	13.1130
37	15	Start Transect	103.6512	13.1221
38	15	End Transect	103.6253	13.1731
39	7	End Transect	103.6087	13.1651
40	7	Start Transect	103.6462	13.0906
41	1	Start Transect	103.6338	13.0848
42	1	End Transect	103.6033	13.1453
43	6	Start Transect	103.6067	13.1641
44	6	End Transect	103.6442	13.0898
45	14	End Transect	103.6607	13.0978
46	14	Start Transect	103.6232	13.1721
47	25	End Transect	103.6459	13.1831
48	25	Start Transect	103.6683	13.1389

49	22	End Transect	103.6702	13.1199
50	22	Start Transect	103.6397	13.1801
51	8	Start Transect	103.6108	13.1661
52	8	End Transect	103.6462	13.0958
53	4	End Transect	103.6400	13.0878
54	4	Start Transect	103.6025	13.1621
55	23	End Transect	103.6418	13.1811
56	23	Start Transect	103.6758	13.1140

Appendix 2: PixPoint File Format

The PixPoint GPS-tracklog import file format is -

[longitude in 7 decimal places],[latitude in 7 decimals],[universal time in 7 decimals],[0.0],[-1.0],[-1.0](these last three are altitude, azimuth, etc... but they do not appear to be important so default values can be used),[space][date in format dd-mmm-yy][space][universal time in format hh:mm:ss][space][UTC]

e.g. -

103.7460000,13.0502000,38455.0875810,0.0,-1.0,-1.0, 13-Apr-05 02:06:07 UTC

Each number must be exactly the right length (i.e. numbers have the required number of decimal places), the commas must be in the correct places, and there needs to be no spaces except before dd-mmm-yy, hh:mm:ss and UTC.

The file can be made in Microsoft Excel, with each number in a different column. The text concatenate command (CONCATENATE) can be used to make the [space][date in format dd-mmm-yy][space][universal time in format hh:mm:ss][space][UTC] part. The file then needs to be saved in a tab-delimited format, opened in Microsoft Word, and the REPLACE ALL menu option used to change all tab characters to commas.

Appendix 3. Daily Tree Count Datasheet

Date: ថ្ងៃទី.....ខែ.....ឆ្នាំ.....

Time start & end: ចាប់ផ្តើមរាប់ម៉ោង.....ដល់.....

Observers: **ឈ្មោះអ្នកសង្កេត**.....

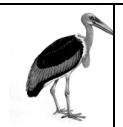
Recorders: ឈ្មោះអ្នកកត់ត្រា:.....

Weather:អាកាសធាតុ: ល្អ អាប់ ភ្លៀង

Equipment: ឧបករណ៍: តេឡេស្កុប សីម៉ែល ភ្នែកទទេ

GPS recording: លេខទីតាំងជីភីអេស.....

Survey type: ទាប់ឆើះ រាន ទូក

លេខដើមឈើ	ឈ្មោះដើមឈើ	ចំងាយទិសដៅ	ផ្ការ?										វាយតំលៃការមើលឃើញ	សត្វងាប់ (ប្រភេទ/ចំនួន)	**ផ្សេងៗ**
សរុប															

Appendix 4. Tree Marking Datasheet

តារាងរាយនាមលេខដើមឈើ

បន្ទាយរានធី ថ្ងៃ ខែ ឆ្នាំ ២០០

ឈ្មោះក្រុមស្មៀវជ្រាវ:

លេខដើមឈើ Tree number	លេខសំណរ Lead number	ឈ្មោះដើមឈើ Tree species	លេខរៀង GPS Number	លេខទីតាំង GPS Location		ដាក់ផ្លាក Metal	ដាក់សំណ Lead	ផ្សេងៗ Comment / Note
				លេខទីតាំងខាងកើត UTM **E**	លេខទីតាំងខាងជើង UTM **N**			

Appendix 5. Weekly Summary Datasheet

Colony Name: **ឈ្មោះបន្ទាយសត្វ (រៀនទី.....)** Period: **អំឡុងពេល.....**

(ចាប់ពីថ្ងៃទី.....ដល់.....ខែ.....ឆ្នាំ.....)

Site: **ទីតាំង** ..... Observer: **ឈ្មោះអ្នកអង្កេត**

.....

Write the daily total for each species likes this: Adults/Chicks (nests) **សរសេរចំនួនសរុបរាល់ថ្ងៃនៃប្រភេទសត្វនីមួយៗដូចជា: មេ/កូន(សំបុក)**

ថ្ងៃខែឆ្នាំ Date	ម៉ោង Time	ជំនួនដើមឈើ No.trees	ចំងាយទិសដៅ Direction Distance											ផ្សេងៗ

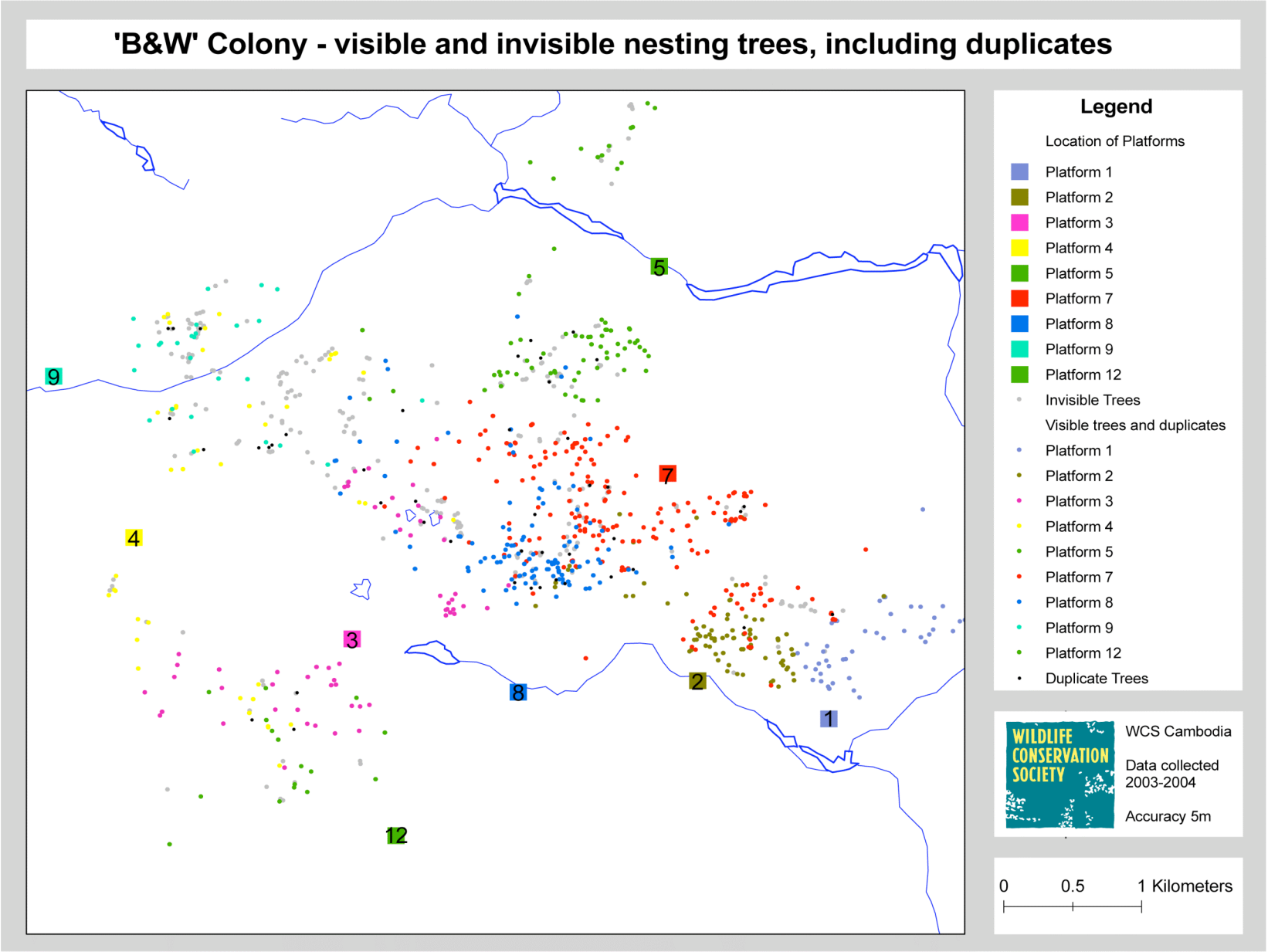
1- [illegible] **Draw Colony Shape Here :**

2- [illegible] **Summary Report of Boat Traffic**

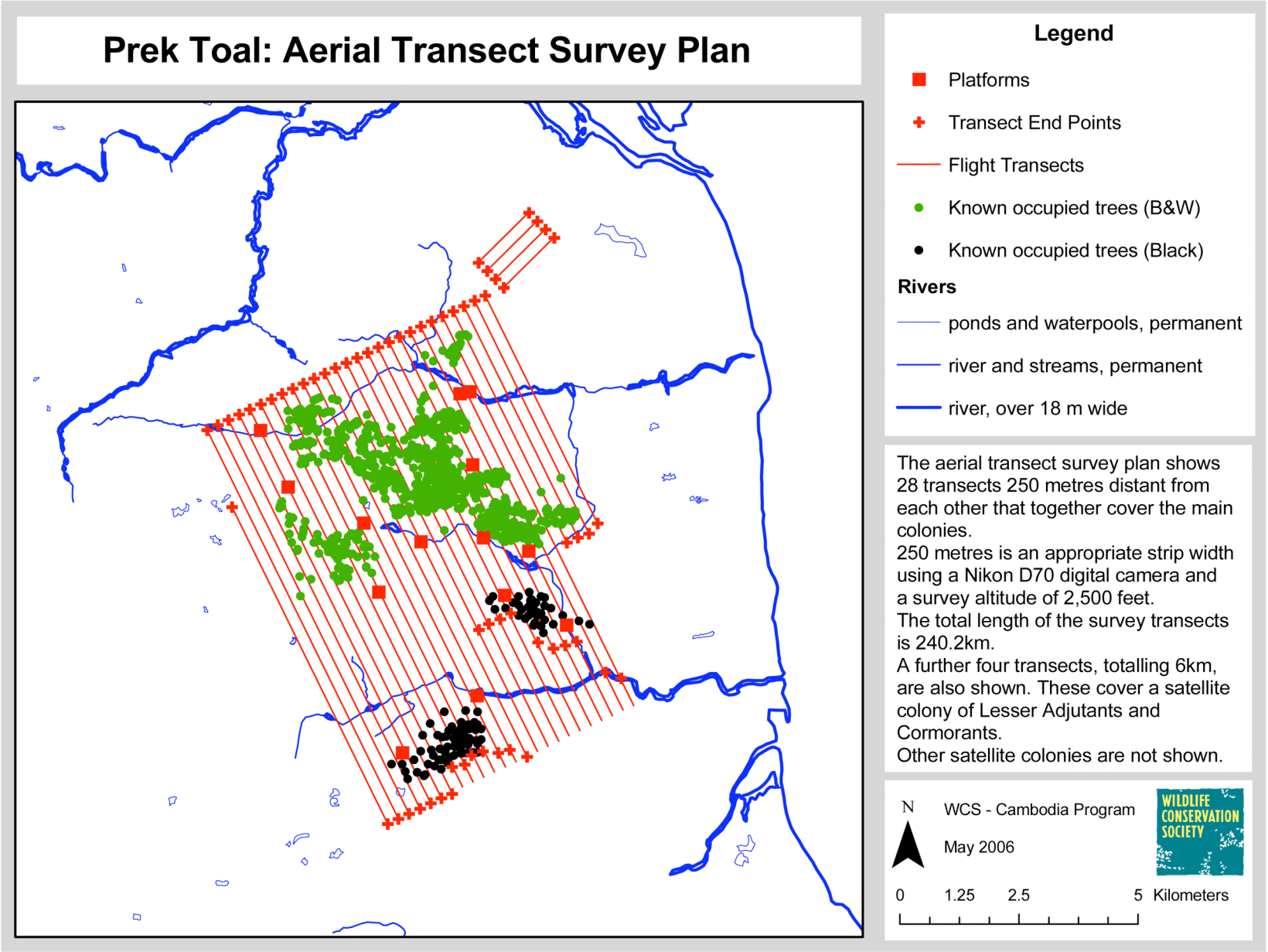
3- [illegible] **Summary Report Of Activities And Result Of Patrol**

4- [illegible] **Summary Report Of Important Wildlife Observation**

Map 1: Tree Marking and mapping: Visible and Invisible trees at Prek Toal



Map 2: Flight Plan for Prek Toal Aerial Transect Surveys



CHAPTER 2:

GUIDELINES FOR MONITORING AND EVALUATING THE WATER SNAKE TRADE FROM TONLE SAP GREAT LAKE, CAMBODIA

Sharon Brooks, WCS Cambodia and University of East Anglia

Background and Previous Research

The exploitation of water snakes at Tonle Sap Lake represents the world's largest snake hunting operation with estimates of over four million snakes being collected per annum. Six species of Homalopsine water snake and two terrestrial colubrids are regularly caught by fishers as well as the periodic capture of up to six additional species. Field research into the sustainability of this activity was initiated in June 2004 and has been ongoing ever since. Although snakes have been accidentally caught in fishing nets for decades, targeted hunting began 10-15 years ago in response to the booming crocodile industry to where the snakes are sold as a source of protein. In more recent years massive declines in snake catch sizes have been reported as well as declines in overall trade in snakes indicating that this activity is unsustainable.

Previous research has provided much needed information on the biology and ecology of the exploited species allowing us to indicate their varying vulnerabilities. While it appears that the populations of all species may be in decline, disproportionate declines have been reported for two water snake species (*Enhydris Bocourti* and *Homalopsis buccata*) that are additionally targeted once they reach a large body size, for their skins and meat.

Previous research has provided us with an understanding of how these activities are operating around the lake. While snake hunting is widespread, intensive targeted hunting which yields the high quantities of snakes observed is occurring in more localised areas. Nonetheless the number of households engaging in this activity for a source of income has been increasing dramatically, as a result of declining fish catches. It is a demand driven activity and therefore our understanding of the markets is crucial to predict how it will continue in the future. While the principal market is the crocodile farm industry, human consumption of snakes in on the increase and it is not unlikely that other markets for these snakes will open up if the demand from crocodile farms continues to crash.

The pythons (*Python molurus* and *Python reticulatus*) and the cobras (predominantly *Naja kaouthia*) are also heavily exploited for their skins, meat and blood, and massive declines in these species have also been reported. While the situation with the cobras and pythons also needs to be addressed, it will require a different strategy to that outlined in this report and it is suggested that these species are not included in the long-term monitoring of species on the Tonle Sap. It is widely accepted that it is illegal to hunt and trade these snakes and it is therefore done so secretly. Enquiring about these particular snakes can, in some circumstances, cause the hunters and traders to become wary and uncooperative. It is therefore advisable that these large valuable snakes are not a predominant feature of this monitoring program.

Aim

While the conservation of water snakes ultimately lies in issues of governance, market dynamics and the existence of alternative livelihood options for people living on the lake, monitoring the impact of exploitation is necessary to inform decision makers on the impact of exploitation as well as to assess the effectiveness of any intervention made. The aim of this monitoring and evaluation program is to track the changes in both the supply (productivity of the snake populations) and demand (available markets) for this resource. Particularly in light of a current market

change, the Cambodian crocodile market crash, it is important to monitor the impact that social and economic changes have on snake hunting.

Objectives for BMS monitoring programme 2006-2011

1. To monitor trade volume of water snakes in order to assess changes in the levels of supply and demand.
2. To monitor the species composition of the catch in order to assess the impact of exploitation on all the species separately.
3. To identify major trade routes and changes in the markets for snakes around the lake.
4. To monitor the Catch Per Unit Effort (CPUE) of all exploited water snakes to infer changes in population sizes.

Study Areas

Snakes are traded in varying amounts from almost every area of the lake. As it would be impossible to monitor the entire lake, previous research has highlighted some priority areas where substantial hunting and trade activities are taking place. It is therefore recommended that long term monitoring continues in these areas in much the same manner. However, in terms of implementing effective conservation, efforts should be made to establish the extent of these activities in the core areas of the lake where other conservation efforts are already being made. Therefore the Boeung Tonle Chhmar Core Area is recommended as a site for a pilot visit with possible extension of activities to this area.

METHODOLOGY

1. Trade Volume:

Study sites

While snakes are exported from the lake at many locations, the majority of trade currently goes through Chong Khneas landing site. This is due to large number of crocodile farms in Siem Reap Province. Previous research on trade has therefore focused on this area for monitoring purposes. Continuation of this monitoring would be advisable to gain temporal data on the volume of trade. As this work has been ongoing since June 2004 the capacity is already in place and cooperation of the various intermediary traders which is vital has already been obtained. Other areas where it would be feasible and worthwhile to monitor trade would be Battambong and Kampong Chnang. Some previous work has also been conducted in these areas and the traders here have been found to be cooperative.

Methods

Monitoring ideally takes place over a 24 hour period on a weekly basis throughout the season with regular visits during the non-hunting season. For each boat that arrives, the volume of snakes in kg being sold is recorded. The snakes are divided into two categories according to the way they are sold: 1. Small-bodied snakes of mixed species that are sold at a low price for local trade; 2. Large-bodied, valuable snakes of up to four species that are sold dead for skins and alive for export. Conversion factors based on repeated counts of known weights of snakes are used to convert weight into number of snakes for both categories of landed snakes. For each landing, the origin of the catch and the price they are sold for is also recorded.

In Kampong Chhnang port it has been possible to collect trade data directly from the traders who write down the quantities they trade, with prices and origin, on a daily basis. For this they receive a small fee. The main reason this has been feasible in this area is due to the cooperation of all of the primary traders, of which there are only two. This has not been possible so far in all areas. This is by far a more cost effective way of obtaining trade data and should be adopted where possible. However, setting this up in many locations will require a lot of coordination effort in order to deliver sufficient supervision.

Analyses

Each day (24 hour monitoring period) is to be treated as a sample day within a month and is assumed to be representative of that week. For each sample day the total quantity of snakes, both in number and in weight, can be calculated and then for each month the mean number of snakes traded per day can be calculated. This can then be used to estimate the total quantity of snakes traded each month. For data collected from traders, assuming data has been obtained from all primary traders (those buying from the boats at landing sites) absolute daily, monthly and yearly amounts in kg can be calculated. Conversion factors can be used to convert weight to number and number to weight depending on what data are available. It is possible that the average weights of snakes will decline as a result of exploitation and therefore these conversion factors need to be constantly reviewed based on data collected in method 2.

Within each month the average quantity of snakes arriving from each location can be calculated in order to determine temporal trends in the areas of the lake that are supplying the snakes throughout the season and across years.

Price of snakes can also be plotted over time by using a mean price per day for both small bodied snakes used for crocodile food and those sold for their skins. This can be used to show temporal trends in price providing insight into the market dynamics for this resource and the economic incentives for exploitation.

Training required

In the field: The capacity to carry out this work is already available in Chong Khneas as this work has been ongoing since June 2004. This method is straightforward and does not need to be carried out by people with a high education level, provided sufficient supervision is available. The cooperation of traders in a few areas, including Chong Khneas, Kampong Chnang and Battambong landing sites has already been shown to be possible, and many are able and willing to write down data for a small fee. Each location will however throw up new challenges to obtaining this data and within an area the activity can change considerably seasonally and year to year. Frequent supervision in the field would therefore be necessary.

In the office: A short training session on how to enter, process and analyse the data would be required.

2. Species composition

Study Sites

This method can be carried out jointly with the trade volume methodology at Chong Khneas and other landing sites. Efforts should be made to ensure that this method is regularly carried out at spatially different locations around the lake. Particularly as the species composition of the catch varies considerably from the North to the South, primarily with respect to the abundance of *Enhydris longicauda*, Cambodia's endemic reptile, monitoring species composition at both ends of the lake would be advisable.

Methods

Data on the species composition of the overall catch can be collected by randomly selecting a known weight of snakes from a boat of known origin. The number of snakes of each species can then be counted and the total quantity of each species can be weighed to determine average weights. The key aspect of this method is obtaining a random sample. Efforts need to be made to select a crate or sack of snakes that have not been sorted (i.e. had any species removed). Where possible this should be carried out throughout the season due to the seasonal differences in the abundance of the various species. This method again relies on good cooperation with the traders at landing sites which has shown to be possible by the people currently carrying out this method.

Analyses

The proportion of each species in the catch can be calculated from the proportion of each species in the sample. Mean values can be calculated for each month and these can be plotted overtime to provide a time series of the relative proportions of each species in the catch. Species composition can also be separated according to the origin of the catch to infer spatial differences. We currently have two years of species composition data and therefore continuation of this method will allow us to assess how the abundance of the various species in the catch is changing year to year.

While more accurate species composition data will be obtained through method IV (See below), this method will provide species composition over a larger area. The data on the average weight of each species will be used to assess changes in the sizes of the species being collected. In a system such as this it is expected that average body size will decline in response to exploitation and there is some indication from comparing data collected in 2000 by Bryan Stuart to that collected in 2004 by Sharon Brooks that this has already occurred to some extent.

Training required

In the field: The capacity to carry out this work is already available as this work has been ongoing since June 2004. This method, as with the trade volume methodology, is straightforward and does not need to be carried out by people with a high education level, provided sufficient supervision is available. The cooperation of traders to carry out this work has shown to be possible in areas including Chong Khneas, Battambong and Kampong Chnang landing sites.

In the office: A short training session on how to enter, process and analyse the data would be required.

3. Trade Routes:

Boats are presently transporting snakes to Chong Khneas from as far as Pursat province due to the high demand this end of the lake. However it is possible that this will start to change with changes in the Cambodian crocodile market. While it is possible that the trade will be reduced as a result of declining demand from crocodile farms, it is also likely that trade to other locations will increase in response. It will be important to follow and document what kind of market shifts take place.

While human consumption of snakes is small in comparison to the volume of snakes consumed by crocodiles, it appears to be on the increase. Traders who transport snakes to urban centres, such as Phnom Penh, have reported increases in demand in recent years. These trade routes therefore need to be monitored in order to document further changes and to evaluate the significance of this trade.

Study sites and methods

Frequent visits to major trading sites around Tonle Sap to discuss the trade of snakes with key informants (fishers and intermediary traders and consumers). This requires keeping meticulous field notes to write down all types of information.

Key areas to be visited:

- Prek Toal area – as a major hunting location on the lake it is important to talk to both hunters and snake traders in this area to find out where the snakes are being sold onto. This information can be gathered via the rangers that will be in this area collecting CPUE data (see method IV.)
- Boeng Chhma / Moat Khla area – It is recommended that this area is visited to establish the extent of snake hunting by talking to fishers/hunters and traders in this area. Frequent visits should be made thereafter to monitor change.
- Chong Khneas landing site – as a major trading site it is important to talk to all the various traders and consumers that visit here to gain information on where snakes are being sold onto, and changes in the supply to and demand from this area. This information can also be gathered via those monitoring the trade in this area.

- Battambong and Kampong Chnang landing sites - These should be visited opportunistically to talk to key traders and buyers to establish changes in supply and/or demand for snakes in these areas.
- Kilometre 9, Phnom Penh – there is a small yet possibly increasing amount of snakes being transported to Phnom Penh from Pursat province and possibly other areas as well. The actual extent of this export, that is likely to be for human consumption, is currently unknown. It is also possible that international export onto Vietnam is occurring from Phnom Penh and this needs investigating.

Analyses

Frequent (quarterly / biannual) reports should be produced to outline the results of all conversations and interviews held. It is important to note the source of the information, the date of the conversation / interview and the context in which all information was given.

Training required

No specific training is required for this methodology as it is less structured and more opportunistic than others. The person visiting these areas may need to be provided with a list of questions / themes to be discussed depending on their ability and level of experience.

4. Monitoring changes in population sizes

The water snake trade is demand driven and therefore a change in the volume of trade is not a useful indicator of the productivity of the snake populations. Due to effective communication between all the intermediary traders and the end consumers as a result of an effective mobile phone network, snakes are almost caught to order. Catch per Unit Effort (CPUE) is a more useful index to assess how the various species are responding to exploitation.

It can be assumed that fishers are hunting in optimal areas as access to markets is not a restricting factor due to the availability of a network of mobile traders to transport the snakes. CPUE can therefore be used as a surrogate for population density.

Study sites

The Prek Toal area, both in and around the core area, has been the main study site for this work so far. Continuation of the work in this area is recommended to gain meaningful temporal data. It would however be useful to expand this work to start obtaining catch data in another area of the lake. The Boeng Chhma Core Area would be a potential location if there is sufficient ranger capacity. Some pilot work would be necessary to assess the current level of snake hunting in this area beforehand.

Methods

CPUE can be measured as the number or Kg snakes caught per 1000m^2 gillnet per day. The current method of obtaining this data is by hiring two rangers to locate transaction points out in the flooded forest where the fishers are selling their snakes to traders who then transport them to the village or landing sites to sell. From this location they are able to intercept the fishers before they sell their catch in order to count the snakes and record information regarding their hunting effort.

The information that is necessary to record is as follows:

- GPS location of data collection
- Distance fisher has travelled to this location from hunting area

- Date and time set / last checked & Date and time checked – this is then calculated as the number of hours the net has been in the water.
- Gillnet size – Length, height and mesh size
- If captured by other gear, details about the type and size of gear. E.g. If hook – number of hooks
- Total weight of snakes captured (Kg)
- The number of snakes of each species
- The price of snakes
- Target – what resource (fish/snakes) they were aiming to catch
- Habitat – What type of habitat the gillnet was set in (Grassland, Flooded forest, Edge of channel, open water etc.).

Analyses

While it is useful to have the data on snakes captured using gear types other than gillnets, the gillnet data will yield the quantity of data needed for analyses. Therefore the first step in the analysis is to separate these data.

1. Sort data to produce a worksheet of gillnet only data
2. Calculate area of net used (length x height) for each mesh size and total area of net used.
3. For each species calculate the CPUE - number snakes per 1000m^2 net per day:
   ((number of snakes / area of net used) x1000) / hours net in water) x 24
4. Temporal trends in CPUE can then be plotted to highlight changes in the abundance of the various species. There will be seasonal differences in their abundances which need to be taken into account when interpreting such trends.
5. Additionally CPUE will depend on spatial area and whether they are a targeted catch or a by-catch (which in turn depends on the price). Comparing CPUE based on these variables will aid us in the interpretation of any observed trends.
6. Comparing the CPUE between different habitat types will help us to determine areas that are important snake habitat.

Data on the catch from other gear types can be analysed separately to look for differences in the species composition of the catch and to provide information on the effectiveness of these other gear types in catching the various snake species.

This data will also yield accurate information about the species composition of the catch in this area. It can therefore be used to check the effectiveness of method II that covers a wider area but is more prone to biases. This will involve looking for differences in the species composition data collected at Prek Toal hunting ground with that collected at the landing site based on catches that originated from Prek Toal. Previous research has shown that data taken from hunting grounds features more pythons and cobras than at landing sites due to the secrecy in which these species are traded. As mentioned previously no active efforts are or should be made to obtain data on these species at trading sites as this may compromise the cooperation of traders.

Training required

In the field: There are four rangers that are sufficiently trained in carrying out this methodology in the Prek Toal area. If it is to be expanded to another area of the lake people will need to be trained in how to carry out this methodology by accompanying them in the field for two to three days. Regular (monthly) sessions are required to discuss progress. As this is a constantly changing system depending on the water level and

availability of alternative resources, it is important to understand how the rangers are deciding on which area to go to, to find the hunters. It is also important to document these changes descriptively and it is therefore advised that frequent (quarterly) reports are produced that include a month by month description of the activity.

In the office: A short training session on how to enter, process and analyse the data would be required.

Final Remarks

Monitoring the snake trade from Tonle Sap is the first step in conserving these snake species. As a low value protein source that is exploited largely to supply an industry that is currently undergoing an economic crash, it is possible that intervention will not be required. However, given the skill that has evolved in catching large quantities of snakes and the continuing decline in other exploitable resources and livelihood options, this should not be assumed. It is crucial to continue to monitor this activity to document the response to this market change. Due to the unpredictable nature of this system, in terms of markets, snake population dynamics and government intervention, ongoing efforts need to be under constant review in order to build in these changes. It would therefore be necessary to adopt a review system where updates on all aspects of the hunting and trade activities are provided, allowing the methods being carried out to be assessed, ensuring that this work progresses in the most effective way

Focusing on the core areas for monitoring purposes is seen as a way of integrating the conservation of snakes into other conservation efforts allowing it to take on a more ecosystem-based approach. If conservation intervention is deemed necessary there are many ways that it could be carried out and at various scales. As it is unlikely that conservation efforts could reach across the entire lake it is important to establish key areas for conservation. Snake hunting is extensive within the Prek Toal area, and it is therefore highly recommended that this would be a key site for water snake conservation. Currently a lot of hunting occurs outside the boundaries of the core area in grassland habitat (Veal trasok and Veal veng). These areas are undoubtedly important habitat for snakes as well as other forms of wildlife and have shown to be important feeding grounds for large water birds. Their inclusion into conservation management in the area should therefore be considered. As mentioned earlier, extension of activities to other core areas is advisable to evaluate their potential as additional sites for water snake conservation.

CHAPTER 3:

MONITORING MOVEMENTS OF RELEASED SIAMESE CROCODILES (*CROCODYLUS SIAMENSIS)* IN THE TONLE SAP BIOSHERE RESERVE USING A VHF TRANSMITTER TRACKING SYSTEM

John Thorbjarnarson, Mark Perry, Heng Sovannara

Project Partners

Fisheries Administration (FiA), Ministry of Agriculture, Forest and Fisheries (MAFF)
Ministry of Environment (MoE)
Department of Wildlife and Ecology, University of Florida, USA
Wildlife Conservation Society, Cambodia Program

Background

The critically endangered Siamese crocodile (*C. siamensis*) formerly ranged across much of South East Asia and Indonesia. Hunting pressure and conversion of wetland habitat led to the extinction of the species across much of its historical range. Cambodia now supports the largest extant populations of *C. siamensis*, with significant areas of apparently suitable habitat remaining. The existence of crocodiles has been repeatedly confirmed yet virtually nothing is known of the population demographics, distribution, and ecology in the Tonle Sap Great Lake system. Siamese crocodiles continue to be sporadically reported across a wide distribution of the Tonle Sap Biosphere Reserve (TSBR), however, low population density, cryptic and elusive behavior and difficulty in accessing the expansive habitat complicate detailed study. Baseline data in all areas of *C. siamensis* biology is required now to assess the feasibility of meeting species recovery, management, and possibly reintroduction goals.

Two wild male Siamese crocodiles were captured by fishermen in Fishing Lot 1 in Pursat province as well as two more from

Moat Klah in Kampong Thom province in 2005 and an other 12 hatchlings in Prek Da fishing lot 2, Batambang province in September2006. These were all confiscated by FiA and kept for later release. TSBR in 2005 and taken to Pursat Provincial Department of Fisheries for later release. They have since been held in a floating pen with approximately 20 other similarly sized crocodiles at Prek Aliehs, Battambang located within Fishing Lot 1. September 5th 2006, both crocs were fitted with VHF radio transmitters attached to the osteoderms of the nuchal shield. These animals will be released in the Prek Toal core area on 1st November 2006 and movements intensively tracked by the Prek Toal Wildlife Conservation Team for an intended period of at least one year. The release and subsequent radio tracking of these animals presents a rare opportunity to study the habitat preferences and ranging behavior of reintroduced specimens in the TSBR. Successful data collection will provide information which will be applied to future management decisions regarding reintroduction and monitoring of *C. siamensis* within the TSBR.

Objectives

1) Monitor post release movements of two wild caught Siamese crocodiles for a period of one year.
2) Collect critically needed information on the ecology, ranging behavior, and habitat preferences of Siamese crocodiles.
3) Assess initial success of reintroducing individual crocodiles to the TSBR.
4) Develop personnel's capacity in radio telemetry techniques and assess the feasibility of expanding telemetry use in the TSBR to wild nesting females.

5) Make findings available to government agencies, conservation NGO's, researchers, and policy decision makers through technical reports and

Study Area

Release will occur in a location to be determined within the Prek Toal Core Area. This location was chosen as the area provides the best ability to protect the crocs and is believed to still contain small breeding populations of wild crocodiles. Prek Toal is also adjacent to the border of Fishing Lot 1 where the animals were initially captured. It is hoped that the released animals will remain within the core area but actual study location will be determined by crocodiles movements throughout the system.

Monitoring Team Training

Three members of the Prek Toal Wildlife Conservation Team received extensive telemetry training over a two-week period in September 2006 and will in turn train other Team members. Training was conducted by an experienced University of Florida researcher and included function of the receiver, antenna, and transmitters with emphasis on signal triangulation and problem solving techniques. Test transmitters were hidden in various "habitats" and the trainees repeatedly tested on their ability to accurately locate the transmitter. Continued practice before releasing the animals followed by training other Team members will increase confidence and accuracy.

Methods/Materials

VHF Tracking System

Wildlife Materials Inc. VHF receiver model # TRX 1000S with a frequency range of 166.000-166.999 kHz was manufactured July 2006. Two antennas will be used, one Yagi 3-element and one Yagi 5-element. Both antennas are folding models, the three element was chosen for ease of use and the five element as a back up with a 30-40% stronger signal magnification.

VHF Attachment

Crocodiles were captured, jaws secured with electrical tape, then removed from the holding enclosure. Biometric data was recorded, scutes clipped for future identification and a visual health inspection conducted (Appendix I). The crocs were then secured to a wooden board with ratchet straps that were placed across the head, midsection and base of the tail. The eyes were covered with duct tape to reduce stress. Baytril enrofloxacin (broad spectrum antibiotic) was administered intramuscularly (injected in the jowl) at 1cc/4.55kg of body mass, protecting the animal against infection for 36 hours.

The VHF transmitters were attached to the four osteoderms of the nuchal shields using 16 gauge sterilized stainless steel surgical wire and marine epoxy adhesive (West Marine model 3761483). Prior to surgery, the nuchal area was scrubbed with 91% isopropyl alcohol, followed with betadine solution then rinsed with saline solution. Multiple subcutaneous injections of a local anesthetic (lidocaine hydrochloride) totaling 3cc/animal were then administered just beneath the nuchal scutes (needle .7mm by 19mm) and allowed five minutes to take effect.

Each transmitter was placed in position and four outer attachment points (wire entry points) marked on the base of the scutes using a permanent marker. The transmitter set aside and a caliper used to align and mark four corresponding exit points to insure correct alignment from one side to the other. (It is

imperative that the holes on each pair of scutes are aligned exactly to avoid having to insert the PVC piping and wires on angles).

A 12 volt battery powered drill and 1/16" titanium bit sterilized by alcohol and fire was used to drill pilot holes through the base on the outside of each of the four scutes (through the entry/exit points marked previously). Each hole was then enlarged using a 1/8" titanium drill bit. Saline solution was poured into the holes during drilling in order to reduce friction and heat. Holes were then flushed with lidocaine to insure no discomfort to the crocodile.

Two separate lengths of 1/8" OD PVC piping were threaded through the aligning holes of each pair of adjacent scutes (one section through both anterior scutes and one through both posterior scutes) and left in-situ before inserting 48cm lengths of sterilized stainless steel surgical wire through the PVC. The PVC piping increases the functional diameter of the attachment wire to reduce the possibility of tearing through the scutes and compromising the attachment. PVC's resistance to algal and bacterial growth is also advantageous.

The transmitter was roughened with course sand paper (60 grit) and cleaned with alcohol to aide bonding with the epoxy, then placed in position. The surgical wires tag ends were run through the holes in the base of the transmitter, crossed back over the top of the transmitter, and twisted together to hold it in place before trimming the excess wire from the ends. Marine epoxy was hand mixed and built up over the surgical wire and base of transmitter, then smoothed out to decrease hydrodynamic drag and reduce the chance of the transmitter catching on snags and other objects post release. Epoxy was spray painted black while tacky and allowed to cure for ten minutes before returning the crocodile to the holding pen. The paint reduces visibility of transmitter by both prey and predators.

The complete procedures from capture to release took 52 minutes and 60 minutes respectively. Both animals appeared to recover quickly from the stress and exhibited normal behavior within minutes of return to the holding enclosure. A follow up visit was performed one week later and animals exhibited no apparent adverse affects from the procedure.

Monitoring Protocol

Obtaining Telemetry Locations

Each triangulated crocodile location coordinate will be calculated from two distinct bearings (minimum) obtained from separate locations varied by at least 60 degrees and no more than 120 degrees apart. If habitat barriers prevent obtaining bearings of at least 60 degrees variance, at least three bearings should be recorded and animals location should be considered as having a high margin of error. Triangulated crocodile locations will be plotted daily on paper charts and data entered into the Locate III database as frequently as possible.

Visual confirmation of the crocodiles locations will be periodically obtained. This will be done by first obtaining and recording a triangulated location, then approaching the VHF signal closely after dark and searching for the animal with a spotlight. Should the croc remain submerged or retreat into cover, a strong surrounding signal will serve as location confirmation. The animal will be disturbed as little as possible during these confirmation events, close proximity GPS location recorded, and detailed notes of the surrounding habitat characteristics made. These locations will be plotted against triangulated

locations to develop an index of the monitoring team's triangulation location accuracy and calculate standard error. Should a pattern of sudden crocodile movements become evident as a result of these close approaches, the need for and methods of approach will be reevaluated and revised by the researchers. The need/benefit of exact location confirmation will be evaluated and revised throughout the study period.

Telemetry Schedule

It is impractical to construct an exact telemetry schedule at the onset of this study. Generally, tracking will be intense at the beginning and nearing the end of the study period with variable intensity in the midterm. Telemetry efforts will begin intensively as the team builds experience, confidence, and proficiency at obtaining locations. Intensity of tracking efforts will be adjusted as needed to best meet research objectives as the study progresses. Intensive tracking will resume as the transmitters batteries begin to reach the end of their service life, this to facilitate ease of recapture for removal or replacement of transmitters.

Monthly scheduled location attempts are to be viewed as a *plan* of action, they shall remain fluid and be adapted as deemed necessary to best facilitate data collection and maintain contact with tracked crocodiles. Intensity of tracking effort required can best be judged by periodic (monthly) meetings to quantify frequency/magnitude of subject movement, search effort required to obtain locations, current habitat characteristics, and problems encountered by the team. Decisions regarding changes to the protocol can then be made. Researchers in the field may occasionally need to take immediate action in case of sudden long distance movement, encountering difficult habitat conditions, or experiencing equipment problems.

Month one, post release, will be a critical period to the success of the study. Monitoring teams will attempt transmitter locations twice per day. Tracking will begin early morning and if successful locations are made, second locations will be obtained as close as practical to sunset (or after dark if necessary). Movements of the greatest magnitude are expected between sunset and sunrise so it is imperative to obtain radio contact before and after these periods. Once per week during, confirmation of the crocodiles exact locations will be obtained as described (see "Obtaining Telemetry Locations" above).

Subsequent months will involve reduced telemetry efforts as determined through analysis of the success and difficulties encountered by the researchers, and frequency/magnitude of study subject movements. The importance of constant flexibility in tracking efforts must be foremost in deciding on tracking schedules and methods. Crocodile movement patterns will be expected to vary during certain periods such as seasonal hydrologic changes and the onset of breeding behavior. Thus it is felt that when water levels are high and the floodplain is flooded and crocodiles can disperse over large areas it is needed to monitor the movement of the crocodiles frequently (twice a day), but when the water levels drop, the floodplains become dry except for scattered ponds, which are the likely dry season habitat for crocodiles, monitoring need not be done so intensively once it has become clear that they have settled down in a certain area. Ideally, most months will require locations of each transmitter equipped crocodile as little as twice per week.

If telemetry locations are not successful, search efforts will be concentrated on that animal until located. Search efforts

will span out in a systematic pattern from the animals last known location after confirming the receiver and antenna are functioning properly. All available resources will be used to locate the transmitter signal including boat, automobile, and foot searches as necessary. If the signal can not be re-established, attempts will be made to positively confirm the crocodile's presence at its last known location via nighttime spotlight searches. If the croc is found and still no signal can be obtained with a properly functioning receiver, the animal should be captured for transmitter removal or replacement.

Data Collection and Storage

Triangulated crocodile locations will be plotted daily on paper charts and data entered into the Locate III database as frequently as possible. Data to be recorded for each triangulated telemetry location will include environmental and habitat characteristics, VHF signal bearings, researcher observations, etc (Appendix II). Location data will be recorded on data sheets or field books which will be copied daily or as often as practical. These copies will be stored in a separate secure location from field books/data sheets.

GPS tracking features will be used to create a record of search location routes during field activities, saved on the GPS, then downloaded as soon as practical. These tracks will be saved according to date; copies will be placed on CD as a backup in case of computer failure.

All data records will be maintained by WCS Cambodia Program offices under the supervision of Heng Sovannara, Project Manager.

Appendix I: Crocodile Biometric and Transmitter Data

Crocodile Scute Clip #101 WCS

- Single Scutes (S): 0,1
- Double Right Scutes (DR): 1,7
- Double Left Scutes (DL): 0,0

- Head Length (HL): 23.8cm
- Snout Vent Length (SVL)*: 85.7cm
- Total Length (TL): 158.5cm
- Tail Girth (TG) **: 36.2cm
- Mass: 14,000g
- Sex: Male

- Wildlife Materials Inc. Transmitter #: HLPM2410
- Manufacture Date: June 2006
- Estimated Battery Life: 425 days
- VHF Frequency: 166.255 kHz
- Mass of final assembly`(transmitter, epoxy, and wire): 176g
- Percent mass (final assembly/crocodile body mass): 1.26%

Crocodile Scute Clip #102 WCS

- Single Scutes (S):
- Double Right Scutes (DR):
- Double Left Scutes (DL):

- Head Length (HL): 28.4cm
- Snout Vent Length (SVL)*: 105.4cm
- Total Length (TL): 201.0cm
- Tail Girth (TG) **: 43.9cm
- Mass: 28,000g
- Sex: Male

- Wildlife Materials Inc. Transmitter #: HLPM2410
- Manufacture Date: June 2006
- Estimated Battery Life: 425 days
- VHF Frequency: 166.196 kHz
- Mass of final assembly (transmitter, epoxy, and wire): 170g
- Percent mass (final assembly/crocodile body mass): 0.61%

***** *measured to the rear of the vent*
*** measured at one whorl behind rear of vent*

Appendix II: Data Collection

Data to be recorded for each triangulated telemetry location include:

- Names of researchers
- Transmitter frequency
- Note any shift in frequency
- Crocodile scute clip number
- Date
- Time
- Cloud cover %
- Air temperature
- Water temperature
- General location
- GPS locations from which bearings are obtained (WGS84-UTM)
- Compass bearing of strongest signal
- Gain Setting on receiver
- Volume setting on receiver
- Notes including habitat type, difficulties encountered, etc.

Additional data to be recorded when crocs specific location is observed include:

- GPS location of animal (WGS84-UTM)
- Crocs position (e.g.- on land, in water, under rookery, dense vegetation, etc.)
- Crocs activity (e.g.- basking, feeding, moving)
- Crocs reaction to observer (submersion, indifferent, etc.)
- Habitat description (including dominant vegetation type/density, water depth, hydrologic characteristics, etc.)
- Any additional notes the observer believes to be relevant

CHAPTER 4:

PROTOCOLS FOR MONITORING BENGAL FLORICAN POPULATIONS AND GRASSLAND HABITAT WITHIN THE TONLE SAP FLOODPLAIN, CAMBODIA

Tom Gray, Hong Chamnan

SUMMARY

The largest global population of Bengal Florican *Houbaropsis bengalensis* occurs on floodplain grasslands surrounding the Tonle Sap. Recent work by WCS / BirdLife has lead to the species' reclassification as IUCN Critically Endangered based on a presumed rapid population decline driven by habitat loss. This makes the species one of the highest priorities for avian conservation in Cambodia. Bengal Florican is an important and useful species for monitoring because:

- It is one of the five Critically Endangered bird species occurring in Cambodia
- Cambodia hold the majority (>>50%) of the worlds population
- Bengal Florican is an obligate grassland specialist; monitoring may therefore detect changes in grassland quality
- Bengal Florican and Tonle Sap grasslands are the target of ongoing conservation, habitat protection and education work
- The lekking behaviour of territorial males makes them obvious and relatively easy to accurately survey

The aims of the Cambodian Bengal Florican monitoring scheme are to:

- Provide long-term monitoring data on Bengal Florican populations and grassland extent
- Allow rapid detection of changes in habitat quality and Florican numbers
- Detect new sites important for Bengal Florican and assess their conservation value
- Input into the management and location of Integrated Farming and Biodiversity Areas (IFBAs) designed to protect Florican habitat
- Assess the success of IFBAs in maintaining Florican numbers and habitat quality
- Give WCS, and other conservation organisations, a presence within Tonle Sap grasslands
- Provide information on the distribution of other important bird species (including large waterbirds from the Tonle Sap colonies; raptors; Manchurian Reed Warbler *Acrocephalus tangorum*)
- Assess nesting success
- Understand Bengal Florican non-breeding distribution, biology and threats

Florican monitoring in the Tonle Sap consists of four aspects:

- Long-term monitoring at key sites to detect and assess trends in Florican numbers
- Rapid surveys of additional grassland to detect new Florican populations
- Habitat assessment
- Nest monitoring and protection
- Surveys of non-breeding season habitat

BENGAL FLORICAN AND TONLE SAP GRASSLANDS

Global distribution and status

The grasslands of the Tonle Sap represent one the last areas of seasonally inundated alluvial grasslands in south and south-east Asia. The grasslands are of exceptional importance for bird conservation supporting at least ten Globally Threatened species (Table 1), including the world's largest breeding population of Bengal Florican (IUCN-Endangered), White-shouldered Ibis *Pseudibis davisoni* (IUCN Critical) and the largest known wintering population of Manchurian Reed Warbler (IUCN Vulnerable). In addition the grasslands support internationally important numbers of wintering Palearctic passerines, including substantial populations of Yellow-breasted Bunting *Emberiza aureola* (IUCN Near Threatened), Red Avadavat *Amandava amandava* (IUCN Near Threatened) as well as important concentrations of wintering raptors (including Great Spotted Eagle *Aquila clanga*, Eastern Marsh *Circus spilonotus* and Pied Harriers *Circus melanoleucos*). Due to the combination of Bengal Florican's charismatic lekking display, familiarity to local people, eco-tourism potential and apparent tolerance of a variety of grassland types it is being used as a flagship for promoting conservation of Cambodia's seasonally inundated grasslands. Since 2002 the species has been the focus of ongoing conservation, educational and research work primarily centred on three sites in Kompong Thom province.

Scientific Name	English Name	IUCN Status	TLS grassland status
Pseudibis davisoni	White-shouldered Ibis	Cr	Not-known
Houbaropsis Bengalensis	**Bengal Florican**	**En**	**Breeding**
Leptoptilos dubius	Greater Adjutant	En	Non-breeding from Cambodia
Grus antigone	Sarus Crane	Vu	Non-breeding from Cambodia
Aquila clanga	Great Spotted Eagle	Vu	Non-breeding from Palearctic
Aquila heliaca	Imperial Eagle	Vu	Non-breeding from Palearctic
Pelecanus philippensis	Spot-billed Pelican	Vu	Non-breeding from Cambodia
Mycteria cinerea	Milky Stork	Vu	Non-breeding from Cambodia
Leptoptilos javanicus	Lesser Adjutant	Vu	Non-breeding from Cambodia
Acrocephalus tangorum	**Manchurian Reed Warbler**	**Vu**	**Non-breeding from Palearctic**

Table 1) Globally threatened bird species of Tonle Sap and their global and TLS grassland status; Species in bold >20% of world population present in TLS grasslands

Bengal Florican is a medium-sized, ground-dwelling Bustard which globally occurs on alluvial grasslands in India, Nepal and Cambodia with historical records from Bangladesh and Vietnam. Populations have declined as a result of habitat loss and hunting and, in the Indian subcontinent, the species no longer occurs outside protected areas. The global population is estimated at less than 1500, more than half of which occur on seasonally-flooded grasslands surrounding the Tonle Sap lake, Cambodia (Table 2). Excluding historical records Bengal Florican have been recorded from Kompong Thom, Seam Reap, Battambang, Banteay Meanchey and Takeo provinces (Table 3) with the majority of the population apparently concentrated in nine populations (Table 3).

Location	Approximate population
Assam, India	250 – 380[a]
Other India	< 120[b]
Nepal	32 – 60[c]
Cambodia	800 – 1000[d]

Table 2) Approximate numbers of Bengal Florican per sub-population from latest estimates [a] Choudhrouy 2000 [b] BirdLife 2002 [c] Baral 2003 [d] Preliminary estimate from Gray in prep.

Area	Province	Approximate population
San Kor	Kompong Thom	<150
Puok	Seam Reap	<150
Kouk Preah; Boeung Trea & Kruos Kraom	Kompong Thom	<125
Baray & Chong Doung	Kompong Thom	<110
Stoung Chikreng	Kompong Thom & Seam Reap	<80
Mongkol Borei	Banteay Meanchey	<80
Sangkae	Battambang	<60
Veal Srangai	Kompong Thom	<50
Preah Net Preah	Banteay Meanchey	<140
Other	Various	<120

Table 3) Approximate populations of Bengal Florican in major grassland blocks in Cambodia (2005). Based on preliminary estimates from 2006 wider survey

The extent of Tonle Sap grasslands has declined spectacularly in recent years with estimates of >60% loss since 1997 due to both succession to scrub following agricultural abandonment and recent very rapid (>25% loss per year) expansion of extensive dry season rice and afforestation for exotic plantations. These changes recently resulted in the species proposed up-grade to Critically Endangered based upon a decline of >80% in three generations based on past and future declines. This rapid habitat loss lead to the proposal, and subsequent approval by the Cambodian government, of 310 km^2 of grassland to be managed as a novel class of protected area; Integrated Farming and Biodiversity Areas (IFBA); where large scale habitat conversion would be forbidden but extensive traditional use would be encouraged under co-management arrangements with local villagers. Efficient management of these IFBAs is clearly reliant upon accurate estimates of Florican population and trends.

Bengal Florican ecology in Cambodia

Despite being a grassland specialist Bengal Florican have been recorded on a variety of grassland types within Cambodia with differing soil types, histories of cultivation, flooding regimes and inundation period, grassland species composition, extent of scrub and amount of human disturbance.Floricans move onto the Tonle Sap floodplain grasslands in December-January, and remain there through the course of the dry season, until at least early June, to breed. In common with almost all other bustards, the Bengal Florican is polygamous, and males display in apparent exploded leks (loose aggregations), making no contribution to parental care. In Cambodia breeding coincides with the dry

season when the Tonle Sap flood-water recedes. During breeding males attain a distinctive black and white breeding plumage which enhances their conspicuousness during elaborate displays, quite different from the extremely cryptic female plumage, which is characterised by intricate brown, black, rufous and buff markings. Male Florican displays are highly conspicuous, comprising an undulating flight sequence that covers 20-40m, approximately 6-10m above the ground, and an elaborate ruffling of head, neck and breast feathers whilst on the ground.

Males appear to hold permanent territories (mean core area 0.3km^2) throughout the breeding season with display activity recorded from February to June peaking between late March and early May. At two sites in Kompong Thom (Kruos Kraom & Stoung) male territories are composed primarily of burnt short grassland (mean grass cover <12cm = 71% within 50m radius of n = 55 territories 2005/2006) with reduced cover of tall scrub and tall grass. Elsewhere however Florican have been observed in areas of dense long grass with only small open burnt areas. In good habitat the density of Florican territories approaches 2 km^{-2} but is usually much less (mean Kruos Kraom 0.19 km^{-2}; Stoung 0.48 km^{-2}; Veal Srangai 0.41 km^{-2} across the entire study site grids).

Female ecology

Due to their cryptic and shy nature the ecology of female Bengal Florican is less well known but it is believed they have similar habitat preferences to males (females have been recorded from all site where males are present) though possibly favouring taller, un-burnt grassland swards. All recorded nests have been found in grassland similar to that occupied by males. Clutch size is one or two and incubation period is assumed to be 25-30 days. Young are precocial. Nesting success is unknown but 63% of nests (n=29) have successfully hatched; nest predation by crows (n=1), dogs (n=1) and people (n=5) has been recorded as has nest abandonment due to burning (n=1).

Non-breeding information

Floricans breed chiefly in the lake's inundation zone grasslands during the dry season and disperse across the agricultural belt surrounding the floodplain with the onset of the flood. They spend the wet season in patchy grasslands within open deciduous dipterocarp woodlands fringing the forested hinterland of northern and eastern Cambodia. The greatest distance between breeding and non-breeding season records is 60.2km. Although floricans have not been found elsewhere during the non-breeding season, the possibility that some disperse to patchy grasslands within the deciduous woodland mosaic further from the Tonle Sap floodplain should not be dismissed.

PROTOCOL FOR LONG-TERM BENGAL FLORICAN MONITORING

Introduction & study sites

Since 2002 annual census' of displaying Bengal Florican have been conducted at three sites in Kompong Thom province. This monitoring provides long-term data on Florican population trends and changes in habitat quality and allows population estimates to be made for these sites. Ideally similar monitoring schemes should be initiated at all IFBAs. The three current survey sites span different parts of the Tonle Sap inundation gradient. (1) **Veal Srangai** closest to the lakeshore with the most prolonged inundation, and the most fertile soils. Here grassland occurs in patches isolated by extensive scrub areas. (2) **Kruos Kraom**, adjacent to Veal Srangai but further from the lakeshore, inundated for a shorter period and experiencing a range of land-uses including deepwater rice cultivation and more recently dry season rice developments which have severely reduce the available grassland habitat (3) Extensive grasslands near to **Stoung** town closer to the lakeshore than Kruos Kraom, but receiving inundation of shorter duration and the most impoverished soils.

Sampling strategy

At each study site survey grids, 1km ×1km squares following the Universal Transverse Mercator (UTM) system, have been established and each 1x1km square has a unique ID code. This sampling scale is designed to be relevant to Bengal Florican home range, ecology and the apparent exploded lek matting system. The survey unit is the number of **displaying** male birds per square. Male displays are elaborate and conspicuous and easily detectable making them the most readily recordable index of Florican abundance. Survey work has shown that, following the established protocol, detectability of displaying males is exceptionally high and the chance of false absence (e.g. non-detection of present birds) is extremely low.

Each year a randomly selected sub-set of squares is surveyed (Table 4). Surveys are timed to coincide with the peak period of Florican display (March-April) and have traditionally occurred at similar times of year at the three sites (Table 4). Whilst slightly changing the timing of surveys is unlikely to significantly affect results it is recommended that this be continued (i.e. Kruos Kraom always surveyed prior to Khmer New Year and Stoung immediately after). The recommended minimum number of squares 1x1km squares for survey each year is given (Table 4). This sample size (representing between half and 2/3^{rds} of the study site) is necessary to reduce uncertainty (i.e. minimise Confidence Intervals to acceptable levels) in order to generate meaningful results

		Number of squares surveyed					
Site	Timing of survey	2002	2003	2004	2005	2006	Recmmndd min
Kruos Kraom	3rd - 4th week March	68	95	76	92	0	40
Stoung	3rd - 4th week April	38	56	52	61	52	45
Veal Srangai	4th week March - 1st week April	58	38	38	0	0	30

Table 4) Timing of surveys and number of squares surveyed (2002-2006) for Bengal Florican territory monitoring at three long-term monitoring sites in Kompong Thom province. Note Veal Srangai not surveyed 2005/2006 and Kruos Kraom 2006.

Survey protocol

Each survey square is visited on **two** occasions and surveyed for **one hour** each time during the peak times of display activity (0530-0930 hrs & 1600-1830 hrs). Squares are accessed on foot or by motorbike and observers make there way to the **centre** of the square (previously entered into a GPS) pausing regularly to scan and listen for Floricans. If any male Florican are observed it is recorded and birds are observed (at a sensible distance) until seen to display (either plume-ruff or jumping display). ALL observations of Florican during the one hour survey period are recorded on the observation form (Appendix A) complete with sex, behaviour and an approximate UTM of the male territory centre if appropriate (where male seen to display). The approximate locations of birds should be recorded on the data-sheet sketch map. A key way to detect displaying Florican is by ear. Calls of displaying males are relatively far-carrying and distinctive. It is therefore essential that observers are **familiar with Florican call**, un-experienced observers should be accompanied by an experienced Florican surveyor until they are confident in detecting birds by call. Surveys should not be conducted during rain as this may reduce Florican activity. Any observations of additional important bird species (e.g. large waterbirds; Manchurian Reed Warbler; Eagles) should be recorded on data sheets noting numbers and approximate UTM.

Habitat data

Simultaneously with Florican territory monitoring observers should collect basic habitat data from the same 1x1km squares. This allows rapid and easy assessment of changes in habitat cover with time (e.g. scrub encroachment; agricultural expansion) within IFBAs and is important in assessing Florican population levels. This data is recorded on the same data sheets as Florican observations (Appendix A). At the end of the 1 hour survey period observers must make a rough sketch map of the square marking extent of different habitat types (grassland; scrub; wetland) any agricultural fields (differentiating dry season and deep water rice), dry season rice head-ponds and dams and any tracks or buildings. For each surveyed square observers also estimate the approximate percentage cover (in three categories 0-10%; 10-50%; 50%+) of various broad habitat types within the entire square. These are:

- Short (below knee length) Grass
- Long (above knee length) Grass
- Scrub
- Deep Water Rice
- Dry season rice field
- Dry Season rice head-pond
- Other cultivation (identify it)

In addition to habitat data from specific survey squares (described above) field-teams should also collect general habitat data from **throughout** the study grids. Observers should mark onto a photo copy of a topo-map the approximate location

- main grassland areas
- Dry season rice headponds and fields
- Areas of deep water rice and plough within the IFBA boundaries

This data can be collected during the field visits on route to specific survey squares.

Equipment required for survey

- Motorbike (to access survey squares) – also useful for standing on to gain height for observations
- GPS (with centres of survey squares entered as way-points)
- Binoculars
- Survey form and pen / pencil

Data management

Survey data sheets for each square should be photocopied and returned to WCS Office, Phnom Penh. For each surveyed square the number of displaying Florican should be entered into a database containing this data for each square for each year of the survey. Densities of displaying males should be calculated by dividing the total number of displaying males observed and the number of squares surveyed. The GPS positions of each displaying male should be entered into a separate spreadsheet containing this information for each year. The habitat data should also be entered and each surveyed square classified as 'Grassland' (either >50% cover of long or short grass) 'Dry Season Rice' (>50% Dry season rice field or head-pond), 'Other agriculture' (>50% deep water rice or other agriculture) or 'Scrub' (>50% scrub).

Site specific population estimates can be calculated from densities of Florican in each broad habitat type and the proportion of squares that are this habitat. For comparisons between years and sites this assumes a constant proportion of non-territorial males. Work from marked birds suggests that less than 1/9 males are non-territorial and therefore don't display. Whilst obviously relatively imprecise this simple methodology should give comparable estimates between sites and years and confidence intervals surrounding estimates can be calculated. See below for a worked example based on data from Stoung in 2006 (Table 5).

	Habitat		Florican			
Habitat type	Squares surveyed	Total area [a]	Number	Density[b]	95% CI density[c]	95% CI Male population
Dry Season Rice	6	7	1	0.4	0 - 0.5	0 - 3
Deep water Rice	4	5	0	0	0	0
Grassland	42	49	17	0.5	0.3 - 0.6	13 - 27

Table 5) Example of calculating Florican population size and 95% confidence intervals (CI). From Stoung 2006 survey data.

NOTES [a] Proportion of habitat (i.e. 6/52 for DSR) multiplied by area of study site (61km^2). [b] Number of Florican divided by number of squares surveyed. [c] Calculated from SDEV of density (SDEV / square root of sample size = SEM; SEM * 1.96 = 95% CI). [d] 95% CI density multiplied by total area of habitat type

Therefore we have an overall site estimate of 13 – 30 displaying males which, assuming equal sex ratio gives a population estimate (95% CI) of 26 to 60 birds.

Outputs

Data collected from long-term Florican monitoring within IFBA study sites allows estimation of habitat composition within sites, population estimates (see above) and determination of population trends. Figure 1 show population trends at the three long-term sites from 2002 till 2006. This shows rapid decline at Kruos Kraom, probably driven by habitat loss to both scrub and dry season rice (which can be quantified using this methodology). At Stoung numbers have remained stable throughout this period though whether this is driven by immigration from other sites or represents a sustainable population is unclear. The figure demonstrates the relative ease of using this data to examine long term trends in Florican populations. For example the slight decline at Stoung 2006 could be part of natural variation or indicate the start of a down-ward trend such as that seen at Krous Kraom. This monitoring data is probably the longest running surveys of biodiversity within semi-natural habitat in tropical Asia and **should be continued**. Continued Long-term monitoring at these sites, and at new IFBAs, is also essential to assess the effectiveness of IFBAs in conserving Bengal Florican.

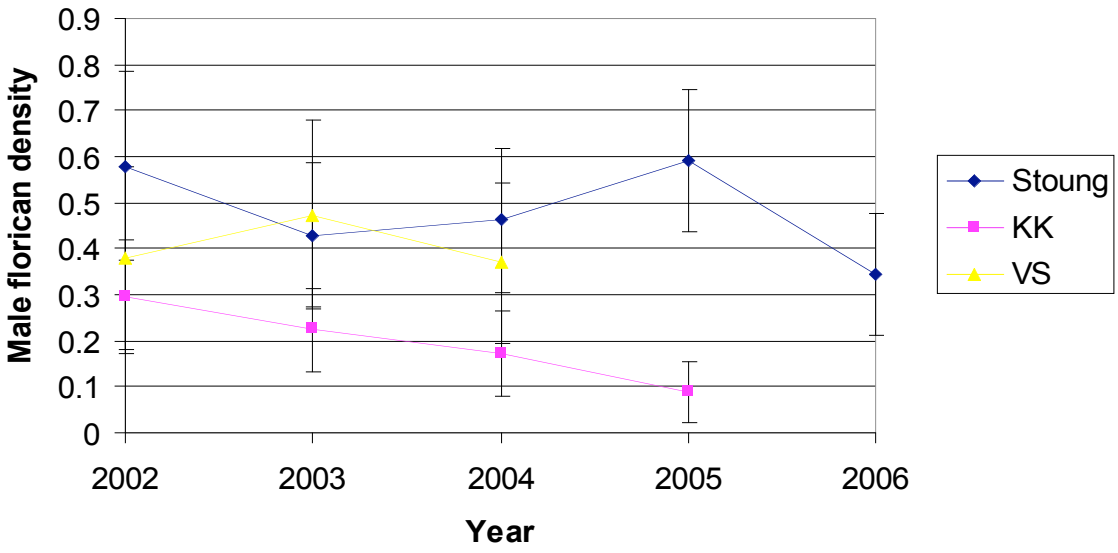


Figure 1) Densities of displaying male Florican at long-term monitoring sites 2002 – 2006. Bars equal 95% confidence intervals of the data;

PROTOCOL FOR RAPID ASSESSMENT OF NEW SITES FOR BENGAL FLORICAN

Introduction

Assessing the distribution and size of populations of Bengal Florican away from the long-term study areas is also an essential component of Florican monitoring. This information can be used to guide expansion of conservation activities by identifying additional sites for inclusion as IFBAs, informing Cambodia-wide estimates of Florican populations, assessing the relative importance of known sites and understanding the wider distribution of grassland and biodiversity within the TLS biosphere.

Traditionally such activities would have involved simple 'motorbike surveys' whereby observers visited a site, drove around and recorded any interesting wildlife observations. However when comparing sites it is important to follow similar sampling methodologies, thereby generating data comparable between sites and useful for scientific analysis. The methodology described below is very similar to that used during the Tonle Sap wider Bengal Florican survey in 2006 and described above under 'Protocol for Long-term Bengal Florican monitoring' and should therefore be familiar to relevant WCS/BirdLife fieldworkers.

Survey Protocol

Areas of interest for survey, identified from a combination of latest land cover classification and consultation with relative stakeholders and WCS experts, should be de-limited on topo-maps A random subset of 1x1km squares within the area should be identified **prior** to the survey. The number of squares selected for survey is likely to be proportional to available resources. It is possible for single observers to survey between 3 and 5 1x1km squares per day. Selected survey squares should be marked upon topo-maps and the centre of the square entered into a GPS. Surveying follows an identical methodology as at long term study sites with the same Florican and habitat data collected. Data is entered onto identical data sheets as used at long-term sites (Appendix A).

During visits to new sites observers should obviously record **all** Florican (and other key bird) sightings, including those away from targeted survey squares, and the approximate boundaries of grassland should be recorded upon a photo-copy of the topo-map. Any dry season rice dams and fields, exotic plantations and other new developments should also be recorded. Ideally GPS tracks of the area visited should be downloaded and a number of digital photographs taken of the site.

Data Management

For each discrete site visited various outputs can be calculated. These include estimation of the area of grassland at each site and approximate density of Bengal Florican. This information can be used to compare sites and generate population estimates therefore guiding conservation activity and decisions. A worked example using data from the 2006 wider survey to compare San Kor (Kompong Thom) and Preah Net Preah (Banteay Meanchey) is provided below.

Area	Squares surveyed	Grass area (km^2) [a]	Florican numbers	Florican density	95% CI density	95% CI Male population
San Kor	24	157	13	0.541667	0.4 - 0.7	64 - 106
Preah Net Preah	16	111	2	0.125	0 - 0.4	0 - 42

Table 6) Example of comparing Florican population size and 95% CI at two study sites based on wider survey data from 2006. [a] Total grassland area from 2005 aerial photographs

This indicates that San Kor held a much larger population than Preah Net Preah. However due to the rapid habitat loss at the former site (a large number of dry season rice dams in development) it was decided not to target further conservation activities here. Also worth noting that due to wider survey methodology (survey areas chosen from JICA) some areas at PNP which were surveyed were not grassland (i.e. had been converted to agriculture between 1997 and 2005). If only including grassland squares (n=4) the population estimate is much higher (mean 60 males 95% CI 0 - 120). This highlights the importance of careful planning of the location of survey squares. The 2005 aerial photos will be invaluable for this.

PROTOCOL FOR NEST MONITORING AND DIRECT PAYMENT SCHEME

Introduction

Early work on Bengal Florican ecology within the seasonally inundated grasslands suggested that poor recruitment could be limiting the population with nest survivorship apparently extremely low. High levels of predation and nest abandonment have been reported for various Bustard species and poor juvenile recruitment is believed to be an underlying cause for population declines in several European species . Understanding this aspect of Bengal Florican ecology is essential particularly in the context of managing sustainable Florican populations within newly created IFBAs.

However the difficulty in finding nests meant data on both nesting success and female habitat requirements for nesting was limited within the Cambodian Bengal Florican population. Between 2000 and 2003, despite intensive conservation and monitoring activity around three core Bengal Florican populations, just nine nests were discovered. Three of these were documented as successfully hatching. At least one nest was destroyed by a pastrolist with the eggs collected for eating (Davidson 2004) and it was suspected that opportunistic nest harvesting was widespread (Hong Chamnan pers com). In order to generate additional data on nesting success, and to lesson the threat of nest harvesting, a direct payment scheme was instigated by WCS in 2004 whereby $20 was paid on the discovery of Bengal Florican nests with an additional $20 paid on successful hatching. This was to encourage people to guard the nests against harvesting and also possible predation by domestic dogs, which was also believed to be high. In 2004 just three nests were reported however in 2005, following more widespread advertisement of the scheme, particularly amongst local pastoralists, and a heavy presence at one field site, 11 nests were discovered and reported to WCS field staff. The aims of the nest monitoring scheme are therefore threefold. 1) To generate data on nest survivorship and female Florican ecology 2) Protect nests from human predation 3) Strengthen relationships and involve local communities in conservation work and give Florican a 'monetary' value to local people. If these aims are successfully met nest monitoring and direct payment could be **the most important aspect** of long-term monitoring activities within grasslands.

Survey Protocol

The most important aspect of the nest monitoring scheme is to establish a clear, unambiguous reporting mechanism between villagers and WCS staff. Ideally every nest discovered within all IFBAs should be included into this scheme. In 2004 just three nests were reported, all from the area south of Kruos Kraom. However in 2005 uptake was considerably greater with eleven nests reported to WCS for monitoring at three sites. The increase in nests reported appears to result from a number of factors

- Increased advertisement amongst potential nest finders. In 2005 fieldworkers made a point of speaking to pastoralists active in areas known to support Florican to explain the scheme
- Heavy WCS presence at site with greatest Florican density (Stoung) Due to the presence of five radio-tracked birds at the site and an increasing Florican population fieldworkers spent a greater proportion of time at this area and had a visible presence

- Improved reporting mechanism In Stoung WCS' activities are well known to a number of high profile people e.g. commune and village leaders who are in regular contact with WCS staff. This has created a clear reporting network for news of nests
- Domino effect Once the first nest finder has been paid, and trust that payments are reliable is established, word is likely to quickly spread about the scheme. It seems likely that this occurred at Stoung in 2005.

However in 2006 only one nest was reported – this was almost certainly because TG was the only presence at the main site for the majority of the breeding season, and communication with local villagers was reduced. It is suggested that a **clearly defined reporting protocol** should be established at all villages within IFBAs. This could involve a designated reporter (possibly paid a small fee) at each village to advertise the scheme and liaise between WCS staff and nest finders.

At all nests the following information should initially be recorded:

- Date nest found
- Number of eggs

Each nest site should then be visited (ideally by the finder) every 2-3 days (**not more regularly**) to check the female is still incubating. At a convenient point during this period the nest should be visited by WCS staff (or possibly local village reporter?) to make sure the nest exists, take a GPS location and pay the initial nest finding fee. The nest finder should be instructed to keep the nest location secret to prevent additional disturbance or nest destruction (which occurred at one monitored nest during 2005) and to collect egg shells if nest hatches or is predated. When the outcome of the nest is known (hatched / predated / abandoned) WCS staff visit the site again, make assessment of whether nest successful and, if necessary, pay the successful nest fee. It is important to note that determining nest success can be difficult (and local villagers are likely to be biased against reporting nest predation) therefore important to carefully examine egg shells for any sign of predation. If possible habitat assessment of the area surrounding a nest should be conducted **after** nest completion. This should follow the same methodology (detailed below) employed at male territory centres in 2005 and 2006. All data should be recorded onto data sheets (see Appendix B for recommended summary sheet for individual nests and Appendix C for recommended season-long nest data sheets).

Habitat variables should be collected from 50-m radius circular plots surrounding nests. Within each plot percentage cover of different height classes of Grass (0-12cm; 12-50cm; >50cm) and Scrub (0-50cm; 50-150cm; >150cm) and the percentage of the plot burnt since the flood recession should be recorded. Relevant WCS staff should be familiar with this technique but new observers should be trained to remove bias. If possible digital photographs of the area surrounding nests should also be taken.

Data management

All nest data should be entered into a WCS database. Locations of nests should be put into GIS projects for each IFBA. The method of data collection (nests visited every 2-3 days) means that Mayfield Nest survivorship estimates can be calculated and compared between sites and years.

PROTOCOL FOR NON-BREEDING SEASON SURVEYS

Introduction

Effective conservation of Bengal Florican relies on understanding distribution, habitat requirements and threats throughout the year. Whilst distribution and male habitat requirements are relatively well known during the breeding season less is understood about the non-breeding biology and seasonal movements of Bengal Florican in Cambodia. Sometime after breeding birds leave Tonle Sap grassland to spend the wet season in scrubby grasslands at the edge of the agricultural / forest zone. Currently non-breeding Bengal Florican records exist for approximately nine areas within Kompong Thom province. By surveying additional potentially suitable sites monitoring should rapidly improve our knowledge of Bengal Florican non-breeding distribution and help identify new important areas within and outside the current IBA network. Land use change, for example development of plantations for cash crop agriculture e.g. Cashew Nuts, could occur rapidly within the area (Ro Borey *pers com.*). Improved information on Bengal Florican wet season distribution is likely to be important to identify areas where such development is likely to severely affect the species.

The aims of non-breeding season surveys are therefore to:

- Determine non-breeding distribution of Bengal Florican
- Identify Bengal Florican broad-scale habitat preferences during non-breeding season
- Improve understanding of threats, particularly land-use change, to non-breeding Bengal Florican populations.

At the moment main aim of this work is to identify distribution and threats as opposed to monitoring as, unlike for displaying males, not enough known of biology at this time of year (timing of movements; inter-annual site fidelity) to be able to confidently assess changes in population at non-breeding sites.

Survey Protocol

Bengal Florican non-breeding distribution and broad habitat preferences are assessed from transect-based presence/absence data collected from randomly located 1.5 km transects within apparently suitable wet season habitat as identified from JICA (or more recent) land cover classification. Previously area for survey have been defined as:

Transects starting from random locations

a) within 5km of previous Florican non-breeding records

OR

b) within same habitat type as classified by JICA land-cover data set

AND

c) within or adjacent to IBA KH017 or IBA KH022

However this methodology can be easily modified and discussion with relevant personnel should be used to identify additional areas for survey.

Each transect is walked by **four observers** 20m apart moving in a perpendicular line at approximately 3kmh^{-1}. This method is likely to flush most Floricans along the transect and has produced up to 1.8 Florican sightings per transect kilometre (Ro Borey 2005). The UTM position and sex of each Florican contact and the distance from the centre of the transect to where the bird was flushed from, should be recorded. In addition any other records of priority bird

species, particularly large waterbirds, should be noted. Each transect is walked twice between either 05:30-09:30 or 14:30-18:30 once between late July and early September and once between mid September and early November. This should capture temporal variation in Florican numbers related to water levels. Care should be taken to ensure the same transect is not walked twice at the extremities of the sampling period, i.e. late July and early November, as this may bias against Florican detection (P Davidson *pers com.*).

Simple data upon habitat factors likely to determine Bengal Florican presence will also be recorded from each transect. At two random points the percentage grass cover in four height bands (0-12cm; 13-50cm; 50-150cm; 150cm+) will be estimated, by observers familiar with this technique. Flood depth will also be recorded at each random point. Along a 250m section of the transect, commencing at a random point, the number of trees (>5m and <5m in height) will be recorded 30m either side of the transect (i.e. the area between the four observers). The presence or absence of small hills, possible important landscape features for Floricans in the non-breeding season, defined as raised areas above the level of the flood within 100m either side of the transect will be recorded. Finally the GPS position of the nearest access road (accessible by Motorbike) will be recorded. All data should be recorded upon data sheets (Appendix D).

Data Management

This methodology will collect simple presence / absence data on Bengal Florican during the non-breeding season. This information is important to assess distribution. Regular visits to non-breeding season sites and discussion with local people should also generate rapid information about land-use change and threats to Florican population during the non-breeding season. It is possible that this can be used to identify areas for inclusion as non-breeding season protected areas. The methodology also leads itself to more intensive scientific analysis (logistic regression of fine-scale habitat preferences; predictive mapping based on land-cover and GIS data sets) which could be conducted as an MSc project.

APPENDICES

Appendix A: Bengal Florican monitoring form for use at Long-term monitoring sites and in the rapid assessment of new sites. Khmer translations of this form exist in the WCS office (Ro Borey has details).

Date	
Observers	

Commune
District
Province

Square UTM	

Time square surveyed	Start	
	Finish	

	Yes	No	UTM	Comments
Florican seen				
Florican display				

Other key bird species present			
	Species	Numbers	UTM

Habitat				Percentage Cover	
	Yes	No	<10	10-50	>50
Has grassland in the square been burnt					
Does the square contain deep water rice					
Does the square contain dry season rice					
Does the square contain other cultivation					

Percentage cover			
	<10	10-50	>50
Short Grass (below Knee)			
Long Grass (above Knee)			
Scrub			

Draw a sketch map of the square marking tracks/dry season rice & any bird records

Appendix B: Recommended lay-out of data sheet for recording individual nest progress (with data from a 2006 nest). Note nest days = number of days from finding nest till nest fate known. For nests which fail between 3 days visits this is recorded as 1.5 nest days.

Nest ID	2006_B
Site	Prohut, Stoung
UTM E	440235
UTM N	1437324

Date	**Eggs**	**Comment**	**WCS Observers**
01/05/2006	1	Nest Found by local villager	
03/05/2006	1	Nest visited by local; female still incubating	
05/05/2006	0; 1 chick	1 chick seen 15m from the nest; female flushed from nearby	TG; MT

Nest Outcome	Success
Overall nest days	5

Details of Money Paid	
10/05/2006	$40 paid by Sen Sienglay

Appendix C: Recommended lay out of season-long nest data sheets (with data from 2006)

Nest ID	UTM_E	UTM_N	Date Found	Finder	Eggs	Nest Fate	Fate Date	Nest days	Direct payment
2006_A	438179	1436633	21/04/2006	WCS	1	Success	05/05/2006	13	No
2006_B	440235	1437324	01/05/2006	Local villager	1	Success	06/05/2006	5	Yes

Appendix D: Florican non-breeding season form. Khmer translations of this form exist in the WCS office (Ro Borey has details).

Transect Number							
UTM start point							
Transect direction							
Time transect started							
Date							
Observers							
Florican sightings							
	Sex	UTM E	UTM N	Distance from transect centre (m)	Time	Notes/activity	
Florican 1							
Florican 2							
Florican 3							
Florican 4							
Florican 5							
Florican 6							
Total number of Florican recorded							
Notes on other bird species							
Species name							
UTM							
Notes							
Habitat Data							
			% grass cover in different cattegories				Flood Depth (cm)
	UTM E	UTM N	0-12	13-50	50-150	150+	
Habitat Point 1							
Habitat Point 2							
Tree density	Start UTM E	Start UTM N	Total trees <5m tall	Total tree >5m tall			
	Yes	No					
Presence of hill							
Distance to moto (km)							

CHAPTER 5:

FIRE MONITORING FOR THE TONLE SAP GREAT LAKE FLOODED FOREST USING MODIS

Tom Clements, Sandrine Pantel, Tom Evans

Introduction

The MODIS (Moderate Resolution Imaging Spectrometer) Rapid Response system has been developed to provide rapid access to MODIS satellite data globally, with initial emphasis on 250m and 1km resolution colour composite imagery and active fire data. The Terra satellite was launched on 18 December 1999 and has been providing continual coverage of the earth's land surface since early 2000. An archived dataset of fire records exists, in addition to near real-time data on active fires. The system has considerable potential for a variety of uses, including:

- Active fire detection. Other WCS country programs download the MODIS data on a daily basis to detect, and if necessary put out, active fires. Available research shows that burning in deciduous dipterocarp forests in Cambodia has been on-going for 1,000s of years, indicating that traditional management practices in these areas should probably be encouraged. However, fire is known to have had a major impact on the Core Areas of the Tonle Sap Great Lake, where local staff have put out fires in the past and would benefit from a warning system.

- Research. As indicated below the seasonality of burning appears to alter annually, possibly in response to fluctuating rainfall. Other issues could include variation between sites, or habitat types (permanently inundated forest v. seasonally inundated forest), or land-use.

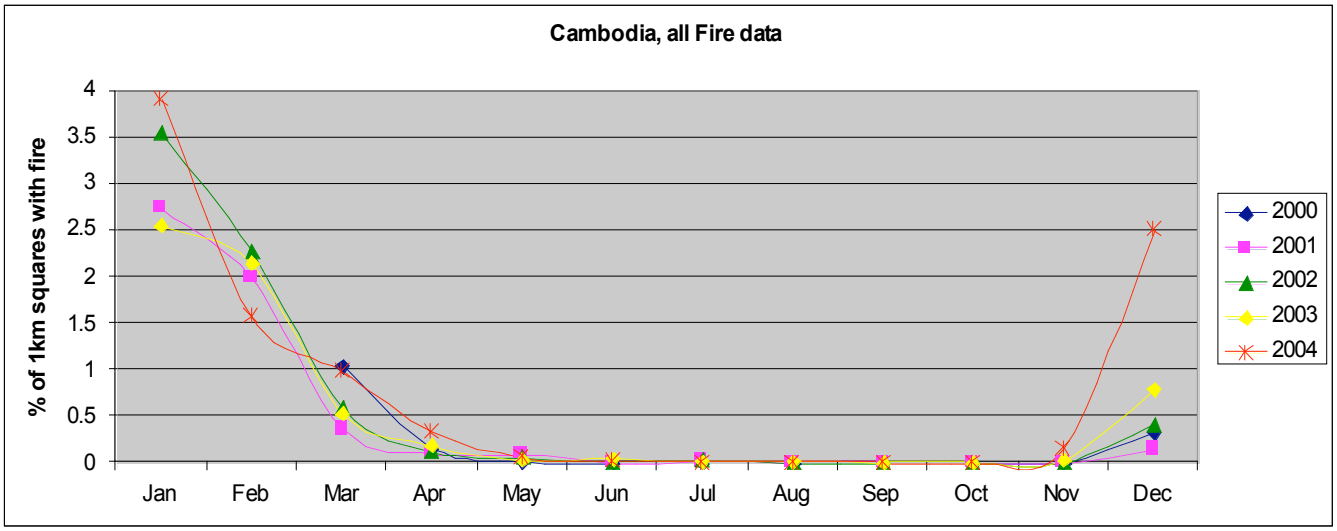
- Monitoring effects of management and changes in land-use.

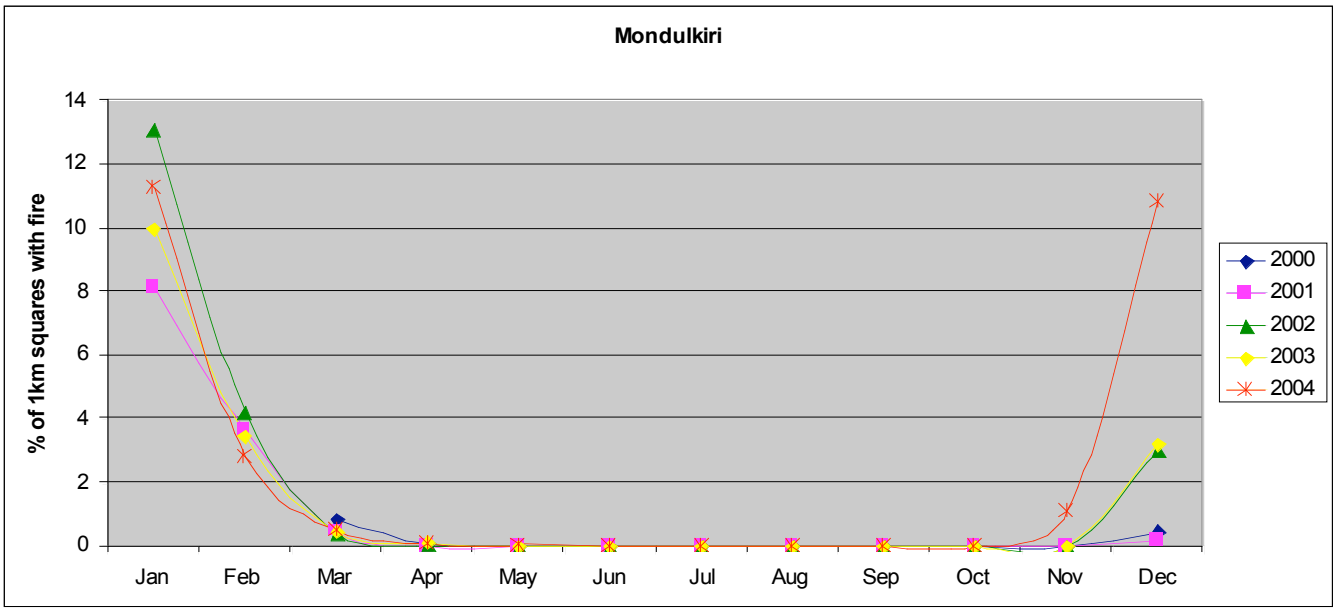
WCS Cambodia has downloaded all available MODIS data from March 2000 to December 2005 for the entire country, and these are available in 8-day and monthly composites. The 2006 dataset will be added when available.

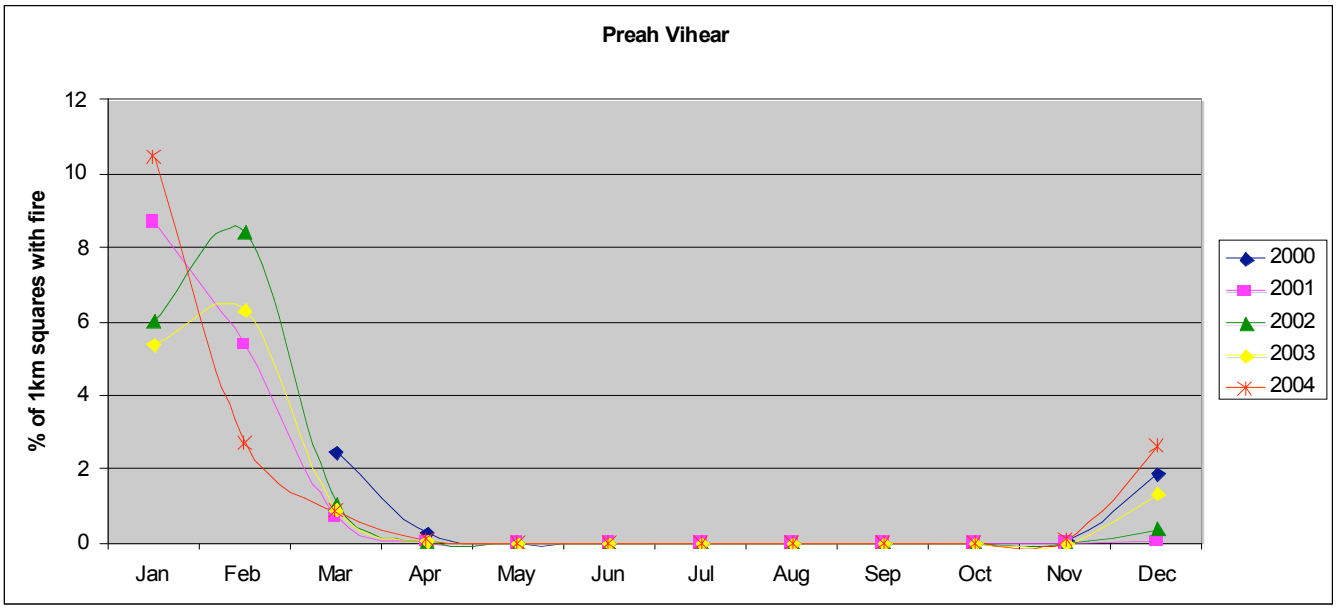
Results

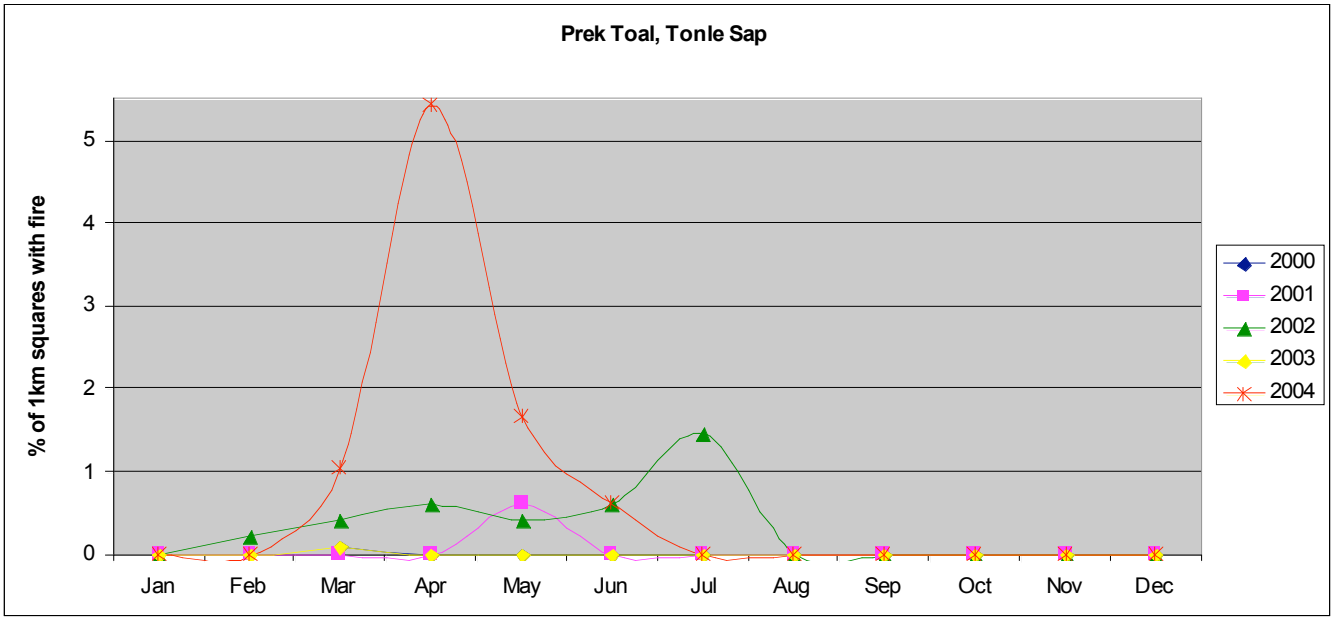
The four graphs show the monthly fire data for all of Cambodia, Mondulkiri province, Preah Vihear province and the Prek Toal Core Area of the Tonle Sap. Fire records should be interpreted as the percentage of 1km squares that show evidence of fire within the month.

All sites in Cambodia (except Prek Toal) show a strong peak in December-February, as expected. 2004-5 and to some extent 2003-4 appear to have been particularly dry years with higher levels of burning. The flooded forests of the Tonle Sap burn much later in the year, when the lake reaches its lowest water level. A fire in April 2004 was particularly severe and almost reached the bird colonies. Interestingly the data suggests that there was another large fire in June-July 2002.


Cambodia, all Fire data
% of 1km squares with fire
4
3.5
3
2.5
2
1.5
1
0.5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2000
2001
2002
2003
2004


Mondulkiri
% of 1km squares with fire
14
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2000
2001
2002
2003
2004


Preah Vihear
% of 1km squares with fire
12
10
8
6
4
2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2000
2001
2002
2003
2004



Notes

According to MODIS, some caveats to bear in mind when using the fire products are:

- The active fires observed with the MODIS instrument are generally very much smaller than the individual 1 km MODIS pixels; it is usually incorrect to assume that the instantaneous fire area is that of the entire pixel.
- Only fires actively burning at the time of the satellite overpass can be detected.
- Algorithm performance depends upon many variables including fire size and temperature, viewing geometry, biome, season, time of day, and properties of accompanying smoke.
- Time series analyses should be performed at a resolution of at least eight days. Analyses based on time periods less than this will be plagued by moderate to extremely large sampling bias errors.

In addition, the results (above) have not taken into account the amount of data lost due to cloud cover or other causes. This information is available, and could be used to correct the results.

The raw dataset classifies fires according to three levels of intensity/certainty: low confidence, nominal confidence and high confidence. For the results (above) these three categories have been merged, however, the raw data are available from MODIS and can be used in future monitoring.

The monthly composites are made from four sets of 8-days (i.e. 32 days total) with the exception of February and August, which are only three sets of 8-days. This should be remembered when analyzing the data. Further proposals for implementation of this analysis across the lake will be made in a separate report which will detail staffing, training, equipment and scope of work.

Appendix 1: Instructions to Download and Process Archived MODIS Data

(taken from Jessica Forrest, jforrest@wcs.org, adapted by Sandrine Pantel)

The MODIS Terra Satellite became operational in December 1999, and data appears to be available from February/March 2000. The satellite suffered initial hardware problems until November 2000 – so the initial data may have some inaccuracies. Data is available in daily or 8-day composite formats (the latter is recommend) at 1km resolution.

(Source: EOS Data Gateway, Land Processes DAAC (LP DAAC)/ U.S. Geological Survey, Sioux Falls, SD, USA, 57198, Phone: 605-594-6116 / Fax: 605-594-6963, Email: edc@eos.nasa.gov)

To download the data:

1. Archived data can be downloaded from the EOS (Earth Observing System) Data Gateway:

   http://delenn.gsfc.nasa.gov/~imswww/pub/imswelcome/ or
   http://edcimswww.cr.usgs.gov/pub/imswelcome/

2. You can select "Enter as a guest" and it will bring you the data query page.

3. You will want to select Land: Modis/Terra

4. For the data set, you will probably want to use either:

   Modis/Terra Thermal Anomalies/ Fire 8-day L3/Global 1km Sin Grid V004

   or alternately,

   Modis/Terra Thermal Anomalies/ Fire Daily L3/Global 1km Sin Grid V004

5. You can either download the data or else request that they mail you a cd.

To process the images:

1. Images were imported into Imagine ERDAS (*.img) format using the import tool (as batch).

   Import Specifications:
   Original file: Modis EOS HDF Format
   All fields as 1 image
   Batch (automatic)
   Added each name to the list.

   Imported files show the projection they are in:
   Sinusoidal WGS 84
   CM = 0, FE = 0. FN=0

2. Reprojected files to the standard projection used by WCS Cambodia Programme (as batch)

   Reproject Specifications:
   Data Prep --> Reproject Images

   UTM Indian Thailand (1975)
   Zone 48
   Meters
   output cell size (default): 926.625433
   Nearest neighbor
   Polynomial approximation: 3
   Tolerance 0.100
   If tolerance exceeded: rigorous transformation
   Ignore zero in output stats
   Rigorous Transformation

3. Used the freely downloadable software Flash Renamer 4.62 to rename files to shortened versions: [mod][julian day][yyyy] (as batch)

   File rename specifications:
   Used add and crop feature to Crop names as follows:
   mod14a2.a2000089.h21v09.004.2003001103342.img becomes
   mod2000089.img

4. Exported files from *.img to ArcInfo Grid format using Erdas Imagine (as batch)

As described in the Modis Thermal Anomalies data, the grid files have the following field values:

0 = not processed (missing input data)
2 = not processed (other reason)
3 = water
4 = cloud
5 = no fire
6 = unknown
7 = low confidence fire
8 = nominal confidence fire
9 = high confidence fire

see mod14a2v4_firedata.pdf for more information.

5. For preparation of Monthly and yearly composite grid files

In the 8-day composite ArcInfo Grid files, I retained these original values in the "**value**" field.

The "**Count**" field shows the number of pixels that have a particular value

I added in 4 additional fields for clarification and for processing (combining 8-day composites into monthly and yearly aggregate files).

Start_Date: The start date of the 8-day composite image (yyyymmdd)

End_Date: The end date of the 8-day composite image (yyyymmdd)

Fire_Cde: For processing, values 0-6 are assigned a value of 0. Values 7 – 9 are assigned a value depending on their position in the 8 day set of each 32 day cycle.

1st 8 days in 32 day cycle: 7, 8, 9
2nd 8 days in 32 day cycle: 70, 80, 90
3rd 8 days in 32 day cycle: 700, 800, 900
4th 8 days in 32 day cycle: 7000, 8000, 9000

Note February and August were only attributed 3 cycles.

Burned: pixel value is 1 for burned areas, 0 for unburned areas.

6. Monthly grid files were created out of the 2000, 2001, 2002 & 2004 set of 8-day composite thermal anomalies data. In additional, six-month period (dry season only) agglomerations were also created. The 8 day period that fire occurred was retained in the monthly data sets, while the six-month data set retains the season of the fire.

   1-32_jan (2003)
   33-56_feb (2003)
   57-88_march (2003)
   89-120_april (2003)
   121-152_may (2003)
   153-184_june (2003)
   185-216_july (2003)
   217-240_aug (2003)
   241-272_sept (2003)
   273-304_oct (2003)
   305-336_nov (2003)
   337-368_dec (2003)

   apr-dec2003-2 : for 2003 dry season, march 30-dec10, indicates fire or no-fire in each pixel.

   apr-dec2003-3 (2003 dry season agglomeration), indicates season and month of fire in each pixel.

   See key_modfire_mnth.xls for attribute data on each grid file. It is located in the "Legend" folder.

   AVL (Legend) files are also provided for viewing the grid files.

   modis_fire2.avl: to view 8-day composites

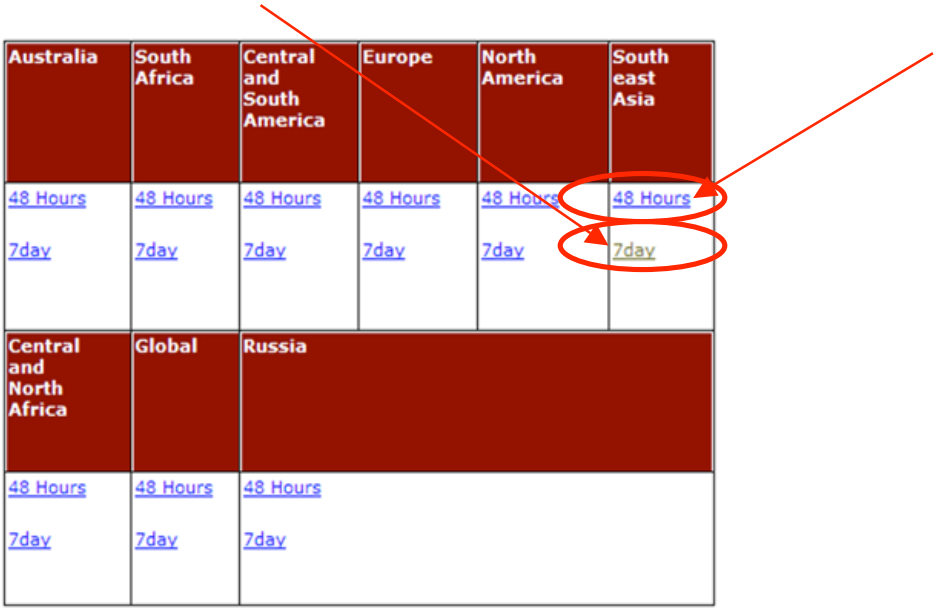
   monthly_grd_confidence3.avl: to view confidence value of fire during a monthly period

Appendix 2: Instructions to Download Active Fire MODIS Data

Composites of active fires in the last 48-hours and 7-days can be downloaded from the University of Maryland's WebFire Mapper.

1. Go to:
http://maps.geog.umd.edu/activefire.asp

2. Right-click and chose to 'Save Target As' for South-east Asia, selecting either 48 Hours or 7day.



3. Save files in C:\MODIS_Fire\GIS_Project\yyyy and unzip the file.

4. **Rename** all the files (.prj, .dbf, .shp and .shx) to the **current date** (dd-mm-yyyy) and add **_48** or **_7d** for 48-hours data or 7days data. **Remember to keep the file extensions**.

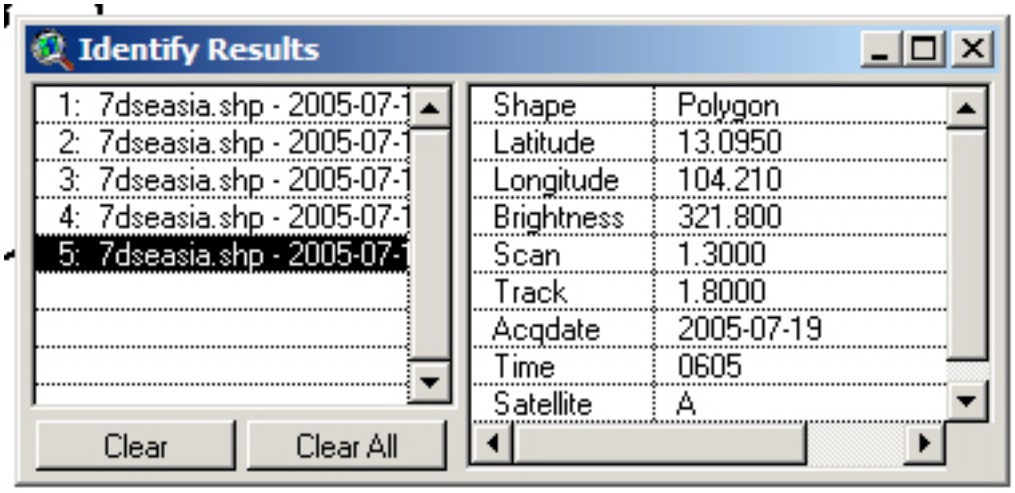
Examples: 21-07-2005_48
12-03-2005_7d

5. Open Arcview, and open the file C:\MODIS_Fire\Active_Data\Fire_Monitoring.apr

6. Add theme  and chose the fire data file

7. Double-click the fire data theme. The legend Editor opens; choose to **Load**. Select **C:\MODIS_Fire\GIS_Project\fire_mask.avl**. The fires will now be displayed in red. Look for active fires in Prek Toal, the Northern Plains and Seima Biodiversity Conservation Area. You may need to turn off the JICA Landuse layer to see the fires.

8. To obtain information on each fire use the information button  and select the fire pixel. **For active fires** record the latitude and longitude, brightness, time and date (Acqdate)



9. The Latitude and Longitude are in **decimal degrees** and **WGS84** map datum. You can use GPS Utility to change these into **UTM** and **Indian Thailand** map datum.

10. Open GPS Utility and make a new file (on the menu click on File/new)

11. Change the units to be D.dddddd and the map datum to be WGS 84 (top right).

12. On the menu, choose Record/new and enter the Latitude (Nxx.xxxx), Longitude (Exxx.xxx) and an ID. Press OK.

13. Change the units to be UTM and the map datum to be Indian Thailand (top right).

14. Write down the new UTM co-ordinates for the fires.

Fires in Prek Toal should be immediately reported to Sun Visal and Long Kheng.

15. Schedule

From 1-July to 31-October download the **7day** dataset **every Monday morning**
From 1-November to 30-June download the **48hour** dataset **every day**.