

NWF/IUCN/WWF Programme for Endangered Species in Asia

*in collaboration with the Wildlife Protection Office,
Ministry of Agriculture, Cambodia*

**Aerial surveys for Kouprey in Cambodia
March 1994**



IUCN Species Survival Commission

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IUCN Species Survival Commission

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NWF/IUCN/WWF Programme for Endangered Species in Asia

*in collaboration with the Wildlife Protection Office,
Ministry of Agriculture, Cambodia*

**Aerial Surveys for Kouprey in Cambodia
March 1994**

by

Dr Robert Olivier and Dr Michael Woodford

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National Wildlife Federation

**IUCN - The World Conservation Union
1994**

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Preface

With the establishment of IUCN offices in Vietnam, Cambodia and Laos and the signing of agreements with host governments, the Species Survival Commission of IUCN, the World Conservation Union, has been able to conduct a number of important projects on endangered species, with the generous financial support of the National Wildlife Federation of the United States. These projects have been conducted as part of a collaborative programme involving the World Wide Fund for Nature (WWF), and where possible, collaboration has also been sought with other conservation NGOs with field programmes in Indochina. This report focuses on one of these projects.

The Kouprey has been an enigmatic animal since its discovery in 1937. It has probably never been a common species, and in recent times has been widely regarded as one of the world's most endangered species of mammal. The various wars in Indochina and continuing troubled security situation have prevented any comprehensive status assessments being made in core parts of its range. In 1988-89, brief ground surveys in Vietnam and southern Laos, supported by the Kouprey Conservation Trust, WWF and IUCN, were conducted in an attempt to locate populations of Kouprey in these areas. No unequivocal evidence of the presence of Kouprey was obtained, however. The difficulties of implementing ground surveys on foot, as well as strong doubts as to the likelihood of locating such a rare, shy and sparsely distributed animal such as Kouprey, led to the recommendation that aerial surveys should be used in an attempt to locate the species. Whilst the use of light aircraft to survey large herbivores such as wild cattle had not been used in Indochina, early accounts of Kouprey behaviour contained information suggesting that, with careful timing to coincide with dry season leaflessness, such an approach might provide a realistic method of finding Kouprey, as well as other wild cattle and larger mammals such as Asian Elephant. With this in mind, and thawing of the tense security situation in parts of Cambodia, planning for such a survey began in earnest in mid 1993, and the survey was conducted in March 1994 by a team comprising Cambodian nationals and two international experts.

The Kouprey survey was one of a number of collaborative projects in Indochina generously funded by the National Wildlife Federation, the Species Survival Commission of the World Conservation Union (IUCN/SSC) and the World Wide Fund for Nature (WWF). This particular project was also partly funded by the People's Trust for Endangered Species and the Food and Agriculture Organization of the United Nations. It is anticipated that the NWF/IUCN/WWF Collaborative Programme on Endangered Species in Southeast Asia will follow-up on the recommendations of this report in an effort to find and Kouprey, and populations of other large herbivores in Cambodia.

Acknowledgements

This survey would not have been possible without the generous financial support of the National Wildlife Federation, IUCN, WWF International, Food and Agriculture Organization of the United Nations and People's Trust for Endangered Species, and the support and assistance of David Ashwell, the IUCN Liaison Officer in Cambodia. We would particularly like to thank David Hulse and Janet Jent of WWF; Simon Stuart and Frank Lambert of IUCN Species Survival Commission; David Steane and Keith Hammond of FAO; and Valerie Keeble and Prof. Beddington of PTES for their support of fund raising efforts.

In Cambodia, we extend our gratitude to Mr Chhim Somean, Head of the Wildlife Protection Office, for his support of this project, and to his staff who undertook to participate in the surveys and assisted with data collection: Thong Bun Than, Pak Vong Somethy, Lao Sophal, Bun Sieng, and Chan Sovana. Claude Bonzan and Christophe Deschamps of *Aviation Sans Frontières* are thanked for their careful and diligent piloting of our survey aircraft. We also extend our thanks to Lt-General Chhum Chheang and Lt-General Proche Bunthan of the International Relations Department, Ministry of Defence for endorsing and supporting this project; and staff of the Governors of Kratie and Mondolkiri Provinces for invaluable assistance and advice.

Valuable information on the distribution of Kouprey was provided by James R. Mellon II, Roger Cox and Nate Thayer, which helped David Ashwell and project executants identify the most appropriate areas for survey. Jim Paine of the World Conservation Monitoring Centre provided the project with existing data on the distribution and status of large mammals in Asia.

Will Duckworth, who was taken ill at the last moment, was to have acted as a second observer, and to him we extend our commiseration, as well as thanks for his contribution to the early planning stages of the project.

Comments on early drafts of this report were kindly provided by David Ashwell, David Hulse, Simon Stuart, Will Duckworth and Frank Lambert. The World Conservation Monitoring Centre assisted by providing information on wild cattle distribution and in preparing a map for the final report, and we would particularly like to thank Jim Paine and Corinna Ravilious.

Acronyms

ATC	Aerial Total Count
FSO	Front Seat Observer
GEF	Global Environmental Facility
GPS	Global Positioning System
FAO	Food and Agriculture Organization of the United Nations
IUCN	The World Conservation Union
NGO	Non Government Organization
PTES	People's Trust for Endangered Species
RSO(L/R)	Rear Seat Observer (Left/Right)
SSC	Species Survival Commission of IUCN
SSE	Secretariat of State for the Environment
TRAFFIC	Trade Records Analysis of Fauna and Flora in Commerce
UNDP	United Nations Development Programme
WCMC	World Conservation Monitoring Centre
WPO	Wildlife Protection Office
WWF	World Wide Fund for Nature

Summary and Recommendations

Summary

Surveys for Kouprey *Bos sauveli* using the Aerial Total Count method were carried out in the Mondolkiri Province of eastern Cambodia between 16 and 26 March 1994. A total of 5,238km² were surveyed, involving a total of 34.7 hours flying. A further 300km² were surveyed in the Stoeng Treng Province, near the border with Laos, on 27 April 1994.

No Kouprey were recorded in either survey area. Rare mammals counted in the Mondolkiri survey area included: 97 Banteng *Bos javanicus birmanicus*, 13 Eld's Deer *Cervus eldi siamensis* and four Gaur *Bos gaurus*. No wild Asian Elephants *Elephas maximus* were seen; the species probably occurs in the area at far lower densities than previously estimated.

Although large herbivore habitat remains extensive in Mondolkiri and in Stoeng Treng, it is evident that little, if any, of this range has escaped human disturbance of some sort, especially hunting. Consequently, wildlife is distributed fairly evenly in the areas of least human activity, but at very low densities. This limited resource probably owes its continued survival to the widespread availability of surface water in the dry season.

Despite the negative aerial survey results, there is sufficient evidence to indicate that a few Kouprey probably survive in eastern Mondolkiri Province, and there is no doubt that if Kouprey still survive, the best chance of finding them lies in Cambodia.

Recommendations

Political circumstances permitting, recommended follow-up actions include:

■ *Field projects*

1. a scientific ground survey for Kouprey in eastern Mondolkiri;
2. a two year, country-wide, ground survey of large mammals, focusing on bovids, Asian Elephant, Eld's Deer and Tiger;

■ *Legislation*

3. a ban on the hunting of bovids, elephants and other large mammals of clear international conservation significance, and a ban on the sale of their horns, bones and meat;

■ *Protected area development*

4. consideration should be given to the establishment of a transfrontier protected area in the Mondolkiri survey area, contiguous with Lok Don in Vietnam. A stretch of the Srepok River should be included in any such reserve;

- *Institutional strengthening*
- 5. an approach to major donors to support an institutional strengthening programme.
- *Captive breeding*
- 6. If populations of Kouprey are discovered and captive breeding attempts are made, these should involve the most experienced international personnel available. Such breeding attempts should be attempted within Cambodia.

Recommendations are fully discussed in section 4 of this report.

1. Introduction

1.1 The Kouprey

The first scientific description of the Kouprey *Bos¹ sauveli* was published only in 1937 (Urbain, 1937). Adding to substantial interest surrounding the late discovery of such a large animal, was the reasonable speculation that the species might have considerable genetic potential for the improvement of domesticated cattle. However, it was not until the early 1950s that any serious attempt was made to investigate the ecology, behaviour and status of Kouprey in the wild (Wharton, 1957 and 1966).

The Kouprey was already a rare animal in the 1950s with an estimated population of around 500 which, with the exception of very limited adjacent areas in Thailand, Laos and Vietnam, ranged entirely within Cambodia. Wharton noted that the Kouprey range overlapped with that of two other wild cattle species, Gaur *Bos¹ gaurus* and Banteng *Bos¹ javanicus*. His findings suggested that ecological separation between these species is maintained by differential habitat preferences, the Kouprey being most strongly associated with open habitats, the Gaur with closed forests, and the Banteng with intermediate formations.

Although by contemporary standards the duration of Wharton's fieldwork seems very limited (approximately two months), his investigations remain the only source of socio-ecological data on the Kouprey. For well over 30 years, the political situation in Cambodia pre-empted any follow-up work and gave cause for mounting concern despite some evidence that the species still survived (Neese, 1976; Thouless, 1987). This concern peaked in 1988 with the compilation of an Action Plan for the conservation of the Kouprey (MacKinnon and Stuart, 1989).

Since fieldwork in the core of the species' historical range - Cambodia - was impossible, the first Action Plan components to be implemented were ground surveys of the peripheral areas in Laos and Vietnam. Between 1989 and 1992, four such surveys were carried out, each returning negative or inconclusive results (Cox *et al.*, 1992). These results, as well as those of a separate questionnaire-based investigation in Laos (Salter *et al.*, 1990), clearly indicated that if the Kouprey survived anywhere in viable numbers, then it would be in Cambodia. However, it was not until the present Government under King Sihanouk as Head of State took power following the UN supervised elections of 1993, that surveys in that country at last became feasible.

Following the recommendations of Cox *et al.* (1992), and mindful of the difficulties of groundwork still posed by uncleared minefields, IUCN (The World Conservation Union) decided to initiate the search for Kouprey in Cambodia from the air. This report documents the aerial surveys carried out under this initiative.

1.2 Wildlife Management in Cambodia

Responsibilities for the management of natural resources in Cambodia are not clearly defined at present, being in a transitional state following certain recent initiatives of the new political regime. Traditionally, responsibility for wildlife management has been vested in the Wildlife Protection Office of the Forestry Department, currently within the Ministry of Agriculture.

1. The authors remain uncertain as to the correct taxonomic nomenclature for these species. The genus *Bos* is used here in order to conform with Hedges (*in prep.*), although it is understood true wild cattle should be accorded the genus *Bibos* while *Bos* is reserved for domestic cattle (Payne, 1991).

Recently, however, a Secretariat of State for the Environment (SSE) has been formed. An early task for this body was to respond to a directive from the King to prepare a new protected areas system for the country. This task was accomplished with technical assistance from IUCN, and on 1 November 1993 the King signed a *Kret* (Declaration) creating a new system of 23 protected areas in four categories, amounting to some 15% of the country's surface area (Kingdom of Cambodia, 1993). The breakdown and location of these areas is shown in Figure 1.

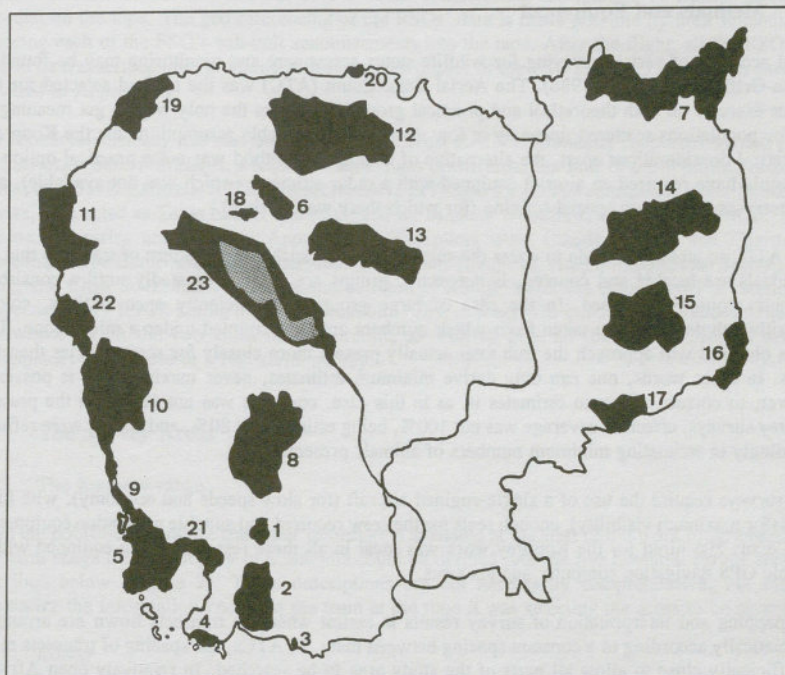
It is important, in terms of planning future wildlife conservation initiatives, to understand that the identification of the new protected areas was based on a desk top exercise. Although the inspection of vegetation/habitat maps, satellite imagery and maps of human settlement, as well as a protected area review by WCMC, was used to help ensure adequate representation of different habitats and floristic communities, there were no recent data on animal distributions and status available to guide the process in the designated time.

Similarly, although the protected areas declaration includes notional management criteria for each category (based on the international standards developed by IUCN), it should be recognised that the administration presently has no capacity to manage the system according to these criteria, nor apparently is there any coherent strategy to rectify this. Until then, uncertainty remains about who should manage what, a situation rooted in the wording of the Declaration itself, which states that "the management and administration of the National Protected Areas System is the joint responsibility of the Secretariat in collaboration with other competent institutions".

The SSE is reported to have a present staff of about 300 people, including 30 in a Department of Nature Protection, although the situation is still not permanent (D. Ashwell, pers. comm.). The SSE's mandate is vague, and is not, as yet, based on any specific legal instruments. Despite this, the SSE enjoys relatively good external support from an Environmental Advisory Team provided by UNDP, from the International Development and Research Centre (a Canadian NGO), and from IUCN.

The Forest Department has approximately 400 staff, of which just over half work in provincial forest offices. The Wildlife Protection Office in Phnom Penh has a nominal strength of 26, but only 14 of these posts are filled. Not surprisingly, the main preoccupation of the Department is to enforce logging regulations, which currently involve an annual harvest limit of 100,000m³ and a total export ban. The WPO's chief function is to enforce the total hunting ban declared in 1988 under Forestry Decree No. 35, although proposed revisions to the wildlife protection component of the Forest Law await ratification. As presently deployed, however, the WPO is unable to enforce the ban, and hunting of all species is prevalent throughout the country. So far, external support for the WPO has been limited to faunal surveys organized by IUCN (including the present aerial survey for Kouprey).

Figure 1. Areas designated for the protection of nature in Cambodia



National Parks

1. Kirirom
2. Phnom Bokor
3. Kep
4. Ream
5. Botum - Sakor
6. Phnom Kulen
7. Virachey

Wildlife Sanctuaries

8. Aural
9. Peam Krasop
10. Phnom Samkos
11. Roniem Daun Sam
12. Kulen - Promtep
13. Beng Per

14. Lomphat
15. Phnom Prich
16. Phnom Nam Lyr
17. Snoul

Protected landscapes

18. Angkor
19. Banteay Chmar
20. Preah Vihear

Multiple-Use Areas

21. Dong Peng
22. Samlaut
23. Tonle Sap

2. Planning and Conduct of the Surveys

2.1 Methods and Equipment

Useful accounts of aerial surveying for wildlife status assessment and monitoring may be found in Norton-Griffiths (1978 and 1986). The Aerial Total Count (ATC) was the method selected for the present exercise on both theoretical and practical grounds. It offers the only way to get meaningful data for populations scattered unevenly at low densities - reasonable assumptions for the Kouprey. Theoretical considerations apart, the alternative of a sampling method was not a practical option as this would have required an aircraft equipped with a radar altimeter (which was not available), and the observers to undergo special training (for which there was no time).

In an ATC, an attempt is made to cover the survey area with such a tight pattern of transects that all individuals are located and counted. If necessary, groups are circled repeatedly until a consistent maximum count is obtained. In the case of large groups in sufficiently open settings, colour diapositive photographs are taken from which numbers are later counted under a microscope. The counts obtained will approach the true total actually present more closely for some species than for others. In other words, one can only derive minimum estimates, never maximum. It is possible, however, to correct minimum estimates if, as in this case, coverage was not 100%. In the present Kouprey surveys, effective coverage was not 100%, being estimated at 80%, and counts were refined accordingly in estimating minimum numbers of animals present.

Such surveys require the use of a single-engined aircraft (for slow speeds and economy), with high wings (for maximum visibility), enough seats for the crew required and suitable navigation equipment. The Cessna 206 hired for the Kouprey work was ideal in all these respects, being equipped with a Trimble GPS navigation computer and six seats.

The mapping and interpretation of survey results is easiest when the transects flown are arranged systematically according to a constant spacing between them. In ATCs, the spacing of transects must be sufficiently close to allow all parts of the study area to be searched. In relatively open African habitats, it is generally assumed that an observer can scan effectively an area up to 1.0km from the aircraft, which, with one observer on either side of the aircraft, allows a transect spacing of 2.0km. However, Cambodian habitat conditions demanded that this spacing be reduced to the minimum possible, according to equipment and pilot limitations, which was 1.0 nautical mile (1.8km).

When navigating with a GPS, the position of the aircraft along any given transect can be monitored continually. This allows the option of organizing the data gathered along discrete fractions of the transect into separate sub-units. If the length of the fraction (or sub-unit) equals the transect spacing, then results can be assigned to squares of known geographical location. These squares can then be mapped as the cells in a grid square array, on which boundaries and other features can be overlaid. In the maps presented here (Figures 4-29), the grid lines correspond to actual whole minutes of longitude (X axis) and half minutes of latitude (Y axis), with each cell representing an area of one square nautical mile (3.43km²).

The optimal crew for an ATC consists of a Pilot, a Front Seat Observer (FSO), and two Rear Seat Observers (RSO). The Pilot is required to navigate the aircraft precisely along each transect, and to maintain a constant (slow) speed and height over the ground. In the present surveys, these parameters averaged 90 knots and 500 feet respectively. The main task of the Front Seat Observer (FSO) is to monitor the GPS so as to announce each transect sub-unit, and to record on a prepared data sheet a range of qualitative variables.

The task of the two RSOs', one on the left (RSOL) and one on the right (RSOR), is to count the numbers of every species (or any other quantifiable variable of interest, such as waterholes) that they see. The record is made onto a hand-held tape recorder. Where a group is too large to count, a photograph is taken for later analysis but both a visual estimate and the number of frames taken are recorded on the tape. The geo-referencing of the RSOs' data is made possible by their immediately repeating each of the FSO's sub-unit announcements into the tape. After the flight, all the RSO data have to be transcribed onto prepared data sheets. Examples of the FSO and RSO data sheets used are provided in Appendix 1.

The Mondolkiri survey was carried out by two external IUCN consultants, supported by two pilots from *Aviation Sans Frontières*; a team of Cambodians drawn from the staff of the Wildlife Protection Office; and David Ashwell, IUCN's Representative in Phnom Penh. The consultants were: Dr Robert Olivier, who acted as Team Leader and FSO; and Dr Michael Woodford, who acted as RSOL. Their mission itineraries are given in Appendix 2. The pilots were Claude Bonzan and Christophe Deschamps. The Cambodian group included: Thong Bun Than, Pak Vong Somethy, Lao Sophal, Bun Sieng, and Chan Sovana. Mr Somethy was selected as RSOR, while the others acted in rotation as a supernumerary RSOR sitting directly behind him. This strategy was intended to balance the quality of observation on the two sides of the aircraft, as well as give all the Forest Officers present participatory experience in a real aerial survey.

2.2 The Survey Areas

2.2.1 The Kouprey range

From the published literature and other information available at the start of the work programme, the historical range of the Kouprey in Cambodia could be divided into the five potential survey areas as described below (Figure 2). These descriptions are not necessarily comprehensive, but merely summarize the information known to the team at the time it was selecting the areas to be surveyed.

A. Kosker

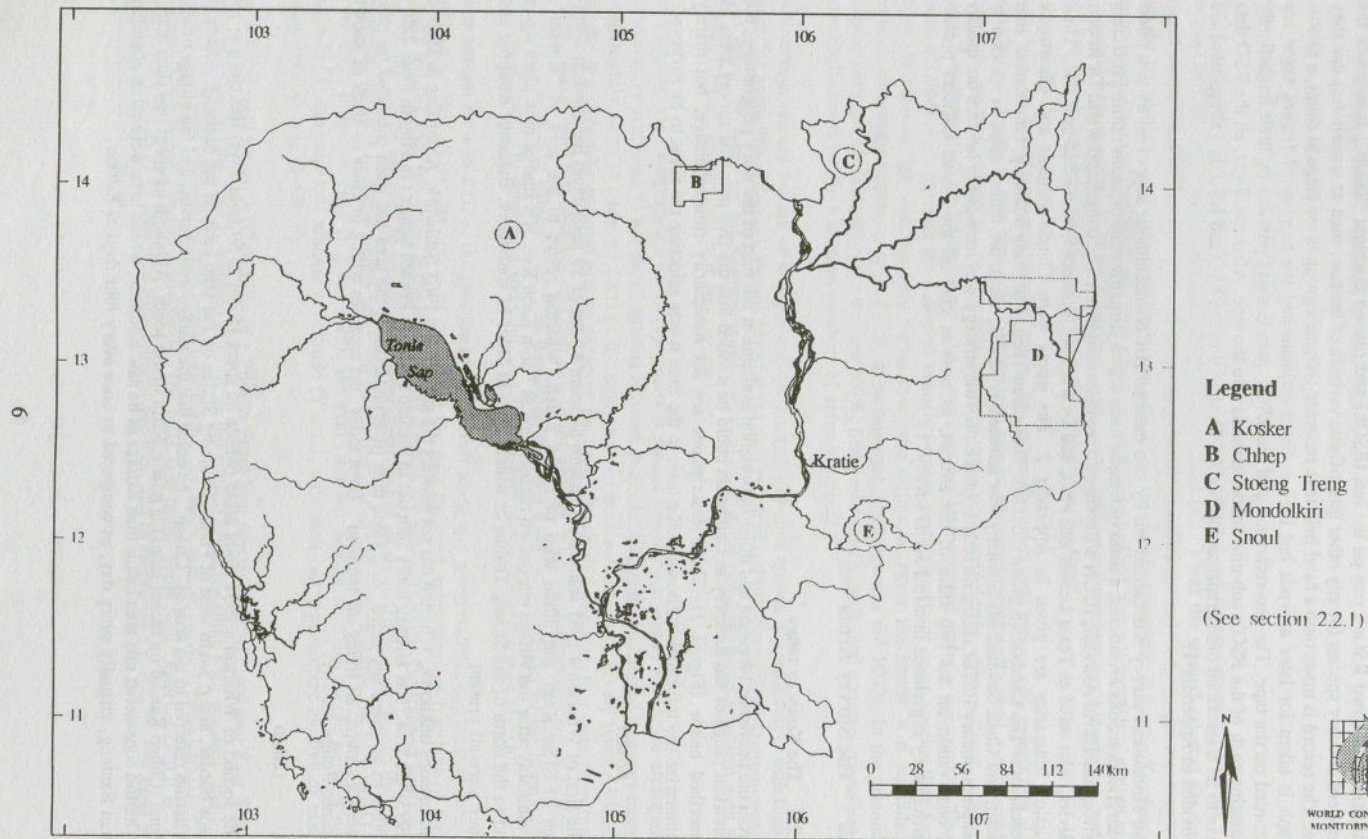
The first of Wharton's 1951 study areas (where he spent 43 out of 59 field days) lies c.80km north-east of Siem Reap and 30km west of Phum Kulen. Wharton refers to the area as "Kosker", presumably after the village marked on recent maps as Phum Kaoh Ker. His studies took place along and to the north of the Stoeng Traling at which time, in order of abundance, Banteng, Kouprey and Gaur were all present.

For reasons unknown, Wharton did not reselect the area for his 1963 fieldwork. According to Mellon (1993) the area "was already badly shot out in the late 60s. The French hunters in Phnom Penh didn't bother to go there any more. And since then (it is understood) the area has been contested by rival guerilla groups, all living off the land". Even today, the area lies within or close to areas of known Khmer Rouge activity.

B. Chhep

The second of Wharton's 1951 study areas (where he spent 16 out of 59 field days) lies close to the Laos border, and c.35km west of Phum Kompong Sralau on the west bank of the Mekong. Although Wharton referred to the area as "Chhep", he noted that the village itself moves, and the village of that name (Chhep Kandal on recent maps) is now c.30km to the south. Although he spent less time there, Wharton considered this area better than Kosker as he saw Kouprey, which here were more abundant than Banteng, virtually every day, as compared to once every four days at Kosker.

Figure 2. Potential Kouprey Survey Areas



Although Wharton reselected the area for his 1963 study, it is understood that little if any fieldwork was undertaken for security and political reasons. The most recent reliable sighting of Kouprey in the area was on 16 March 1969, when J. Mellon sighted two females. Mellon was also of the opinion that the area "may still have" some (Mellon, 1993). Neese (1976) and Salter *et al.* (1990), also give reports from Lao informants who asserted that Kouprey still survived in this part of Cambodia, the latest reported sighting being June 1989, but D. Ashwell (*in litt.*, 1994) reported that the area has been the focus of guerilla activity since 1979 and that these guerrillas live off the land with the help of automatic weapons.

C. *Stoeng Treng*

Prior to the team's assembly in Cambodia, the IUCN office there had proposed an area in the far north of Stoeng Treng Province (basically the region between the Tonle Kong and the border with Laos) as a potential survey area. The area indicated was quite large, and it was estimated this would take c.16 hours to survey. The proposal to survey this area was based on interviews conducted by R. Salter (IUCN Laos) which indicated that four of the five areas where Kouprey had been recorded in the 1980s were adjacent to this area.

Although a possible Kouprey print had been found near the Cambodian border in 1991, on the Houei Kiang plains, the final conclusion was that the level of human activity in the relevant areas of Laos is such that future Kouprey surveys would be more likely to yield positive results in other less heavily disturbed parts of Indochina (Cox *et al.*, 1992). M. Woodford, who had participated in the 1991 survey in Laos, was of the opinion that the adjacent parts of Cambodia would hold no more promise. Accordingly, the proposed survey area did not appear an obvious priority and was not surveyed by the consultant team. However, an opportunity to survey this area arose subsequent to the team's departure, and the area was partially surveyed by D. Ashwell, Pak Vong Somethy, T. Mundkur and J. Davies on 27 April 1994, using the same pilot and aircraft as at Mondolkiri.

D. *Mondolkiri*

Prior to the team's assembly in Cambodia, the IUCN office there had proposed an area between the east bank of the Mekong and the Vietnam border as a potential survey area. The region indicated was relatively large, and it was estimated this would take c.52 hours to survey. The area's prime features include the Tonle Srepok and two protected areas, the Lomphat and Phnom Prich Wildlife Sanctuaries which were set up partly in the hope they would include Kouprey. From the town of Lomphat, the Srepok River flows south-east for c.100km before crossing into Vietnam, where it forms the northern and eastern boundaries of the Yok Don Natural Reserve.

There are several early references to the general area of Lomphat and the country on either side of the Srepok River as Kouprey range. Wharton made a brief visit to Lomphat in 1951, and later selected a nearby area on the northern border of Mondolkiri Province (just south of the river) for his 1963 study. However, it is understood that he undertook little if any fieldwork for security and political reasons. Nevertheless, the area he chose roughly corresponds with the one supposedly still used in the dry season by the Kouprey which visit the Yok Don Reserve in Vietnam during the wet season (Laurie *et al.*, 1989).

Additional evidence that Kouprey survive in the eastern part of Area D included, from north to south, the following:

- reports received recently by the Forest Department of a group sighted in the triangular wedge between the north bank of the Srepok River and the Vietnam border. Laurie *et al.* (1989) also reported the adjacent area of Vietnam (north of Yok Don) as Kouprey range;

- research by Mr Nate Thayer (a well-known journalist resident in Cambodia who speaks fluent Khmer) produced information sufficiently convincing for him to mount an expensive two-week ground expedition in March-April 1994, to look for Kouprey in the area west and south of the point where the Srepok River crosses into Vietnam, and adjacent to Yok Don. Coincidentally, Mr Thayer planned to be on the ground at the same time as the IUCN team would be in the air, necessitating an agreement as to overflight dates that would least disturb the groundwork. (The results of the Thayer expedition are discussed in 4.1.1);
- reports received by the survey pilots from hospital staff in Mondolkiri of a Kouprey group seen in an area c.50km to the north-east, between a hill called Phnom Yok Lom and the Vietnam border. This information was later repeated to the consultants during a stopover in Mondolkiri; and,
- Mellon (1993) expressed the opinion that the chances of finding a few herds of Kouprey, as opposed to scattered individuals, were better in Area D than elsewhere in the country. He also stated that "this is an area of few roads and villages. More important, it appears to have escaped the violence in western Cambodia", a statement corroborated by the maps and information available to the team. Mellon's final advice was to "take a map of Mondolkiri, cut the region up into squares, and give each square a thorough going over with a small plane and two sharp eyed spotters in the back seat".

E. Snoul

Sauvel (1949), provides the first reference to Kouprey in the Snoul area (c.60km south-east of Kratie), and Wharton (1957), confirmed their continued presence after a visit in 1951. At one time, a single female Kouprey inhabiting the Snoul area became very tame and was photographed regularly by visitors. However, when J. Mellon visited the area in 1969, foresters told him that this particular animal had last been seen in 1966, and that no other Kouprey had been seen there since.

2.2.2 Selection of areas for aerial survey

The decision as to which of these areas would be surveyed during the present mission was made as follows. For security reasons, permission to fly had been obtained for areas east of the Mekong only - thus, areas A and B were eliminated immediately. As time constraints would certainly prevent the surveying of all the eastern areas, it was decided to put these in order of priority.

From the information and opinion available, Area D (Mondolkiri) was given top priority because it included both old records and recent reports of Kouprey, as well as including two Protected Areas (Lomphat and Phnom Prich) intended to provide sanctuary for the species. Furthermore, it was the most proximate to the survey base at Kratie. Nevertheless, it was realised that the whole of Area D would be too large to complete in the time available, so it was decided to identify a highest priority zone within it. Only once this was surveyed would a further decision be made according to the time remaining as to whether to continue with more of Area D, or move to Area C or E.

In determining the top priority zone within Area D, it was agreed that Kouprey were as likely to occur outside the Cambodian Protected Areas as within: certainly, protected areas had not been established in relation to any data to the contrary (1.2). It was, therefore, decided to ignore the boundaries of the protected areas and concentrate on Area D's eastern portion along the Vietnam border. Not only did this cover the part that was expected to be the least disturbed by man (owing to its distance to settlements in Vietnam and Cambodia), but also it still included the Wharton area, the purported dry season range adjacent to Yok Don, and the locations of all recently reported sightings.

The final survey zone is described by the angular outline shown east of the Mekong on Figure 3. The northern and southern borders being set by mountainous terrain and thickening tree cover, and the eastern by the Vietnamese frontier. The uneven western border was chiefly determined by settled areas: these were avoided partly because they posed some threat to aircraft security, and partly because Kouprey were unlikely to be found there.

Although the survey zone described above was the only area surveyed according to the ATC method (2.1), simple reconnaissance surveys were also conducted over Area E (Snoul), Area C (Stoeng Treng: by a separate team), and Kaoh Enchey Island in the Mekong River. The results obtained in all four areas are presented in section 3.

2.2.3 Ecological considerations

In both the ATC survey zones, the dominant vegetation type is deciduous dry dipterocarp forest, different variants of which occur in a mosaic that also includes patches of semi-deciduous and evergreen forest. Leaf fall in the deciduous species takes place during a well defined dry season from October to April. At this time, widespread burning of the understorey in all habitats is normal practice, although the prevalence of fire appears somewhat reduced in the thicker forests. Open savanna type woodland is extensive, though areas totally devoid of trees are small and rare, being most likely limited to seasonally inundated pans and old clearings made by shifting cultivators. Detailed accounts of the species composition of Kouprey habitats and the influences of soils, rainfall, fire and man may be found in Wharton (1957 and 1966) and Laurie *et al.* (1989).

Given the mosaic of habitats in the survey areas, and the possibility that phenological events might be asynchronous between different patches, even of the same type, it was anticipated that visibility might vary widely across the survey zones. It was considered important, therefore, to try and record this variation. Accordingly, the FSO rated every sub-unit according to one of four visibility indices (Table 1), each defined in terms of a subjective assessment of the proportion of the RSOs' counting strip considered visible.

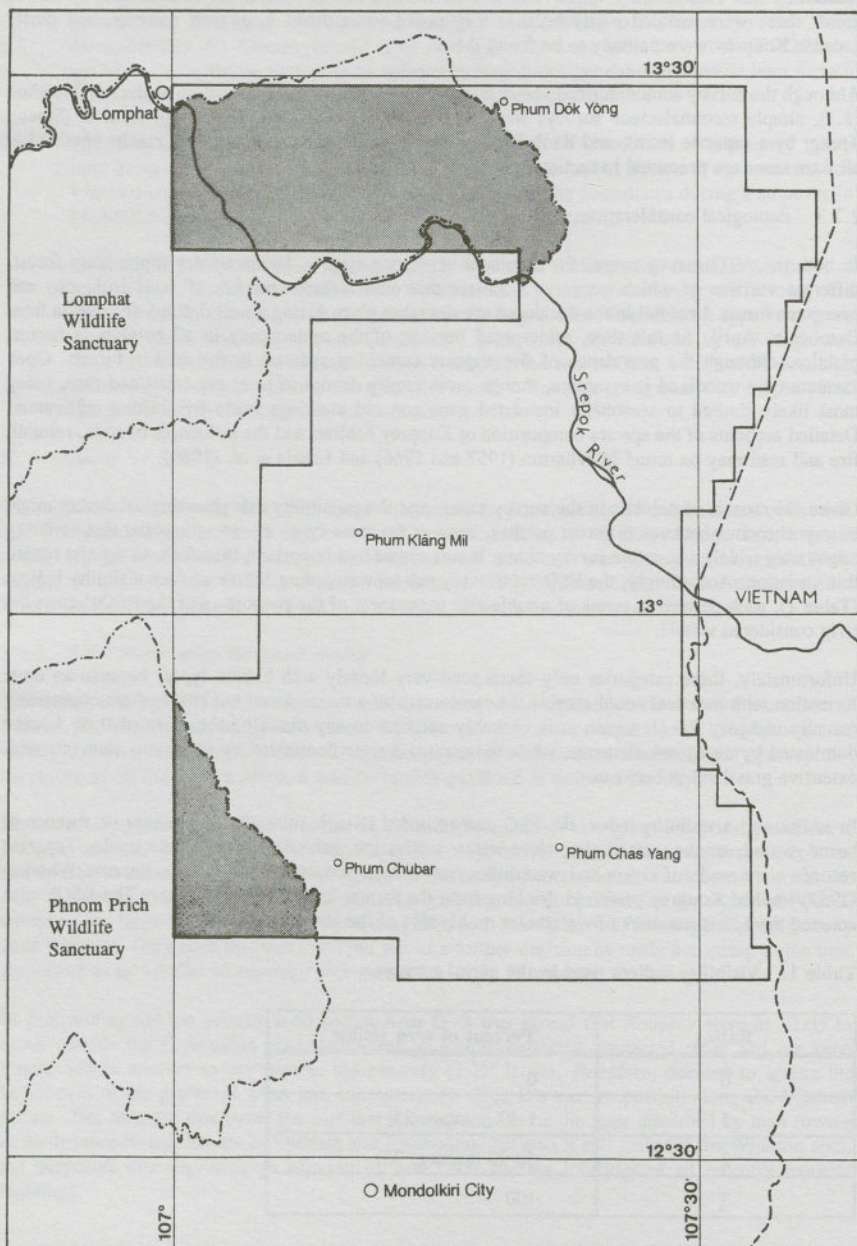
Unfortunately, these categories only correspond very loosely with habitat types, because an open formation with new leaf could receive the same score as a more closed but still leafless community (usually category 2). However, it is probably accurate to say that all habitats rated 0 or 1 were dominated by evergreen elements, while those rated 3 were dominated by deciduous elements with extensive grassland in between.

In addition to a visibility index, the FSO also recorded in each sub-unit the presence or absence of burnt ground, smoke, waterholes, river water, cultivation, habitation and vehicle tracks. Separate records were made of rivers and waterholes (rather than simply surface water), because Wharton (1957) implied Kouprey preferred drinking from the former and avoided the latter. The RSOL also counted the actual numbers of waterholes on his side of the aircraft.

Table 1. Visibility indices used in the aerial surveys

Rating	Percent of area visible
0	0
1	1-49 (average 25)
2	50-99 (average 75)
3	100

Figure 3. Mondolkiri aerial survey area. Shading indicates portions of the Phnom Prich and Lomphat Wildlife Sanctuaries that overlapped with the survey area



Unfortunately, it did not prove possible from the air to distinguish between salt licks, which Wharton (1957) considered an essential feature of Kouprey habitat, and normal waterholes or wallows. It had been intended that the FSO record the presence or absence of termitaria (often used as salt licks), but they proved so difficult to see in Mondolkiri that the FSO decided not to look for them, so as to devote the limited time available per sub-unit to better assessment of the other variables. The data sheet used by the FSO to record these variables in flight is shown in Appendix 1.

2.3 The Work Programme

The timing of the surveys reported here was planned to coincide with the late dry season, a period in which the deciduous tree species that predominate in the habitats apparently preferred by Kouprey could be expected to be at their most leafless, thus affording optimal visibility from the air.

The work programme began with a half-day Workshop on 11 March 1994, at which the consultants reviewed for staff of the Wildlife Protection Office the principles and practice of aerial survey and current knowledge of the Kouprey.

The air surveys were carried out from a base in Kratie, the closest town to the survey area which had both an airfield and to which it was possible to deploy supplies of aircraft fuel (avgas) by boat. The period available for aerial work amounted to 13 days between 14 March (the arrival of the avgas in Kratie), and 27 March (the end of the team leader's availability), with the single day survey of Stoeng Treng being conducted on 27 April, by a separate team. The first day (15 March) was devoted to a simulation survey flight in which all crew members rehearsed their role, followed by a reconnaissance flight of the Mondolkiri survey area that was also used to inform the Provincial Governor of the survey programme. The aircraft had to return to Phnom Penh for a mandatory service on 20 March, so no surveying could be carried out on that day.

Surveying was limited to one flight a day, starting at c.0700 and averaging 3.5 hours in duration. Allowing for the so called "dead time" between take off and the start of the first transect, and between the end of the last transect and landing, the amount of time spent "on the line" averaged 1.8 hours per day. Although shadows were fairly long at the start of the day's surveying, this was offset by the greater likelihood of bovines being found in the open during the coolest hours. The reverse argument, together with less stable (i.e., less comfortable) flying conditions, was used to reject the option of two flights a day, but in the event this anyway would have proved beyond the capabilities of the crew available (see Appendix 4). Afternoons were spent in transcribing data and mapping progress.

3. Survey Results

3.1 Mondolkiri

The survey of the 4,754km² Mondolkiri area (Fig. 2) took place between 16 March and 25 March 1994, and involved 16.4 hours of transect flying and 30.8 hours overall.

3.1.1 Qualitative data

Visibility. Fig. 4 indicates clearly the mosaic of differing tree densities encountered. The most frequent visibility index rating was "2" (52% of all grid squares), followed by "3" (39%), "1" (8.5%) and "0" (0.5%). On the basis of the average percentage of the observers' strips considered visible in each class (see 2.2.3), it can be estimated that the coverage actually achieved approximated to an 80% sample, as opposed to the 100% aimed for in an ATC. The quantitative data obtained has been corrected accordingly.

River Water. As shown in Fig. 5, surface water from river sources was fairly evenly distributed across the survey area.

Waterholes. Water filled pans and wallows were extremely well distributed throughout the study area, occurring in 51% of all grid squares. Fig. 6 is a composite of the FSO's presence/absence records, and the RSOL's count.

Burnt Areas. Fig. 7 shows all grid squares in which there was evidence of grass fires. This evidence was extremely widespread, being noted in 38% of all grid squares.

Vehicle Tracks. Fig. 8 shows the grid squares in which vehicle tracks were noted. While it is known that vehicle tracks can persist for years, and no distinction could be made between bullock carts and motorized vehicles, the data do suggest significant levels of disturbance in all but the south-eastern quadrant of the survey area. It is thought that most of the tracks seen were made by selective loggers. No actual vehicles were spotted moving on these tracks. It is worth noting that the network of vehicle tracks is no more extensive now as those indicated on 1:250,000 mapsheets compiled from 1973 data (D. Ashwell, pers. comm.).

Habitation. Human habitation was noted primarily on the edges of the survey area as shown in Fig. 9. Some of the structures sighted appeared to be unoccupied at the time.

Elephant Tracks. In the areas shown in Fig. 10, the unmistakable footprints of elephants were noted in the dried mud around waterholes or along animal trails, but from their distribution it is believed these probably were made by working elephants, and that the data are therefore probably best interpreted as an index of human disturbance.

Smoke and Fire. Smoke and fire were recorded, whenever seen, as an index of current human activity, most likely hunting or logging (Fig. 11).

Cultivation. Cultivation was noted in the survey area as shown in Fig. 12. Uniform shading denotes recent cultivation, with either crops or crop residues evident in fields with well formed bunds. The checkered shading denotes old and abandoned fields with eroded bunds and without crops.

Figure 4. Visibility Index: map showing visibility in the Mondokiri survey area. Percent of area visible increases with rating index, with 3 denoting 100% visibility (see Table 1).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
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Figure 5. **Distribution of surface water from river sources in the Mondolkiri survey area**

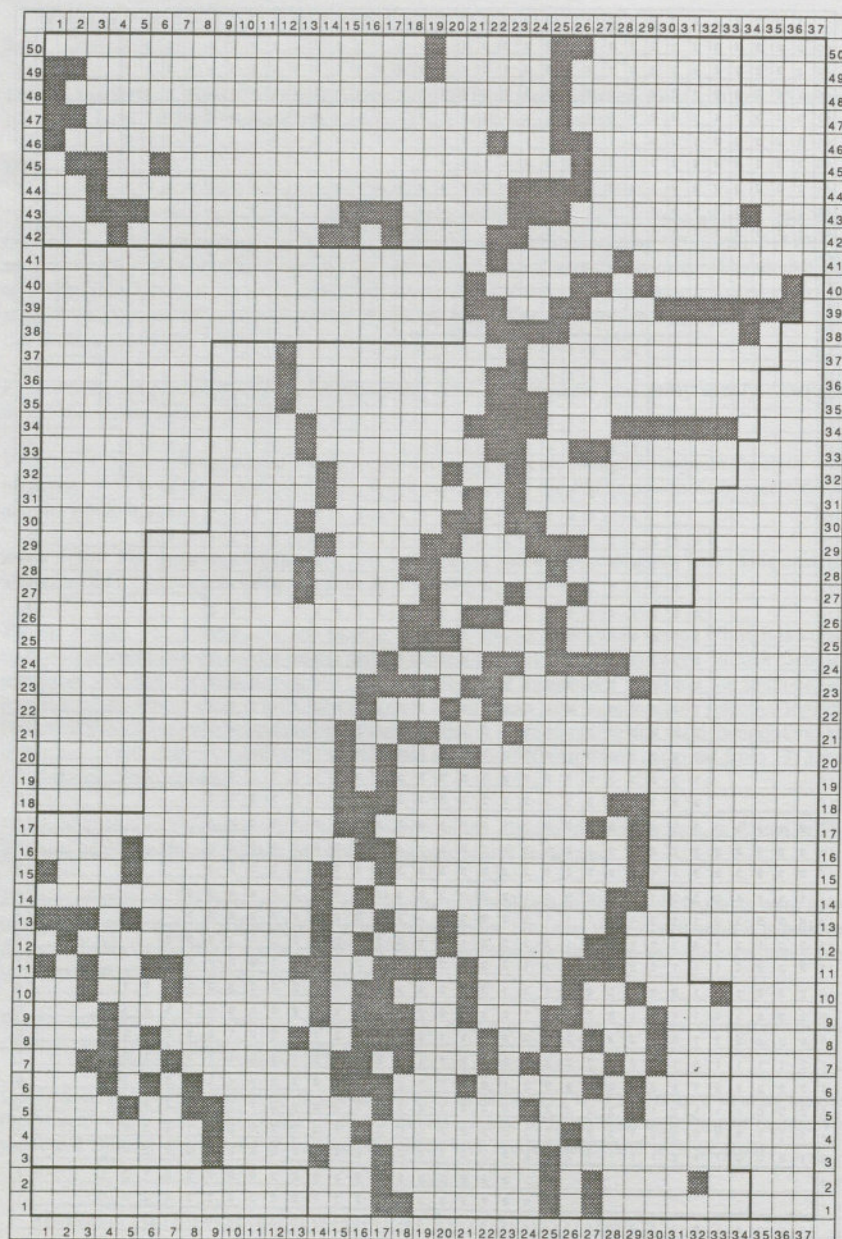


Figure 6. Distribution of water-filled pans and wallows in the Mondolkiri survey area

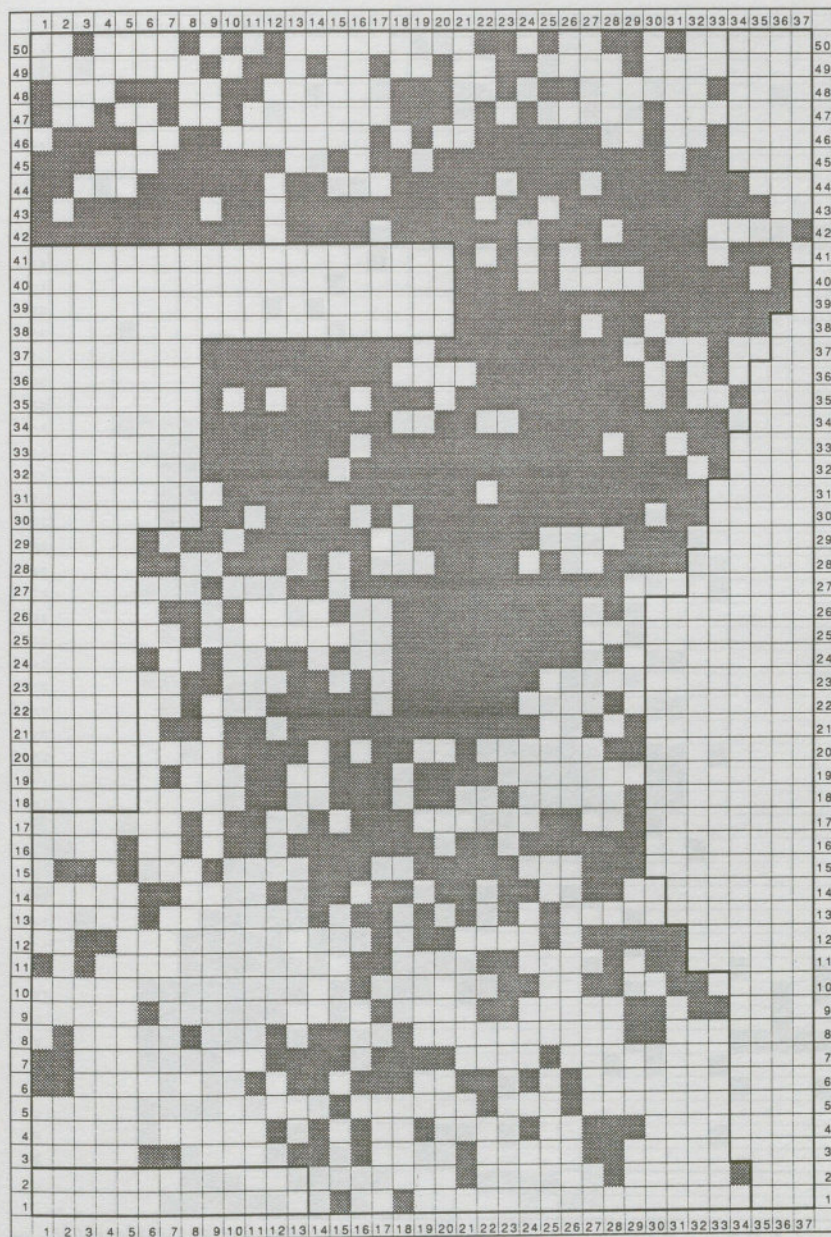


Figure 7. Distribution of grid squares containing burnt areas within the Mondolkiri survey area

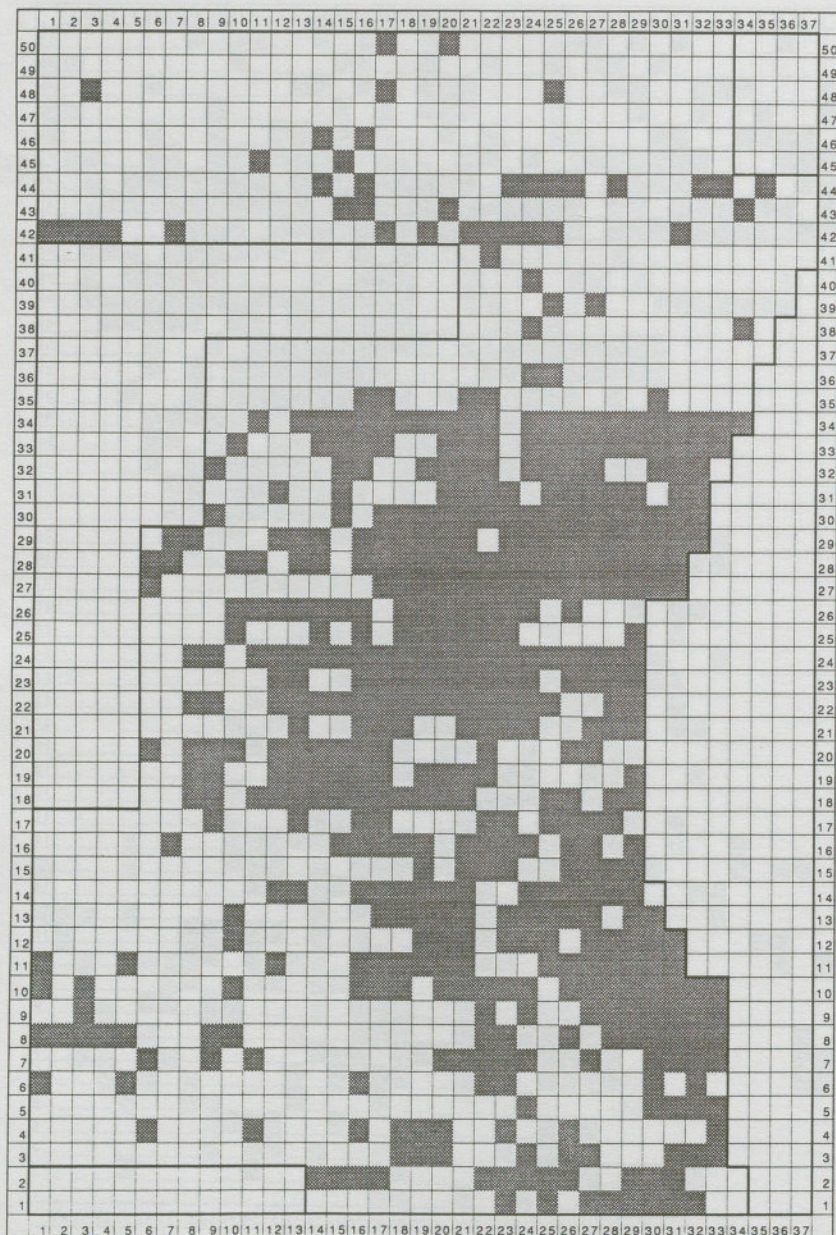


Figure 8. Distribution of vehicle tracks in the Mondolkiri survey area

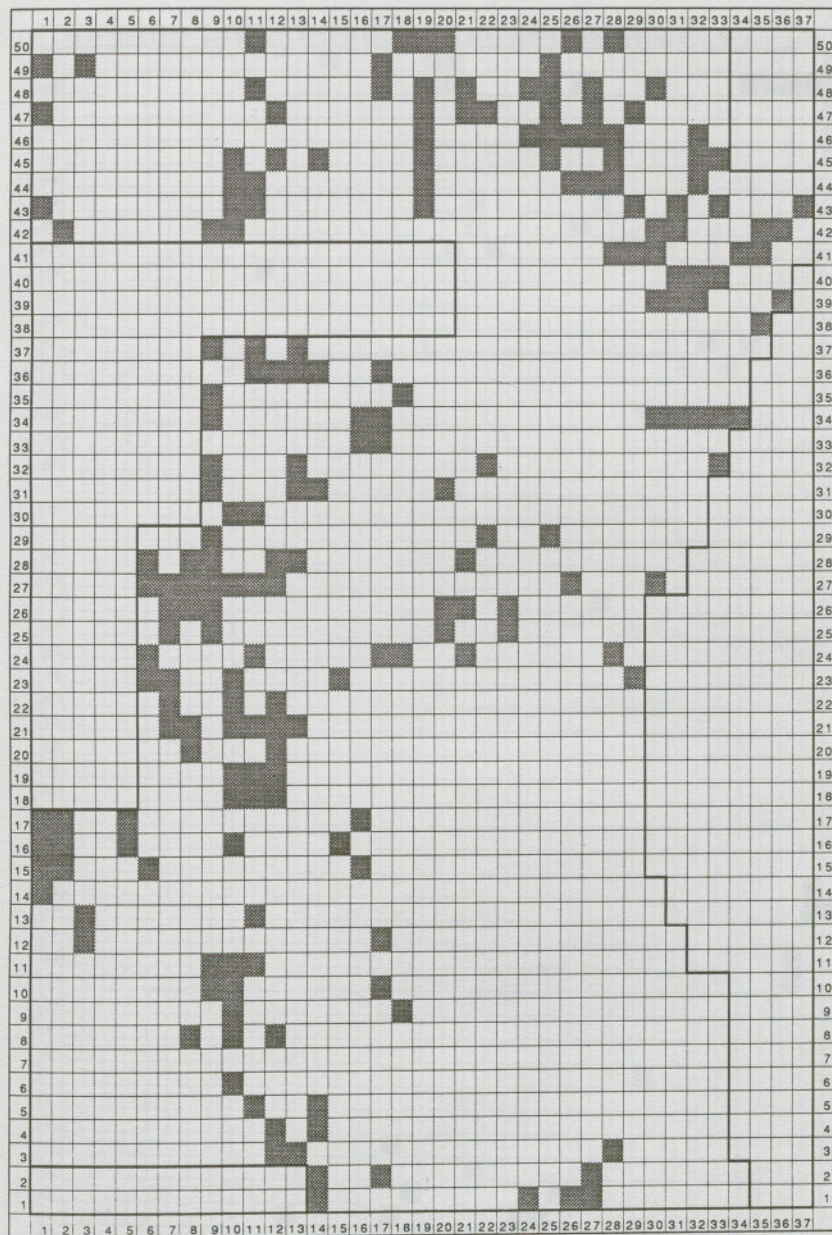


Figure 9. **Distribution of grid squares with human habitation within the Mondolkiri survey area**

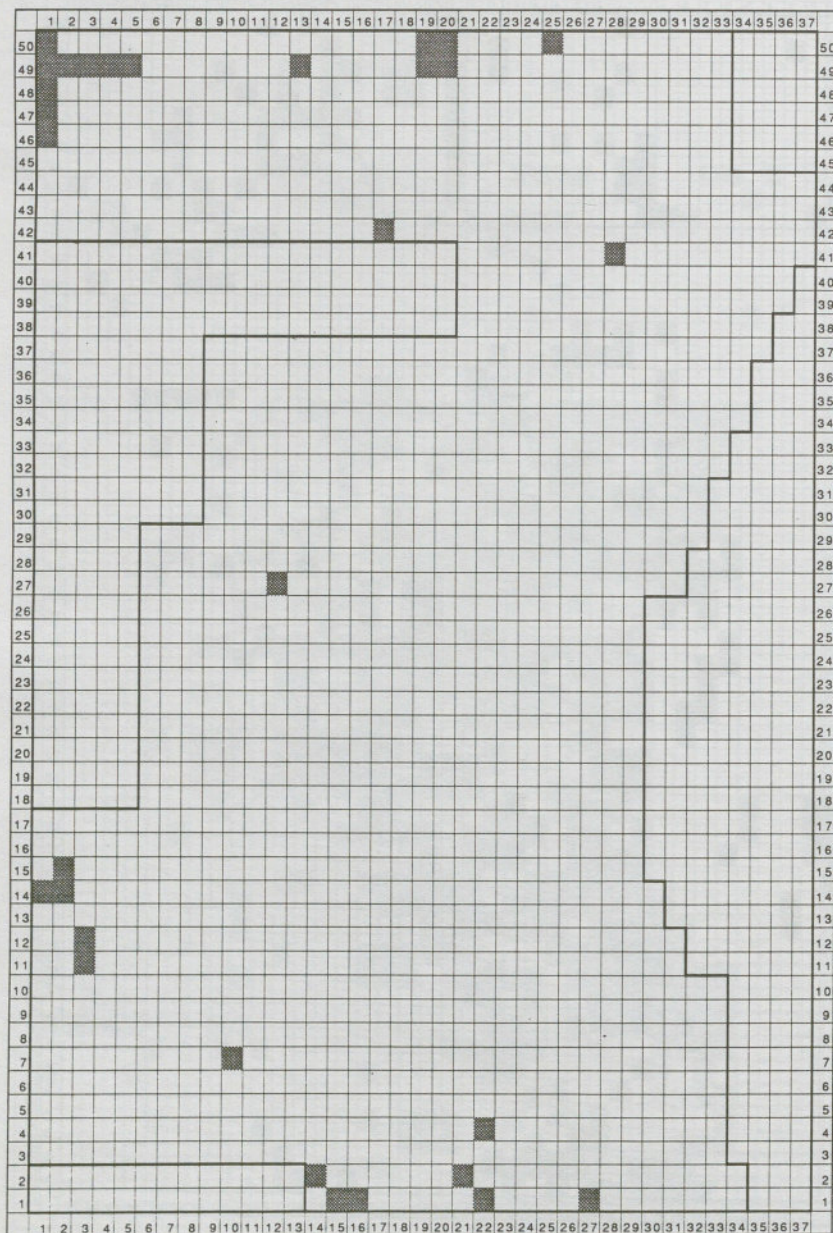


Figure 10. Distribution of elephant tracks noted in the Mondolkiri survey area

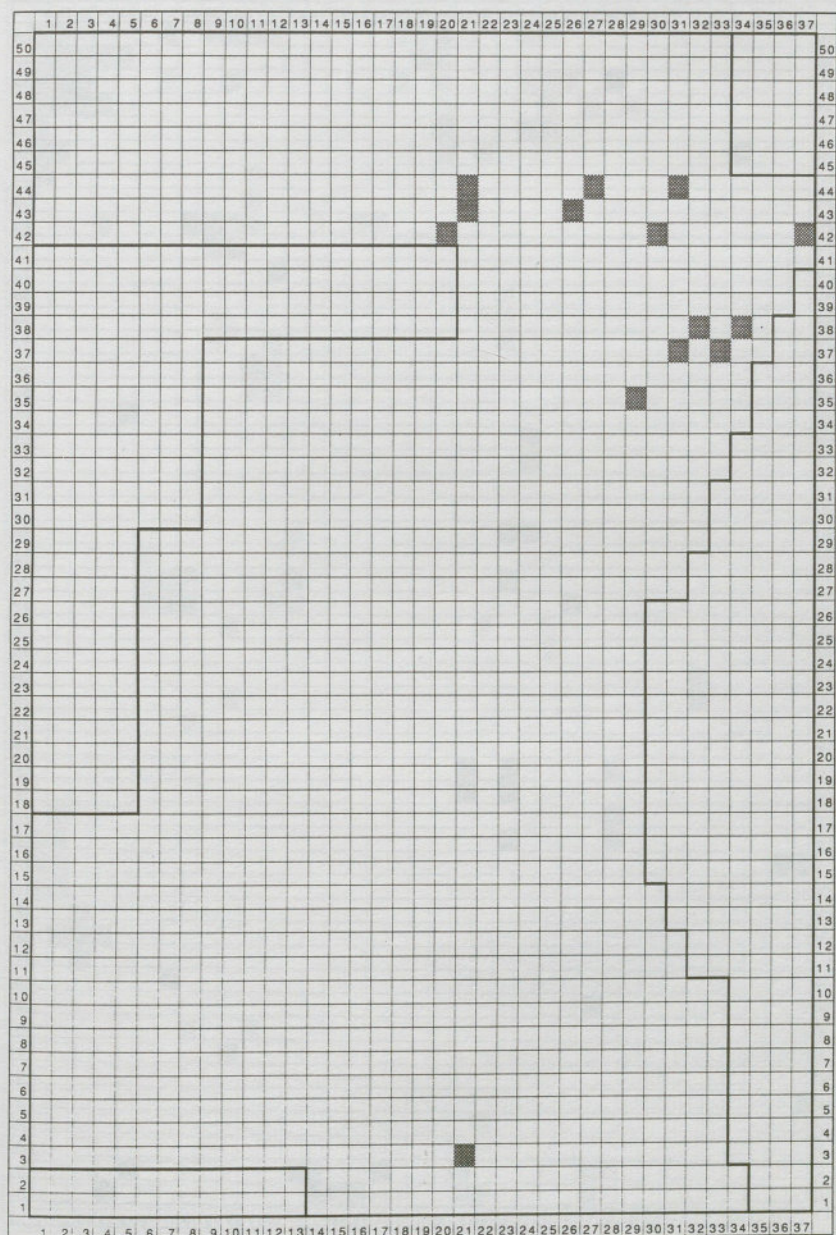


Figure 11. Distribution of smoke and fire in grid squares within the Mondolkiri survey area

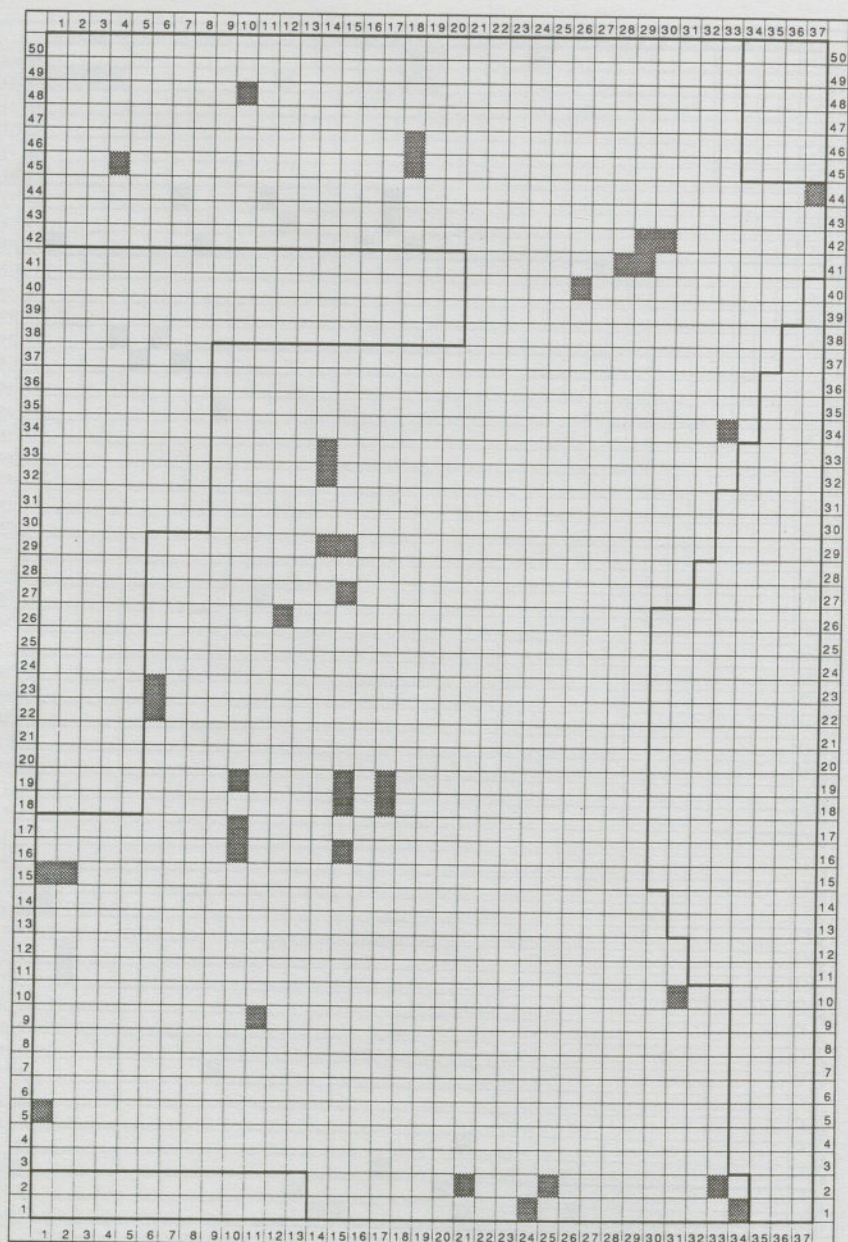
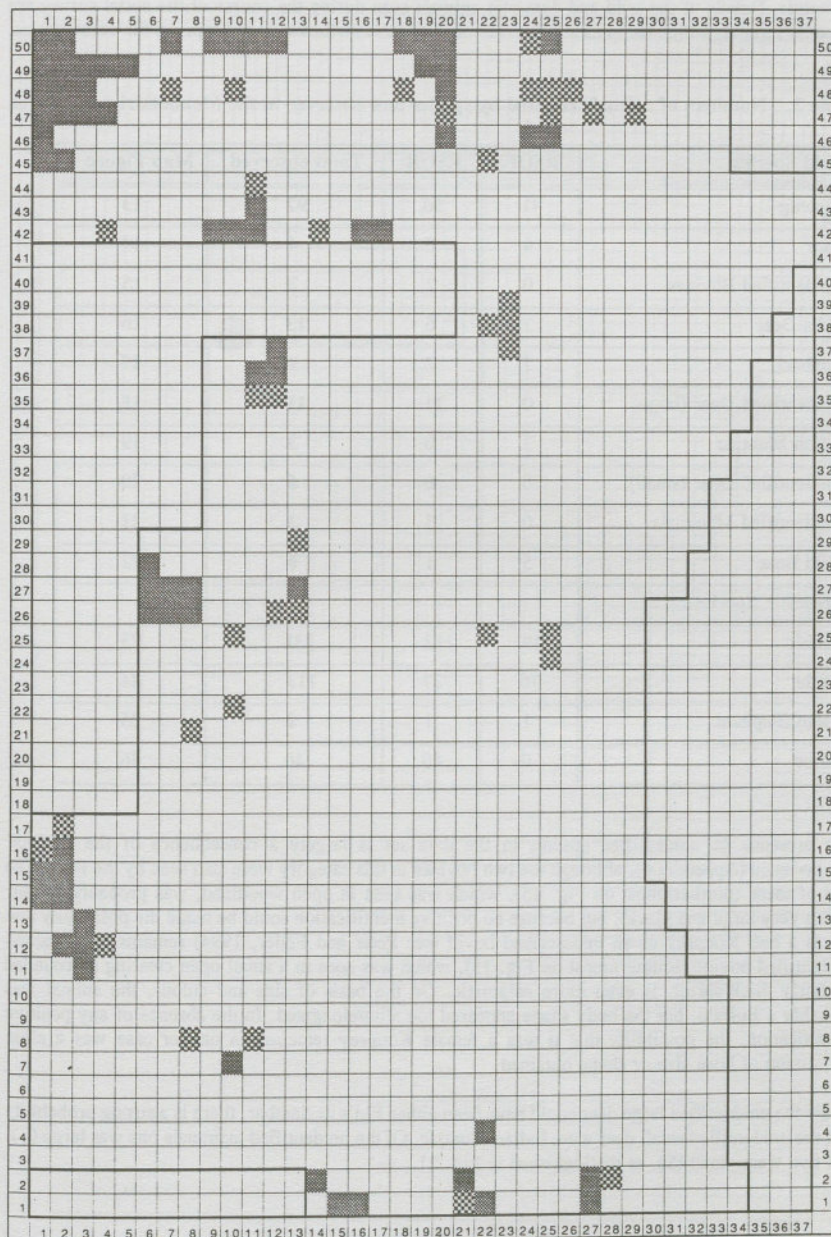


Figure 12. Distribution of cultivation as noted in grid squares during the Mondolkiri survey



3.1.2 Quantitative data

Mammals. Details of the wild and domestic animals seen during the course of the aerial survey are given in Table 2, which includes a cross reference to the distribution map prepared for each species.

Table 2. Numbers of animals counted by species and observer in the Mondolkiri survey area

Wild Species	RSOL	RSOR	Total observed	Map Figure
Banteng	41	56	97	13
Gaur	4	0	4	14
Unidentified Bovines	0	2	2	15
Eld's Deer	7	6	13	16
Sambar	7	2	9	17
Unidentified Deer (large)	0	11	11	18
Indian Muntjac	3	0	3	19
Unidentified Deer (small)	0	6	6	20
Unidentified Mammals	0	3	3	21
Wild Boar	5	1	6	22
Domestic Species				
Buffalo	119	112	231	23
Cattle	76	37	113	24
Asian Elephant	1	1	2	25
Horse	0	40	40	26

The presence of unidentified species in the data set is largely a consequence of the RSORs' inexperience (Appendix 4), although the two bovines in this category were also seen by the FSO. The first of these (northernmost on Fig. 15), which was seen in open woodland, was probably a Gaur (being very large and black), but because no positive identification could be made the possibility that it was a bull Kouprey or an undescribed bovid (see Peter and Feiler, 1994) remains. The second unidentified bovine (southernmost on Fig. 15), which was seen in a small open clearing surrounded by fairly thick forest, is even more enigmatic. On the basis of size and colour, the animal was probably a Buffalo, but the body shape appeared too slim/elongated. In the absence of any positive identification, the possibility that it was a female Kouprey remains. In neither case was a clear impression of horn size or shape obtained.

While the unidentified large deer could have been either Eld's or Sambar, there is a strong probability that the unidentified small deer were Indian Muntjac. Of the unidentified mammals one was large (L), and two were small (S), as distinguished in Fig. 21.

Figure 14. Distribution and number of Gaur observed during the Mondolkiri surveys

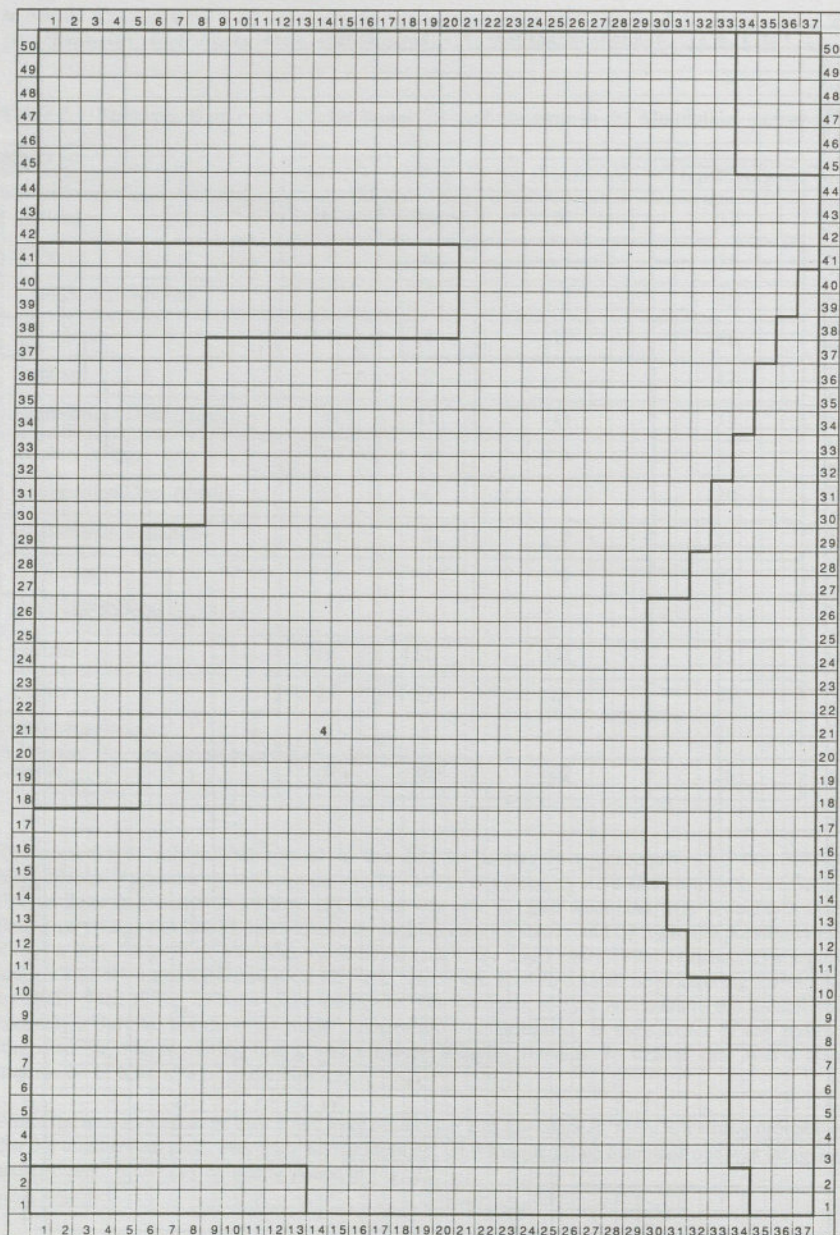


Figure 16. Distribution and number of Eld's Deer observed during the Mondolkiri surveys

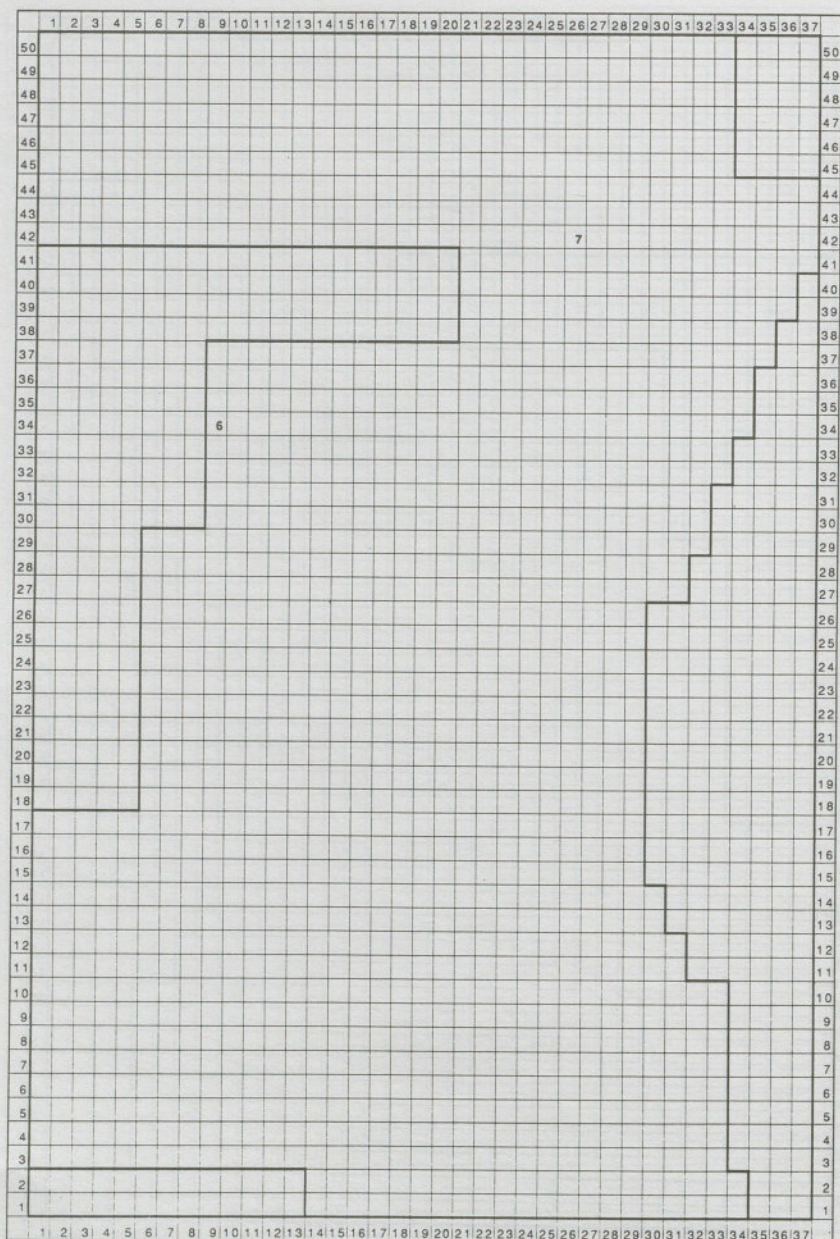


Figure 17. Distribution and number of Sambar observed during the Mondolkiri surveys

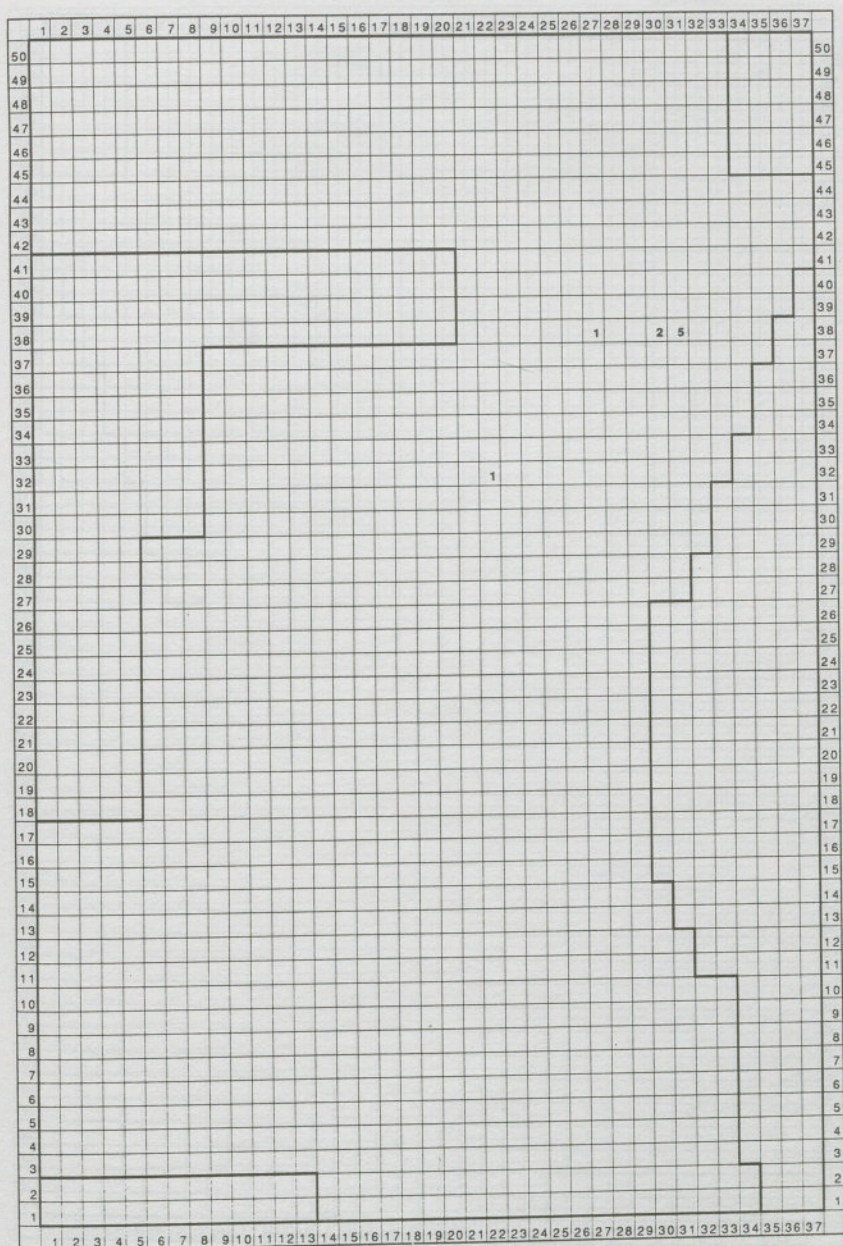


Figure 18. Distribution and number of unidentified large deer sighted during the Mondolkiri surveys

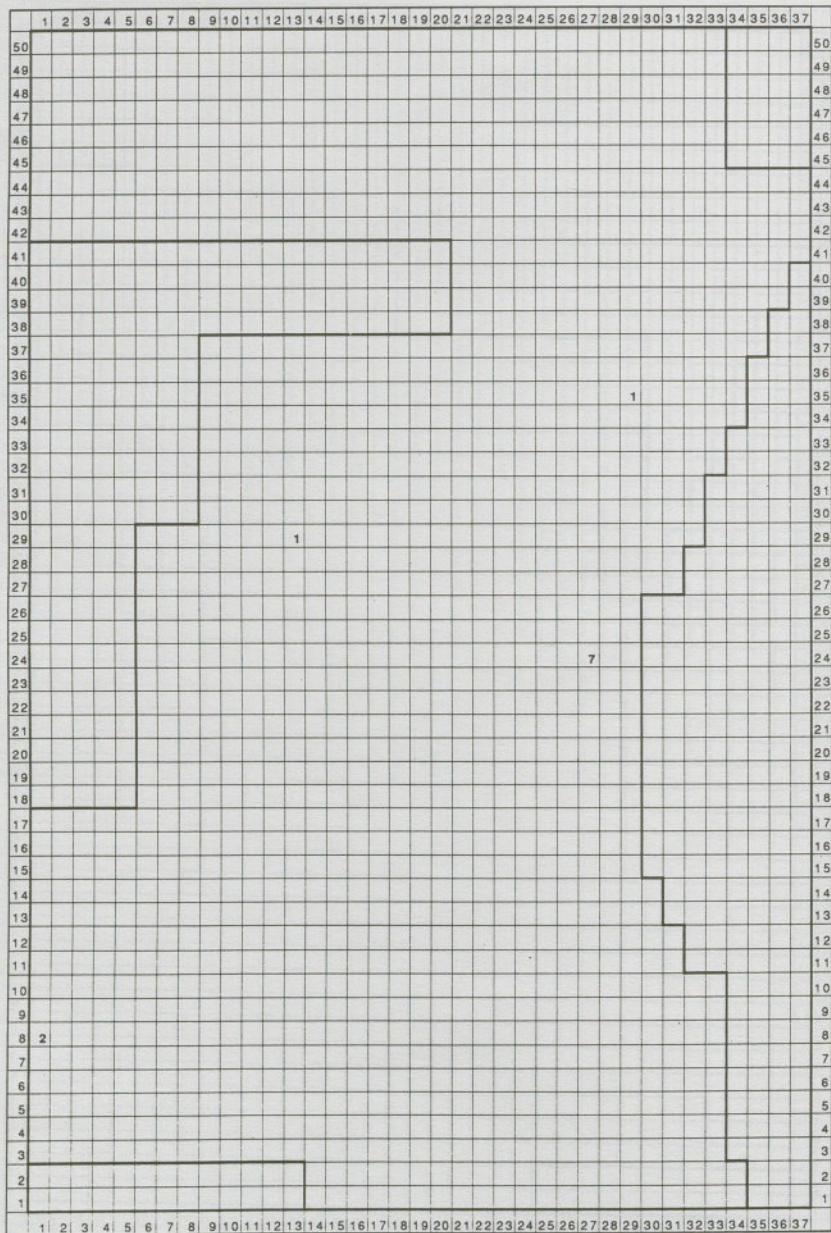


Figure 19. Distribution and number of Indian Muntjac observed during the Mondolkiri surveys

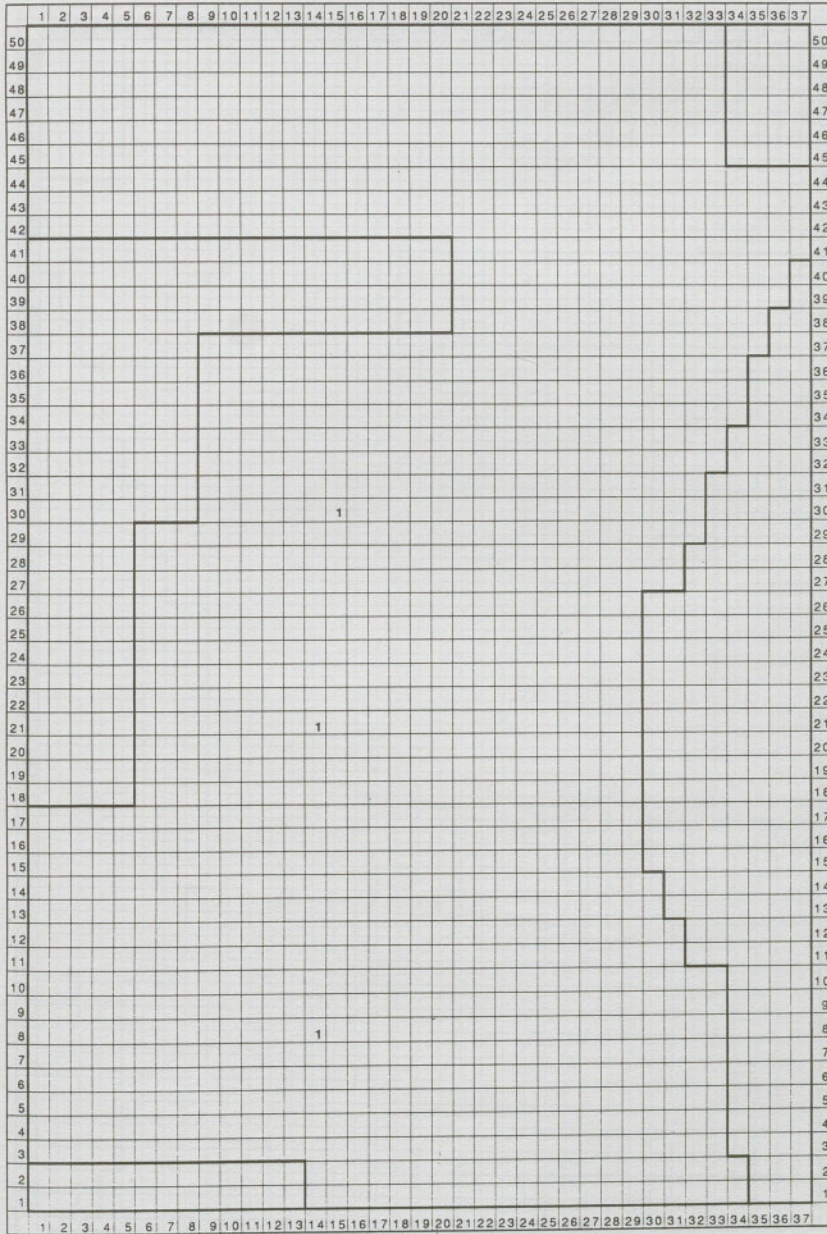


Figure 20. Distribution and number of unidentified small deer sighted during the Mondolkiri surveys

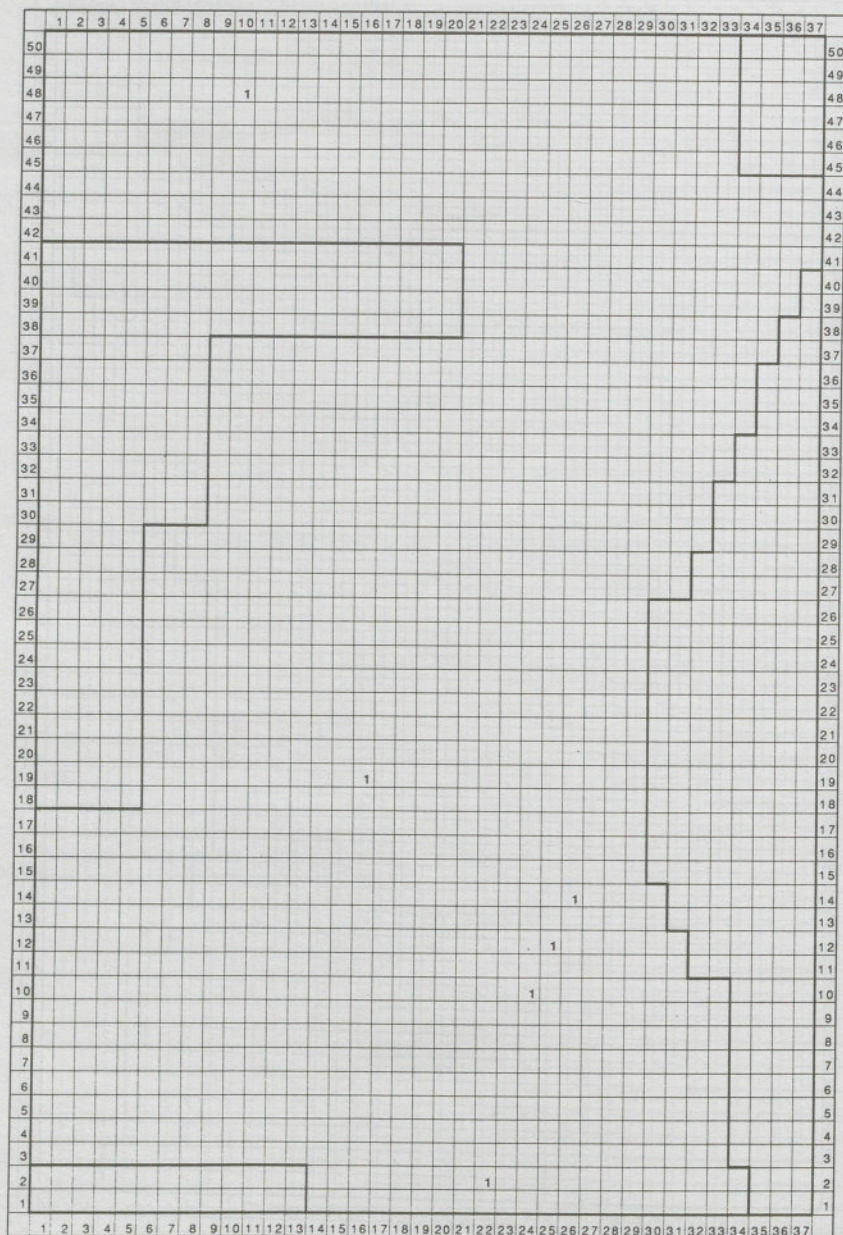
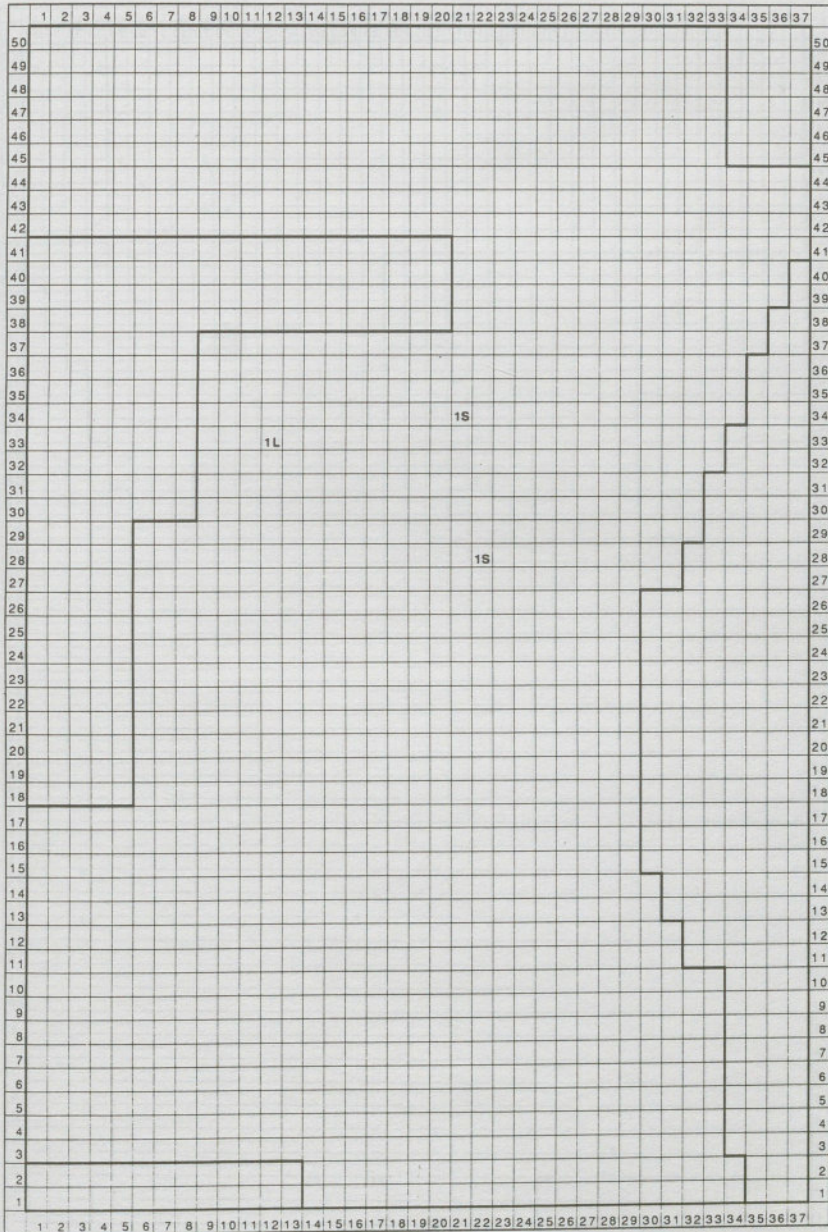


Figure 21. Distribution and number of unidentified mammals sighted during the Mondolkiri surveys



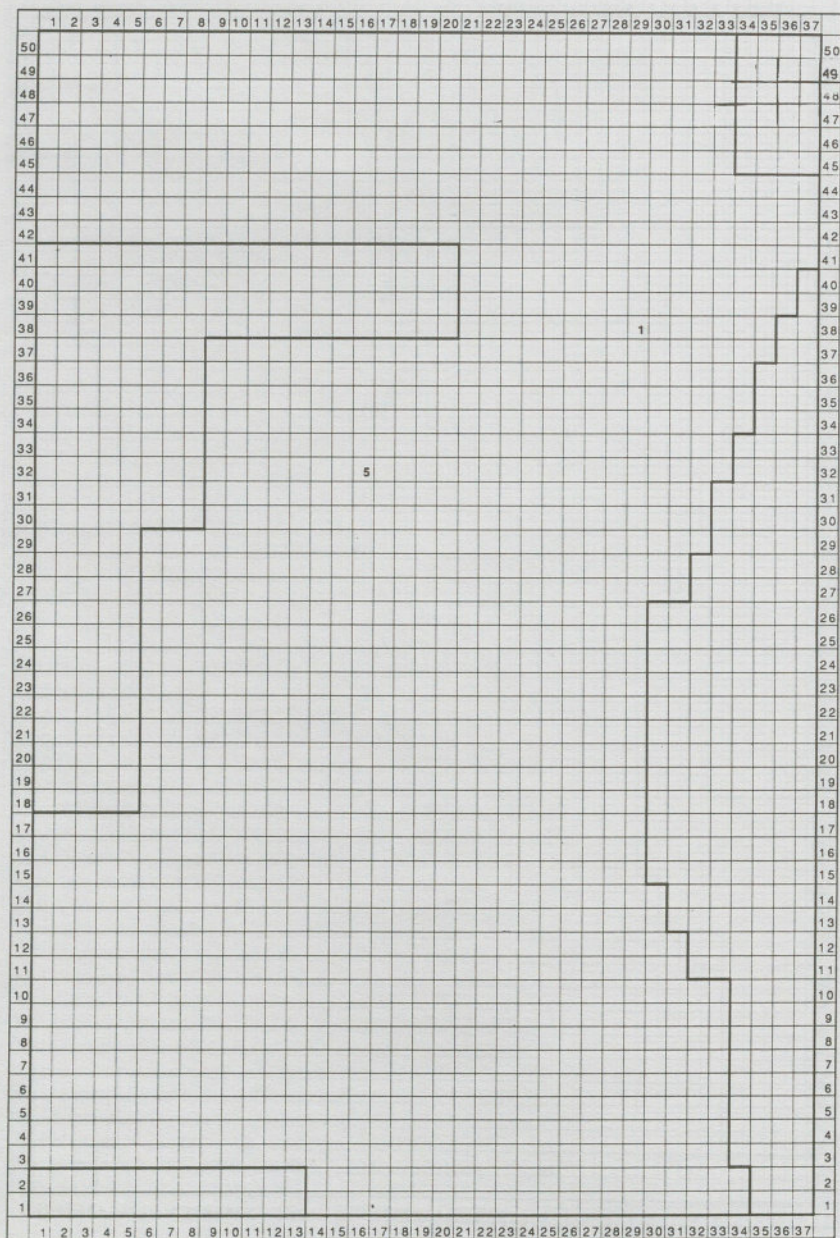


Figure 23. Distribution and number of domestic buffalo observed during the Mondolkiri surveys

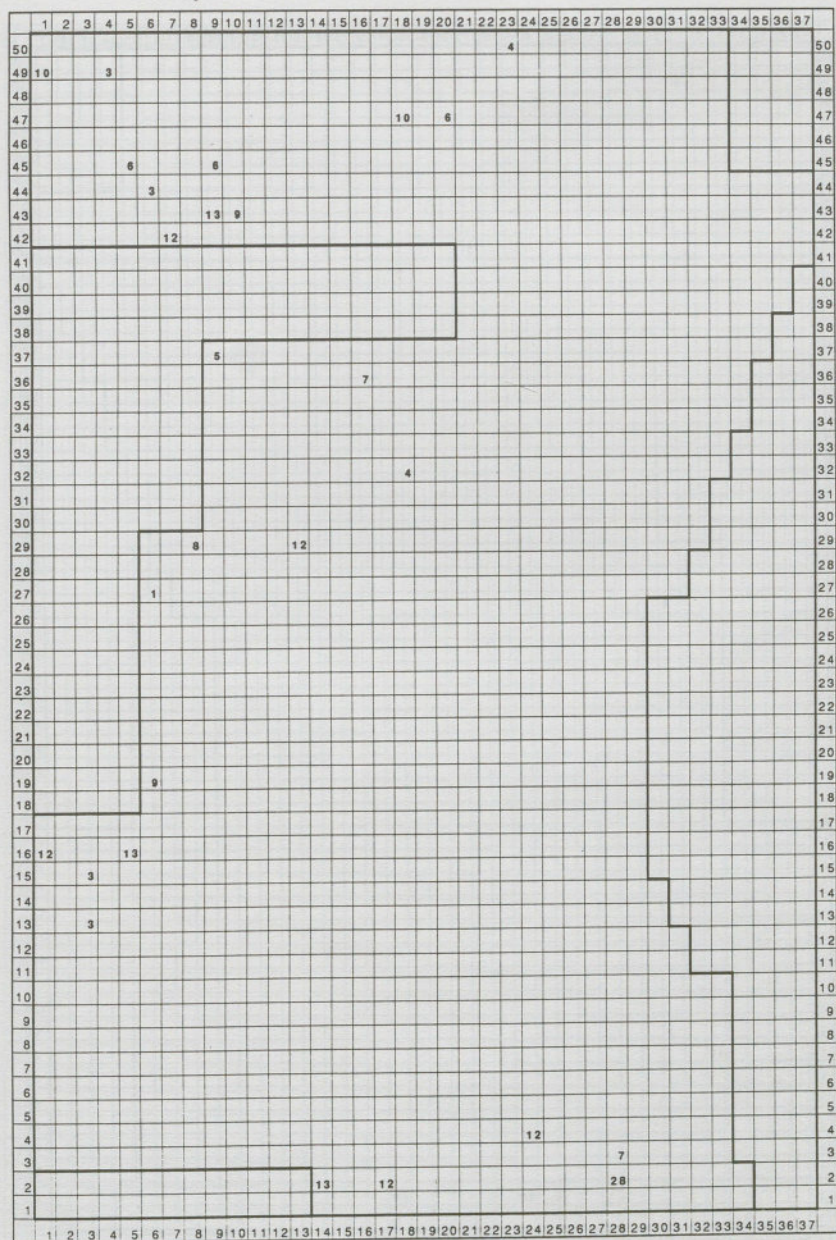


Figure 24. Distribution and number of domestic cattle observed during the Mondolkiri surveys

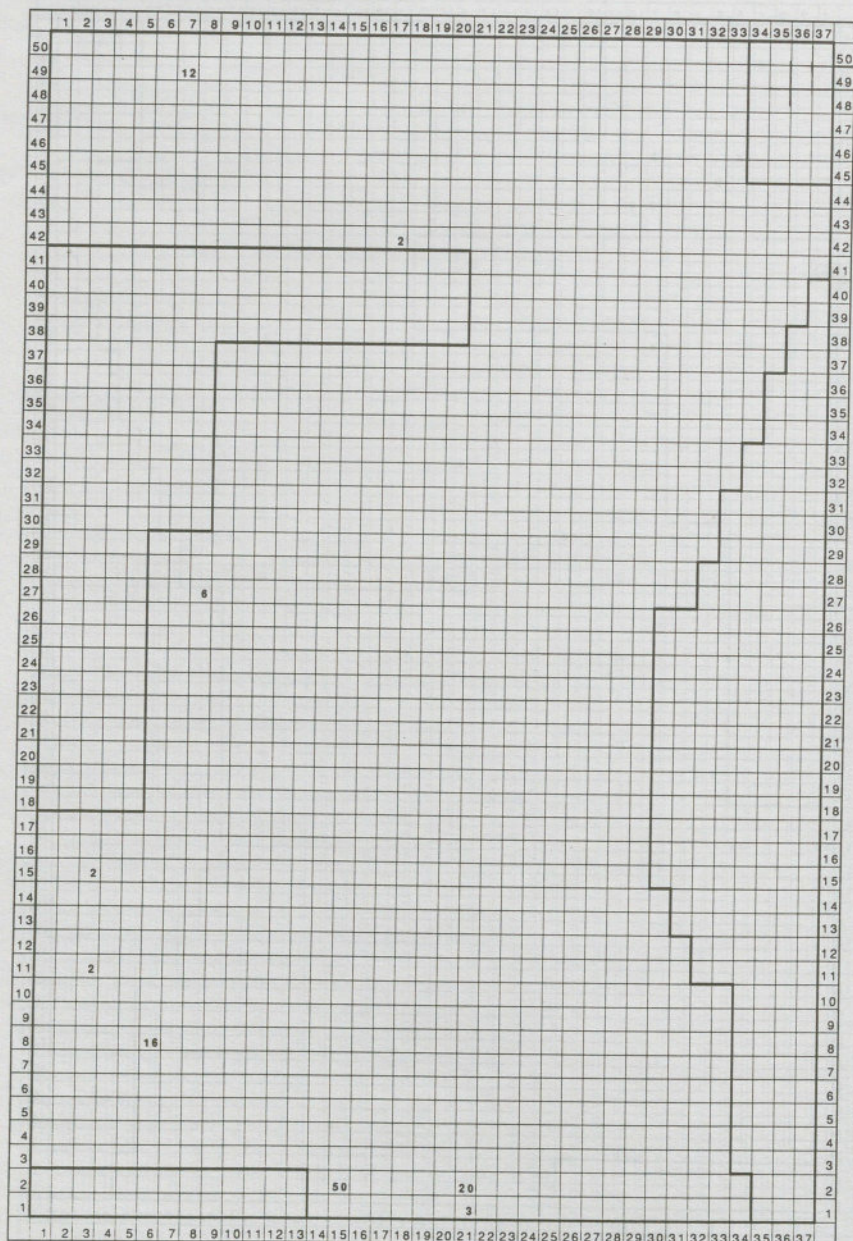


Figure 25. Distribution and number of domestic elephant observed during the Mondolkiri surveys

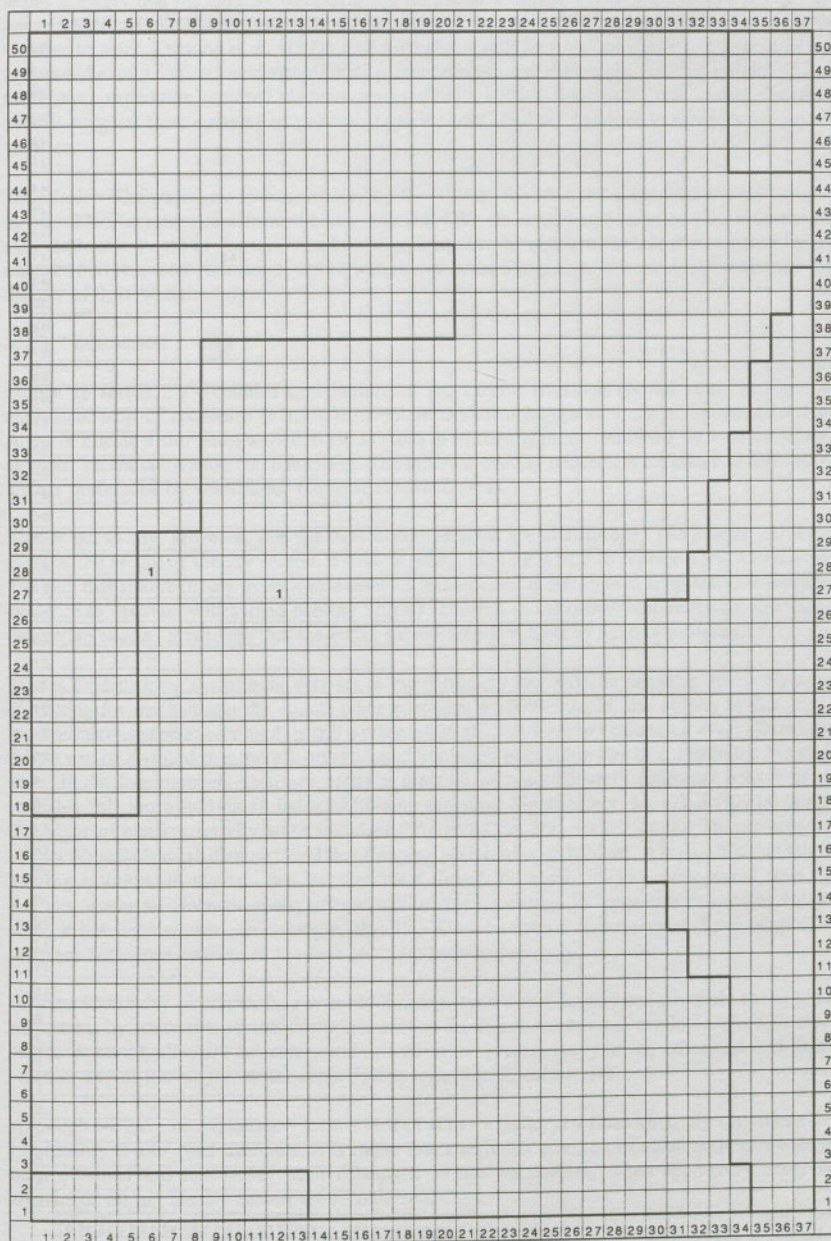
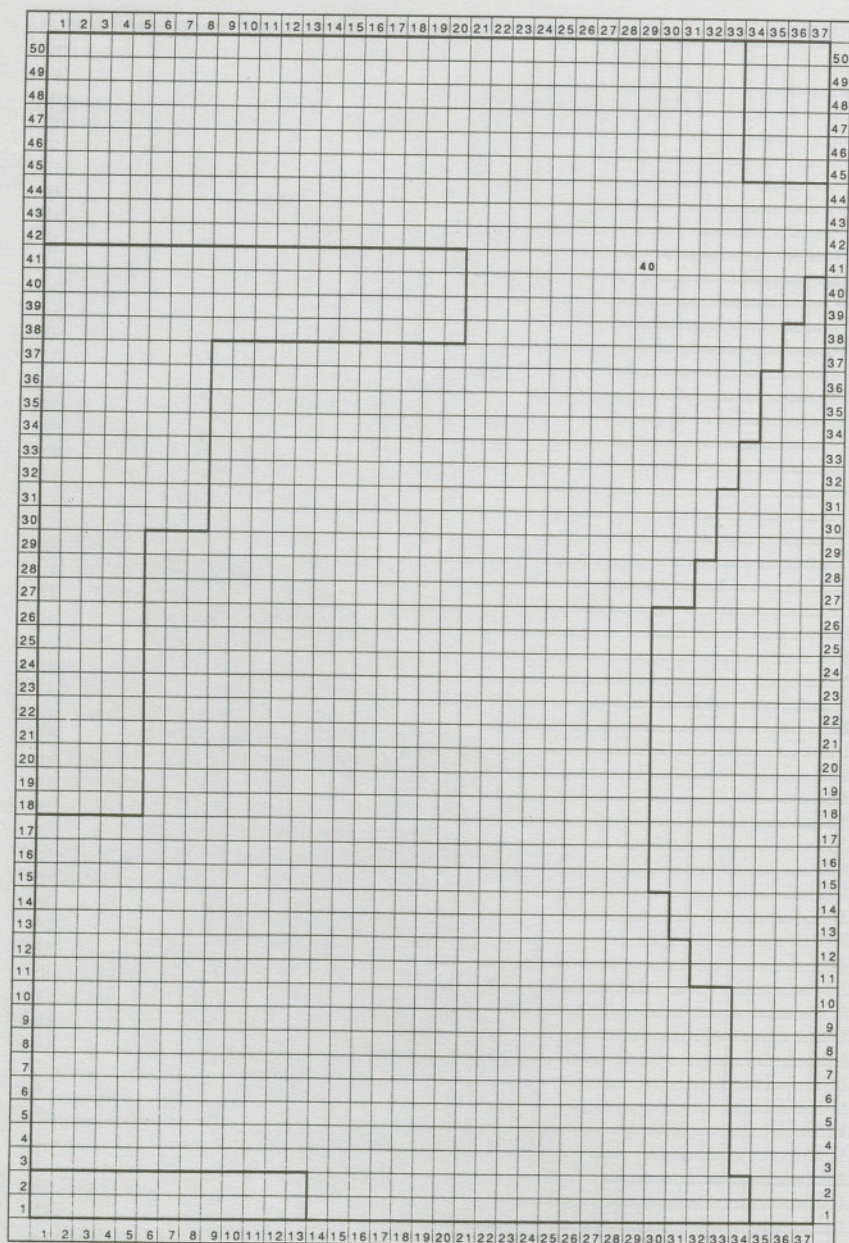


Figure 26. Distribution and number of horses sighted during the Mondolkiri surveys



Although two domestic elephants were recorded, no wild elephants were seen. This was disappointing given advance reports of 200-400 in the survey area (N. Thayer, pers. comm.). Unfortunately, it seems unlikely that the animals were over the border in Vietnam, partly because this is supposedly poorer dry season habitat for water dependent species, with low numbers present in Yok Don from October to April (Dawson *et al.*, 1993), and partly because if they had moved out on a seasonal basis, one would expect indirect evidence of their presence in the wet season but there was none. Although the Thayer expedition reported elephant tracks (Dioli, 1994a), their rarity and limited distribution overall suggests that, contrary to previous reports, wild elephant numbers in the area are probably very low.

Waterholes. The waterhole counts obtained by the RSO on the left hand side of the aircraft are shown in Fig. 27. The total count from the one side was 880. Assuming equivalent numbers on the other side, and taking note of the total number of grid squares in which waterholes were noted (Fig. 6), one can derive a total estimate of 2,432 waterholes in the study area as a whole, giving a minimum density of 0.51 waterholes/km².

3.1.3 Discussion

Figure 28 shows the combined distributions of the various livestock species seen. In Fig. 29 an equivalent map of combined wildlife distribution is shown alongside areas of human disturbance. Areas of human disturbance were defined as those in which any of the following were noted: domestic animals, recent cultivation and habitation. The minimal overlap between these data sets demonstrates a clear preference by wildlife for the least disturbed areas.

That is not to say, however, that the least disturbed areas are undisturbed. The present survey took place at the height of the dry season, a time in which hunting is said to replace agricultural activity. The fact that smoke (likely to indicate a hunters' campfire) was not sighted frequently, is insufficient evidence to discount widespread hunting activity. Bearing in mind that vehicle tracks also facilitate pedestrian access, it is likely that the entire survey area is subject to hunting pressure.

This is evident from the present data set in the extremely low wildlife densities noted. Even when correcting for the fact that the counts made represent an 80% sample, the density of Banteng, the most numerous species recorded, is still a mere 0.026 animals/km², or one animal every 40km². From this, it can be deduced that there is an estimated minimum population size of c. 120 in the Mondolkiri area. If the low numbers seen are partly a function of predominantly nocturnal behaviour, then probably this too would be an index of hunting pressure. Significantly, M. Dioli (1994a) confirms that signs of hunting activity were abundant throughout the area visited by the Thayer expedition. Whilst Wharton's work demonstrated that Kouprey preferred open habitats, it is possible that intensive hunting activities in the last few decades have forced the survivors into sub-optimal, less open, habitats and/or to adopt more crepuscular habits. Such a change in behaviour can not be ruled out since it has been shown, for example, that Roe Deer in Britain and Germany have adopted very different behaviour patterns in the face of heavy hunting pressure.

In areas where dry season surface water is limiting, even a few hunters can decimate the wildlife of huge areas by concentrating their activities around the few water sources available. Fortunately, dry season water supplies are extremely widespread in the present study areas, otherwise it is doubtful whether any of the bigger, water dependent species would still survive.

Although we have no explanation for the lack of active logging at a time when dry conditions would presumably favour road transport, it is likely that a different picture of human activity would have been obtained had the survey been conducted in the wet season, when apparently many areas abandoned during the dry season are recolonized.

Figure 27. Distribution of waterholes (RSO) and number observed in grid squares during the Mondolkiri surveys

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
50		1						1														1	1	1					1								50
49								1						1									2					1									49
48																				1			1														48
47						2		1																					1								47
46	1	1	1	1				3								1	1					1	2	2		1		1		1						46	
45	1	1	1				1	2	4	3	1		1		1		1	3	1	2	1	1	5	1	1	2	1	1		2	3					45	
44	1	2				3	1	4	2	1	1	1				1	2	3	3	1		1	3	2	2	2	1	3	1	2	1					44	
43	1	1		2	2	2	1		2	2		2	2	4	2	1	4	1	2		2	4	1	4	5	2	3	1	2	2		1				43	
42	2	1	3	2	1	1	1		2	3		2	1	1	1		1	1		2	3	2	1	1	1	1	2	1								42	
41																						1	1	1			2	4	1	1		2	1	1		41	
40																						1	2	1	1		3	1	2	1				1		40	
39																							1	3	3	3		1	3	1	1	3	3	1		39	
38																								2	1	4	4	1		2	1		3	2		38	
37								1	1	1				2	3				1	1	2	6	3	1		1	2	1		1						37	
36								3	2	1		1	1	3	3								2	5	3		4	2		2	1					36	
35								3	1		1					1	1					2	1	2	3	2	2		1					1		35	
34								1		1	1	1	1	1					2				1	1	2	1	1	1	2	1	1	1				34	
33								4	1	1	2	1	1			5	1	2	1	1	3	3	1		3	2	2		1	1						33	
32								4	2	1	4	2	3		3	3	4	1	3	1	1		2	1	2	1	2	1	4	3	1					32	
31								2	2	2	2	3	2	1		1	2					2	1	4	2	1	1	2	1							31	
30								3	1	1	1	1		1	2	1	2	2		1	1	2	1	2	2				1							30	
29							1		1	2	1	1	1						3	2	2	1	1					1	1	1						29	
28					6	2		1	1	1		1	2						1	3	2	5	1				2	1	1							28	
27																	1	1	1	3	1	3	2	3	1	1	1									27	
26							1												2	2	3		3	1	2	1	2	3								26	
25							1													1	2	2	1	1												25	
24								1		1											3	3	1	2	2	2	3	3								24	
23							1	1			1	1							2	2	2	2	3	2	2											23	
22							1			1	1	2	1						2	4	2	2	2	1					2								22
21							1	1	1	1	1	2	1	2	2					1	1	2						2								21	
20									2	1	2	1	3	2								1						1								20	
19									1	1			1	2								2	1													19	
18									1			1	1	1	1																					18	
17								2			1	1															2	1		2							17
16						1		1	1		1	1	1								1	1			2	2										16	
15			2									1	1	3					2	2	1	1						1	2	2						15	
14						1	1						1	2	1	1	1	1			1			1		1	1									14	
13													1	1		2	1	1	1			1		1												13	
12				1																1	1			1		1	3	2	1							12	
11																							1	2				1		1						11	
10																							1			1				2	1					10	
9																								1						1	1	1				9	
8			1												1															2							8
7	2	1											6	9	1			1	1	2					1											7	
6	3	1								1	13	2				1				2	1				1											6	
5															1								1			2										5	
4											2				2										2		2	2								4	
3											1	1	2								1								1							3	
2																																					2
1																			1																		1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37

Figure 28. Combined livestock distribution in the Mondolkiri survey area

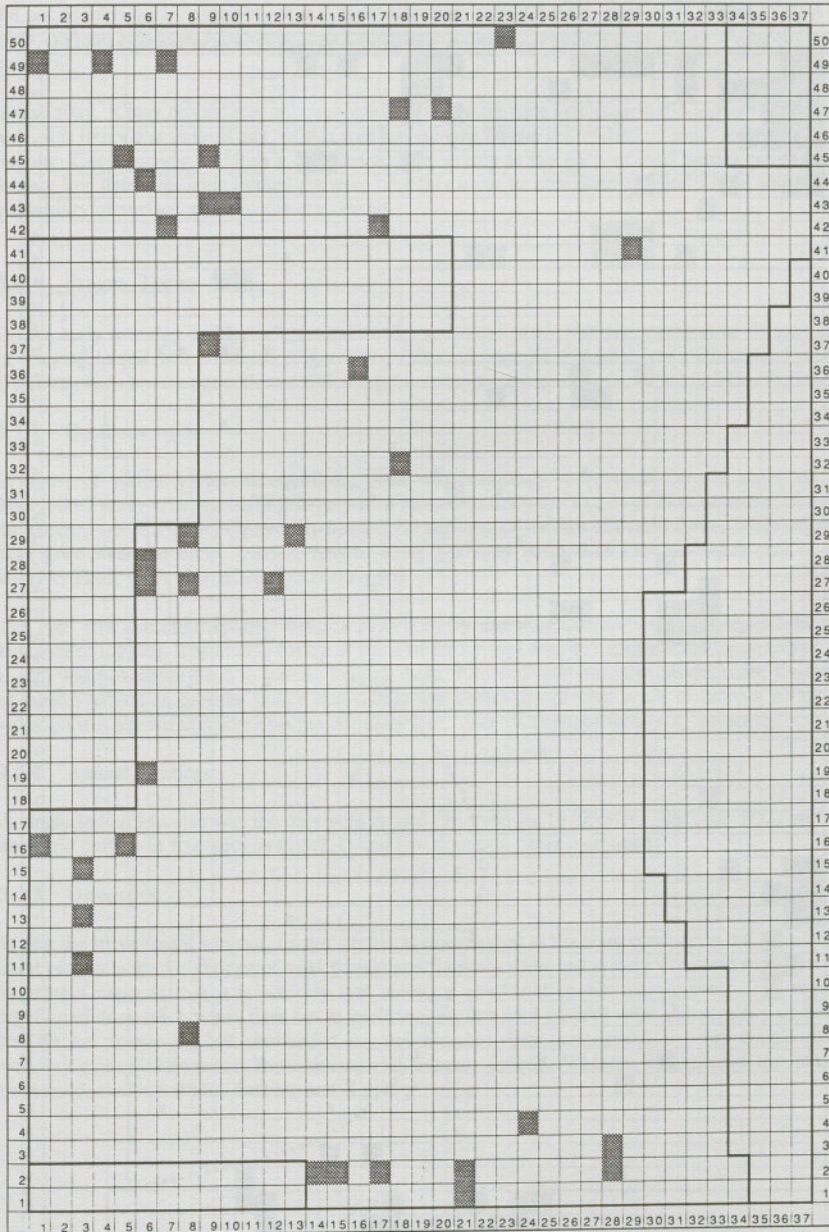
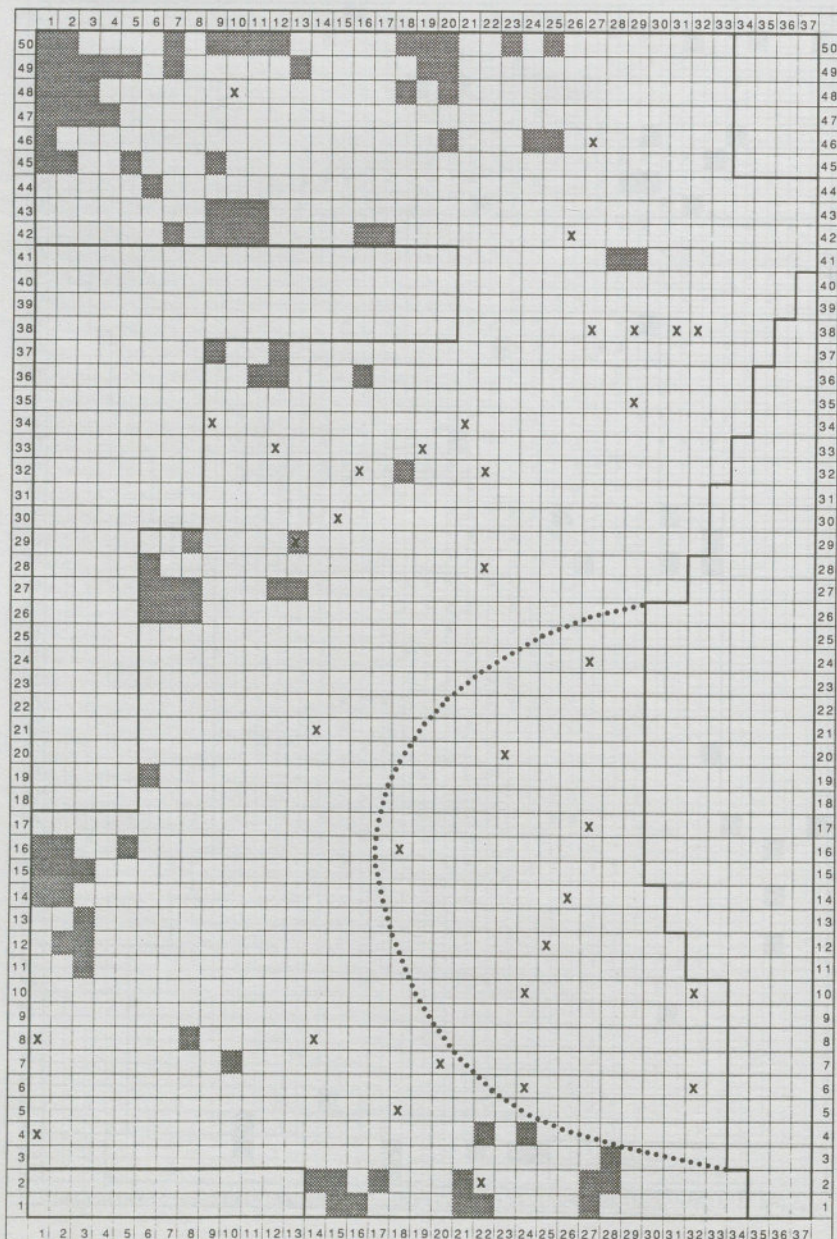


Figure 29. Combined wildlife distribution (X) and areas of human disturbance (shaded). The dotted line indicates a preliminary outline of the core area proposed for protected status (see 4.2.1).



With regard to this area, it is also worth noting that in recent decades a remnant and armed ethnic minority group from Vietnam (known by the political acronym FULRO) lived off the land in this area and fought against Vietnamese authorities from time to time. It is likely that other Cambodian hunters did not use this area extensively at this time. However, the FULRO people were settled in USA in 1993, and the area is now becoming more accessible to other Cambodian hunters (D. Ashwell, pers. comm.).

In summary, it may be said that although wildlife habitat remains extensive in the Mondolkiri survey area, it is likely that little, if any, of this area has escaped human disturbance of some sort, especially hunting. Consequently, wildlife is distributed fairly evenly in the areas of least human activity, but at very low densities. This limited resource probably owes its continued survival to the widespread availability of surface water in the dry season.

3.2 Stoeng Treng

On the early morning of 27 April, a total of 87 nautical miles (>160km), arranged in six transects of varying length was surveyed (Figure 30). Distance between transects was two nautical miles. Quantitative data were not collected following the methodology used by the Mondolkiri survey team.

3.2.1 Qualitative data

In terms of visibility, the Stoeng Treng area was manifestly more open than in much of the Mondolkiri study area, consisting largely of a mosaic (usually on a scale of 1km or more) of open dipterocarp woodland, dry dipterocarp open forest and smaller patches of denser forest. Visibility was very good over the entire transect length, being generally more than 1km on either side of the aircraft. Thus, more than 300km² was surveyed.

The area was substantially disturbed, as evidenced by the wide distribution of vehicle tracks and evidence of logging. The muddy nature of some of the streams near the northern border with Xe Pian (Laos) was presumably due to intense logging there. Fire was seen on only one occasion. Evidence of human habitation (houses and/or rice fields) was commonly present south of latitude 14°08'N, although it is known that some people currently live "near" Kamphuol further to the north.

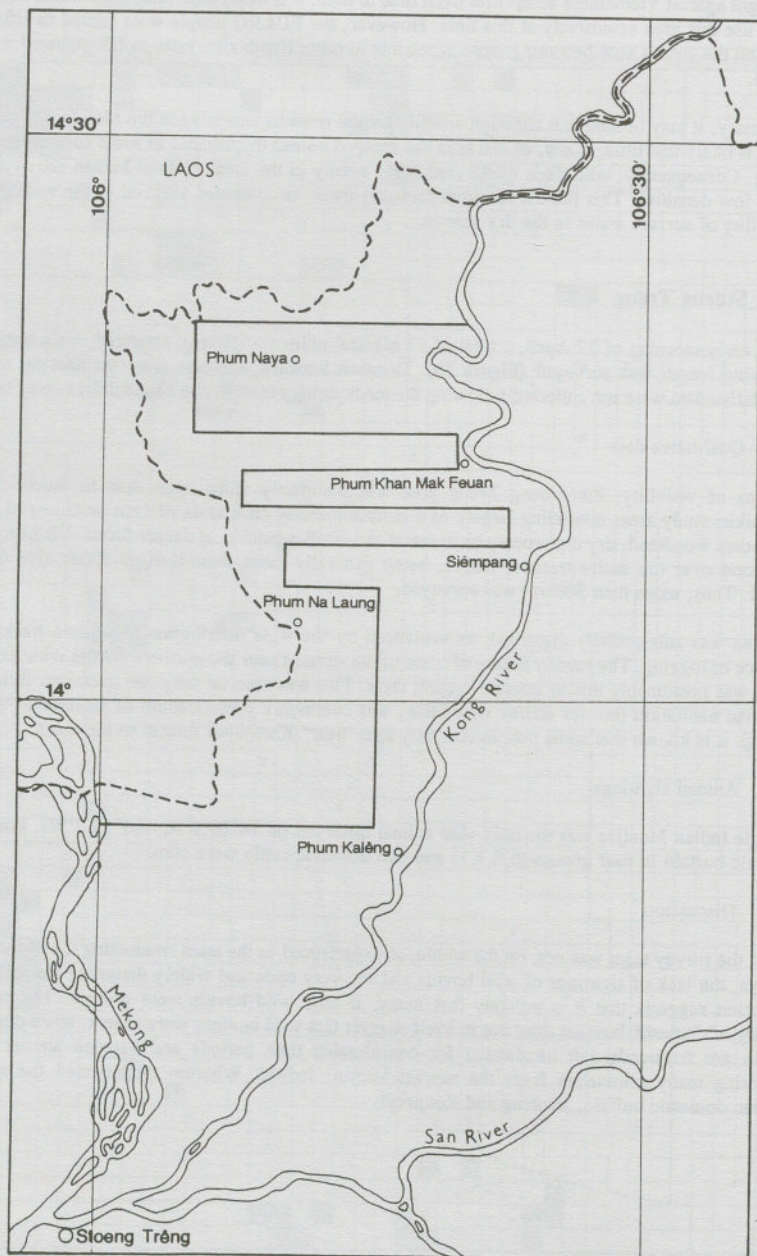
3.2.2 Animal sightings

A single Indian Muntjac was the only wild animal observed (at 14°09.9'N, 106°18.2'W). Fourteen domestic buffalo in four groups (6,5,2,1) and two domestic cattle were seen.

3.2.3 Discussion

Whilst the survey team was not, on the whole, as experienced as the team conducting the Mondolkiri surveys, the lack of sightings of wild bovids and the very open and widely disturbed nature of the vegetation suggests that it is unlikely that many, if any, wild bovids were present. The regular sighting of domestic bovines does not in itself suggest that wild bovines were absent, since domestic buffalo are frequently left unattended for considerable time periods and become almost feral, wandering many kilometres from the nearest human: indeed, Wharton documented the mixing between domestic buffalo, Banteng and Kouprey.

Figure 30. Stoeng Treng survey area, showing the position of transects flown



3.3 Snoul

A brief reconnaissance of the area around Snoul was undertaken on 25 March 1994. Whatever may formerly have been the case (2.2.1), the area now looks very unpromising as Kouprey habitat. The area between Samraong and Snoul is heavily settled and cultivated, albeit in a mosaic with thick forest. To the east of the road between the two towns, the cultivation dwindles out rapidly into a huge tract of closed canopy forest with only the occasional small clearing.

3.4 Kaoh Enchey Island

It was reported to the team that a fisherman in Kratie hospital claimed that there were Kouprey on Kaoh Enchey Island (7km long, 1km wide) in the Mekong, only 70km to the north. The man was later interviewed, and following this a reconnaissance that also took in the adjacent islands of Kaoh Chroem and Kaoh Norong was flown in the afternoon of 17 March 1994.

The forest on all the islands, some of which was very dense, had been extensively logged. Although there appeared to be no habitation in use, there was old cultivation in places, and cattle and buffalo were present. No wild mammals were seen.

4. Conclusions and Recommendations

Although no Kouprey were observed, this survey was the first of its kind in Southeast Asia and, as such, has provided valuable information on large mammals in Cambodia. Rare mammals counted in the Mondolkiri survey area include 97 Banteng *Bos javanicus birmanicus*, 13 Eld's Deer *Cervus eldi siamensis* and 4 Gaur *Bos gaurus*. No wild Asian Elephant *Elephas maximus* were seen. These results suggest that the large mammal populations of eastern Cambodia have undergone serious decline, and that species such as wild cattle and, in particular, Asian Elephant probably occur in the area at far lower densities than previously estimated.

The confirmation of the persistence of Eld's Deer is of particular significance since this species is on the verge of extinction in other parts of its range, such as Thailand, Vietnam and Laos. Banteng populations in Southeast Asia area also in serious decline, despite presence in a number of protected areas, and efforts to safeguard viable populations in Cambodia will be required if they are to survive in this country. Despite the existence of extensive good habitat for wild cattle and other large mammals, active measures to protect them from hunting need implementation if they are to survive in the long term. Evidence collected during the survey suggests that hunting pressure is high throughout their Cambodian ranges.

4.1 The Kouprey

4.1.1 Current status

The failure to spot any Kouprey in the very areas where the prospects of doing so were considered logically the best, inevitably must increase international concern regarding the survival prospects of the species. However, there is still enough evidence from hunters and other sources to suggest that the Kouprey is probably not yet extinct. As mentioned previously, it is conceivable that intensive hunting pressure during the last decades have forced Kouprey and other bovids to adopt more crepuscular habits and/or to spend more time hiding under the cover of trees.

On 17 February 1994, E. Bradley-Martin was shown the skulls of two female Kouprey in a market in Poi Pet, and having seen his photographs the first author (R.O.) can agree with this identification. It is significant that despite being on the Thai border in western Cambodia, the shop owner asserted not only that the skulls came from Mondolkiri in the east, but also that this area was the only recent source of Kouprey material. It is conceivable that the Bradley-Martin skulls are the same as the two female skulls reported by Nash (1992). Dioli (1994b) mentions three skulls in Poi Pet, and one in Phnom Penh. There is no way of knowing how old any of these specimens are.

The Thayer expedition (mentioned in 2.2.1) was in the field from 27 March to 7 April 1994, soon after completion of the aerial surveys. Apart from being in Mondolkiri Province, the exact area covered is being kept a secret, not least because the expedition found a series of footprints that by their shape and dimensions could not be attributed to either Gaur or Banteng, but which fit the description of Kouprey tracks given by Wharton (1957). It was concluded on the basis of these footprints as well as sightings by the team's guides over the previous ten years, that an estimated 7-8 Kouprey almost certainly survive in the area visited (Dioli, 1994a).

On the basis of the aerial data, it can be concluded that if the Kouprey does survive in the surveyed areas, it does so at a lower density than either Gaur or Banteng, species whose density - whatever that really may be - was sufficient nonetheless for them to get recorded, but whose total numbers cannot exceed the low hundreds.

This conclusion can only be countered by evidence for factors that would be likely to make the Kouprey less visible to an aerial observer than the other two species. Documented evidence, in fact, points in the opposite direction. In terms of body and group size, Kouprey should be at least as visible as either Gaur or Banteng. In terms of habitat preferences, Wharton (1957) was quite clear in concluding that of the three, the Kouprey was the species most strongly associated with open habitats. Whilst hunters in Cambodia have consistently insisted that Kouprey is very shy and is found in more closed habitats such as the boundary of open and closed forests (D. Ashwell, pers. comm.), there is no hard evidence at the present time to support this claim. Kouprey, anyway, are likely to move into cover at the first indication of human presence, particularly since hunting pressure has been consistently high.

Whilst all three bovids might have sought shade, it is hard to see how this could have affected their visibility to differing degrees. It was apparent to the observers that it was easier to spot running than stationary animals. Although the Gaur seen did not run, Banteng invariably did and, according to Wharton, Kouprey are the most nervously disposed of the three, so one would have expected them to run also.

There are other factors linked to the Kouprey's apparent habitat preference that would serve to depress its density in comparison to the other two species. Unlike Gaur and Banteng, Wharton never saw the Kouprey browsing, although he was told by locals that tree leaves and fruits were eaten "on occasion". Under the circumstances prevailing in the late dry season, when the understorey of the more open habitats is almost entirely burnt (Figures 4 and 7), a large grazing animal unable to increase significantly the proportion of browse in its diet simply could not attain high densities. Similarly, by being predictably attracted to a scarce resource (i.e., remaining patches of grass), the effects of hunting pressure would be greatly magnified in comparison to species with a more flexible diet. A possible greater dependence on scarce salt resources would have a similar effect.

The question thus arises as to whether the Kouprey could still survive at greater density in some other more favourable habitat. By definition, this would be more open, with better dry season grazing and less dry season burning. The habitat in the Chhep area is reported to remain much as Wharton described it, with truly open grassy glades more abundant than in the Mondolkiri area and it is probably a safe conclusion to say that the grazing available would be better than in Mondolkiri. Similarly, the presence of large termite mounds in the Chhep area suggests salt licks may also be more widespread there than in Mondolkiri. Suitable patches of open forest and grassland, each up to a few kilometres in extent, also occur quite extensively within the Lomphat Wildlife Sanctuary (D. Ashwell, pers. comm.).

However, the extent of this "optimal" habitat is almost certainly tiny in comparison to the woodlands of Mondolkiri, in which case an animal as large as a Kouprey remains extremely vulnerable to hunting in such open country, even if essential resources are less patchy. This could explain why the areas chosen by Wharton as the best suited for a Kouprey study seem to be the same as those in which it was first hunted out (2.2.1).

The Kouprey thus appears to be in a "no win" situation. It offers an easy target in its optimal habitat because of its open nature and limited extent. Optimal habitat probably never was extensive, at least within the period of the species scientific existence: it was already rare when first described (1.1). Although sub-optimal habitat is still widespread, it has a low carrying capacity. Although this sub-optimal habitat offers more cover, the Kouprey remains vulnerable to hunting throughout its range.

4.1.2 Further action to locate the species

The Kouprey is of sufficient interest and importance, both to the Cambodian people and internationally, to merit a continued effort to locate survivors. As shown by the present work, if

Kouprey do survive it is at such low densities as to render a continued aerial search cost-ineffective as a primary location method. On the other hand, the ground surveys for Kouprey have received a similar judgement (1.1). However, unless the search is to be abandoned altogether, the shortcomings of those surveys must be examined and overcome to the extent possible. The problems with the IUCN supported ground surveys carried out to date are:

- (i) political circumstances limited the choice of survey areas to ones outside Cambodia where the relative chances of finding Kouprey have always been considered poorest; and
- (ii) very short time frames obliged the surveyors to act on the information immediately available, which was limited and of uncertain quality. Previous ground surveys were badly planned or suffered undue hardship in execution. With more time, it would be possible to conduct necessary preparatory research to identify the most promising areas for survey. With an extended presence, it also becomes possible to mount a rapid response to random new reports.

The first constraint changes often, and if circumstances change unfavourably and ground survey in Cambodia is again deemed impossible, then the search for Kouprey probably is best postponed. The key to a successful ground survey in Cambodia thus lies in resolving the second constraint.

If the results of the Thayer expedition are accepted, then this can be considered "high quality" information on the basis of which a second expedition to the same area would be justifiable. Nevertheless, a period considerably longer than 12 days is to be recommended, as well as a smaller and more scientific team. If an unequivocal Kouprey location is pinpointed, a subsequent intensive aerial search of that locality would be worthwhile if it could be mounted without too great a time interval.

If the Thayer results are discounted, or a follow-up expedition is mounted and fails, then the second constraint can only be resolved by designing a project with a time frame that allows the development of an optimal information base.

The approach recommended would involve a ground survey project of a minimum two years' duration, coordinated by a promising wildlife biologist working with two or three Cambodian counterparts. The individual chosen should be prepared to spend long periods in the field under uncomfortable conditions. This suggests a young person without family ties. Since so much of the relevant information is transmitted verbally, the coordinator will need to learn Khmer, and so needs to have a proven language aptitude.

The recommended strategy would be to design and mount a press and radio campaign aimed at exposing information known to hunters and loggers that would otherwise not come to light. This requires (a) an incentive, presumably a reward, but designed in such a way that it does not encourage the killing of Kouprey and (b) a network through which information can be passed reliably and as quickly as possible from the man in the bush to the project coordinator.

It is suggested that initial priority be given to setting up this campaign and network, which would be sustained throughout the life of the project. Once established, however, the coordinator and counterparts should visit selected areas and conduct intensive local surveys. Although Kouprey would remain the species of prime interest, it is suggested that these surveys be conducted in the guise of a general large mammal survey for two reasons. Firstly, any overt interest in the Kouprey is likely to stimulate responses that might otherwise not be provided: information about the species unearthed by an unfocussed enquiry built on carefully structured questions is likely to be far more robust.

Secondly, very little is known regarding the distribution and status of other Cambodian large mammals, several of which may be globally or locally endangered, and this information can be gathered at virtually no extra cost.

Attending to any "hot tips" reaching the team via the dedicated Kouprey information network would always take precedence over the more routine and systematic approach described latterly. In this way, it is hoped that the chances of both obtaining and successfully following up reliable information about the Kouprey will be maximized, while at the same time returning information on a range of species that will prove valuable in planning protected areas and wildlife management strategies.

4.1.3 Action to conserve the species

As and when located, concerted action must be taken to try and improve the Kouprey's conservation status. This is almost certainly so critical that *ex situ* as well as *in situ* measures must be considered.

M. Dioli's (1994b) proposal that he "try to capture a juvenile male Kouprey" would in itself contribute nothing towards an *ex situ* programme, and merely further erode the viability of the surviving wild population. It is suggested that IUCN, with advice from the relevant SSC Specialist Groups (Captive Breeding, Veterinary), raises this matter with the Cambodian authorities to ensure no such attempts at isolated capture are permitted.

A better, albeit expensive, strategy might be to attempt to capture an entire group by funnelling into a stockade. In any case, a capture operation and subsequent captive breeding programme along the lines envisaged in the Kouprey Action Plan (MacKinnon and Stuart, 1989) must remain an option which, if exercised, must be an international effort involving the most experienced personnel available. That said, however, any captive breeding programme could and should be located in Cambodia itself.

Any *in situ* measures will centre on protected areas. If none exists in the area where Kouprey are discovered, one should be newly created, the size of which would need to be large. Either way, there will be a requirement to establish an effective management presence, something that is lacking in all protected areas at present (1.2). Enforced hunting restrictions will also be necessary, since habitat protection alone is clearly insufficient to protect large mammals such as Kouprey. Prohibition of the sale of bovid horns, meat etc. would assist in implementation of a hunting ban.

4.2 Wildlife Management in Cambodia

4.2.1 Protected areas

As noted in the introduction (1.2), the current protected areas of Cambodia were established without reference to current data concerning animal populations and distribution, and may therefore be anticipated to have some shortcomings as far as the conservation of large mammals is concerned. Given the provision of Article 3 of the Declaration, which states that the "protected area system may be amended or extended in the future on the basis of scientific information relating to biological conservation", the present results merit consideration in this context.

Although the bulk of the Lomphat and Phnom Prich Wildlife Sanctuaries lay to the west of the Mondolkiri survey area, the data obtained indicate an overall trend of lessening human influence and higher wildlife densities as one moves east and south. The south eastern corner was the only extensive part of the study area in which no vehicle tracks were noted (Fig. 8). On faunistic grounds at least, this area may be more worthy of conservation status than those presently declared east of the

Mekong². The idea is reinforced by contiguity with the Yok Don Reserve in Vietnam, offering the possibility of a transfrontier conservation area that would protect the dry as well as wet season ranges of species known or suspected to undertake seasonal movements across the border, including Kouprey and Asian Elephant. Nevertheless, further assessment of the relative importance of such a reserve and those already gazetted at Lomphat and Phnom Prich are required, and such an assessment should be made a priority in future conservation planning in this area.

A new reserve in the Mondolkiri survey area might be important for the conservation of Gaur *Bos gaurus* and/or the mainland race of the Banteng *Bos javanicus birmanicus*. According to Hedges (in prep.), modified by Berkmuller *et al.* (1993) with respect to Laos, the confirmed or suspected presence of Gaur is recorded in about 220 existing or proposed protected areas in nine countries other than Cambodia, while that of the mainland Banteng is recorded in about 50 existing or proposed protected areas in four countries other than Cambodia. Nevertheless, these bovids are severely threatened in most parts of their range in Southeast Asia, where uncontrolled hunting is of major concern.

Disturbing reports that highlight these concerns as they relate to Indochina include those of M. Phipps who encountered a trader from Lomphat who reported that between 1988 and 1993, 100-150 bovid trophies were purchased per month during the dry season (staff of the Wildlife Protection Office believe that this figure was too high, although numbers probably exceeded 150 per season). Of these, approximately 60% were said to have been those of Gaur and 40% Banteng. During December 1993 a larger harvest than usual occurred³, with almost 300 skulls/horns of wild cattle being sold in Lomphat, just prior to the departure of the FULRO people (pers. comm. to TRAFFIC Southeast Asia and D. Ashwell). Furthermore, 100 pairs of horns of Gaur and Banteng, and three pairs of horns of wild Water Buffalo were counted during a brief 1991 survey of markets in Laos and along the border between Laos and Thailand. Also counted were the horns of eight Eld's Deer (Srikosamatara *et al.*, 1992).

The creation of such a reserve would also make a significant contribution, particularly if it were contiguous with Yok Don in Vietnam, to the conservation of the Indochinese race of Eld's Deer *Cervus eldi siamensis*. This species has recently been recorded from only three reserves in Vietnam, including Yok Don; two in Thailand; and one in Laos and is seriously threatened, or perhaps extinct in some of these (WCMC print out, May 1994; Ratajszczak, 1991; Berkmuller *et al.*, 1993; W. Duckworth, pers. comm.).

The inclusion of a stretch of the Srepok River in any such protected area would ensure that riverine habitats were represented and greatly enhance tourism potential. A preliminary outline of the core area proposed for protected status is given by the dotted line on Fig. 29.

The outline shown incorporates a large proportion of the area which N. Thayer asked the team not to fly over until an agreed date (2.2.1). It is likely, therefore, that the locality in which his expedition

2. It is notable however that 27 Banteng were seen in the small part of the Phnom Prich WS that fell into the extreme south-western corner of the survey area (shaded on Fig 2). This area was also devoid of vehicle tracks, habitation, cultivation and domestic livestock. However, all these were prevalent in the portion of the Lomphat WS that fell into the extreme north-western block of the survey area (also shaded on Fig 2), where 78 buffalo, 14 cattle and no wildlife were counted.

3. D. Ashwell (pers. comm.) notes that it is possible that wild cattle suffered particularly heavy hunting pressure in 1993 as the FULRO people attempted to gather as much money as possible prior to their resettlement in USA.

claims to have found Kouprey tracks is included. The relative positions of the Srepok River and Yok Don Reserve, the northern boundary of which is formed by the river, may be determined by cross reference to Fig. 3.

In the 1960s, the Chhep area lay within the Preah Vihear Kouprey Reserve which at that time encompassed a huge area on the Lao and Thai borders (see Fig. 2.2 in MacKinnon and Stuart, 1989). In the new system, defined by the King's decree, Preah Vihear was reduced to a tiny 5,000ha Protected Landscape in order to avert conflict with logging and mining concerns and to provide for a reallocation of land to other less well protected habitats in Cambodia (D. Ashwell, pers. comm.).

The 400,000ha Koulen-Promtep Wildlife Reserve, in the vicinity of the old Preah Vihear Reserve, incorporates lowland evergreen, mixed and deciduous forests and wetlands, as well as Wharton's study area at Koh Ker (D. Ashwell, pers. comm.). However, the establishment of a new sanctuary in that area may also deserve further consideration. Whilst there is a slim possibility that Kouprey may still occur in the original reserve, there is also the possibility that the present protected area system fails to incorporate an example of the habitat found in the Chhep area, and which is believed to be "optimal" for Kouprey.

4.2.2 Institutional strengthening

Successful *in situ* conservation, whether of Kouprey in particular or biodiversity in general, will require significant strengthening of the country's presently weak and confused wildlife management administration. As described in section 1.2, there are two relevant administrative agencies. One is the new SSE which, with technical assistance but no field organization, has some technical but little field potential. The other is the WPO which, with no technical assistance but an established field presence (through its parent Department), has little technical but reasonable field potential.

It is in relation to Protected Areas that the existing, albeit poorly defined, mandates of these two agencies overlap. A suggested solution compatible with the provisions of the relevant Declaration is for the SSE to retain a dominant planning role, and for the WPO to assume responsibility for management and administration in the field (i.e., plan implementation). The WPO would continue to enforce all relevant wildlife legislation, both inside and outside Protected Areas.

This strategy would require the training and redeployment of an adequately enlarged WPO, a move requiring both committed political and donor support. It is suggested that the Government, with help from IUCN, approach the donor community for help in preparing and implementing such an institutional development programme. Until some such initiative is taken, there can be no hope for the sustainable conservation and management of any of the country's natural resources. Given its enormous economic importance, the prospects of obtaining donor support for the forestry sector as a whole must be good. Given also contemporary appreciation of the need to conserve biodiversity, it should in turn not prove difficult to obtain the support needed for development of the WPO included within a sectoral programme. GEF/World Bank has already stated an interest in exploring the possibility of a programme in Cambodia (K. MacKinnon, pers. comm.).

Pending any major institutional development programme, IUCN should continue to assist in the development of Cambodia's protected area system by integrating the assistance it already plans to give the SSE in this context (D. Ashwell, pers. comm.), and the large mammal survey project proposed above which would be best suited to implementation through the WPO. Further development of the proposal to create a transfrontier conservation area adjacent to Yok Don in Vietnam might be a key feature of any such an integrated approach that would also build upon the preliminary IUCN-sponsored work reported here.

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APPENDICES

1. The first of these is the fact that the number of people who are employed in the service of the Government has increased from 1,144,144 in 1944 to 1,200,000 in 1945. This is a very significant increase, especially in view of the fact that the total population of the United States is only 130,000,000.
2. The second of these is the fact that the number of people who are employed in the service of the Government has increased from 1,144,144 in 1944 to 1,200,000 in 1945. This is a very significant increase, especially in view of the fact that the total population of the United States is only 130,000,000.
3. The third of these is the fact that the number of people who are employed in the service of the Government has increased from 1,144,144 in 1944 to 1,200,000 in 1945. This is a very significant increase, especially in view of the fact that the total population of the United States is only 130,000,000.
4. The fourth of these is the fact that the number of people who are employed in the service of the Government has increased from 1,144,144 in 1944 to 1,200,000 in 1945. This is a very significant increase, especially in view of the fact that the total population of the United States is only 130,000,000.
5. The fifth of these is the fact that the number of people who are employed in the service of the Government has increased from 1,144,144 in 1944 to 1,200,000 in 1945. This is a very significant increase, especially in view of the fact that the total population of the United States is only 130,000,000.

APPENDICES

Appendix 2. Work Programme

	MH arrives Phnom Penh
10 March	RO arrives Phnom Penh
	Workshop with WPO
	Fuel despatched by boat
14	Team and fuel arrive Kratie
15	Morning rehearsal flight
	Afternoon reconnaissance of Mondolkiri
16	Morning survey of Mondolkiri
17	Morning survey of Mondolkiri
	Evening survey of Kaoh Enchey Island
18	Morning survey of Mondolkiri
19	Morning survey of Mondolkiri
	Aircraft to Phnom Penh, p.m.
20	Aircraft returns, p.m.
21	Morning survey of Mondolkiri
22	Morning survey of Mondolkiri
23	Morning survey of Mondolkiri
24	Morning survey of Mondolkiri
25	Morning survey of Mondolkiri
	Survey of Snoul on return leg
27	Return to Phnom Penh
	Debriefing meeting with Head of WPO
30	RO departure from Phnom Penh
	MH departure from Phnom Penh
27 April	Survey of Stoeng Treng

Appendix 3. Technical Evaluation of the Aerial Survey

Since the authors are unaware of any aerial survey of a similar nature ever having been conducted in Asia before, the lessons to be drawn from a brief technical evaluation of the present application may assist those considering or planning similar work in the future.

1. General Limitations

The present surveys have demonstrated, by the range of animal species seen and variables assessed, that aerial survey can be used in Asia as a valid research and monitoring technique in open forest formations. For any given species however, the technique ceases to be cost-effective once its density falls below a certain threshold (as for the Kouprey), and the denser the cover, the sooner will that threshold be reached. Similarly, for any given habitat, thresholds will occur at higher densities for small species than for large.

Even when applied in habitats with a workable species-cover combination it must be understood that results, in common with those derived in African habitats, return only indices of population size, not accurate measures. Consequently, the utility of aerial survey lies in its ability, rapidly and over vast and otherwise inaccessible areas, to:

- confirm the presence (but not necessarily absence) of key species;
- distinguish areas of low or high density relative to the same or other species; and
- identify population trends and changed distributions when repeated exactly at regular intervals.

To the above general limitations, may be added the following specific constraints likely to be relevant in Asian applications.

2. Specific Constraints

Availability of suitable aircraft

The aircraft of choice for low level wildlife surveys (single-engined, with high wings) are relatively uncommon in tropical Asia. Very often, therefore, aerial surveys are not a viable option simply because a suitable aircraft is unavailable.

Availability of Experienced Crew

Assuming an aircraft is available, the availability or otherwise of a trained and experienced crew will greatly affect the cost-effectiveness of a survey, and the quality of the data obtained. The Cambodia experience can be used as illustration.

Pilots. Hours of experience do not make a survey pilot. The height, speed and navigational configurations required are unfamiliar and require great concentration, under associated conditions of often considerable discomfort (heat, turbulence). Both the pilots used in the Kouprey survey exhibited low fatigue thresholds, and one developed severe motion sickness when flying in survey mode. As a result, the time of actual survey (e.g., on transect) averaged 1.8 hours per day: experienced crews can manage at least three hours. A further consequence is that survey hours

represented a relatively low percentage of total hours flown ($18.2/34.7 = 52\%$), an index of relative cost-inefficiency; hence, a bigger area could have been covered at the same cost, if daily time "on the line" could have been increased.

While these sorts of problems were not altogether unexpected, there was another serious consequence to the use of pilots inexperienced in the technique that had not been anticipated. In an ATC, it is common practice to circle around any animal or group that needs further observation. This requires the pilot to put the aeroplane promptly and decisively in a steep turn to the side indicated if visual contact is not to be lost. Reestablishing contact once lost is difficult in any circumstances, especially if there is no recognizable terrain feature in the vicinity to use as a point of reference.

The rather uniform wooded habitats of Cambodia demanded an extremely rapid and steep turn which, while not beyond the aircraft's performance capability, was beyond that of the pilots. This is the reason the two animals which could have been Kouprey remain "unidentified" - they simply could not be relocated after the initial glimpse. Given the reason for the survey, this was a serious, but unsolvable shortcoming.

Observers. Even those practised at spotting game on the ground take time to become competent aerial observers, as a whole new set of "search images" relating to altered perspectives have to be acquired. In the present case, one consultant who was to act as an observer fell ill shortly before the project and was unable to participate: the Cambodian forest officers used as aerial observers in his place had little if any experience of game viewing, even on the ground. Not surprisingly, their ability to interpret what they saw was poorly developed. For example, to them the second unidentified bovine appeared to be pig-sized, while to the more experienced FSO the same animal was clearly very much larger. Adding to search image and interpretive problems, was that of motion sickness which affected all Cambodian participants without exception.

A final point relevant to observing, was that in the present case *nobody* involved had a search image for the Kouprey. In retrospect, it would have been well worth IUCN's effort to obtain a copy of Wharton's film and show this to all participants before the survey.

Conclusion. The important lesson to be drawn from these experiences is that, depending on the importance of the project and the funds available, it may in fact be more cost-effective to pursue the apparently more expensive option of bringing in experienced crew from outside, and perhaps even the aircraft, rather than the cheaper one of using locally available but inexperienced personnel. In the 1994 surveys, however, this was not possible since ultimate authorization for such an undertaking rests with the Ministry of Defence, who in early 1994 were too busy planning military battles to deal with such requests.

If the hiring of an aircraft with a pilot inexperienced in low level survey techniques is unavoidable, then this should be done within the terms of a formal lease contract which, subject to obvious safety provisos, specifies the daily and overall performance targets required. Without such contractually binding "terms of reference" it may prove very difficult to get an inexperienced pilot to fly for the hours required to ensure a cost-effective exercise. Regrettably, this was another unsatisfactory feature affecting the 1994 Kouprey surveys. Finally, where inexperienced observers are used, every possible means should be used to develop search images appropriate to the task in hand. It would also be pragmatic to have an adequate supply of airsickness pills for inexperienced observers and pilots.

