

# MONITORING OF JAVAN RHINOCEROS IN CAT TIEN NATIONAL PARK, VIETNAM

JULY – DECEMBER 2003



BY  
VUONG DUY LAP, PHAN QUOC VINH, LAI VAN KIET,  
LE VAN TAN AND DAVID MURPHY

WWF – ASIAN RHINO AND ELEPHANT ACTION STRATEGY IN VIETNAM



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CAT TIEN NATIONAL PARK CONSERVATION PROJECT  
AREAS TECHNICAL REPORT NO. 7  
APRIL 2004

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## Executive Summary

The Vietnamese subspecies of the Javan Rhinoceros (*Rhinoceros sondaicus annamiticus*) is the rarest large mammal and a top conservation priority internationally and in Cat Tien National Park where the last population is located. In order to make informed management decisions on the future of the rhino the Cat Tien National Park Conservation Project, supported with funds from WWF-US/AREAS and the U.S. Fish and Wildlife Service, initiated the Rhino and Patrol Monitoring Units (RPMUs) in 2001 to increase the collection of data and security of the rhino. In 2003 it was recommended that the RPMUs continue their work but reduce in size so as to minimize disturbance within the core area of the rhino range. In July 2003 the RPMUs were restructured to one 4-man unit.

The 4-man RPMU completed monthly field surveys in every month from July – December 2003 spending a total of 260 man-days in the field and travelling a total of 117 km. The start of a performance-based allowance in September has encouraged the RPMU to spend a greater number of days in the field resulting in an increased and sustained work effort. During surveys the RPMU have recorded new data on footprints, wallows, dung samples, food plants, and maintained automatic camera-traps. The operation of automatic camera-traps has still been restricted by technical failure and the limited time capacity of the RPMU.

Recommendations for management are: Maintain security in the area within and surrounding the rhino range especially at key rhino habitats (such as Phuoc Son, Bau Trau, and The Bat Cave); Maintain a relationship with a relevant facility to test new dung samples for DNA in order to improve the technique, identify sexes, and compare results; Alongside external specialists, discuss a contingency plan outlining management options if no male rhino are confirmed in Cat Loc in the near future, and; To continue monitoring the Cat Loc rhino population, and build on the staff capacity currently in place, it is important that park management maintain the current members of the RPMU in their positions, secure financial support, and communicate with external specialists for ongoing scientific support.

## Acknowledgements

Thank you to the guard stations of Phuoc Son, Ben Cau, and Gia Vien who have supported the RPMU during their visits and accommodated the regular workload of guard station members when they have been on RPMU surveys. And to Mr. Tran Van Mui, the director of Cat Tien National Park, Mr. Luu Van Hao and Mr. Nguyen Manh Han of the Forest Protection Department, and Mr. Pham Huu Khanh of the Scientific and Technical Department, who have supported this activity through a commitment of staff.

Grateful thanks also go out to Gert Polet of the Cat Tien National Park Conservation who has provided strategic advice on the management of the RPMU and comments on the draft document.

We would like to thank Pruthu Fernando at Columbia University who carried out the DNA tests, and Ngo Minh Man who identified the rhino food plants.

The work of the RPMU has been made possible through the financial support of WWF-U.S. (through AREAS: the Asian Rhino and Elephant Action Strategy) and the U.S. Fish and Wildlife Service.

The photograph on the cover was taken by David Murphy and Vuong Duy Lap in 2001.

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## Introduction

Since the confirmation of Javan Rhinoceros (*Rhinoceros sondaicus annamiticus*) in Cat Loc (Schaller *et al.*, 1990) the subspecies has been a conservation priority. Subsequent surveys highlighted the critically small size of this last remaining population listing the subspecies as the world's rarest large mammal (Haryono *et al.*, 1993; Nguyen Xuan Dang and Pham Huu Khanh, 1999; Polet *et al.*, 1999). The initiation of the Cat Tien National Park Conservation Project in 1998 focussed activities on rhino conservation including education and socio-economic activities to reduce disturbance of the rhino population and their habitat. The Project also initiated the formation and operation of two Rhino Patrol and Monitoring Units (RPMUs) in 2001 that have been financially supported by WWF's Asian Rhino and Elephant Action Strategy (AREAS) and the U.S. Fish and Wildlife Service's Rhino and Tiger Fund. The purpose of the RPMU has been to use committed staff of the national park to expand the information on the rhino in order to make informed management decisions on this subspecies.

The results of the RPMUs have suggested that the Javan Rhino population in Cat Tien National Park is in a more critical condition than previously thought. The initial estimates of a population of 7–10 individuals have appeared too high and a reanalysis of footprint sizes suggested a possible 3 individuals (Bui Huu Manh, 2001; Van Strien, 2001). However, there is still conflicting evidence to the size and demography of this population. The estimate of a possible 3 individuals was contradicted by recent DNA test results, conducted by Columbia University – New York – USA, from faecal analysis that suggested the presence of a male and female and 5–6 individuals. In either scenario the population is on the brink of extinction, but the presence of breeding potential determines whether the population can still pull away from that brink. As there have been no signs of breeding in recent years and the sex ratio of the population is still uncertain, more work is required to clarify these subjects. A Javan Rhino workshop at Cat Tien National Park in 2003 addressed these topics and suggested priorities for the future.

The Javan Rhino workshop was attended by representatives from CTNP, CTNP-CP, provincial authorities, and Dr. Nico van Strien (International Rhino Foundation / IUCN-SSC Asian Rhino Specialist Group) and Dr. Nguyen Xuan Dang (Institute of Ecology and Biological Resources). The workshop highlighted the continual level of human disturbance around the range of the Javan Rhinos (from illegal entry into the forest, use of loud machinery in adjacent agricultural land, grazing of cattle within the park boundary etc.) and lack of data on the demography of the population. As the recent DNA evidence has suggested the presence of both male and female rhino, the lack of any signs of breeding in recent years is possibly because the high level of disturbance, that has made the rhinos now solely nocturnal, is preventing breeding behaviour. The major recommendations from this workshop were to reduce human disturbance in and around the rhino range, and continue to improve the collection of data, and so the work of the RPMU, but reduce the size of the RPMU to minimize disturbance within the rhino core area.

Acting on the recommendations of the workshop the size of the RPMU was reduced, monthly surveys have been maintained with priorities on improving and sustaining the quality of data collection, and dung has been collected where possible for further DNA analysis.

# Methods

## RPMU Staffing

The RPMU was restructured in July 2003 for several reasons. The team was reduced to one unit to minimize disturbance in the rhino range. Members of the team were also changed as all members of the two previous RPMUs were rarely present for all survey days because of other work commitments for heads of guard stations and farming commitments for local resident team members. The new RPMU is lead by the rhino officer, Vuong Duy Lap, who chose team members on the basis of physical endurance for extended fieldwork and the close proximity of their guard stations to the rhino range. The members of the RPMU are as follows:

1. Vuong Duy Lap (Science and Technical Department),
2. Phan Quoc Vinh (Phuoc Son guard station),
3. Lai Van Kiet (Gia Vien guard station), and
4. Le Van Tan (Ben Cau guard station)

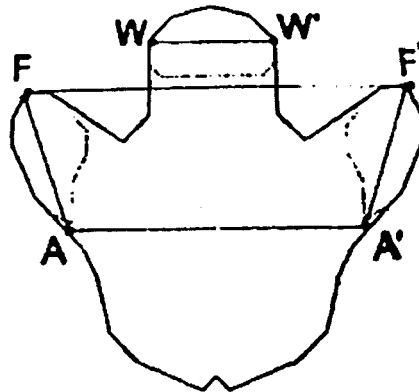
In an effort to increase the amount of man-hours spent in the field a performance-based allowance was introduced for the team in September. Under the scheme team members would retain their base allowance for 7 field days and earn a bonus for each extra day spent in the field beyond 7 days, with a maximum bonus for 10 days.

## Methods

Field surveys comprise of walking existing trails and recording data on indirect rhino observations. Indirect observations are: footprints (to determine footprints of individuals, area usage, and paths of movement), dung (to collect DNA to identify individuals), browse (to determine food plants), wallows (to determine key sites and water availability), and other sign. For each footprint the following data was recorded: footprint measurements (Fig. 1), direction, left or right foot, and slope. For all observations and survey routes exact coordinates are recorded and included in GIS maps of RPMU patrols. Every month two photo-trap units were also maintained at key sites. A detailed description of the field survey methods is available in previous reports (Bui Huu Manh, 2002; Murphy *et al.*, 2003a).

At the end of every survey the rhino officer then transfers all field data and samples to the park headquarters where they are collated and stored (Murphy *et al.*, 2003b).

Figure 1. Parameters for the measurement of a rhino footprint.



# Results

## RPMU Work Effort

In the period from July to December 2003 the RPMU have walked a total of 116.9 kilometres and spent a total of 252 man-days in the field (Table 1). Since the introduction of performance-based allowances there has been a significant increase in the number of man-days spent in the field, but not the number of kilometres walked per survey. The greater number of man-days spent in the field have been spent searching around sites where sign was recorded.

Table 1. The RPMU work effort from July – December 2003, in Cat Tien National Park.

Survey Period	Km walked by RPMU	Number of man-days in the field
20 – 26 July	17.8	28
13 – 21 August	23.4	36
17 – 26 September	17.5	40
15 – 27 October	16	52
11 – 22 November	21	48
16 – 29 December	21.2	56
<b>Total</b>	<b>116.9</b>	<b>260</b>

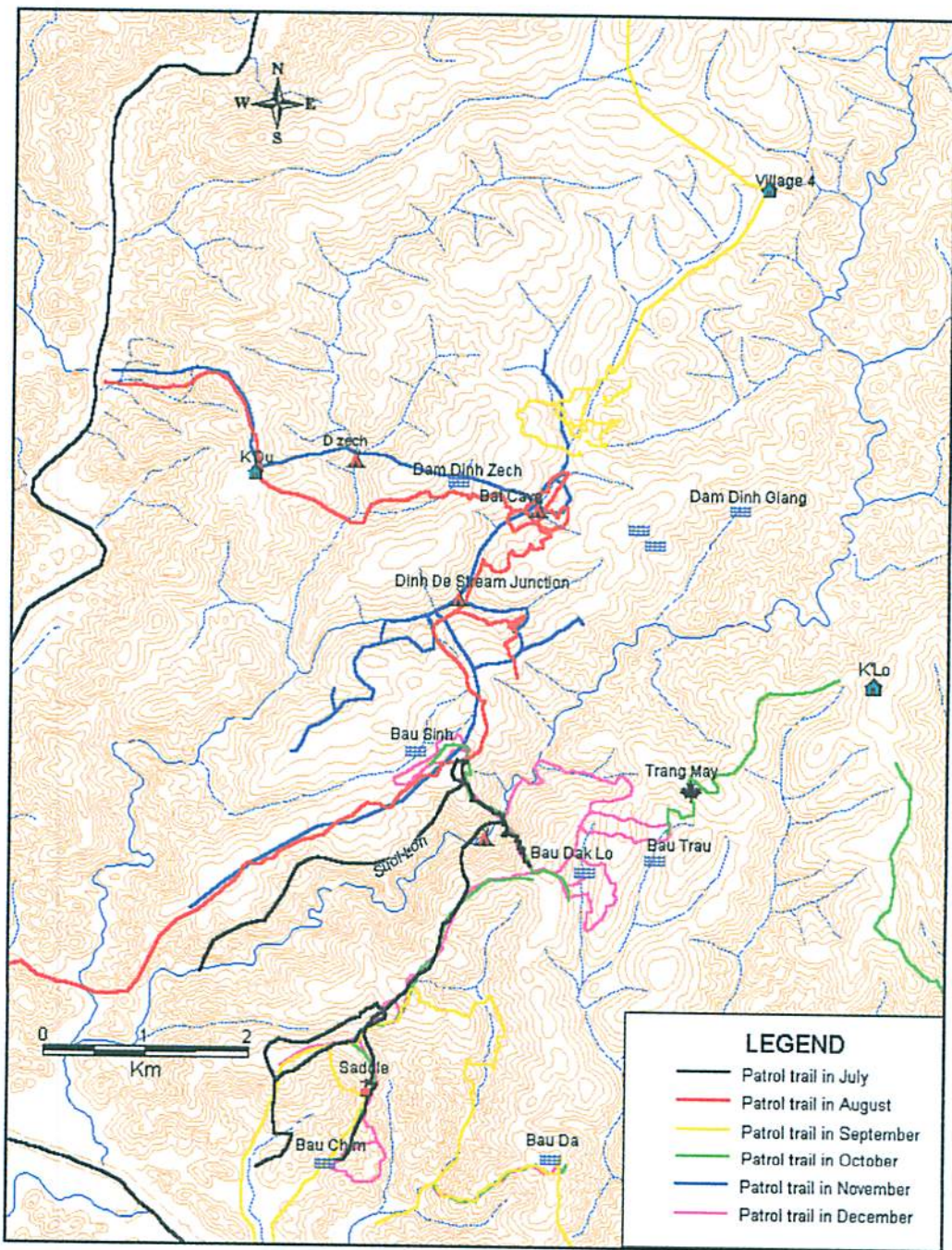
The survey routes and sites covered by the RPMU have been mainly sites of known rhino activity so as to maximize the amount of regular data gathered (Map 1). These have been focussed: from Phuoc Son north to Bau Trau and then further north to K'Lo K'It; and from Bau Sinh north to the Bat Cave and then further north to Village 4. Areas not previously surveyed include Bau Da and Bau Cau (near Village 4).

## Footprints

The most frequently encountered sign of rhino were footprints. The measurement of footprints was impaired in months of heavy rain (August) where most of the footprints were washed away. Footprints were recorded on all of the main sites of rhino activity (Map 2). The main tracks of footprints followed and recorded are summarized in Table 2. Their direction illustrates the routes of movement favoured by the rhino, which are: Phuoc Son to Bau Trau to K'Lo (No.s 2, 3, 4, 8, 10); Suoi Son across Suoi Lon to Bau Trau (No. 1, 5); Suoi Sinh to the Bat Cave (No. 7, 9). Another possible route is Bau Da to Bau Trau (No. 6), but the complete route has not been confirmed. Each track was made by a single rhino with the exception of track No. 8 where so many tracks covered the area it was possible it was made by more than one individual.

Focal areas of activity represented by a concentration of footprints are: Bau Chim–Yen Ngua–Bau Trau and Suoi Sinh–Dinh De–the Bat Cave (Map 2; Table 2).





Map 1. Survey routes and sites covered by the RPMU from July – December 2003, in Cat Tien National Park.

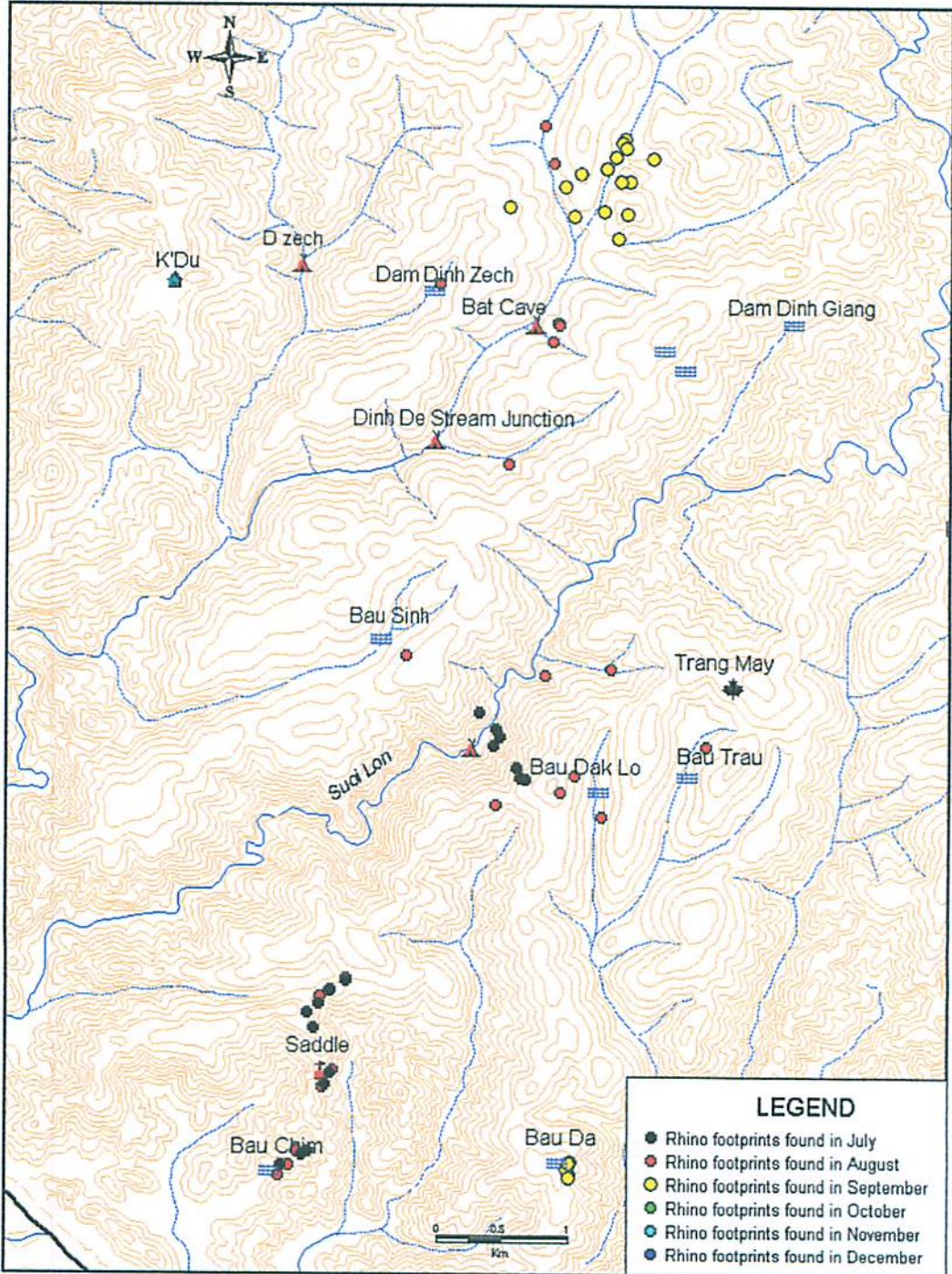
Table 2. The main tracks of rhino footprints followed and measured from July – December 2003, in Cat Tien National Park.

No.	Date recorded	Location	Direction	Approximate Footprint Age	Number of Footprints Measured
1	20/7/03	Suoi Sinh	To Bau Trau and Bau Dak Lo	Very new	22
2	20/7/03	Suoi Tre	To Suoi Lon and K'Lo	2–4 days	22
3	21/7/03	Suoi Lon	From Suoi Lon to Dak Lo	2–4 days	18
4	24/7/03	The Saddle (Yen Ngua)	To Suoi Tre	2–4 days	43
5	20/8/03	Suoi Dinh De	To Suoi Lon	5–7 days	38
6	19/9/03	Bau Da	From Bau Trau	4–5 days	50
7	23-25/03	Dinh Vu area (including the hill, Suoi Dinh De, and cashew hill of Village 4)	Many directions. Some to Bat Cave. 8 sets of tracks, possibly from the same rhino	3–4 hours	243
8	15/10/03	Bau Chim	From Dinh De to Bau Sinh. 3 sets of tracks, most likely from the same rhino	4–5 days	53
9	27/10/03	Suoi Sinh/Dinh De Hill	To Bau Sinh. 2 sets of tracks, most likely from the same rhino	3 days	47
10	16/12/03	The Saddle	To and from Bau Chim	1 day	61
11	28/12/03	Bau Trau	From Bau Dak Lo	4–6 days	13

All footprints were measured and the measurement of footprints from July – August supports the observation from previous reports that the width of the rhino footprint varies with slope (Bui Huu Manh, 2001, 2002). The variation in the width of FF' (Fig. 1) with slope seems to be best explained by the rhino contracting the outer toes for traction when walking uphill and spreading the outer toes for stability when walking downhill (Appendix). Unfortunately this variation in footprint width eliminates the possibility of recognizing individuals from measurements unless comparisons are made only with footprints on the same type of slope and soil.

The measurements of the width of the central toe WW' (Fig. 1) appears to vary little with slope. However, this measurement has limited use to distinguish between individuals as: soil types can effect the width of WW'; only measurements from some plaster-casts can be used, as the right points for measurement can not be seen from tracks in the soil; and only on good plaster casts can the correct measurements be made (Nico van Strien, pers. comm.).

Eight plaster-casts of footprints were made at Bau Chim on 27/10/03. As a rhino visited the saltlick the previous night the plaster-casts are very clear. All are currently stored in the Science and Technical Department of Cat Tien National Park.



Map 2. Rhino footprints recorded from July – December 2003, in Cat Tien National Park.

## Dung

Rhino dung was found at the Bat Cave, Suoi Dinh De, Dinh Vu Stream and Hill, and along the rote from Bau Chim to Suoi Lon (Table 3 and Map 3). Only four samples were collected that were still relatively fresh and not in water (Table 3).

Table 3. Rhino dung recorded from July – December 2003, in Cat Tien National Park.

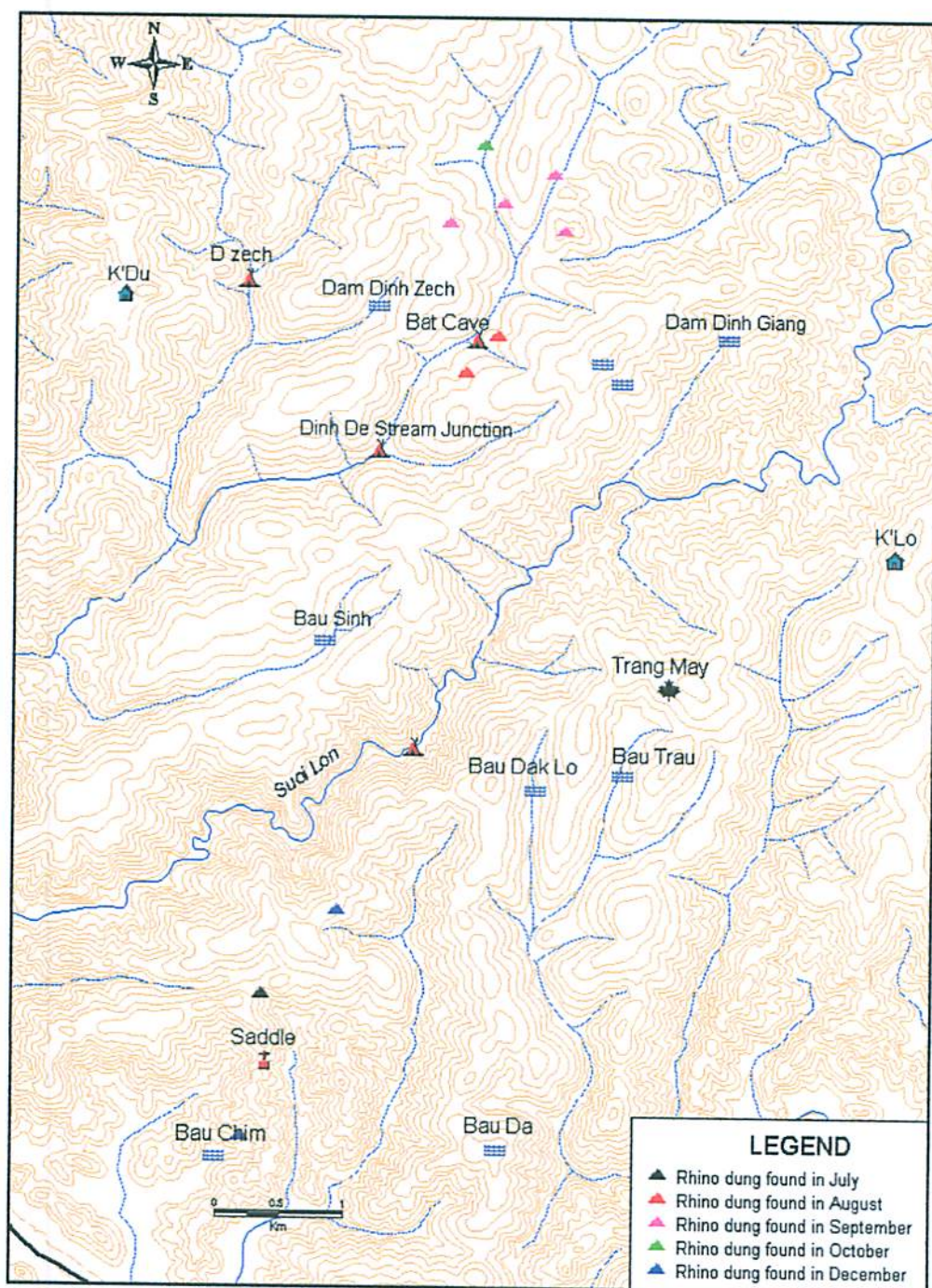
No.	Date recorded	Location	Number	Approximate Age	Sample taken?
1	17/8/03	Bat Cave	4	7–10 days	No, in water
2	19/8/03	Suoi Dinh De	1	Old	No, too old
3	23/9/03	Upstream Dinh Vu	1	3–4 hours	Yes
4	23/9/03	Upstream Dinh Vu	1	3–4 hours	Yes
5	25/9/03	Dinh Vu Hill	1	1 month	No, too old
6	25/9/03	Dinh Vu Hill	1	1 month	No, too old
7	15/11/03	Bat Cave	1	1 week	Yes
8	16/12/03	Bau Chim Hill	1	1 day	Yes
9	25/12/03	Bau Chim to Suoi Lon	1	4 day	Yes

## Browse

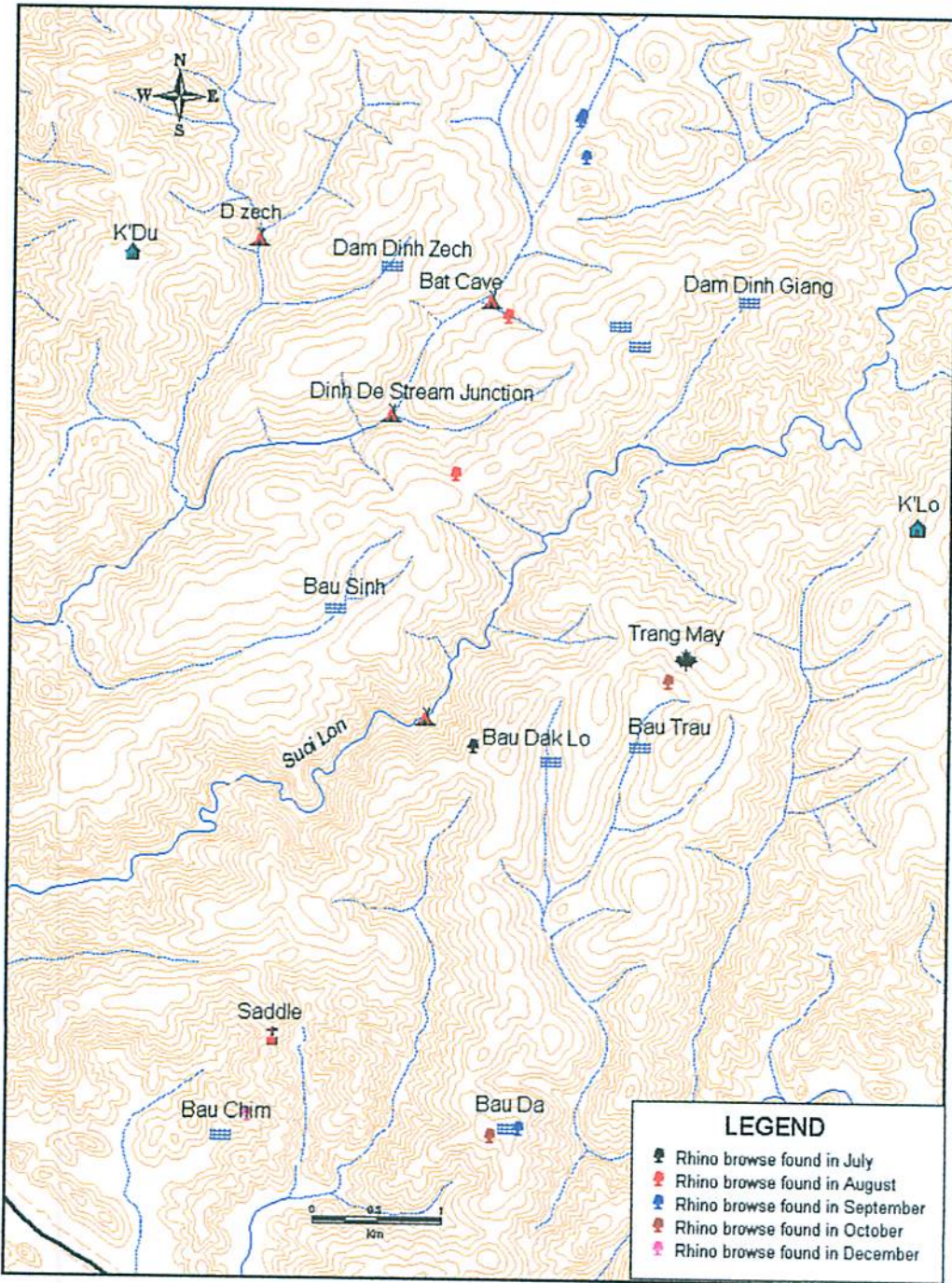
Signs of rhino browse were found at Dinh De Stream, Bau Da, Dinh Vu, and Suoi Tre (Table 4 and Map 4). Botanical samples were collected of browsed species at all sites and included *Peltophlorum dasyrrachis* (Caesalpinioideae), *Barringtonia* sp. (Lecythidaceae), *Barringtonia micrantha*, Myrtaceae, and *Gnetum gnemon* (Gnetaceae) (Table 4). Signs of rhino browse were also seen on *Diospyros longipedicellata*. Unfortunately not all samples could be identified because not enough material was taken from the plant and there were no descriptions of the structure of the plants sampled. To improve the identification of rhino food plants the RPMU will need to gather more data for each plant. In 17 October browsing signs were also encountered at Bau Trau. The plant that was browsed were Nhip leaves (*Gnetum gnemon*), and as the RPMU had previously collected samples of these at this site they further collections were not made on this occasion.

Table 4. Botanical samples collected that had been browsed by rhino from July – December 2003, in Cat Tien National Park.

No.	Date collected	Location	Species	Approximate age of rhino browse	Habitat
1	23/8/03	Dinh De Stream	<i>Peltophlorum dasyrrachis</i> (Caesalpinioideae)	5–7 days	Wood trees
2	23/8/03	Dinh De Stream	<i>Barringtonia</i> sp. (Lecythidaceae)	5–7 days	Wood trees
3	19/9/03	Bau Da (9 samples)	<i>Barringtonia micrantha</i> , Myrtaceae, 7 unidentified	4–5 days	Wood trees and shrubs
4	25/9/03	Dinh Vu (upper stream)	Unidentified	2 days	Wood trees and shrubs
5	17/10/03	Bau Da	Nhip leaves – <i>Gnetum gnemon</i> (Gnetaceae)	-	Wood trees and shrubs
6	17/12/03	Suoi Tre	Unidentified	15 days	Bamboo



Map 3. Rhino dung recorded from July – December 2003, in Cat Tien National Park.



Map 4. Rhino browse recorded from July – December 2003, in Cat Tien National Park.

## Wallows

Rhino wallows were found at the Bat Cave, Dinh De, Dinh Vu, Bau Trau, and Bau Chim (Table 5 and Map 5).

Table 5. Rhino wallows recorded from July – December 2003, in Cat Tien National Park.

No.	Date recorded	Location	Approximate age	Habitat
1	17/8/03	Bat Cave	5–7 days	Wood trees
2	16/8/03	Dinh De	5–7 days	Bamboo
3	19/9/03	Bau Da	1 month	
4	25/9/03	Dinh Vu Stream	1 day	
5	1/10/03	Bau Trau	1 month	
6	16/12/03	Bau Chim	1 day	Forest edge/ Regenerating wetland
7	20/12/03	Bau Trau	5–7 days	
8	20/12/03	Bau Trau	5–7 days	

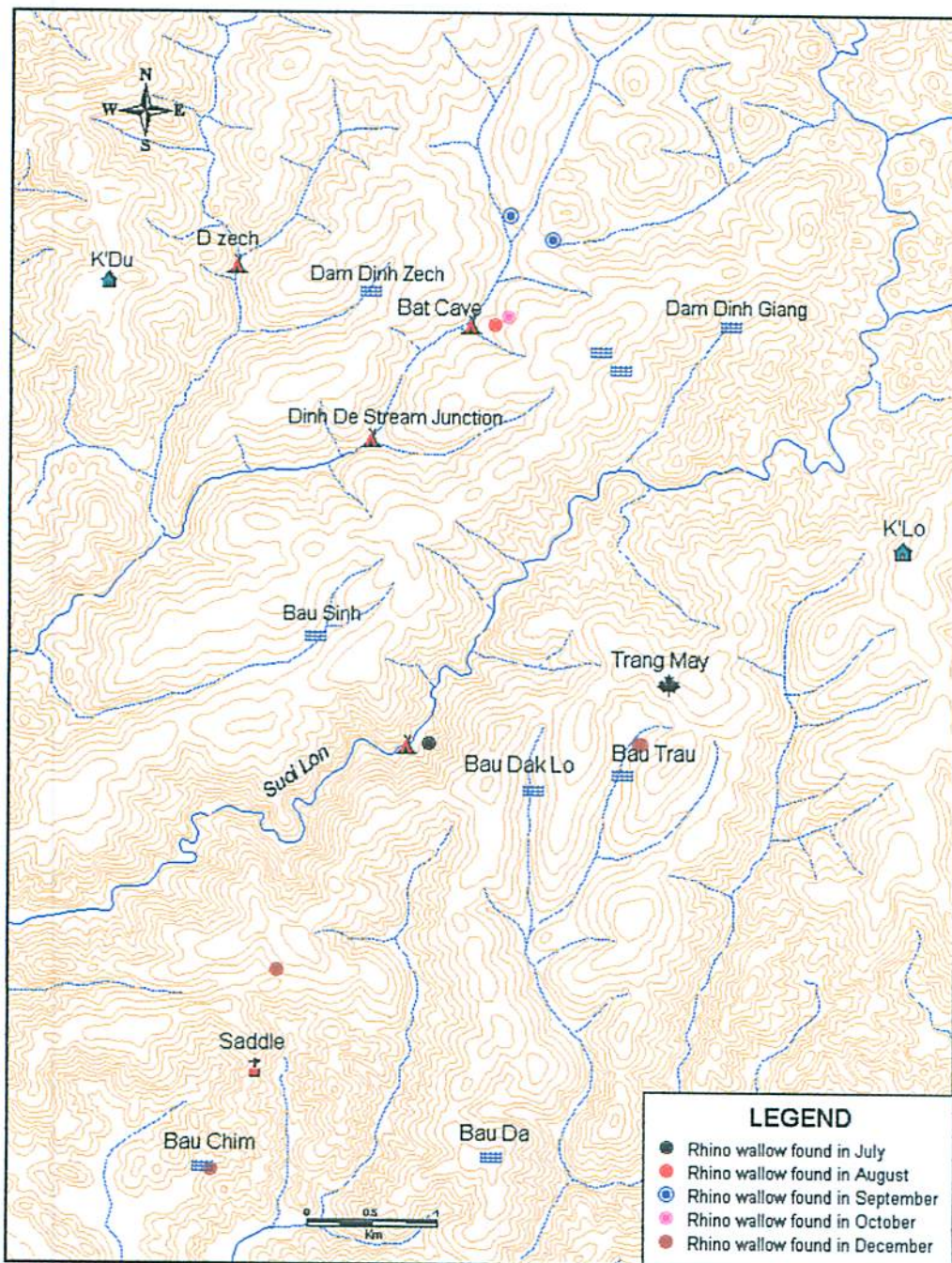
## Photo-traps

There were no results from the two photo-traps that were maintained at Bau Chim and Yen Ngu. Photo-trap units regularly malfunctioned, and rhino occasionally avoided the units with their tracks detouring around a photo-trap location.

## Human Disturbance

Traps and snares were occasionally found within the rhino range. In July a trap line was found near Suoi Lon containing 2 Wild Pigs (*Sus scrofa*) (one female and one juvenile) and a Siamese Fireback (*Lophura diardi*). All animals were released. In November two traps were found on Dinh Giang Hill, one containing a dead Red Jungle Fowl (*Gallus gallus*). In December an empty trap line was found at Bau Dinh Giang. Whenever traps and snares were found they were immediately destroyed by the RPMU.

Two old hunting shelters were found at Dam Dinh Giang in November.



Map 5. Rhino wallows recorded from July – December 2003, in Cat Tien National Park.



# Discussion

## How many rhino are there in Cat Loc?

There has been no method that has been able to give an exact population size of the rhino in Cat Loc. The most useful methods so far have been footprint sizes together with approximate range sizes and notes from local residents. DNA extracted from the colon cells found in dung has also been able to provide population estimates. However, all of these methods are open to error and have produced conflicting results.

The results of the surveys from July – December 2003 show little variation in footprint size. Routes of rhino movement are based around two possible territories on either side of Suoi Lon Stream: Phuoc Son – Bau Trau – K'Lo, and Bau Sinh – The Bat Cave. This supports earlier work by the RPMU suggesting that there are 2–3 individual rhino (Bui Huu Manh, 2001, 2002). However, there is territory overlap as shown by routes between these possible territories (Bau Sinh – Bau Trau), footprints of one individual found at all major sites overlapping with the footprint range of another individual (Van Strien, 2001), and as indicated by few of key resources such as sallicks, feeding sites, wallows that would need to be shared.

Because of survey practicalities the whole range cannot be sampled all at the same time to record simultaneous rhino activity in more than one site (unless through a large photo-trap effort, which is currently not feasible because of flash disturbance). During some of the monthly surveys the RPMU did find recent rhino activity in more than one location. In July there were very new footprints in Suoi Sinh, Suoi Tre, Bau Chim, and Yen Ngua. In September there were many fresh tracks a few hours old recorded at Dinh Vu. In October there were footprints approximately 3 days old recorded at Suoi Sinh and footprints a few hours old recorded at Bau Chim. And in December there were new footprints recorded at both Bau Chim and Bau Trau. But because of the small size of the area one or two individuals could have made these signs, moving between areas within a short period of time.

DNA results in 2003 from dung samples that had been collected from 2001 – 2003 concluded there were 5–6 individuals. This was a surprising result considering the little variation in footprint size and the small size of the area. As DNA tests are open to error through contamination it is possible that these results are incorrect. Additionally this method needs to be repeated to test the technique. During the July – December 2003 survey period the RPMU have tried to reduce the chances of contamination using rubber gloves and disposable spatulas to take dung samples. As 5 new dung samples have been collected it is important to have these tested as soon as possible to repeat this method and compare results. The laboratory at Columbia University suspended rhino DNA testing and is seeking further USFWS support to continue this important work.

Currently the estimate of the rhino population is low and still uncertain. It is unlikely that there will be a more accurate estimate of the rhino population without an improvement in the methodologies for identifying individuals from footprint sizes and/or DNA typing. Because of the limited habitat range and low footprint variation it is likely that the population is 2 or 3 individuals. However, whether the population is 2–3 or 5 it is still critically low and will not pull away from extinction unless there are new rhino born.

## Are the rhinos breeding?

The most worrying result is that there has been the continued absence of any signs of breeding. In the last 6 months, and during all previous RPMU surveys (Bui Huu Manh, 2001, 2002), there have been no footprints or other sign of juvenile rhino. As discussed during the rhino workshop in April 2003 this lack of breeding sign may be because human disturbance is discouraging rhino breeding behaviour, or that there are no more male rhinos at present. A

lack of males is supported by interviews with local hunters who think that there are only 3–4 female rhino remaining (Van Strien, 2001). DNA results from 2003 concluded that there was the presence of both male and female animals, but possible contamination puts these results in to doubt without further repetition. Recent results from surveys have not identified male or female rhino, with the only confirmed individual being a female from a photo-trap who visited Yen Ngu (The Saddle) on 27 June 2001 (photographed by an automatic camera-trap).

Further evidence is required to conclude that there are no male rhino remaining, but if the population has no breeding potential then the sub-species is effectively extinct. Suggestions to save the remaining individuals have been translocating them to another site, or translocating in a male from the Indonesian subspecies (*Rhinoceros sondaicus sondaicus*) to Vietnam to allow the Cat Loc population to breed (though the subspecies will then be lost). An added advantage of translocating a male Indonesian Javan Rhino individual to Cat Loc would be that a second Javan Rhino population would be secured outside of Ujong Kulon. To have only one secure population in Ujong Kulon leaves the species dangerously exposed to a catastrophe such as disease or volcanic eruption. Preference for the establishment of a second Javan Rhino population should be given within Indonesia. Securing the unique *R. s. annamiticus* sub-species will not be achieved with a translocation of an Ujong Kulon animal to Cat Loc as the long-term survival of a population in Cat Loc can still not be guaranteed through limited area and resources, and human disturbance, and as any offspring would be hybrids between the two subspecies. A translocation of the remaining 2–3 rhino out of Cat Loc would be logistically very difficult (because of the capture and transport of rhino in the terrain and habitat of Cat Loc) and would also raise the question where they should they be taken? If the Cat Loc rhinos were ever captured a possible location for transfer would be the north of the Nam Cat Tien sector because of the presence of suitable habitat including good vegetation, wetlands for wallowing, protection from the forest guard stations in the area, and close proximity to Cat Loc thereby reducing transportation time and so any risks of a rhino dying from stress.

#### **What are the important rhino habitats?**

Important habitats for the rhino are indicated by the presence of resources needed for survival. These are: food plants and saltlicks for diet, water, and wallows for temperature regulation. Important feeding sites are Dinh De Stream, Bau Da, Dinh Vu, Suoi Tre, and Bau Trau. These are because of the botanical diversity at particular sites and availability of food plants. Important wallow sites are Bau Trau, Bau Dak Lo, Bau Chim, the Bat Cave, Dinh De, and Dinh Vu. There is only one known saltlick in the area, at Bau Chim. The importance of this site is illustrated by semi-regular visits by the rhino, and with two recorded visits in October 2003, even though it is close to human habitation.

Further pressures on the remaining rhino are the few areas of resources within the current rhino range. There is only one known saltlick, and botanical diversity is patchy because of historic disturbance to the forest. Rhino activity is concentrated around resource sites and especially those of minimal human activity such as The Bat Cave and Bau Trau.

The fact that the rhinos now appear to be visiting the Phuoc Son saltlick with more regularity is a promising response to the reduction of disturbance at this site. But illegal human activity still persists within the rhino range. Trap and snare lines threaten the remaining rhino through possible injury and continued human disturbance.

#### **Has the performance of the RPMU improved?**

In the period from July – December 2003 the performance of the RPMU was improved. The restructured team has worked well together under the leadership of the rhino officer. The performance-based allowance has also encouraged the team to spend the full 10 days in the field (and now often up to 12 days) maximising the data gathered. The quality of data gathering has also been maintained through work alongside the rhino officer and following of the set methodologies. As mentioned above, the collection of dung samples has also

improved through the use of rubber gloves and spatulas. The team has become more autonomous including fieldwork, survey plans, logistics, and with the rhino officer leading the team in the field, handling of the data, and having increasing financial management of the team.

#### **Are photo-traps effective?**

Current photo-trapping efforts have been limited because of equipment failure and rhino avoiding photo-trap sites. This potential disturbance of rhino (most likely from camera flash) is also why there have only been two photo-trap units maintained every month in order to minimize any disturbance. The use of cameras still has potential to increase the information on the rhino but not as is currently practised. At present the RPMU cannot carry out 10-12 days of field surveys and cannot maintain more than 2 photo-traps per month, so any expansion on current photo-trap efforts would need to be carried out by additional dedicated staff. For any future photo-trapping activity it may be better to use a digital infrared game camera that uses 16 non-visible infrared lights to photograph the animal (and no flash) to further reduce any disturbance. Also there is the potential to use a digital video camera that is motion sensitive and films in low-light environments without the need of a light source. The advantage of trialling such a video camera would be: no disturbance from a flash; as the video camera records for a couple of minutes when activated there is the potential to record behaviour and also confirm if more than one animal passes in close succession (such as the site where dung from possibly two individual rhino was found); and the chance to record the first video footage of this subspecies.

#### **What is the future for the rhino?**

Without any new rhino born the subspecies will become extinct within 30–40 years (the approximate remaining lifespan of the rhinos in Cat Loc). Therefore it needs to be clarified whether it is disturbance effect on behaviour or a lack of males that is limiting breeding. If no more males are present in Cat Loc in the near future then translocation might be the only way to save the remaining individuals or a population in Cat Tien National Park. However, before any translocation is contemplated, managers would have to be very certain that there are no males remaining. To attempt to answer this question future surveys need to focus on identifying the sexes of the remaining rhino through the continued collection of dung and refinement of this technique.

Recommendations for management are:

- Maintain security in the area within and surrounding the rhino range especially at key rhino habitats (such as Phuoc Son, Bau Trau, and The Bat Cave),
- Maintain a relationship with a relevant facility to test new dung samples for DNA in order to improve the technique, identify sexes, and compare results,
- Alongside external specialists, discuss a contingency plan outlining management options if no male rhino are confirmed in Cat Loc in the near future, and
- To continue monitoring the Cat Loc rhino population, and build on the staff capacity currently in place, it is important that park management:
  - Maintain the current members of the RPMU in their positions,
  - Secure financial support, and
  - Communicate with external specialists for ongoing scientific support.

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## Appendix: Javan Rhino footprint data

Every table details the footprint data for each rhino track that was followed. As it was not possible to follow and record every footprint for each track, series of footprints are separated on each table.

July

Date	Location	Habitats	GPS		WW'	FF'	FA	FA'	AA'	Left / right	Slope	Walking direction	Notes
			X	Y									
20/07/2003	Head of Suoi Lon	Bamboo + rattan	107.32475	11.66106	86	175	79	55	203	Left	Downhill	To Bau Trau and Bau Dac Lo	
					87	193	72	72	230	Left	Downhill		
					87	177	63			Right	Downhill		
					97	180	40	55	203	Left	Downhill		
					89	186	64	59	208	Right	Downhill		
					79	186	60	70	190	Right	Downhill		
					70	170	70	70	205	Right	Downhill		
					90	180	65	68	205	Left	Downhill		
					85	20	70	70	210	Left	Downhill		
					80	186	65	65	190	Right	Downhill		
					75	186	60	65	200	Right	Downhill		
					80	186	65	65	205	Right	Downhill		
					88	155	56	70	185	Right	Downhill		
					80	175	67	65	198	Right	Downhill		

				83	178	65	70	200	Right	Downhill	
				83	175	65	65	200	Left	Downhill	
				95	175	75	80	200	Left	Downhill	
				82	170	65	70	189	Right	Downhill	
				95	170	58	60	180	Right	Downhill	
				82	200				Right	Downhill	
				90	170	65	65	205	Left	Downhill	
				80	155	70	75	192	Left	Downhill	

Date	Location	Habitats	GPS		WW'	FF'	FA	FA'	AA'	Left / right	Slope	Walking direction	Notes
			X	Y									
21/07/2003	Suoi Lon	Bamboo + rattan	107.32475	11.66106	83	185	62	75	188	Right	Uphill	From Suoi Lon to Dak Lo	
					105	192	80	78	205	Left	Level		
					93	194	71	86	201	Left	Uphill		
					104	167	64	60	184	Right	Uphill		
					107	155	75	74	190	Right	Uphill		
					95	165	70	65	198	Right	Uphill		
					100	165	90	75	185	Right	Level		
					105	165	75	83	195	Right	Uphill		
					100	155	84	84	180	Left	Uphill		
					93	162	75	75	195	Left	Uphill		
					95	150	80	80	190	Left	Uphill		
					95	165	75	80	195	Left	Uphill		
					95	152	80	80	185	Right	Uphill		

					100	155	74	70	186	Left	Uphill	
					100	150	75	65	185	Right	Uphill	
					105	180	75	73	190	Left	Uphill	
					100	175	75	82	190	Left	Uphill	
					80	140	65	75	155	Left	Uphill	
					95	147	65	72	180	Right	Uphill	
					90	155	75	75	190	Left	Uphill	
					90	155	65	70	180	Right	Level	
					85	170	70	75	180	Left	Level	

Date	Location	Habitats	GPS		WW'	FF'	FA	FA'	AA'	Left / right	Slope	Walking direction	Notes
			X	Y									
24/07/2003	The Saddle (Yon Ngua)	Bamboo	107.3097	11.63144	100	140	78	70	185	Right	Uphill	From Bau Chlm to Suoi Tre	Beginning of track
			107.31311	11.63747	95	155	67	75	190	Right	Uphill		End of track
					95	150	75	68	180	Right	Uphill		
					100	148	65	80	180	Right	Uphill		
					90	174	85	85	195	Left	Uphill		
					100	165	76	85	195	Left	Uphill		
					100	160	90	80	195	Right	Uphill		
					100	195	63	70	174	Left	Uphill		
					85	195	60	62	170	Left	Uphill		
					90	185	64	65	180	Left	Uphill		
					100	194				Left	Uphill		
					94	182	60	55	190	Left	Uphill		
					94	188	60	55	190	Left	Uphill		





				100	170	60	60	170	60	60	170	Right	Uphill				
				85	190	70	67	180	180	180	180	Left	Uphill				
				90	192	56	65	180	180	180	180	Left	Uphill				
				100	180	55	53	175	175	175	175	Left	Uphill				
				96	175	62	65	172	172	172	172	Left	Uphill				
				90	178	65	62	172	172	172	172	Right	Uphill				
				100	165	55	60	176	176	176	176	Right	Uphill				
				93	160	63	60	175	175	175	175	Left	Uphill				
				94	177	60	60	176	176	176	176	Left	Uphill				
				89	170	50	65	185	185	185	185	Right	Uphill				
				88	172	65	60	175	175	175	175	Left	Uphill				
				95	180	54	50	172	172	172	172	Right	Uphill				
				94	190	60	65	185	185	185	185	Right	Uphill				
				90	150	58	55	180	180	180	180	Left	Uphill				
				90	175	55	56	170	170	170	170	Right	Uphill				
				90	175	48	50	170	170	170	170	Right	Uphill				
				88	170	55	57	180	180	180	180	Left	Uphill				
				85	160	55	60	175	175	175	175	Left	Uphill				
				90	185	58	55	185	185	185	185	Right	Uphill				
				90	165	65	54	175	175	175	175	Right	Uphill				
				96	190	65	64	185	185	185	185	Left	Uphill				
				95	180	60	55	175	175	175	175	Left	Uphill				

August

Date	Location	Habitats	GPS		WW'	FF'	FA	FA'	AA'	Left / right	Slope	Walking direction	Notes
			X	Y									
17/08/2003	Bat Cave Hill	Wood forest (non-bamboo) + shrubs	107.32589	11.6811	75	180	60	60	200		Level	From Suoi Dinh De to Suoi Lon	
					85	185	65	70	195		Level		
					95	190	70	80	205	Right	Level		
					85	185	62	70	195	Right	Level		

Date	Location	Habitats	GPS		WW'	FF'	FA	FA'	AA'	Left / right	Slope	Walking direction	Notes
			X	Y									
20/08/2003	Suoi Dinh De area	Mixed forest	107.32237	11.68158	90	194	70	60	197	Right	Level	To Suoi Lon	
					91	163	72	64	189	Left	Level		
					82	190	60	60		Right	Uphill		
					94	187	54	55	190	Left	Level		
					97	158	67	71	180	Right	Level		
					82	192	57	68	199	Right	Level		
					80	165	52	52	185	Right	Level		
					90	169	54	50	193	Left	Uphill		
					90	172	45	48	189	Left	Uphill		
					97	162	47	62	172	Right	Uphill		
					97	168	58	46	174	Left	Uphill		
					97	182	57	58	185	Right	Uphill		
					92	184	60	62	188	Right	Level		



September

Date	Location	GPS		Habitat	WW'	FF'	FA	F'A'	AA'	Left /right	Slopo	Walking direction	Notes
		X	Y										
19/09/2003	Bau Da	11.63061	107.32995	Wood forest (non-bamboo) + shrubs	95	190	80	76	205	Right	Level	From Bau Trau to Bau Da	
					85	178	70	60	195	Right	Level		
					86	180	73	71	202	Right	Level		
					85	163	78	70	195	Right	Level		
					90	195	72	72	195	Right	Level		
					98	165	75	75	205	Right	Level		
					90	180	70	63	200	Right	Level		
					95	170	70	68	185	Right	Level		
					96	193	75	76	201	Right	Level		
					95	190	70	72	198	Right	Level		
					95	198	77	77	205	Right	Level		
					97	192	85			Right	Level		
					94	189	65	70	205	Right	Level		
					88	179	72	70	192	Right	Level		
					105	175	64	75	202	Right	Level		
					100	175	75	75	192	Right	Level		
					95	188	75	75	200	Right	Level		
					90	170	75	70	190	Right	Level		
					85	175	65	65	195	Right	Level		
					90	174	65	65	195	Right	Level		
					90	170	65	65	190	Right	Level		

					95	175	65	65	195	Right	Level
					97	176	60	65	195	Right	Level
					100	185	65	65	195	Right	Level
					100	194	87	78	195	Right	Level
					90	178	67	68	198	Right	Level
					108	185	74	75	210	Right	Level
					107	194	84	85	204	Right	Level
					110	189	75	74	205	Right	Level
					86	187	77	83	196	Right	Level
					92	187	80	75	204	Right	Level
					87	184	70	65	205	Right	Level
					85	174	70	65	205	Right	Level
					90	177	65	65	195	Right	Level

Date	Location	GPS		WW'	Habitat	FF'	FA	FA'	AA'	Left / right	Slope	Walking direction	Notes
		X	Y										
19/09/2003	Bau Da	11.63061	107.32995	90	Wood forest (non-bamboo) + shrubs	160	64	58	195	Left	Level	From Bau Trau to Bau Da	
				90		188	76	60	200	Left	Level		
				84		184	70	70	195	Left	Level		
				80		195	60	66	205	Left	Level		
				96		183	81	72	205	Left	Level		
				107		177	75	72	193	Left	Level		
				93		183	73	75	189	Left	Level		

					100	180	90	75	205	Left	Level	
					95	185	80	75	200	Left	Level	
					100	165	70	65	190	Left	Level	
					85	180	75	65	200	Left	Level	
					85	185	60	64	193	Left	Level	
					95	175	76	60	200	Left	Level	
					87	187	65	60	198	Left	Level	
					99	190	71	87	190	Left	Level	
					97	175	68	75	200	Left	Level	

Date	Location	GPS		Habitat	WW'	FF'	FA	F'A'	AA'	Left /right	Slope	Walking direction	Notes
		X	Y										
23/09/2003	Cashow nut hill of Villago 4	11.70082	107.33377	Bamboo + wood tree (mixed)	89	178	66	60	189	Right	Level		
					98	175	44	54	215	Right	Level		
					94	175	47	51	198	Right	Level		
					100	205	87	80	191	Right	Level		
					83	182	55	56	194	Right	Level		
					112	188	65	65	197	Right	Level		
					95	177	56	56	198	Right	Level		
					100	189	60	65	199	Right	Level		
					87	185	50	55	195	Right	Level		
					90	187	56	57	194	Right	Level		
					91	177	45	60	187	Right	Level		

								105	212	57	65	203	Right	Level
								99	189	60	59	190	Right	Level
								105	174	71	85	192	Right	Level
								101	165	79	72	174	Right	Level
								99	171	86	84	188	Right	Level
								107	188	71	65	193	Right	Level
								98	190	83	72	161	Right	Level
								101	170	65	64	188	Right	Level
								102	206	84	75	190	Right	Level
								105	198	68	74	192	Right	Level
								107	200	70	66	194	Right	Level
								98	170	55	55	192	Right	Level
								90	185	71	68	200	Right	Level
								99	185	67	62	194	Right	Level
								94	193	58	60	195	Right	Level
								85	175	54	56	189	Right	Level
								103	176	55	55	195	Right	Level
								101	194	55	54	201	Right	Level
								91	182	54	56	185	Right	Level
								108	204	79	78	192	Right	Level
								100	193	67	73	198	Right	Level
								115	192	71	72	209	Right	Level
								95	189	60	58	202	Right	Level
								93	174	52	55	197	Right	Level
								105	194	65	63	181	Right	Level

								98	189	53	55	191	Right	Level		
								97	196	55	65	200	Right	Level		
								95	192	55	57	186	Right	Level		
								93	186	74	60	200	Right	Level		
								87	176	50	60	199	Right	Level		
								99	182	62	58	201	Right	Level		
								87	197	58	55	189	Right	Level		
								87	181	52	58	192	Right	Level		
								97	186	77	65	212	Right	Level		
								95	197	70	64	198	Right	Level		
								90	177	55	56	198	Right	Level		
								104	207	65	64	190	Right	Level		
								105	208	65	64	190	Right	Level		
								103	204	60	66	195	Right	Level		
								110	208	50	64	206	Right	Level		
								102	200	68	70	203	Right	Level		
								102	182	62	63	193	Right	Level		
								100	195	69	68	185	Right	Level		
								98	171	70	70	183	Right	Level		
								99	170	62	60	185	Right	Level		
								103	196	78	83	192	Right	Level		
								110	175	67	66	193	Right	Level		
								111	180	82	83	161	Right	Level		
								100	164	71	72	162	Right	Level		
								121	176	73	83	193	Right	Level		







					95	188	60	60	204	Left	Level
					100	180	65	67	194	Left	Level
					97	195	70	66	204	Left	Level
					110	182	64	60	192	Left	Level
					102	186	61	60	195	Left	Level
					96	185	50	60	193	Left	Level
					103	190	68	70	191	Left	Level
					94	172	67	58	189	Left	Level
					115	197	70	64	190	Left	Level
					104	193	73	65	188	Left	Level
					99	201	89	81	177	Left	Level
					112	201	88	82	201	Left	Level

Date	Location	GPS		Habitat	WW'	FF'	FA	F'A'	AA'	Left /right	Slope	Walking direction	Notes
		X	Y										
24/09/2003	Head of Suoi Dinh Do area	11.69851	107.33396	Mixed forest	98	182	54	55	206	Right	Level		
					80	187	68	58	190	Right	Level		
					80	205	67	56	197	Right	Level		
					74	193	57	62	185	Right	Level		
					70	209	68	60	200	Right	Level		
					75	175	50	55	180	Right	Level		
					75	180	55	60	170	Right	Level		
					88	200	75	68	190	Right	Level		


Date	Location	GPS		Habitat	WW'	FF'	FA	F'A'	AA'	Left / right	Slope	Walking direction	Notes
		X	Y										
24/09/2003	Head of Suoi Dinh Da area	11.69851	107.33396	Mixed forest	96	186	73	70	183	Left	Level	-	
					101	199	75	74	196	Left	Level		
					96	185	64	56	202	Left	Level		
					111	185	54	68	195	Left	Level		
					104	193	73	65	188	Left	Level		
					99	201	89	81	177	Left	Level		
					112	201	88	82	201	Left	Level		
					96	186	73	70	183	Left	Level		
					101	199	75	74	196	Left	Level		
					112	195	77	79	203	Left	Level		
					112	190	62	62	197	Left	Level		
					102	192	78	75	185	Left	Level		
					97	175	60	67	205	Left	Level		
					107	180	50	56	190	Left	Level		
					99	185	66	55	184	Left	Level		
					93	193	59	61	190	Left	Level		
					112	185	66	68	175	Left	Level		
					98	194	52	52	195	Left	Level		
					103	170	63	63	200	Left	Downhill		



					95	165	56	65	184	Right	Uphill		
					96	175	64	70	200	Right	Uphill		
					94	187	60	67	200	Right	Uphill		
					92	192	65	62	195	Right	Uphill		
					90	174	57	55	188	Right	Uphill		

Date	Location	GPS		Habitat	WW'	FF'	FA	F'A'	AA'	Left / right	Slope	Walking direction	Notes
		X	Y										
25/09/2003	Hill by Suoi Dinh Vu	11.69608	107.33396	Bamboo forest	97	190	67	60	185	Left	Downhill		
					125	191	74	74	200	Left	Downhill		
					109	197	69	77	210	Left	Downhill		
					98	201	76	76	178	Left	Downhill		
					117	201	80	75	195	Left	Downhill		
					100	178	71	70	202	Left	Downhill		
					105	184	75	70	172	Left	Downhill		
					111	193	80	80	180	Left	Downhill		

Date	Location	GPS		Habitat	WW'	FF'	FA	F'A'	AA'	Left /right	Slope	Walking direction	Notes
		X	Y										
26/09/2003	Hill by Suoi Dinh Vu	11.69778	107.3289	Mixed forest	104	188	74	65	186	Right	Uphill		
					105	172	58	57	196	Right	Uphill		
					95	176	60	55	193	Right	Uphill		



						98	175	55	47	190	Left	Uphill		
						97	190	55	57	194	Left	Uphill		
						101	167	65	50	197	Left	Uphill		
						100	170	50	62	193	Left	Uphill		
						90	170	58	57	185	Left	Uphill		
						95	178	55	65	190	Left	Uphill		



October

Date	Location	Habitat	GPS		WW'	FF'	FA	F'A'	AA'	Left / Right	Slopo	Walking direction	Notes
			X	Y									
15/02/2003	Bau Chim	Bamboo forest	107.3132	11.6377	100	172	64	59	185	Right	Uphill	From Bau Chim to Suol Tre	
					105	167	70	70	185	Right	Uphill		
					95	180	54	57	191	Right	Uphill		
					100	161	42	58	180	Right	Uphill		
					105	173	64	55	178	Left	Uphill		
					95	155	60	59	160	Left	Uphill		
					95	180	50	53	183	Right	Uphill		
					100	170	64	58	178	Right	Uphill		
					107	192	68	64	195	Right	Downhill		
					92	174	42	40	194	Right	Downhill		
					99	164	47	55	185	Left	Downhill		
					95	191	52	60	202	Right	Downhill		
					94	168	54	55	195	Left	Downhill		
					95	204	52	65	205	Left	Downhill		
					105	175	67	60	179	Right	Downhill		
					100	180	60	63	177	Left	Downhill		
					105	167	60	65	195	Right	Uphill		
					95	147	40	50	190	Right	Uphill		
					84	160	52	54	180	Right	Uphill		
					95	170	58	60	164	Left	Uphill		
					100	168	55	62	172	Right	Uphill		



					93	200	66	67	187	Right	Uphill	
					98	183	73	72	182	Left	Uphill	
					89	163	70	70	168	Left	Uphill	
					95	182	76	60	201	Left	Uphill	
					99	172	72	73	182	Left	Uphill	
					104	176	75	58	180	Right	Uphill	

Date	Location	Habitat	GPS		WW'	FF'	FA	FA'	AA'	Left / Right	Slope	Walking direction	Notes
			107.3132	11.6377									
27/10/2003	Suoi Sinh	Mixed forest	107.3183	11.6661	104	188	79	80	199	Right	Level	From Dinh Do to Bau Sinh	
					101	185	77	76	187	Right	Level		
					99	180	62	62	187	Right	Level		
					101	193	75	68	192	Left	Level		
					111	183	72	78	189	Right	Level		
					103	202	70	64	187	Right	Level		
					95	182	65	65	174	Right	Level		
					112	189	85	72	180	Right	Level		
					111	175	76	70	197	Left	Level		
					118	180	84	87	185	Right	Level		
					101	165	72	78	206	Right	Downhill		
					101	182	66	70	199	Right	Downhill		
					98	184	71	73	184	Right	Downhill		
					111	198	65	66	203	Right	Downhill		
					106	188	67	67	190	Right	Downhill		
					108	195	82	78	187	Right	Level		





December

Date	Location	Habitat	GPS		WW'	FF'	FA	F'A'	AA'	Left / right	Slope	Walking direction	Notes
			X	Y									
07/12/2003	Suoi Tre	Bamboo forest	-	-	88	168	61	68	188	Right	Uphill		
					60	149	71	70	180	Right	Downhill		
					95	170	50	60	200	Right	Downhill		
					93	185	64	65	194	Right	Downhill		
					85	176	70	87	194	Right	Downhill		
					98	183	71	70	195	Left	Downhill		
					95	174	59	60	199	Left	Downhill		
					89	161	50	50	179	Left	Downhill		
					90	169	76	80	190	Left	Downhill		

Date	Location	Habitat	GPS		WW'	FF'	FA	F'A'	AA'	Left / right	Slope	Walking direction	Notes
			X	Y									
16/12/2003	The Saddle (Ven Ngua)	Bamboo forest	107.305355	11.632445	83	185	60	58	200	Left	Level	From Suoi Tre to Bau Chim and return	
					85	170	62	62	203	Right	Level		
					95	162	65	67	185	Right	Level		
					84	169	70	61	199	Left	Level		
					83	162	60	65	192	Right	Level		
					67	167	60	50	184	Right	Level		
					100	180	65	68	199	Right	Level		
					91	177	61	70	195	Right	Level		



