

**A Report on the
Presence, Distribution and
Population Density
of Sumatran Rhinoceroses
(*Dicerorhinus sumatrensis harrissoni*)
in Tabin Wildlife Reserve,
Lahad Datu, Sabah, Malaysia.**



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1.0 Introduction

- 1.1 The Sumatran, Javan and Indian rhinoceroses are the most remarkable animals on earth and are of great cultural importance in Asia (Mohd. Khan et al. 1995). The Sumatran rhino (*Dicerorhinus sumatrensis*) is the smallest and the most primitive of the five living rhinoceros species in the world (Van Strien 1974). They are hairy, two-horned with distinctive three-toed feet. Previous studies on Sumatran rhino in the field are mainly based on hoof prints. The other species with three toes that would be confused with the Sumatran rhino is the Malayan tapir (*Tapirus indicus*) but is not found in the island of Borneo.
- 1.2 Historically, *D. sumatrensis* were found as far north in Bhutan and India, and down south to Myanmar, Thailand, Peninsular Malaysia, and the islands of Sumatra and Borneo. The species is now struggling for survival in a few pockets of Myanmar, Thailand, the Malay peninsular, Sumatra and Borneo (Khan, 1989 cited by Choudhury, 1997). Foose (1999) estimated about 300 individuals confined only in Peninsular Malaysia, Sumatra and Borneo. Two subspecies exist. The subspecies in Sumatra and Peninsular Malaysia is scientifically known as *Dicerorhinus sumatrensis sumatrensis* while the subspecies in Borneo is referred as *Dicerorhinus sumatrensis harrissoni* (Mohd. Khan et al, 1995). Choudhury (1997) reported a few individuals in northeastern India.
- 1.3 It is believed that the estimated 100-150 individuals in Sumatra are confined in small areas such as Gunung Leuser in the north, Sungai Ipuh and Kerinci-Seblat in the west, Berbak in the east and Bansen Selatan and Way Kambas in the south. In the Malayan Peninsular, the estimated 70-100 individuals are distributed in areas of Belum, Gunung Inas and Ulu Selama in the north, Taman Negara in the center and Endau Rompin in the south. In the island of Borneo, the estimated 50-70 individuals are mainly found in Tabin and Danum Valley (Foose, 1999).
- 1.4 A total of 40 rhinos have been captured for captive breeding program (Foose, 1999). Out of this, 26 have since died. There are four active rhino breeding centers namely in Cincinnati Botanical Garden, USA, Sungai Dusun in Peninsular Malaysia, Way Kambas in Sumatra and Sepilok in Sabah, Malaysia. Only the center in the USA has successfully bred and conceived a baby Sumatran rhino in 2001. The duration between the last captive born is about 120 years. To place on record, Sepilok was successful in breeding the rhinos naturally in 1995 and opened the way to breeding of the animals in other centers (Bosi, 1995).
- 1.5 The population of Sumatran rhino in the wild is gradually dwindling due to conversion of forestland into agriculture and poaching. A kilogram of rhino horn is worth about USD45000.00 in the international market (Bradley-Martin & Bradley-Martin, 1991 cited by Boonarata 1997). In Sumatra the rhino horn sells at US2000.00 per kg and up to US18000.00 per kg in Taiwan (Soemarna et al., 1994 cited by Reilly et al., 1997). The rhino represents a case of one of the least sustainable uses of a resource in human history and poaching continues at a high level (Mohd. Khan et al, 1995). The rhino horn is an important ingredient in traditional Chinese medicine (Mjoberg, 1999). In the Middle East, the horns are craved into dagger handles and mugs for the Sultans and Rulers. The horns are believed to cure many ailments and neutralize poisons in the drinks.

- 1.6 A fine example of the drastic decline in Sumatran rhino population is in the island of Borneo. The species has been recorded throughout the island of Borneo (Harrison 1956 cited in Boonratana, 1997). In fact one early Naturalist mentioned how common the animals are in Sarawak, Dutch Borneo or Kalimantan and North Borneo (Sabah) (Mjoberg, 1999). Now, they are found scattered only in three separate habitats in the eastern part of Sabah. The population is still not accurately determined. Foose (1999) has indicated a population size of 50-70 individuals while others have given a lower figure of about 30 or less (Ambu, 1995, Mohd. Khan et al.1995).
- 1.7 The subspecies *D. s. harrissoni* that are found in Borneo is possibly the most endangered of the subspecies (Mohd. Khan et al.1995). The species is listed under Schedule I Part I of the Wildlife Conservation Enactment 1997 and therefore afforded full protection by the government. Their precarious number in the wild has rightfully made IUCN to place the Sumatran rhino under its critically endangered species list (Mohd. Khan et al, 1995, Boonratana, 1997).
- 1.8 Logging in any forms facilitates poaching activity. The most recent killing involving an adult female happened in a selective logging concession along the Kalimantan/Sabah border on March 2001 (Sabah Times, April 17th, 2001). Mohd. Tajuddin Abdullah (1985) reported that rhinos have never been found closer than 0.5km to a disturbed or logging area. In this fatal case, the rhino has no other place to move away from the disturbance.
- 1.9 SOS Rhino is a US-based non-profit non-governmental conservation organization working with government agencies in the conservation of the Sumatran rhinos in Sabah, Malaysia. The goal of SOS Rhino is to prevent extinction of the species. The aim is to increase the population in the wild. Malaysia's image in conservation will be enhanced if we are successful in bringing the Sumatran rhino out of the critically endangered list. On the contrary extinction of the species has a negative impact on the country where it occurred.
- 1.10 This paper evaluates SOS Rhino's *in situ* conservation program that determines the presence, distribution and density of Sumatran rhino in Tabin wildlife reserve. The study also included the threats to their existence and survival, and to make recommendations on averting extinction. This study covers a period from December 2000 to December 2002.

2.0 Study area

- 2.1 Tabin Wildlife Reserve (TWR) was gazetted as a wildlife reserve in March 1984 and covers an area of about 120521 ha or 1205 square km (Maryati et al. 1999). It is situated in the Dent Peninsular with GPS readings approximately between N5° 6.00' and N5° 21.00' and E118° 30.00' and E118° 57.00'.
- 2.2 TWR is under the jurisdiction of the Forestry department Sabah. A Tabin Wildlife Management Committee is established and chaired by the Director of Forestry Department. Other members of the committee include the Wildlife department, Ministry of Tourism, Environment, Science and Technology, Ministry of Finance, Department of Conservation, Tabin Wildlife Resort Sdn. Bhd., and State Attorney's Chamber.
- 2.3 Sales (1994) cited in Boonratana (1997) recorded about 71 species of mammal and 220 species of birds in Tabin reserve. Sumatran rhinos have been found to inhabit this forest.

- 2.4 The Tabin area consists of two major rock formations, the *mélange* (olistostome) and volcanic facies. Mud volcanoes, mud flow and mud seeps cap the underlying terrain in places and are aligned along structural trends (Tahir, 1989). More than 90% of the reserve has been logged previously (Shukor et al. 1989) that ceased in 1989 (Malim & Maryati, 1999). The core area of TWR comprises an area of approximately 8000 ha of primary forest (Jomitin, 1999).
- 2.5 The northern and eastern parts of TWR are predominantly flat lowland while the remainder comprises of moderate to steep slopes above 100-300m a.s.l. reaching up to 570 m a.s.l. (Dalimin & Ahmad, 1999). An aerial view of TWR showed two prominent ridges running from west to the northeast. They are the Rugged hill and Huttons. The southwestern part and the mid southern part of the reserve are moderately steep. The northeastern part of the reserve is mainly flat marshy Nipah swamps. (Appendix 1).
- 2.6 The forest type comprises of virgin forest, secondary forest, riverine forest, and Nipah palms swamp forest. Malim & Maryati (1999) indicate that the primary vegetation was mainly lowland dipterocarp forest but is now a typical secondary dipterocarp forest with open canopy and dense tangled vegetation in the lower layers. *Macaranga* species dominate together with woody climbers, gingers, rattans and ferns. The core area is mainly virgin forest. The secondary forest ranged from healthy regenerating dipterocarps to poor degraded forest. The former is found mainly on the higher and steeper ridges.
- 2.7 TWR is drain by several rivers. The main ones are Tabin river, Tagas Tagas river, Lumpongon river, Maruap Besar river, Kapur river in the north while the Silabukan river Mitambabula river and Mitamba river are in the south. All these rivers flow into the Segama river, one of Sabah's major rivers (Appendix 2).
- 2.8 There are seven mud volcano areas in TWR . The major mud volcanoes and springs are shown in Appendix 3. The rocks and water in the area are highly saline, with salinity ranging between 20-30% (Dalimin & Ahmad, 1999). The main mud volcanoes are Lipad located about 2km from the western boundary and the other is within the core area. The former is larger with approximate 100m diameter while the latter, about 30m diameter. Many wild animals especially ungulates and monkeys frequent these sites.
- 2.9 Oil palm plantations have common boundary with the reserve except for the swampy northeastern part. Thus, the periphery of the reserve has a network of plantation roads. Within the reserve there are also many old logging roads (Appendix 2).
- 2.10 There are three villages on the northern fringes of the reserve. The human population in these three villages is about 400 individuals (Justin Lanjang, per comm.,). They are mostly of the ethnic Muslim group called Tidung and fisherman by profession, depending very much on the Segama River and its tributaries. Oil palm workers are also found settling along the boundary of the reserve, mainly in the south.

3.0 Methodology

- 3.1 In this study both intensive and extensive surveys were conducted to determine the presence, abundance and distribution of *D. sumatrensis* in the Tabin wildlife reserve. The evidence of hoof prints is used for this study. The study area is covered using the 'fishbone' method (Appendix 4). The fishbone method allows systematic survey coverage of the reserve that can be repeated over times.
- 3.2 An aerial survey was conducted to look at the land use around the reserve, documenting them in sequential pictures and to look for illegal activities inside the reserve. The baseline data is required which will be compared when another aerial survey are conducted over the same flight path.

- 3.3 In the fishbone method, a linear transect from west to east was established. This is referred to as the reference transect. At about 7km interval, a north and south linear transects are established. Van Strien (1985) cited in Reilly et al. (1997) has suggested a distance of 8km as sufficient to separate prints but also observed shifts in the home range of female and subadult rhinos, noting instances where home ranges exceeded the 8km diameter range size assumed to eliminate the possibility of overlap.
- 3.4 A reference transect is the existing road from the Tabin wildlife office in the west to the core area, a distance of 22 km and is extended to 42km to the east using line transect. From this 42 km reference transect, eight linear transects were made namely north and south transects at KM7, KM21, KM32 and KM42. These line transects do not exit the border but stop short at least 3 - 5 km to prevent easy entry into the reserve. Along these transects, small base camps are established at 5km interval except for the south transects at KM32 and KM42 where transects are less than 5km because of the short distance to the boundary. From each of these base camps, the teams made four transects in the north, south, east and west directions of approximately 5km per transect (Appendix 4).
- 3.5 The basis of this census is to look for and measure the rhino front hoof prints. The field teams searched for rhino tracks determine the freshness and to measure as many prints as possible. For statistic analysis, a minimum of 20 hoof prints is recommended. The GPS reading is taken to indicate location of these prints. The measurement of the hoof prints involved the distance between the medial and lateral toes, the length from the tip of the middle toe to the tip of the heel, and the length of the middle toe (Picture 1).
- 3.6 Rub marks on tree trunks, signs of browsing and wallows were other evidences used to detect the presence of the animal. Photo-trap cameras were used in identifying individual animal. Dung, urine and hair samples were collected and preserved for future DNA fingerprinting. A successful DNA fingerprinting will enable researchers to determine the sexes and individual profiles.
- 3.7 The duration of the census exercise for the Sumatran rhino in TWR was 24 months covering a period from December 2000 to December 2002. The field teams undertaking the intensive surveys comprised of 14 personals. The general survey on 8th to 20th October 2002 involved a total of 73 people.

4.0 Results

- 4.1 The presence of the animal in TWR is undisputable. A 6-member field team and a postgraduate student have seen a rhino passing through their jungle camp in the morning of 22nd February 2002. They were able to confirm that it was an adult male with about 6-7 inches anterior horn. The hoof print measured 19cm diameter. A wildlife ranger has encountered a rhino around the mud volcano in the core area in 1998 (Jomitin, 1999).
- 4.2 Throughout the study, a total of 59 surveys were conducted over 24 months period and out of this, 24 surveys successfully found rhino evidence. A total of 15 surveys revealed hoof prints between one to 21 days old (Pictures 2 & 3). They were distributed in the southwest, within the mud volcano in the core area and towards the east of the core area. Majority of the findings was confined within the 8000 hectares core area (Appendix 6). Dung, urine and hair samples have been found and collected for future genetic study.

- 4.3 The photo-trap cameras have been used extensively but have so far failed to capture any picture of the Sumatran rhino. Instead, many pictures of elephant, sambar deer, barking deer, wild pigs and macaque were successfully taken (Picture 4).
- 4.5 The study also showed that the rhinos are mainly concentrated in the middle of the reserve within the 8000 hectares core area (Appendix 5). Fresh rhino hoof prints were seen at the mud volcanic area on two occasions (Picture 5 & Appendix 6). It was also noticed that these fresh tracks became unnoticed after a period of least than three weeks. Tracks in open canopy are easily washed off by rain. The nearest print to the main SOS Rhino base camp is about 4km and the furthest is about 29km (Table 5).
- 4.6 The rhino population is determined by three factors (Boonratana, 1997):
- (i) Known - based on the minimum number of individual seen and identifiable tracks.
 - (ii) Probable - based on number of tracks sets and recent presence of other types of evidence.
 - (iii) Possible - based on presence and location of other types of evidence.

Table 1 shows the summarized result of the intensive and general surveys.

Date	Location of surveys	Hoof prints sizes	GPS reading	Remarks
16 - 20.12.00	KM22			NSF
5-11.01.01	Core area	21cm dia.		Fresh , 1-2 days
17 - 25.01.01	Core area			No new tracks. No evident of old tracks
4 - 15.02.01	Core area			NSF
24 - 1.03.01	Core area			NSF
24 - 28.04.01	Prepare transect north from KM7			NSF
21 - 28.04.01	Core area			NSF
16 - 21.05.01	NW from KM7	19 cm dia, 7cm mid toe.	N05 14.437' E118 33.265'	Old - about 6 months
		20cm dia.	N05 14.401' E118 32.301'	As above
6 - 12.06.01	Prepared transect south from KM21			NSF
5 - 11.06.01	Prepare transect north from KM21	18cm dia.	No GPS	Old tracks.
5 - 12.07.01	Continue transect north from KM7			NSF
5 - 11.07.01	NW from KM7	16cm dia	N05 13.290' E118 33.200'	Old tracks, and also a wallow

20 - 25.07.01	SW from KM7	18cm dia.	Elev. 207m N05 10.235' E118 33.183'	Old tracks - 6 months Top of ridge and along old logging roads
6 - 13.08.01	NW from KM7	18cm dia. 7cm mid toe	Elev. 73m N05 15.035' E118 33.473'	Old tracks along old logging road
22 - 25.08.01	NW Rugged hill to search for mud volcano			NSF
7 - 12.09.01	Core area	18cm dia. 7cm mid toe 19cm dia. 7cm mid toe 22cm dia. 7cm mid toe		Fresh tracks - 3 days old
19 - 24.09.01	Continue south transect from KM21	19cm dia. 7cm mid toe 20cm dia. 7cm mid toe	N05 11.311' E118 38.527' As above	Old prints
6 - 10.09.01	NW from KM7	18cm dia. 6cm mid toe		Tracks - 3 weeks old
19 - 23.09.01	Continue transect from core area to the east			NSF
2 - 4.10.01	NW			NSF
6 - 13.10.01	Continue transect north from KM21			NSF
6 - 13.10.01	Continue transect to the east			NSF
18 - 24.10.01	Continue transect north from KM21			NSF
18 - 23.10.01	Continue the transect to the east	16cm dia. 5cm mid toe	Elev. 174m N05 12.309' E118 42.276'	Old tracks Dried dung - collected
4 - 13.11.01	Continue the transect to the east	18cm dia. 7cm mid toe 20cm dia. 8cm mid toe	Elev. 97m N05 12.295' E118 43.057' As above	Fresh tracks - 1-2 days Dung, urine & hair collected
24 - 28.12.01	NW from KM7			Team A. NSF

24 - 28.12.01	NW from KM7	No measurement taken	Elev. 300m N 0672613 UTM0572761	Team B. Track - one week old
29 - 3.01.02	SW from KM7	20cm dia. 7cm mid toe	N05 10.793' E118 33.441'	Team A Tracks.
29 - 3.01.02	SW from KM7			Team B Saw the same prints as the other team
7 - 15.01.02	Prepare transect from KM21 to the East			NSF
7 - 14.01.02	Survey north and south of KM21			NSF
18 - 24.01.02	Stamping 3	20cm dia. 22cm length		Tracks - 5 days Also found dung
4 - 13.02.02	Base camp 2			NSF
4 - 13.02.02	Stamping 4 (KM27)	20cm diam. 21cm length 7cm mid toe	Elev. 76m N05 12.320' E118 42.583'	Tracks - 3 day old 8 very clear prints Plaster cast of print
18 - 27.02.02	Continue transect to the East	19cm dia. 19cm length 7cm mid toe	Elev. 62m N05 12.277' E118 44.572'	22.02.02 Sighting adult Male 6-7inches horn plaster cast of print
		18cm dia. 20cm length 7cm mid toe	Elev. 124m N05 12.235' E118 43.427'	25.02.02 Passed camera trap Tracks - <1week
		20cm dia. 21cm length 7cm mid toe	Elev. 90m N05 12.178' E118 43.282'	25.02.02 Passed camera trap Tracks - <1 week
7 - 20.03.02	Base camp 3 Lumpangon			NSF
7 - 21.03.02	KM32 north and south			NSF
8 - 23.04.02	Prepare transect north and south from KM42	22cm dia. 23cm length 7cm mid toe	Elev. 14m N05 12.330' E118 47.086'	Prints - 3 days Junction of Lumpangon River
3-11.06.02	KM7 north	22cm dia. 23cm length 7cm mid toe		Team A (Spore) Old prints
		20cm dia. 21cm length 7cm mid toe		Rugged Hill Old prints - 3 clear, 2 unclear
3-11.06.02	KM21 south			Team B (Spore) NSF

3-11.06.02	KM27 north			Team C (Spore) NSF
3-11.06.02	KM 27 East	20cm dia. 21cm length 7cm mid toe 22cm dia. 23cm length 7cm mid toe		Team D
4 - 15.07.02	NW			NSF Encroachment
21 - 28.07.02	SW from KM21			Team A NSF
21 - 27.07.02	SE from KM7			Team B NSF
4 - 13.08.02	South transect from KM21			Team A NSF Humans with gun
4 - 13.08.02	East transect from KM27	21cm dia. 22cm length 7cm mid toe	Elev. 75m N05° 12.482' E118° 43.137'	Team B 4 fresh tracks - one week old
19 - 27.08.02	KM27			Team A NSF
19 - 27.08.02	North of KM17			Team B NSF
8 - 20.10.02	General survey			NSF
4 - 12.11.02	North of KM27 Hutton ridge			NSF
20 - 26.11.02	South of KM27			NSF
6 - 14.11.02	North of KM25 Hutton ridge	20cm dia 21cm length 7cm mid toe 20cm dia. 21cm length 7cm mid toe	Elev. -16m N05° 13.345' E 118° 41.839' Elev. -16m N05° 13.751' E118° 42.502'	One print - 3 weeks old Found on 11.11.02 25 prints - 1 week old
23 - 27.11.02	Return to north of KM 25 to make plaster casting			NSF No new prints found

8 - 22.11.02	NE from KM32	20cm dia. 21cm length 7cm mid toe	Elev. 235m N05° 13.463' E118° 45.663'	6 prints - a week old Found on 12.11.02
		21cm dia. 22cm length 8cm mid toe	Elev. 157m N05° 13.920' E118° 45.783'	6 older prints - more than a week
		Dung	Elev. 146m N05° 12.540' E118° 45.331'	About one month old
14 - 27.11.02	NW from KM21			NSF Poachers
13 - 15.12.02	NE from KM42			NSF
9 - 20.12.02	KM42	20cm dia. 23cm length 7cm mid toe	Elev. 178m N05° 12.801' E118° 45.331'	60 fresh prints around KM32 on old logging road
4 - 15.12.02	KM42	21cm dia. 22cm length 7cm mid toe	Elev. 175m N05° 12.425' E118° 43.693'	52 fresh prints about one day found on 14.12.02 Fresh dung collected
		20cm dia. 21cm length 6cm mid toe	As above	

NSF - no significant finding

Note: A UMS-led expedition was conducted to study the granite hills on the northern part of Tabin reserve in October 2000. The fauna team found old rhino hoof prints in the riverine forest. There were two prints sizes; 17cm dia. found along an old logging road and 20-21cm dia. that were found on sandy wallow along the Tabin river. The GPS reading for the 17cm dia. is N05° 18.960' and E118° 44.326' while the other one is N05° 18.691' and E118° 44.280'.

4.7 Based on the field data and other evidence, the population of Sumatran rhino in Tabin wildlife reserve is estimated as follows:

Area covered = 550 km square (45.8% of TWR)
 Known = 6
 Probable = 16
 Possible = 32

5.0 Area covered

5.1 The calculation of the area covered in the surveys is as follows:

KM7 north (10km) and south (5km)	= 10km x 15km = 150 square km
KM21 north (10km) and south (6km)	= 10km x 16km = 160 square km
KM32 north (10km) and south (2.5km)	= 10km x 12.5km = 125 square km
KM42 north (10km) and south (1.5km)	= 10km x 11.5km = 115 square km

Total area = 550 square km

Percentage of area covered = 550/1200 = 45.8% (Appendix 4)

6.0 Known number of rhino at Tabin reserve

- 6.1 To estimate the number of known rhino at Tabin, we use the evidence of fresh tracks that is between 1 - 21 days old. The sizes of the tracks are considered together with the distance between the tracks.
- 6.2 The three areas where fresh rhino hoof prints were discovered are the KM7 Southwest, Core area (mud volcano) and between KM27 to KM32 (Appendix 6). The distance between the hoof prints at the southwest to the core area is about 11.45km. The distance between hoof prints at core area and that found between KM27 and KM32 is on average 7.1km (Table 5 & 6). The distance between the hoof prints at southwest and that found between KM27 and KM32 is on average 18.6km.

Table 2 Shows the summary of fresh tracks found during the study

Date of survey	Location	Hoof print sizes	Remarks
5 - 11.01.01	Core area (mud volcano)	21cm dia.	1-2 days old
7 - 12.09.01	Core area (mud volcano)	18cm dia. 19cm dia. 22cm dia.	3-day old
6 - 10.09.01	KM7 Southwest	18cm dia.	3 weeks old
4 - 13.11.01	East transect KM27-32	18cm dia. 20cm dia.	1-2 days old
18 - 24.01.02	KM27 area	20cm dia.	5 days old
4 - 13.02.02	KM 27 area	20cm dia.	3 days old
18 - 27.02.02	KM27 area	18cm dia. 19cm dia. 20cm dia.	19cm dia. rhino was sighted
8 - 23.04.02	KM32 area	22cm dia	3-day old
3 - 11.06.02	KM27 area	20cm dia. 22cm dia.	Fresh less than a week
4 - 13.08.02	KM27	21cm dia.	1 week old
6 - 14.11.02	KM25 Huttons	20cm dia. 20cm dia.	3 week old 1 weeks old

8 - 22.11.02	KM32 NE	20cm dia. 21cm dia.	1 week old 1-2 week old
9 - 20.12.02	KM42	20cm dia.	1-3 days old
4 - 15.12.02	KM42	20cm dia. 21cm dia.	1-3 days old

6.3 Based on the tracks sizes, location and dates of the discovery of the tracks, the number of known rhinos at Tabin is 6. There are 2 rhinos with print size of 18cm dia. and one each for hoof print sizes 19 cm dia., 20cm dia., 21cm dia. and 22cm diameter. The 19cm diameter hoof print is the rhino that passed through the camping site.

7.0 Probable number of rhino in Tabin reserve

7.1 To estimate the probable number of rhino in Tabin we have to consider all tracks found, location and sizes. Nico Van Strein (1985) cited by Reilly et al. (1997) has indicated that a distance of about 8km for separation of two individuals is relevant. The distance between prints is shown in Table 6 & 7.

Table 3 Shows the date and sizes of tracks found during the study

Date of survey	Location	Sizes	Remarks
5 - 11.01.01	Core area (mud volcano)	21cm dia.	1-2 days old
16 - 21.05.01	NW KM7	19cm dia. 20cm dia.	About 6 months old As above
5 - 11.06.01	KM21 north	18cm dia.	Old tracks
5 - 11.07.01	NW KM7	16cm dia.	Old tracks
20 - 25.07.01	SW KM7	18cm dia.	Above 6 months
6 - 13.08.01	NW KM7	18cm dia.	Old tracks
7 - 12.09.01	Core area (mud volcano)	18cm dia. 19cm dia. 22cm dia.	3-day old " "
6 - 10.09.01	SW KM7	18cm dia.	3 weeks old
19 - 24.09.01	East of KM21	19cm dia. 20cm dia.	Old tracks "
18 - 23.10.01	East transect KM21	16cm dia.	Old tracks
4 - 13.11.01	East transect KM21	18cm dia 20cm dia.	1-2 days old "
29 - 3.01.02	SW KM7	20cm dia.	Old tracks
18 - 24.01.02	Transect to the east	20cm dia.	5 day old
4 - 13.02.02	KM27	20cm dia	3-day old

18 - 27.02.02	Transect to the east	18cm dia. 19cm dia. 22cm dia.	1 week old Animal sighted 1 week old
8 - 23.04.02	KM42 north and south	22cm dia.	3-day old
3 - 11.06.02	KM7 north	22cm dia. 20cm dia.	Old prints "
3 - 11.06.02	KM27 east	20cm dia. 22cm dia.	1-week old "
4 - 13.08.02	East transect KM27	21cm dia.	1 week old
6 - 14.11.02	North KM25 Huttons	20cm dia. 20cm dia.	3 weeks old 1 week old
8 - 22.11.02	KM32 NE	20cm dia. 21cm dia.	1 week old 1-2 weeks old
9 - 20.12.02	KM42 east transect	20cm dia.	1-2 days old
4 - 15.12.02	KM42 east transect	21cm dia. 20cm dia.	1 day old "

7.2 We can consider four areas where rhinos are distributed namely, northwest, southwest, core area (mud volcano) and areas between KM27-32 East. The probable number of rhino in Tabin is 16; four in the northwest, two in the southwest, four in core area (mud volcano) and six between KM27 to KM32. The probable number is inclusive of the 6 known number.

8.0 Possible number of rhino in Tabin reserve

8.1 To estimate the possible number of rhino in Tabin, we will consider all the tracks found, sizes of hoof prints and survey area covered. The area covered by this study is about 550 square km, which represents about 45.8% of the total area of Tabin reserve. We have calculated the shortest distance between the main rhino base camp and hoof prints is about 4km. We therefore make assumption that rhinos will stay at least 4km away from human presence (villages, oil palm squatters and wildlife office). About 536 square km (areas along the boundary) will not be use by the rhinos. In this sense we have only about 664 square km of area used by the rhinos or 55% of the reserve. The area not covered by our study is about 114 square km, which can carry about 3 individuals. Thus the minimum possible number of rhino in Tabin reserve is about 19 individuals.

8.2 Assuming that the reserve is well protected and rhinos are free to roam around without the 4km limitation, the possible number of rhinos that can be found in Tabin is about 32 individuals.

9.0 Discussion

9.1 The first Asian Rhino Specialist Group (ARSG) meeting was conducted in Malaysia in 1982 where for the first time, a critical analysis of Asian rhino distribution, numbers and conservation requirements was carried out (Mohd. Khan et al, 1995).

- 9.2 Many species or communities of species will need specialized census technique. For rare species that is species of very low density or very low visibility, a subjective abundance rating may be all that is possible. Sometimes a detailed survey of intensive study sites plus a very much more generalized distribution survey may be appropriate (Rodgers, 1991).
- 9.3 To obtain the most accurate Sumatran rhino census in TWR is a daunting task as we are dealing with a shy, illusive species that is very low in number. It is vital that the field team covers as much ground as possible. The fish-bone technique allows the team to cover the most remote part of the reserve and a wider area. This technique is also repeatable.
- 9.4 The census technique based on hoof print sizes, date of finding and location is dependent on several factors; human skill and experience, weather and ground conditions, and area of coverage. Luck is probably an important factor too. Boonratana (1997) has indicated the importance of quality surveyors of major surveys that employ several teams. The general wildlife survey of October 2002 involving about 73 people did not yield any evidence of rhino. Based on the feedback from the survey teams, the areas covered were limited by human fitness and majority of the survey members are first timer in the forest and inexperience as far as wildlife inventory work is concerned.
- 9.5 A general survey can be undertaken again as transects are permanent and well established. Boonratana (1997) has recommended that extensive survey be carried out on biennial basis as this will provide better information on the status of the Sumatran rhino in TWR.
- 9.6 Van Striens (1974) has indicated that male has bigger home range that can be more than 30 square km. Female with calf tends to have home range of about 15 square km. Assuming that the home range of Sumatran rhino is 30 square km, the reserve can ideally sustains about 56 individuals. However, only about four fifth of TWR is suitable for Sumatran rhino. Thus, TWR can possibly carry about 32 rhinos.
- 9.7 The presence of small hoof prints points to a breeding rhino population in the reserve. Boonratana (1997) has reported not finding any calf hoof print during his study. He cautioned that hoof prints from elephant calf can be confused to that of rhino calf and that rhino calf prints may be disregard.
- 9.8 Van Strien (1974) has found that rhino live within reach of mud volcanoes. Large herbivores require substantial amount of minerals which plants are unable to provide to meet their nutritional requirement. Although not documented, a helicopter pilot has seen rhinos running away from the sea. It is obvious that it was going for the salt. It is not surprising to encounter more rhino evidence in the middle, northwestern and northern part of the reserve as these areas are relatively flatter, have at least three mud volcanoes and large extend of riverine forest providing ample feed as compared to the other parts of the reserve (Pictures 6 & 7).

9.10 As a comparison, Boonratana (1997) covered an area of 210 square km or 17.5% of the total area of TWR. His rhino estimate 3 known, 5 probable and 9 possible. Malim and Ambu (1995) as cited by Boonratana (1997) estimated between 9 to 20 rhinos. The data was obtained from an extensive survey conducted by the wildlife department Sabah. Foose & Van Strien (1998) estimated the rhino population in TWR between 20-35 individuals. The rhino survey carried out in 1982 by 5 teams in 8 working days and covering a distance of 250km revealed at least 7 rhinos living partly or entirely within the remaining 28000 hectare of primary forest of TWR. In the 1986 survey carried out by 3 teams involving 7 days and covering approximately 157km indicated a minimum of 6 rhinos that were using the core area and the adjacent undisturbed forests, which has of about 11700 hectares. In the 1988 survey by six teams covering a distance of 229km indicated a minimum of two or three adult rhinos residing in the core area (Shukor et al.1989). Jomitin (1999) revealed that there were at least three rhinos residing in the core area and the surrounding forest. His survey team encountered a rhino in the core area. Thus, our finding indicates that the rhino population in TWR has not increased tremendously over the years.

Table 4. Comparison of past and present surveys

Year	No of teams/persons	Area/Distance covered	Duration of survey	Location	Findings
1982	5	250km	8 days	Core area & part of 28000ha	7 rhinos cited by Shukor et al. 1989
1986	3	157km	7 days	Core area & adjacent 11700 ha	Min. 6 rhinos Cited by Shukor et al. 1989
1988	6	229km	5 days	Core area	Min. 2-3 adult rhino Shukor et al. 1989
1995	General survey			TWR	9-20 rhinos Ambu & Malim (1995) cited by Boonratana (1997)
1996	1/4 persons	Approx. 210 sq. km		TWR	Known - 3 Probable - 5 Possible - 9 Boonratana (1997)
1998	3/12 person	3 transects	10 days	Core area	3 rhinos Jomitin (1999)
2001/2	2/14 persons	550 sq. km	24 months	TWR	Known - 6 Probable - 16 Possible - 32 Bosi (2003)-this report

10.0 Threats

10.1 TWR is possibly carrying between 19 to 32 rhinos. There is a sign of breeding after small rhino hoof prints were discovered. There is also sign of human presence and illegal logging activities in the reserve, which are now getting nearer to areas where field teams found higher concentration of rhino presence. Although there is no concrete evidence of rhino poaching in the reserve, the situation may change when these animals are easily encountered as both parties converge on the same area.

- 10.2 The aerial survey of April 2002 revealed the extensive oil palm plantation around the reserve. It also showed the massive network of plantation roads and that at times they appear like fingers spreading inside the reserve. There were also many active clearing on the southern part of the reserve. The survey also revealed the massive network of rivers on the northern part of the reserve. Illegal felling was obvious from the air especially on the northeastern part of the reserve and also encroaching further into the middle of the reserve (Appendix 8).
- 10.3 Ground surveys have confirmed the observation from the air. Team members are frequently encountering unauthorized people in the forest (Appendix 9). They claimed to be fishing but some of the groups have firearms. Active camps were found in the reserve where many trees have recently been felled along the major river towards the east of the reserve. They are waiting for the monsoon and heavy rain to carry their logs out to the estuary and to the Sulu sea.
- 10.4 The situation is becoming alarming and worrying because the active illegal felling and human encroaching are getting closer to areas where fresh tracks of rhinos are frequently encountered. This worry is compounded by the fact that a male rhino had passed an active camp indicating that this animal may quickly adapt to the presence of human in their territory. This is supported by experience in Sepilok breeding center that shows how quickly a wild caught rhino can acclimatize to human; within 14 days.

11.0 Habitat and carrying capacity

- 11.1 According to Forestry department report (1992) approximately 3.35 million hectare of Sabah is under natural forest, and out of this 132600 hectare is for wildlife. The other forested area comprises of 246000 hectare under the Parks and 503000 hectares under forest plantation. Recently, another 30000 hectares of riverine forest is been converted into a wildlife sanctuary by the wildlife department Sabah (Appendix 10).
- 11.2 The home range of Sumatran rhino is between 10 to more than 30 square km (Van Strien cited by Boonratana, 1996). If we based on the density of one individual per 10 square km reported for *D. sumatrensis* (Van Strien, 1986), the carrying capacity of forestland for wildlife in Sabah is about 168 individuals. TWR alone can ideally carry 120 individuals. On the conservative side, if we base on the density of one individual per 30 square km, the carrying capacity of TWR is about 56 rhinos.
- 11.3 Present available data on Sumatran rhinos showed that they are found in only three distinct areas in the east coast of Sabah (Ambu, 1995). Besides TWR they have been recorded in Danum Valley conservation area (DVCA) and around the Sabah Foundation's concession area, and Lower Kinabatangan Wildlife Sanctuary. DVCA comprises of about 60000 hectares of pristine forest. Sabah Foundation concession area is approximately one million hectare. The Sabah Foundation concession area including DVCA has a potential of carrying more rhinos than TWR.
- 11.4 The possible population of Sumatran rhino in TWR of at least 32 individuals is genetically unviable. Boonratana (1997) stated that the minimum viable breeding population is 50 animals. Frankel & Soule (1981) as cited by Boonratana (1997) stated that a minimum effective population size of 500 individuals is required to ensure long-term survival of the species.

- 11.5 Being a browser, they are only able to eat from plants that are within their reach. They do step on young saplings to reach the crown. They also consume wild fruits and play some role as agent of seed dispersal (Mohd. Tajuddin Abdullah, 1985). Van Strien (1985) has reported that they consume as many as 321 plants comprising more than 147 species in Sumatra. In Peninsular Malaysia on the other hand showed that the rhinos feed on 49 plant families, 102 genera and 181 species. This constitutes about 46% of the total plant family in Peninsular Malaysia. About 78% of the foods are commonly found in lowland and hill forest (Mohd. Tajuddin Abdullah, 1985). Due to this inherent nature, Sumatran rhinos require large home range. However, this range can be reduced if more feed are available within the habitat. Primary forest provides feed sources but are scattered throughout. Secondary forests provide more feed for the animals and in theory means smaller home range. The presence of mud volcanoes in the habitat is very crucial for Sumatran rhino.
- 11.6 Studies have shown that Sumatran rhinos are solitary animals although there are overlapping territories (Van Strein, 1974, 1985). In captivity, a male will quickly injure the female when she is not ready for copulation. Thus, breeding occurs only when the female is sexually receptive. It is also shown that the male will aggressively and continuously chase the female. Thus, there is a need for adequate space for these animals to live in a common habitat otherwise they will end up fighting. It is also true for the males. As studying this behavior is difficult in the forest their behaviors in captivity provide some clues to their character in the wild.
- 11.7 While abundant feed resources in a habitat can reduce the home range of this species, their solitary characters point to the fact that they require ample space to separate between and within sexes. In this case, there is a need to conserve large tract of forestland especially lowland riverine forest to ensure a sustainable and viable Sumatran rhino population.
- 11.8 The other constraint to the long-term survival of the Sumatran rhinos is fragmentation of the forest and that they are without any possibility of being linked by forest corridor. The quality of forestland for wildlife has direct impact on the carrying capacity. The other type of forestlands can hold more rhinos but this will be a case of a protected species in a poorly protected areas.

12.0 Recommendations

- 12.1 There is an urgent need to protect TWR effectively. Increasing the number of enforcement units from both the wildlife and forestry departments is relevant. More guard posts are required at strategic sites of the reserve to discourage human encroachment into the reserve.
- 12.2 Conservation based organizations universities and researchers should be encouraged to participate and complement the enforcement efforts of the two agencies. NGOs such as SOS Rhino and local university can assist in this endeavor. While undertaking research and surveys, they become eye and ear of the government. The establishment of a Tabin Wildlife Management Committee is timely and more NGOs in wildlife conservation should be invited to join the committee.
- 12.3 The government has allowed a private sector in developing TWR as tourism destination. The concessionaire must share the responsibility in protecting the reserve. As TWR is such a huge area, the government should consider allowing more than one company to develop the reserve. If they are located strategically along the boundary of the reserve, encroachment can easily be contained.

- 12.4 NGOs that engage with the community should be encouraged. For example, SOS Rhino is now working on its community outreach program to engage and promote among villagers and oil palm plantations the concept of sustainable conservation. They are being engaged to help with wildlife conservation. The oil palm plantations play an important role in reducing poaching, as almost the entire reserve is surround by oil palm crops.
- 12.5 Intensive and general surveys are required to be undertaken on a yearly basis. Shukor et al. (1989) and Boonratana (1997) have recommended an urgent follow-up survey to substantiate the declining number of rhinoceros population at much regular intervals. Survey is now made easier by the presence of permanent linear transects allowing repeatability and consistent data collection and comparison. Frequent surveys will provide more accurate rhino census, which is an important tool in rhino management.

13.0 Summary

- 13.1 TWR is one of the largest wildlife forest reserves in Malaysia. In Sabah, the other wildlife reserve is Kulamba covering an area of about 30000 ha. TWR can carry at least 56 rhinos which exceed the minimum number required for viability status. Based on our finding, there is a possibility of 32 rhinos in TWR and that fall below the minimum number for long-term genetic viability. In view of this, there is a need to undertake similar surveys in the Sabah Foundation concession area and Lower Kinabatangan wildlife sanctuary to ascertain the presence, abundance and density of rhino. With those data in hand, we will be able to decide how best to manage these populations as one meta-population. Research on rhino nutrition will provide pertinent information on plants consumed, and directly gives an idea of carrying capacity. It is also useful in terms of relocation of rhinos to another habitat. Research on genetic fingerprinting using the dung will provide the demographic data that will help in fine-tuning the overall management of Sumatran rhino in Sabah.
- 13.2 Although Sabah has quite an extensive land under forest, they are not specifically meant for wildlife. The forest reserves are protected from unauthorized human encroachment but illegal loggings activities are frequently reported in the media. TWR is not an exception. The problem of illegal human encroachment in TWR is long standing and serious. The rhinos in Tabin reserve are at risk of being poached.
- 13.3 Fragmentation of forests is also affecting the survival of this species. Only recently the Malaysian government has introduced the environmental impact assessment (EIA) policy for any land development. One of the important mitigation measures is provision for wildlife corridors and rescue operations.
- 13.4 The forest in Sabah can easily carry more than 500 rhinos if these animals do not have any value to humans. As compared to wild elephant, orangutans, wild pigs and porcupine, rhinos do not pose any conflict with human.

- 13.5 The survival of Sumatran rhinos in Sabah is faced with many uncertainties despite the stringent laws to protect them. Among them are:
- i. Legal status of their habitats is uncertain. The status of the forest reserve can be altered in the Legislative Assembly.
 - ii. Poaching and illegal logging are common and have been reported frequently in the media although enforcement is continuing.
 - iii. The present areas allotted for wildlife is not only inadequate but fragmented to effectively sustain a minimum effective long-term viable population of 500 individuals.
 - iv. The nature of being solitary animals means inter-species conflict is likely when in close proximity due to space limitation.
 - v. Captive breeding program has not shown much success.

14.0 Conclusion

- 14.1 Base on our study, TWR continues to support a reasonable number of Sumatran rhinos despite the threats from illegal loggings and human encroachment. If illegal human activities can be controlled effectively, rhinos will gradually use more of the habitat, have more feed and propagate. Presently, our study showed that rhinos in TWR tend to be at least 4 km away from human settlements. Protection of the reserve from human encroachment and illegal logging may induce the rhinos to move closer to the boundary.
- 14.2 As genetic viability of a species depends on a certain number of individuals, the population of rhinos at TWR may be low for such purpose. Thus, there is a need to undertake similar surveys on all known rhino habitats and only with knowledge of their population can we manage the population effectively.
- 14.3 Our priority right now is to undertake more surveys to determine the presence, distribution and population density of all the rhinos in Sabah. At the same time there must be serious effort in enforcement to combat encroachment, illegal logging, trapping and poaching in rhino habitats.
- 14.4 Two major researches by local Malaysian students and sponsored by SOS Rhino are underway in TWR. The study on the nutrition of Sumatran rhino will provide invaluable data on plants and fruits consumed by Sumatran rhino in the wild. This data will give an idea of the carrying capacity of the habitat and is very useful when deciding where to relocate Sumatran rhino in the future when necessary. The other research is the study on the genetic micro-satellites and chromosome so that the individual and sex can be ascertained precisely. This data is important in understanding demographics of the species.

15.0 Acknowledgement

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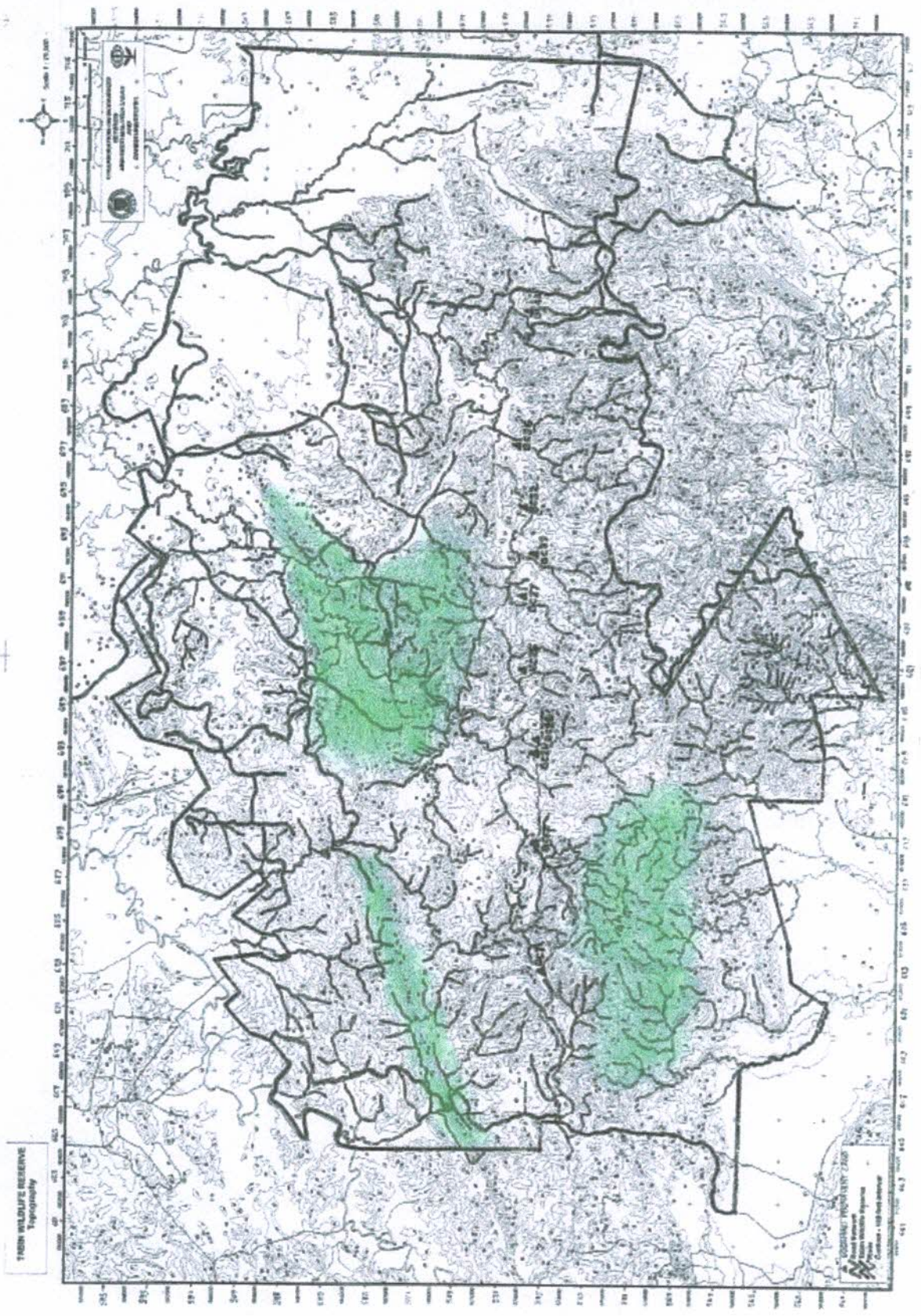
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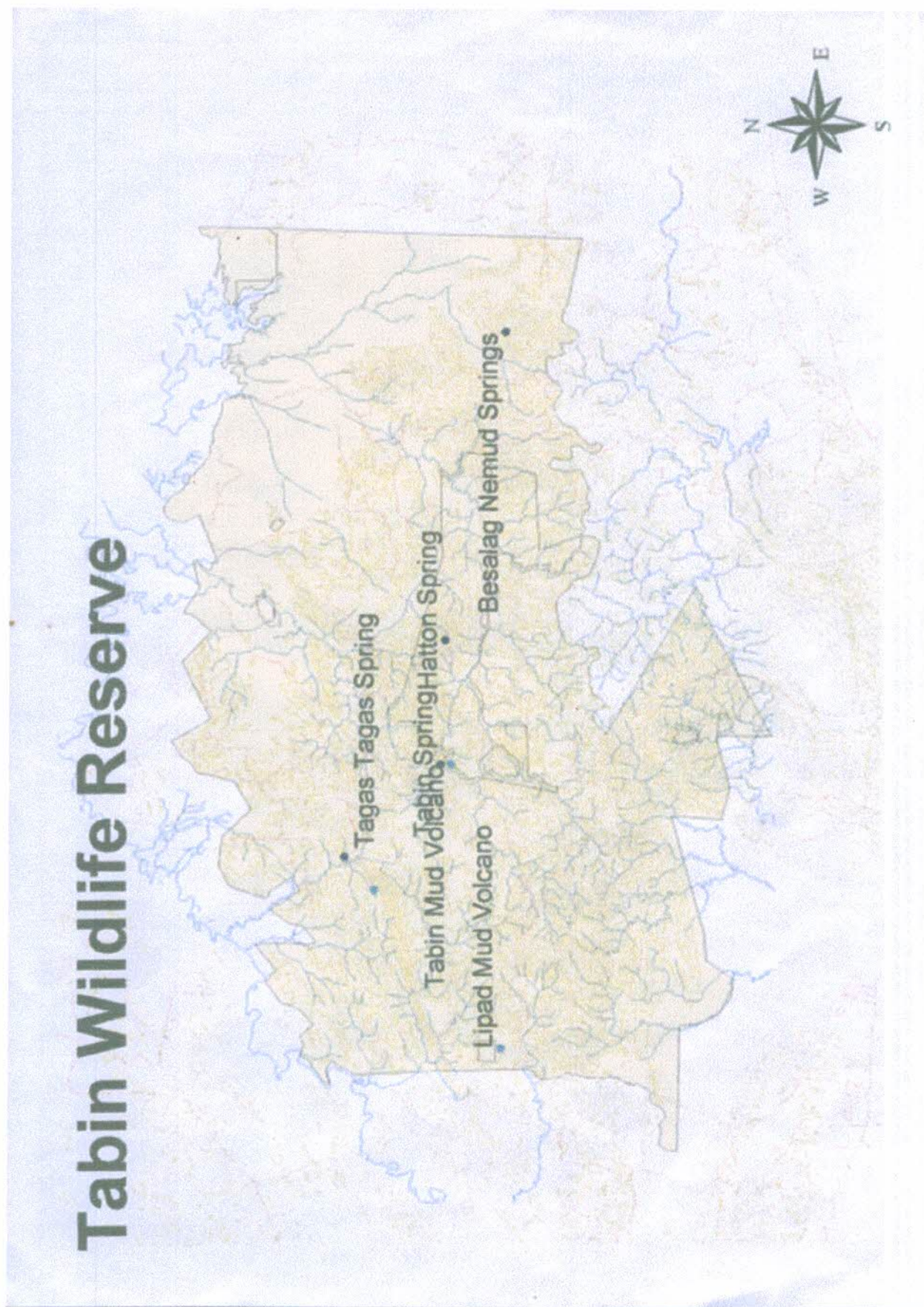
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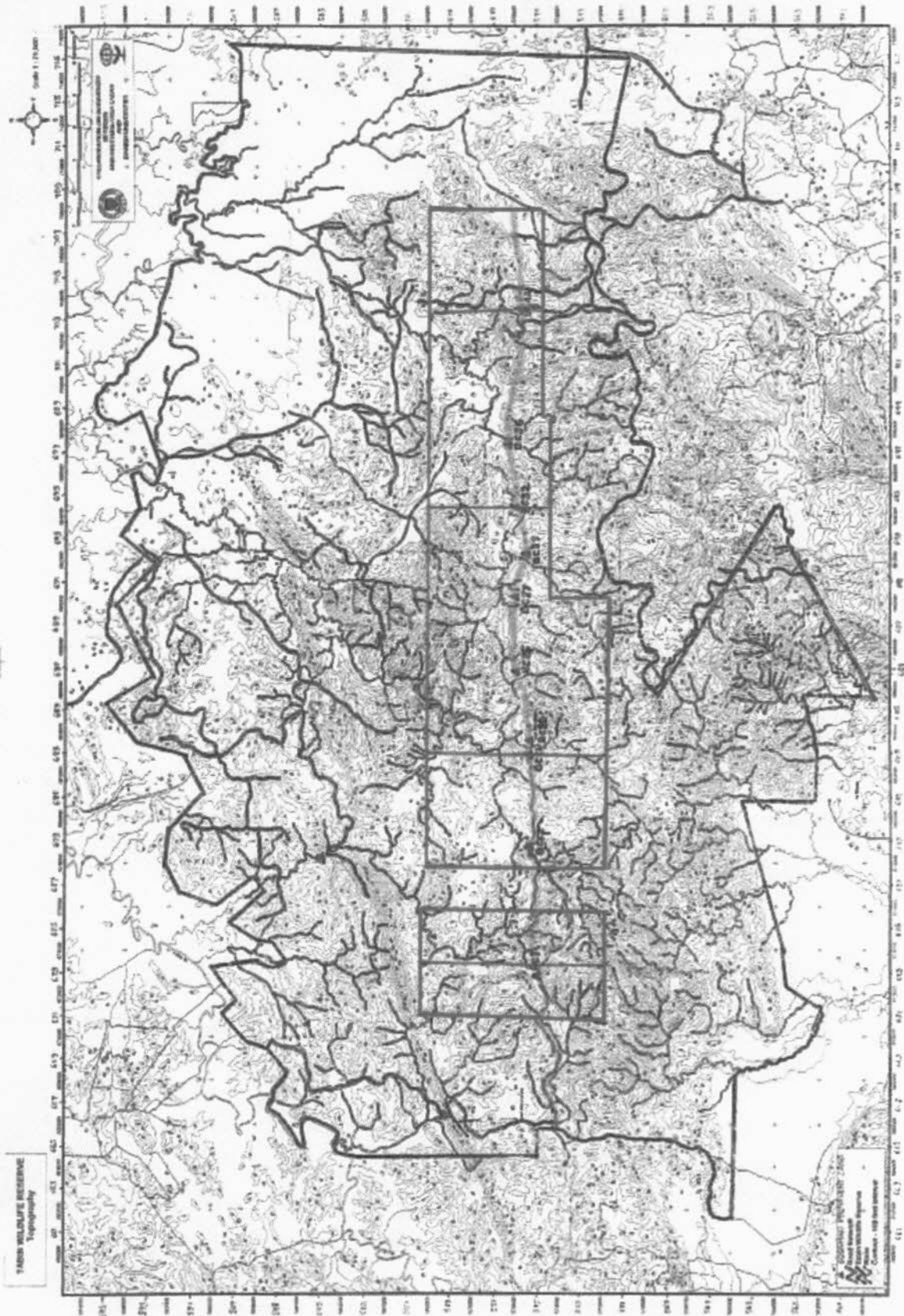
Appendix 1 Topographic Map of Tabin Wildlife Reserve. Showing the rugged hills (North West,) and Huttons Ridge (min North), swamps (North East) and steep ridges (South West)



Appendix 3 Showing the Springs and Mud Volcanoes.



Appendix 4 Topographic Map of Tabin Wildlife Reserve showing the areas covered by the 24 month surveys.



Appendix 5 Rhino Presence and Prints in TWR between 12/00 - 12/02



Appendix 6 Location of Fresh Hoof Prints in TWR from 12/00 - 12/02

▲ Rhino prints

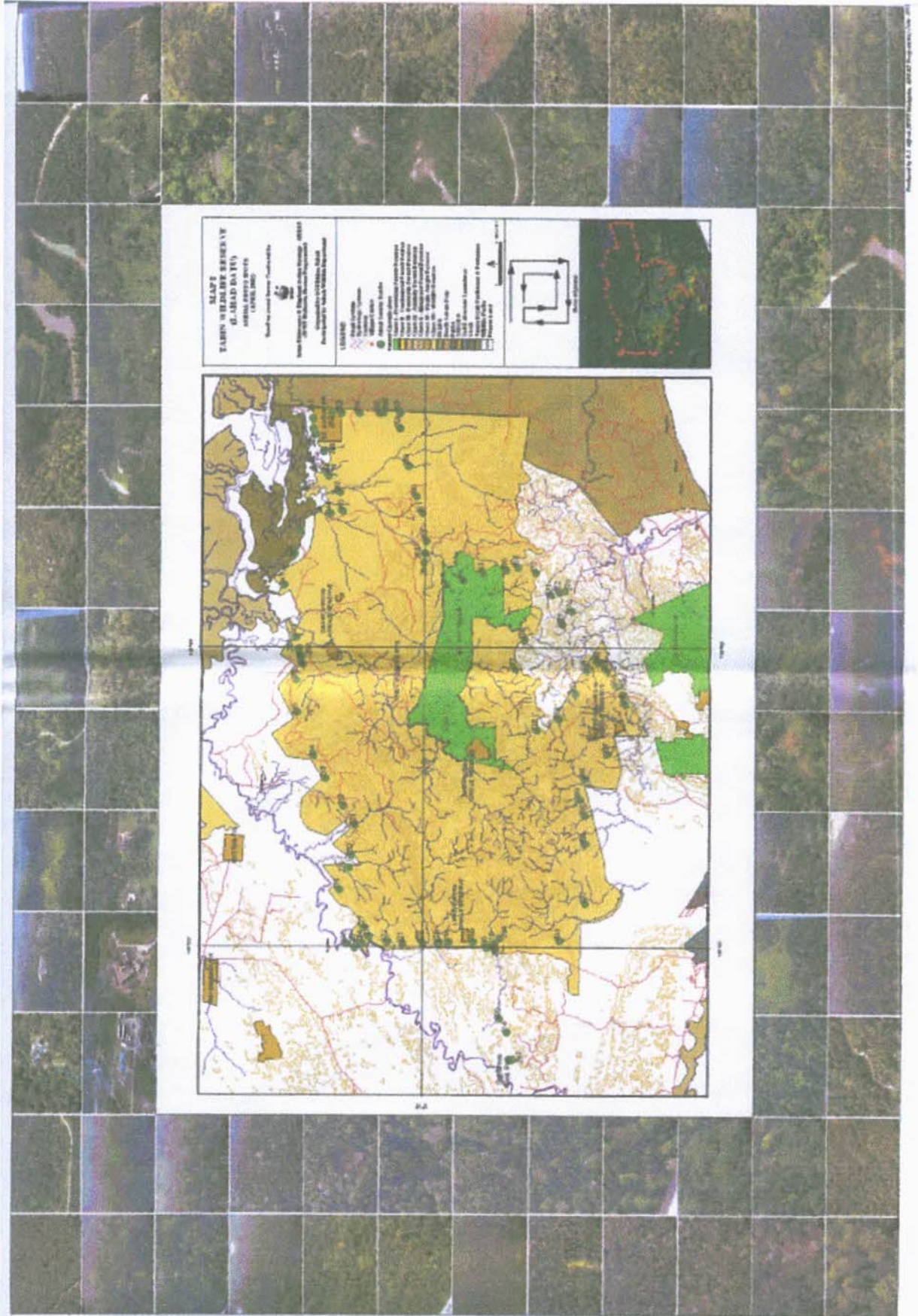


Appendix 7 Transect in TWR between 12/00 - 12/02

● All info points



Appendix 8 Aerial Photo Spots



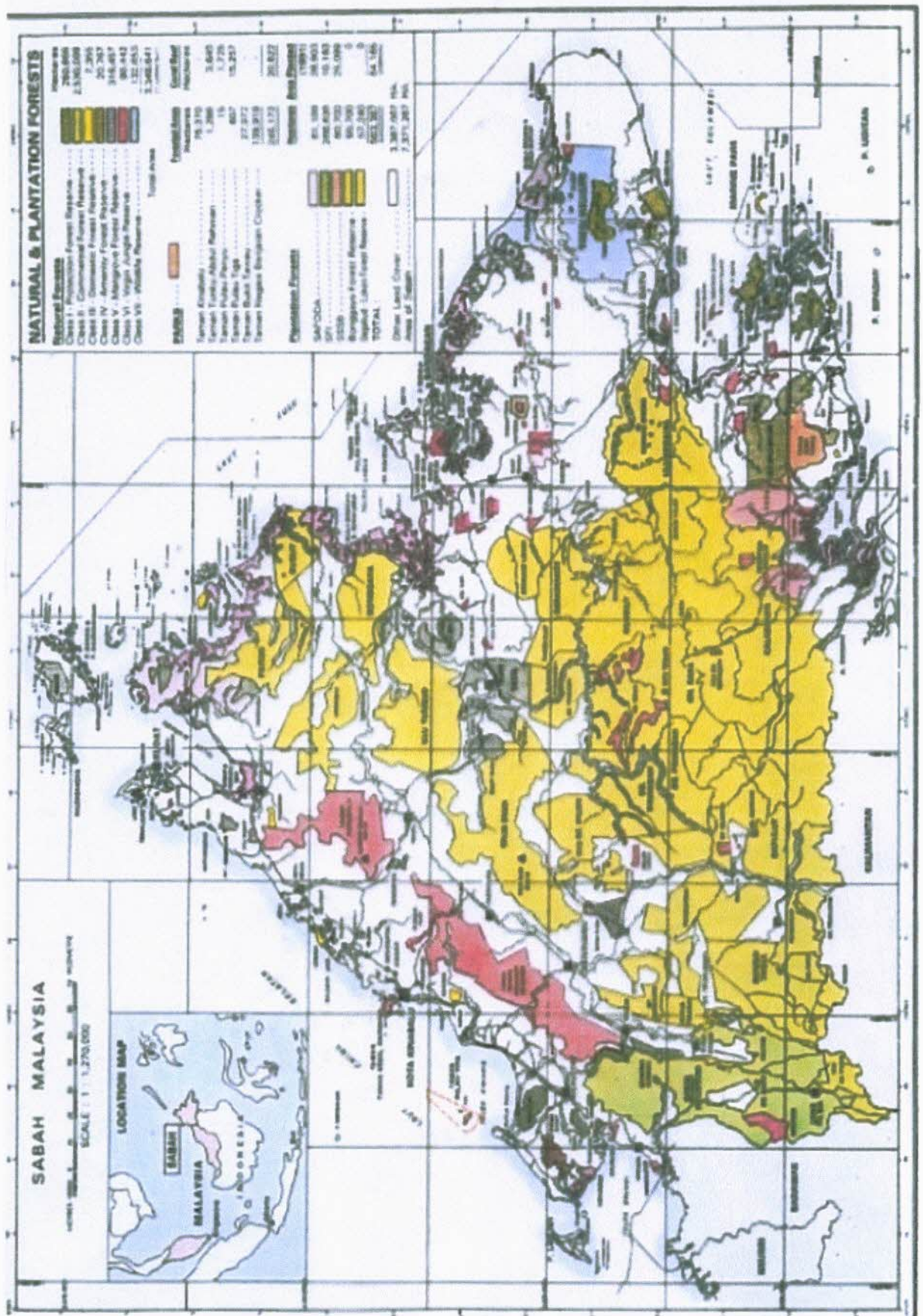
Map 7: Tario Wildlife Reserve, Sarad Basin, Aerial Photo Spots, 2002-2003

Appendix 9 Rhino and Human Presence in TWR between 12/00 - 12/02

- ▲ rhino seen
- human encroachment
- ▲ Rhino prints



Appendix 10 Forestry Department Sabah Map, showing natural and plantation forest.



Picture 1 Shows rhino hoof print and measurement. The white powder is used to illustrate hoof print better for photo graphic purposes.



Picture 2 Shows fresh rhino hoof prints



Picture 3 Shows a fresh rhino hoof print



Picture 4 Shows various animals taken by photo trap cameras



Picture 5 Shows rhino hoof prints at mud volcano.



Picture 6 Shows panoramic view of Huttons Ridge. The area South of Huttons is the core area where many fresh tracks of rhino's were found.



Picture 7 Shows aerial view of the mud volcano in the core area. Rhino's have been found to frequent the site.



Table 5 The Distance (km) between Rhino Prints location in Tabin Wildlife Reserve up to Dec 2002 (SOSRhino)

Data No.	Date Taken	GPS Reading	Distances from Station (km)	Data No.	Date Taken	GPS Reading	Distances from Station (km)
1	21/02/2002	5 207630 118 749090	27.3	45-47	14/12/2002	5 206772 118 728438	25
3	07/05/2002	5 208900 118 716200	23.7	61	07/08/2001	5 224415 118 532520	4.04
8	01/10/2000	5 311520 118 73800	28.7	62	10/08/2001	5 250970 118 563130	8.52
9	07/01/2001	5 205080 118 666710	18.2	64	01/10/2000	5 316000 118 738770	29
10	16/05/2001	5 248950 118 554420	7.62	65	01/06/2001	5 182000 118 559000	6.69
11	05/07/2001	5 221500 118 553330	5.96	66	26/07/2001	5 211110 118 712300	23.3
16	19/09/2001	5 188520 118 642120	15.6	67	07/01/2002	5 250000 118 530000	5.97
18	18/10/2001	5 205150 118 704600	22.4	68	17/08/2001	5 182760 118 559720	6.74
19-20	04/11/2001	5 204920 118 717620	23.8	69-70	15/05/2002	5 208900 118 716200	23.7
22	29/12/2001	5 179880 118 557350	6.61	72-79	06/06/2002	5 210503 118 715442	23.6
23	11/04/2001	5 209310 118 785220	31.3	80-89	07/06/2002	5 207508 118 728002	25
24	16/05/2001	5 240020 118 538350	5.65	90-94	08/06/2002	5 207733 118 732902	25.5
25	05/07/2001	5 222500 118 541900	4.83	101-102	06/06/2002	5 208900 118 716200	23.7
34	09/09/2001	5 182760 118 559700	6.73	103-104	08/06/2002	5 207733 118 732902	25.5
36	12/11/2002	5 232008 118 763043	29	110	11/11/2002	5 223080 118 704463	22.5
39	05/06/2002	5 250900 118 574100	9.52	111	12/11/2002	5 230248 118 764995	29.2
40	07/06/2002	5 257400 118 571500	9.71				

Table 6 Distances (km) between all Sumatran Rhino Prints Location upto December 2002 (SOS Rhino)

Prints Location	Distances (km) between all Sumatran Rhino Prints Location upto December 2002 (SOS Rhino)																
	1	3	8	9	10	11	16	18	19-20	22	23	24	25	34	36	39	40
1	0	3.6	10	9.1	19.68	21.34	11.7	5	3.5	20.69	4	21.65	22.47	20.57	1.7	17.78	17.59
3	3.6	0		5.5	16.08	17.74	8.1	1.3	0.1	17.09	7.6	18.05	18.87	16.97	5.3	14.18	13.99
8	10	0	0	10.5	21.08	22.74	13.1	6.3	4.9	22.09	2.6	23.05	23.87	21.97	0.3	19.18	18.99
9	9.1	5.5	11	0	10.58	12.24	2.6	4.2	5.6	11.59	13.1	12.55	13.37	11.47	10.8	8.68	8.49
10	19.68	16.08	21.08	10.58	0	1.66	7.98	14.78	16.18	1.01	23.68	1.97	2.79	0.89	21.38	1.9	2.09
11	21.34	17.74	22.74	12.24	1.66	0	9.64	16.44	17.84	0.65	25.34	0.31	1.13	0.77	23.04	3.56	3.75
16	11.7	8.1	13.1	2.6	7.98	9.64	0	6.8	8.2	8.99	15.7	9.95	10.77	8.87	13.4	6.08	15.89
18	5	1.3	6.3	4.2	14.78	16.44	6.8	0	1.4	15.79	8.9	16.75	17.57	15.67	6.6	12.88	12.69
19-20	3.5	0.1	4.9	5.6	16.18	17.84	8.2	1.4	0	17.19	7.5	18.15	18.97	17.07	5.2	14.28	14.09
22	20.69	17.09	22.09	11.59	1.01	0.65	8.99	15.79	17.19	0	24.69	0.96	1.78	0.12	22.39	2.91	3.1
23	4	7.6	2.6	13.1	23.68	25.34	15.7	8.9	7.5	24.69	0	25.65	26.47	24.57	2.3	21.78	21.58
24	21.65	18.05	23.05	12.55	1.97	0.31	9.95	16.75	18.15	0.96	25.65	0	0.82	1.08	23.35	3.87	4.06
25	22.47	18.87	23.87	13.37	2.79	1.13	10.77	17.57	18.97	1.78	26.47	0.82	0	1.7	24.17	4.69	4.88
34	20.57	16.97	21.97	11.47	0.89	0.77	8.87	15.67	17.07	0.12	24.57	1.08	1.7	0	22.27	2.79	2.98
36	1.7	5.3	0.3	10.8	21.38	23.04	13.4	6.6	5.2	22.39	2.3	23.35	24.17	22.27	0	19.48	19.29
39	17.78	14.18	19.18	8.68	1.9	3.56	6.08	12.88	14.28	2.91	21.78	3.87	4.69	2.79	19.48	0	0.19
40	17.59	13.99	18.99	8.49	2.09	3.75	15.89	12.69	14.09	3.1	21.58	4.06	4.88	2.98	19.29	0.19	0
45-47	2.3	1.3	3.7	6.8	17.38	19.04	9.4	2.6	1.2	18.39	6.3	19.35	20.17	18.27	4	15.48	15.29
61	23.26	19.66	24.66	14.16	3.58	1.92	11.56	18.36	19.76	2.57	27.26	1.61	0.79	2.67	24.96	5.48	5.67
62	18.78	15.18	20.18	9.68	0.9	2.56	7.08	13.88	15.28	1.91	22.78	2.87	3.69	1.79	20.48	1	1.19
64	1.7	5.3	0.3	10.8	21.38	23.04	13.4	6.6	5.2	22.39	2.3	23.35	24.17	22.27	0	19.48	19.29
65	20.61	17.01	22.01	11.15	0.93	0.73	8.91	15.71	17.11	0.08	24.61	1.04	1.86	0.04	22.31	2.83	3.02
66	4	0.4	5.4	5.1	15.68	0	7.7	0.9	0.5	16.69	8	17.65	18.47	16.57	5.7	13.78	13.59
67	21.33	17.73	22.73	12.23	1.65	0.78	9.63	16.43	17.83	0.64	25.33	0.32	1.14	0.76	23.03	3.55	3.74
68	20.56	16.96	21.96	11.46	0.88	17.74	8.86	15.66	17.06	0.13	24.56	1.09	1.91	0.01	22.26	2.78	2.97
69-70	3.6	0	5	5.5	16.08	17.64	8.1	1.3	0.1	17.09	7.6	18.06	18.87	16.97	5.3	14.18	13.99
72-79	3.7	0.1	5.1	5.4	15.98	19.04	8	1.2	0.2	16.99	7.7	17.95	18.77	19.87	5.4	14.08	13.89
80-89	2.3	1.3	3.7	6.8	17.38	19.54	9.4	2.6	1.2	18.39	6.3	19.35	20.17	18.27	4	15.48	15.29
90-94	1.8	1.8	3.2	7.3	17.88	17.74	9.9	3.1	1.7	18.89	5.8	19.85	20.67	18.77	3.5	15.98	15.79
101-102	3.6	0	5	5.5	16.08	19.54	8.1	1.3	0.1	17.09	7.6	18.05	18.87	16.97	5.3	14.18	13.99
103-104	1.8	1.8	3.2	7.3	17.88	16.54	9.9	3.1	1.7	18.89	5.8	19.85	20.67	18.77	3.5	15.98	15.79
110	4.8	1.8	6.2	4.3	14.88	16.54	6.9	0.1	1.3	15.89	8.8	16.85	17.67	15.77	6.5	12.98	12.79
111	1.9	5.5	0.5	11	21.58	23.24	13.6	6.8	5.4	22.59	2.1	23.55	24.37	22.47	0.2	19.67	19.49

Table 7 Distances (km) between all Sumatran Rhino Prints Location up to December 2002 (SOSRhino)

Prints Location	Distances (km) between all Sumatran Rhino Prints Location up to December 2002 (SOS Rhino)															
	45-47	61	62	64	65	66	67	68	69-70	72-79	80-89	90-94	101-102	103-104	110	111
1	2.3	23.26	18.78	1.7	20.61	4	21.33	20.56	3.6	3.7	2.3	1.8	3.6	1.8	4.8	1.9
3	1.3	19.66	15.18	5.3	17.01	0.4	17.73	16.96	0	0.1	1.3	1.8	0	1.8	1.8	5.5
8	3.7	24.66	20.18	0.3	22.01	5.4	22.73	21.96	5	5.1	3.7	3.2	5	3.2	6.2	0.5
9	6.8	14.16	9.68	10.8	11.15	5.1	12.23	11.46	5.5	5.4	6.8	7.3	5.5	7.3	4.3	11
10	17.38	3.58	0.9	21.38	0.93	15.68	1.65	0.88	16.08	15.98	17.38	17.88	16.08	17.88	14.88	21.58
11	19.04	1.92	2.56	23.04	0.73	0.01	0.78	17.74	17.64	19.04	19.54	17.74	19.54	16.54	16.54	23.24
16	9.4	11.56	7.08	13.4	8.91	7.7	9.63	8.86	8.1	8	9.4	9.9	8.1	9.9	6.9	13.6
18	2.6	18.36	13.88	6.6	15.71	0.9	16.43	15.66	1.3	1.2	2.6	3.1	1.3	3.1	0.1	6.8
19-20	1.2	19.76	15.28	5.2	17.11	0.5	17.83	17.06	0.1	0.2	1.2	1.7	0.1	1.7	1.3	5.4
22	18.39	2.57	1.91	22.39	0.08	16.69	0.64	0.13	17.09	16.99	18.39	18.89	17.09	18.89	15.89	22.59
23	6.3	27.26	22.78	2.3	24.61	8	25.33	24.56	7.6	7.7	6.3	5.8	7.6	5.8	8.8	2.1
24	19.35	1.61	2.87	23.35	1.04	17.65	0.32	1.09	18.06	17.95	19.35	19.85	18.05	19.85	16.85	23.55
25	20.17	0.79	3.69	24.17	1.86	18.47	1.14	1.91	18.87	18.77	20.17	20.67	18.87	20.67	17.67	24.37
34	18.27	2.67	1.79	22.27	0.04	16.57	0.76	0.01	16.97	19.87	18.27	18.77	16.97	18.77	15.77	22.47
36	4	24.96	20.48	0	22.31	5.7	23.03	22.26	5.3	5.4	4	3.5	5.3	3.5	6.5	0.2
39	15.48	5.48	1	19.48	2.83	13.78	3.55	2.78	14.18	14.08	15.48	15.98	14.18	15.98	12.98	19.67
40	15.29	5.67	1.19	19.29	3.02	13.59	3.74	2.97	13.99	13.89	15.29	15.79	13.99	15.79	12.79	19.49
45-47	0	20.96	16.48	4	18.31	1.7	19.03	18.26	1.3	1.4	0	0.5	1.3	0.5	2.5	4.2
61	20.96	0	4.48	24.96	2.65	19.26	1.93	2.7	19.6	19.56	20.96	21.47	19.66	21.46	18.43	25.16
62	16.48	4.48	0	20.48	1.83	14.78	2.55	1.87	15.18	15.08	16.48	16.98	15.18	16.98	13.98	20.7
64	4	24.96	20.48	0	22.31	5.7	23.03	22.26	5.3	5.4	4	3.5	5.3	3.5	6.5	0.2
65	18.31	2.65	1.83	22.31	0	16.61	0.72	0.05	17.01	16.91	18.31	18.81	17.01	18.81	15.81	22.51
66	1.7	19.26	14.78	5.7	16.61	0	17.33	16.56	0.4	0.3	1.7	2.2	0.4	2.2	0.8	5.9
67	19.03	1.93	2.55	23.03	0.72	17.33	0	0.77	17.73	17.63	16.63	19.53	17.73	19.53	16.53	23.23
68	18.26	2.7	1.87	22.26	0.05	16.56	0.77	0	16.96	18.86	18.26	18.76	16.76	18.76	15.76	22.46
69-70	1.3	19.6	15.18	5.3	17.01	0.4	17.73	16.96	0	0.1	1.3	1.8	0	1.8	1.2	5.5
72-79	1.4	19.56	15.08	5.4	16.91	0.3	17.63	18.86	0.1	0	1.4	1.9	0.1	1.9	1.1	5.6
80-89	0	20.96	16.48	4	18.31	1.7	16.63	18.26	1.3	1.4	0	0.5	1.3	0.5	2.5	4.2
90-94	0.5	21.47	16.98	3.5	18.81	2.2	19.53	18.76	1.8	1.9	0.5	0	1.8	0	3	3.7
101-102	1.3	19.66	15.18	5.3	17.01	0.4	17.73	16.76	0	0.1	1.3	1.8	0	1.8	1.2	5.5
103-104	0.5	21.46	16.98	3.5	18.81	2.2	19.53	18.76	1.8	1.9	0.5	0	1.8	0	3	3.7
110	2.5	18.43	13.98	6.5	15.81	0.8	16.53	15.76	1.2	1.1	2.5	3	1.2	3	0	6.7
111	4.2	25.16	20.7	0.2	22.51	5.9	23.23	22.46	5.5	5.6	4.2	3.7	5.5	3.7	6.7	0

For any Comments or Feedback please do not hesitate to contact us.

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