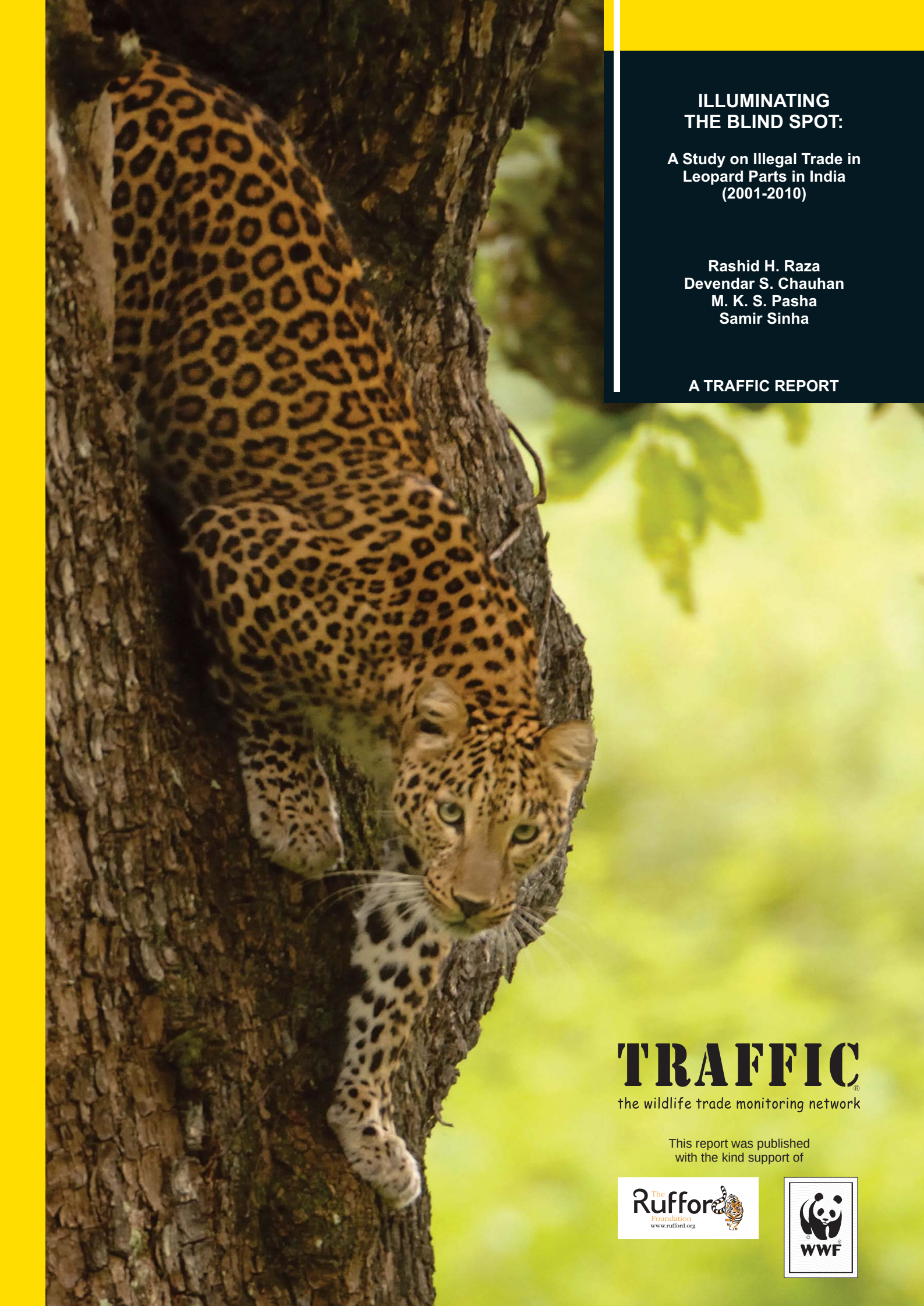


A photograph of a leopard resting on a tree trunk. The leopard is looking towards the camera with a calm expression. Its fur has a distinctive spotted pattern. The background is a soft-focus green forest.

ILLUMINATING THE BLIND SPOT:

A Study on Illegal Trade in
Leopard Parts in India
(2001-2010)

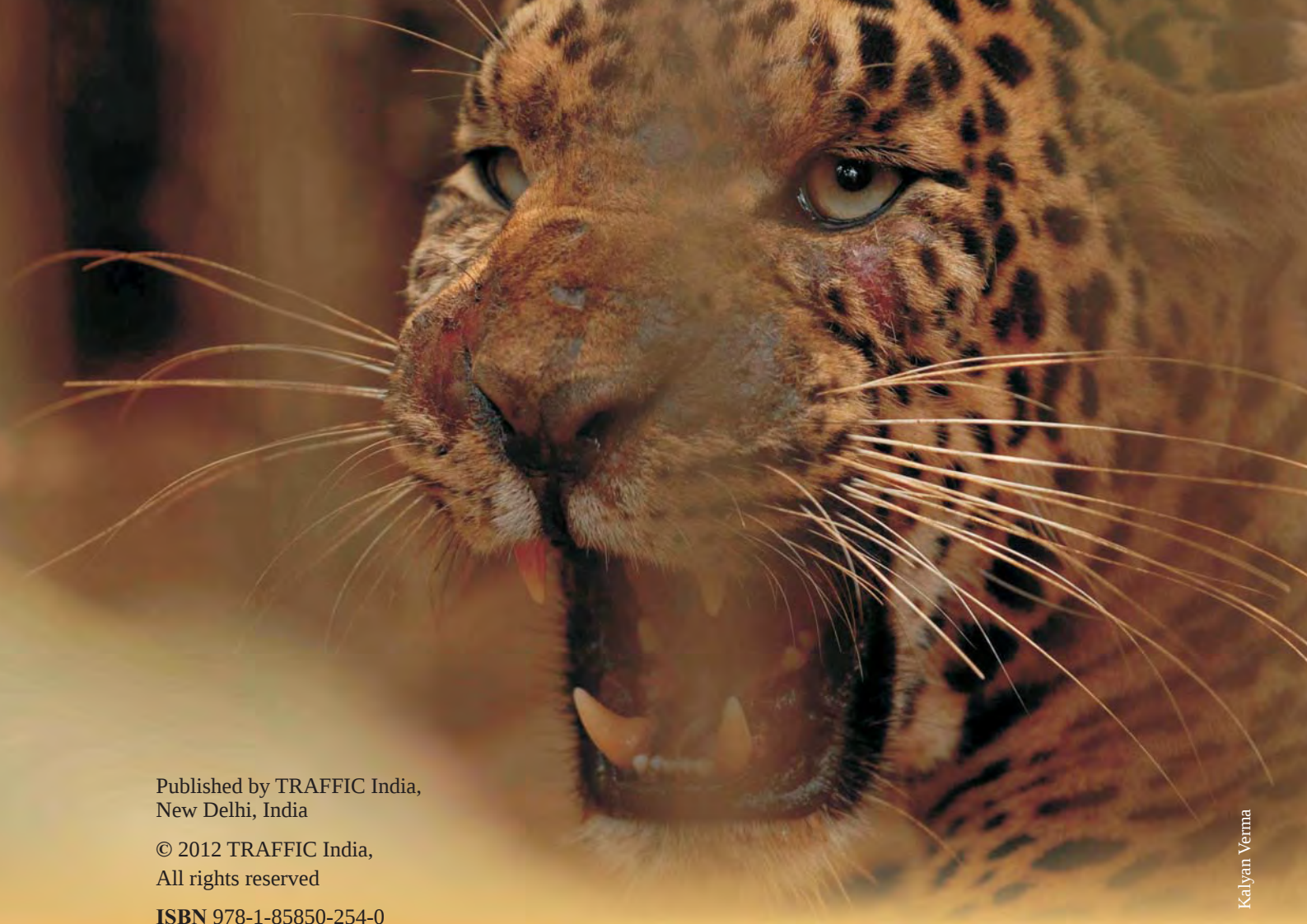
Rashid H. Raza
Devendar S. Chauhan
M. K. S. Pasha
Samir Sinha

A TRAFFIC REPORT

TRAFFIC
the wildlife trade monitoring network

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ILLUMINATING THE BLIND SPOT:

A Study on Illegal Trade in Leopard Parts in India (2001-2010)

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Samir Sinha



G. S. Bhardwaj

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WWF-India Secretariat :
Pirojsha Godrej National
Conservation Centre
172-B, Lodi Estate,
New Delhi-110 003
India

Tel: +011-41504777/4778
Fax: +011-41504779
www.wwfindia.org

Ravi Singh
Secretary General & CEO

Foreword

Almost every person who has an interest in wildlife has a favourite leopard story. Anecdotes of sudden sightings, of fear, stalking and disappearance in broad daylight; of a brilliant presence in the fork of a tree after a sharp shower - the leopard shining as the light in the forest returns; of maulings, fights and the snarling warn of a fear- filled cornered animal, with the lithe grace gone from it; of a leopard walking the sun-lit road; of a mother followed by small and incredibly beautiful two month old cubs; memories of strength, beauty, natural grace and a feigned laziness.

The leopard is among the most charismatic large animals of the world. In the forests that the leopard inhabits, it plays an important ecological role. In fact, in many of our wilderness areas where the tiger has been recently extirpated, the leopard is the top carnivore.

It has inspired awe and marvel among generations of naturalists and yet the leopard remains one of the least studied of our big cats. Meanwhile, the conservation problems that the leopard faces have assumed crisis proportions. In contrast to the lack of scientific data, news headlines are very familiar with the leopard. Scarcely a month passes without a newspaper recording about the lynching of, or a mauling by, a leopard.

Another cause of leopard deaths that also makes news with increasingly disturbing frequency is that of illegal trade of skins and other body parts. The beautiful skin of this cat is in much demand in illegal international markets, and its bones are sometimes used as a substitute for tiger bones. Insatiable market demand combined with lack of will and resources to combat the threat can quickly decimate this species.

I hope that this study will provide a much needed analysis of the illegal trade in leopard body parts in India and catalyze effective conservation action. The conservation of leopard in India needs to be upscaled now, when the species is relatively widespread for as many recent examples show, bringing back of a species in a landscape or relocation is both difficult and carries high costs in many factors of value.

If India does not approach the conservation of this superb creature with urgency, our memories may just fade to impressions of half shadows in the gathering mist of an evening as we approach the best of our forests.



Ravi Singh

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EXECUTIVE SUMMARY

The Leopard *Panthera pardus* is a widespread species in India. It is protected by national law (*Wildlife (Protection) Act 1972*) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, listed in Appendix I). However illegal trade in Leopard body parts (skin, bones, and claws) continues to threaten the survival of the species in the wild. Even though the Leopard is found all across the country there is no reliable estimate of its population. A review of literature regarding population densities of Leopard in Asia indicates that although the species may have a wide geographical range, it is unlikely to occur in relatively high abundance. Leopard-human conflict is a serious problem in India and the subcontinent and is another cause of significant mortality of Leopards.

TRAFFIC undertook a study on the illegal trade in Leopard parts in India with an aim to provide, firstly, indicators of the severity of the trade in Leopard parts in India, and secondly, to identify regions where effective and enhanced enforcement measures will help to have a significant impact in curbing this trade.

A database of seizures of Leopard body parts in India was compiled from newspaper records, supplemented by records of the State Forest departments for the years 2001-2010. The date and location of seizure, and type and quantity of Leopard parts seized were recorded. No other record of mortality, either natural or due to conflict with people was included. *Thus this database exclusively reflects reported incidents of illegal trade of Leopard body parts and probable minimum number of Leopards killed and in illegal trade.* However, it is acknowledged that Leopards killed in conflict may end up in illegal trade. Conflict is a significant cause of mortality of Leopards and its linkages to illegal trade need to be studied in greater detail.

During 2001-2010, a total of 420 incidents of seizures of Leopard body parts were reported from 209 localities in 21 out of 35 territories in India (27 States, 7 Union territories and 1 National capital territory of Delhi). Most of the States (20 out of 27) have reported seizure incidents, 123 out of 593 (21%) of districts have reported one or more seizures during the past 10 years. *These reported seizures account for at least 1127 Leopards poached and in illegal trade. This translates to a recorded seizure of 2.2 Leopards every week.*

Another key finding is that Leopard skins dominate the illegal market of Leopard body parts: 371 (88.3%) seizure incidents involved only skins. An additional 23 (5.5%) incidents involved skins with other parts such as claws, bones or skulls. Seizures of bones are a very minor fraction whether alone or with other body parts.

However, these data only reflect the trade which was detected. In order to estimate the ‘undetected’ part of the trade ‘Mark-Recapture open population models*’ were used.

* Mark-Recapture is a method commonly used in ecology to estimate population size.

As per this analysis, it was estimated that a total of 424.95 ± 33.97 (mean $\pm$ standard error) localities were active in Leopard trade during 2001-2010.

The total estimated number of Leopards poached and in illegal trade in the decade of 2001-2010 is 2294.54 ± 403.34 standard deviation (95% confidence interval, 1565.86 - 3139.00). This gives an estimate of at least four Leopards poached and in illegal trade, every week for the past 10 years.

These results more than double all reported Leopard related statistics on illegal trade (total number of localities involved in trade and the total number of Leopards killed). However keeping in mind the nature and limitations of the data, these estimates are conservatively presented as an improved lower limit of the magnitude of Leopard trade in India.

Delhi has emerged as the most important hub of illegal trade in Leopards, with more than 26% of all Leopards accounted for in reported seizures. It is followed by Uttar Pradesh and Uttarakhand. Together with the neighbouring states of Himachal Pradesh and Haryana (which also recorded sizeable volume of seizures) this region forms the epicentre of illegal trade in Leopard parts. Uttarakhand leads in the number of incidents of seizures involving relatively small number of Leopards killed, indicating that this State is a major source. This is in contrast to Delhi, which is a major centre of collection and trade of Leopard body parts. In Delhi, individual seizure incidents have generally involved larger numbers of Leopard parts and products than seizure incidents in other States. Northern India accounts for more than half of all seizure incidents nationwide and accounts for 67.8% of Leopards killed. In fact 75% of localities associated with trade of Leopard body parts are likely to be concentrated in 7% of the country, in the northern zone. Although the high concentrations of localities in northern India stands out in contrast to other regions, lower levels of reporting or relatively weaker law enforcement effort and effectiveness may obscure patterns in other regions. As such, the overall results should be read with these caveats in mind. This is especially true for north-eastern India from where very few seizure records are available.

For the entire country, the mean number of days separating two successive seizure incidents is 8.6 days; however 56% of seizures are separated by just five days or less. More than 70% of seizures have occurred within 10 days of each other. On average 3.5 seizures every month has been recorded for the past 10 years. Since this is only the *detected* part of the trade, it indicates a high magnitude of trade in Leopard body parts.

TRAFFIC India's findings on Leopard trade are an indication of the enormity of this threat to the future of Leopard in the wild. Some of the essential and immediate steps required to be undertaken in curbing this threat to Leopards are given below.

Recommendations

Improve understanding of the dynamics of Leopard trade in India and across the region

Creation of a systematic, centralized and publicly accessible database on wildlife crime is essential in understanding dynamics of illegal wildlife trade. An impressive baseline has been established with the launch of ‘tigernet’ (www.tigernet.nic.in/), an official database of the National Tiger Conservation Authority on Tiger mortality and crimes in India. This initiative needs to be expanded to other species highly impacted by illegal trade, including the Leopard.

By its very nature of being able to survive in forest edges, the Leopard comes into conflict with people. Human-Leopard conflict is a major driver for Leopard mortality and while it has not been analysed for the purposes of this study, further research is needed in order to evaluate how such conflict may be facilitating poaching of Leopards and illegal trade in their parts.

Strengthen Wildlife Law Enforcement

Despite recent progress, wildlife law enforcement continues to receive a low priority in India. Within the country, a Task Force needs to be created for States with high rates of illegal trade in Leopard. The Task Force will help to analyse the patterns of these crimes and target the key offenders and should have representatives across multiple agencies such as the Forest, Police, Para-Military, Army, Railway Protection Force, the Central Bureau of Investigation, and the Wildlife Crime Control Bureau to coordinate such actions.

Since regions highly vulnerable to illegal trade in Leopards straddle the borders of several adjacent States (in the northern, central and southern zones), enhanced interstate coordination and communications between enforcement agencies would be essential.

Given the highly organised and transnational nature of wildlife crime, as in the case of Tiger and Leopard skin and bones trade, an organised multinational effort needs to be put in place. The recently established South Asia Wildlife Enforcement Network (SAWEN) and India’s bilateral agreements with various countries including Nepal and China are good opportunities to build upon such regional collaboration and support. Many of the issues related to strengthening of wildlife law enforcement, are not specific to Leopards alone but, if implemented well, will also have a likely significant, positive impact on efforts to control of illegal wildlife trade overall.

Improve scientific knowledge on Leopards

While information on the Leopard-human conflict and its resolution is rapidly accumulating, there is little knowledge base to assess the impact of high rates of human-induced mortality on Leopards. Knowledge on Leopard’s ecology and biology remains scarce. India does not have a national program for population estimation and monitoring for the Leopard and little scientific data exist on the vital rates of their populations. It is critical to build the knowledge base on Leopard ecology, if this Prince of Cats is to be conserved with its effective ecological role as a key predator in the ecosystems it inhabits.

1. INTRODUCTION

Kalyan Verma

1 INTRODUCTION

The Leopard *Panthera pardus* is found throughout India with the exception of deserts and the Sundarban mangroves, it has a wide altitudinal range and occurs all along the Himalayas with the exception of high-altitude deserts (Khan, 1986, Daniel, 1996; Johnsingh *et al.*, 1991) and it is the most common and widely distributed species among large carnivores in India (Johnsingh *et al.*, 1991). The Leopard is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which prohibits international commercial trade in the species (and its body parts or derivatives) between all CITES Parties. India has been a Party to CITES since 1976. Within India, the trade of live or dead Leopard or its body parts and derivatives has been prohibited since the implementation of the *Wildlife (Protection) Act* (WLPA) in 1972. However, the international demand for Leopard skins, bones and other products continues to encourage poaching and illegal trade, threatening the survival of the species.

TRAFFIC undertook a study to document and analyse the illegal trade in Leopard parts in India. Data across 10 years (2001-2010) were collated to understand the magnitude of illegal trade and identify the geographic ‘hotspots’ of trade to aid in conservation and enforcement efforts. By synthesizing detailed information on this illegal trade, it is aimed, firstly, to provide, indicators of the severity of the trade in Leopard parts in India, and secondly, to identify geographic areas where interventions, including more effective and enhanced enforcement measures, would lead to a significant decrease in this illegal trade. These are essential first steps in developing strategies to combat this deadly trade threatening the survival of Leopards in India.

1.1 Population and conservation status

Although the Leopard is the most widely distributed large carnivore in India, information on its distribution and abundance is remarkably scarce (based on literature searches conducted for this report). In fact, comparatively more is known at present regarding the distribution and abundance of Tiger *Panthera tigris*, a much rarer species. The Leopard is understood to be widespread



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(Daniel, 1996) and populations exist outside India’s network of Protected Areas (PAs), as well as in sub-optimal habitats and human-dominated landscapes (Seidensticker *et al.*, 1990).

In 17 ‘Tiger bearing’ states in India, the Leopard occupies ca 1 74 066 km² of area, nearly double the area occupied by the Tiger (Jhala *et al.*, 2008). However a finer resolution and more detailed analysis, covering 13 districts in south-central Madhya Pradesh found that nearly 80% of the 52 370 km² predominantly forested landscape may be poor or marginal quality habitat for Leopards, largely due to lack of wild prey species and

proximity of villages (Edgaonkar, 2008). Further, only 12% of the 2569 transects surveyed in south-central Madhya Pradesh recorded Leopard presence (Edgaonkar, 2008).

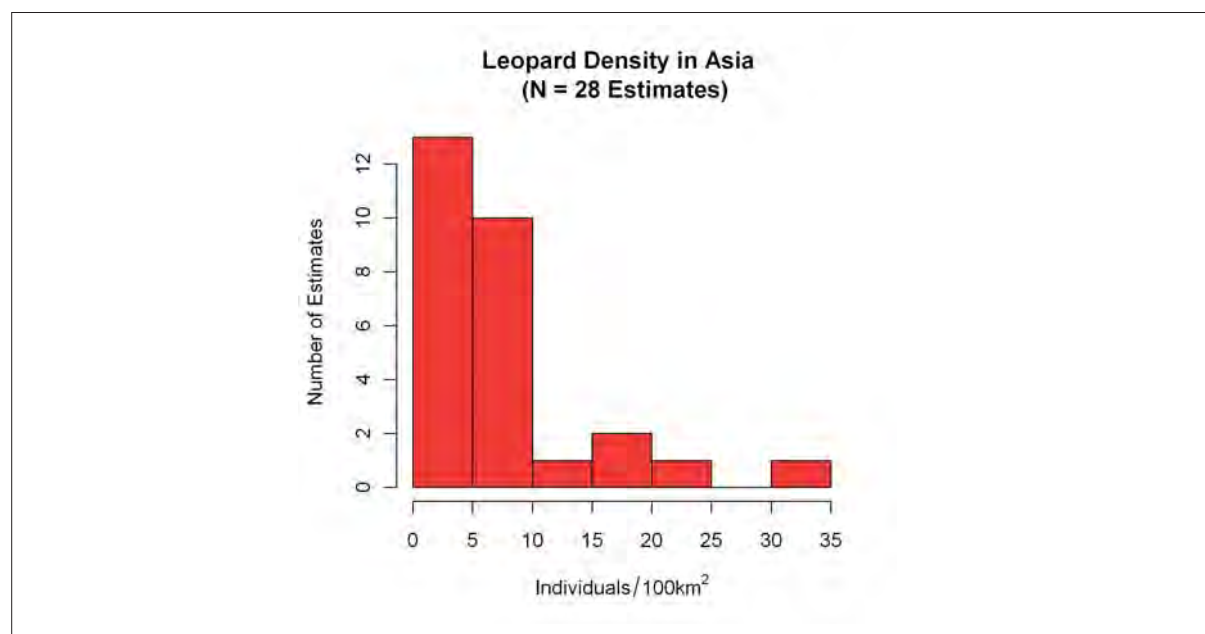
Even in regions such as north-eastern India with more than 60% forest cover, there are indications that the Leopard may not be abundant. A camera trapping study conducted in Namdapha Tiger Reserve in Arunachal Pradesh, did not record a single photo capture of Leopard, with an effort of >1500 trap days (Datta *et al.*, 2008). This points to the rarity of Leopards in the landscape, presumably due to extensive hunting of carnivores as well as their prey species, (Datta *et al.*, 2008).

Determining population numbers of Leopards is a bigger challenge still. Population monitoring for a species such as the Leopard is difficult owing to the elusive nature of the animal and its widespread distribution. A compilation of 28 estimates from 19 studies suggests that densities above 10 individuals/100 km² may be quite rare (See Table 1.1 and Figure 1.1). Considering that ecologists have tended to study Leopards in the best possible habitats in the landscape, and that in the majority of its range in India conditions may be less than favourable, densities in most part of the range might be fewer than 5 individuals/100 km².

Thus although the species may be widespread in geographical extent, it is unlikely that it occurs in relatively high abundance.

Figure 1.1

A compilation of Leopard densities in Asia



A compilation of Leopard densities in Asia based on information compiled in Table 1.1. Most of the estimates are fewer than 10 individuals/100 km², the majority being fewer than 5/100 km². Although some studies are from outside India, they may represent habitat conditions in India. Two studies reported estimates from the same study sites. These were included as separate estimates considering that these two cases represent changed conditions over different time periods.

Table 1.1
Density estimates for Leopard in Asia¹

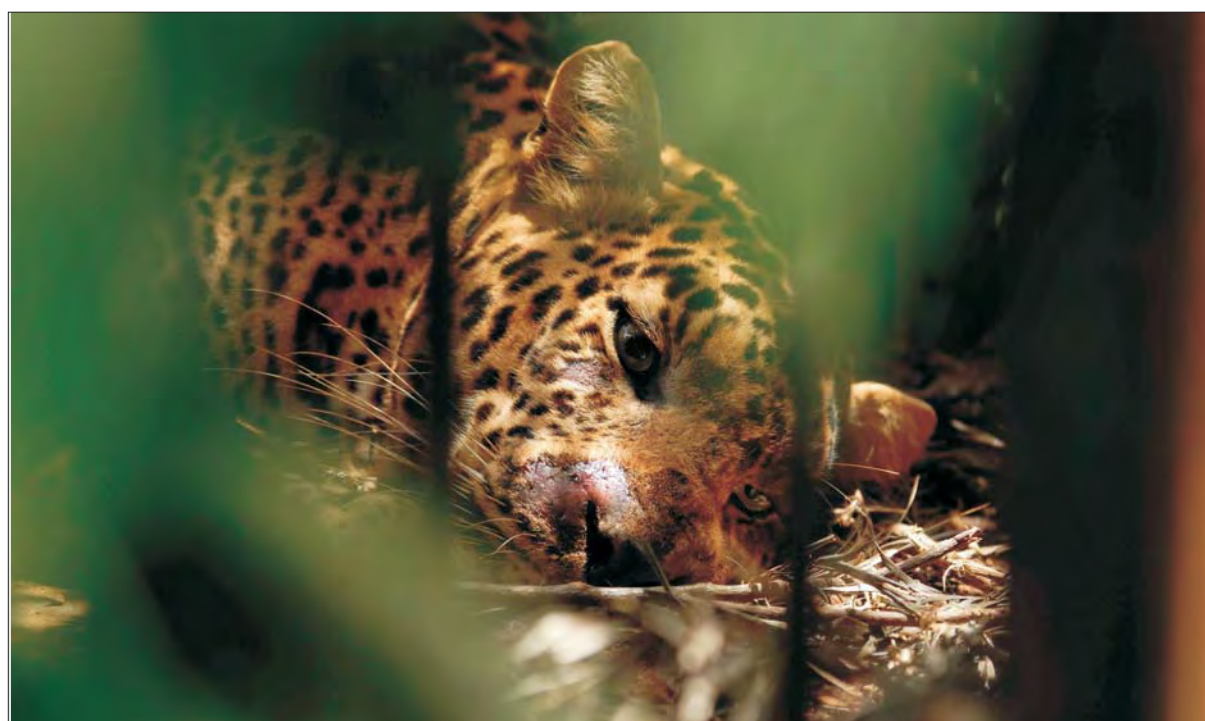
Site	Density	Standard Error	Country	References
South Armenia	0.34		Armenia	Khorozyan <i>et al.</i> (2008)
South Armenia (potential density based on prey abundance)	7.18	3.06	Armenia	Khorozyan <i>et al.</i> (2008)
Jigme Sigme Wangchuk N.P- High altitude forests	1.04	0.01	Bhutan	Wang and Macdonald (2009)
Chilla-2004	9.76	3.5	India	Harihar <i>et al.</i> (2011)
Chilla-2005	8.68	2.8	India	Harihar <i>et al.</i> (2011)
Chilla-2006	3	2.11	India	Harihar <i>et al.</i> (2011)
Chilla-2007	2.07	1.63	India	Harihar <i>et al.</i> (2011)
Gir	14.3		India	Vijayan and Pati (2002)
Junnar (Mahatrashttra)	3.85		India	Athreya <i>et al.</i> (2004)
Kamti	7.5	2.8	India	Edgaonkar (2008)
Churana	9.3	2	India	Edgaonkar (2008)
Lagda	7.3	5.1	India	Edgaonkar (2008)
Sanjay Gandhi National Park	33		India	Forest dept., quoted in Athreya <i>et al.</i> (2007)
Sariska	23.5	8.12	India	Chauhan <i>et al.</i> (2005)
Moyar valley-Sigur Plateau (Nilgiris-Western Ghats)	6.24		India	Pers. comm. Joseph Vettakavan (WWF- Tiger project report in prep)
Java (favourable habitat)	20		Indonesia	Santiapillai and Ramono (1992)
Java (moderately favourable habitat)	10		Indonesia	Santiapillai and Ramono (1992)
Huai Kha Khaeng Wildlife Sanctuary-Thailand (Dry forests)	4		Thailand	Rabinowitz (1989)
Huai Kha Khaeng-1996	7.88	2.97	Thailand	Simcharoen and Duangchantrasiri (2008)
Huai Kha Khaeng-1997	5.21	1.59	Thailand	Simcharoen and Duangchantrasiri (2008)
Huai Kha Khaeng-1998	4.86	2.56	Thailand	Simcharoen and Duangchantrasiri (2008)
Kaeng Krachan National Park	4.78		Thailand	Ngoprasert (2004)
Bamu, Fars	1.87	0.07	Iran	Ghoddousi <i>et al.</i> (2010)
Royal Bardia National Park	5		Nepal	Wegge <i>et al.</i> (2009)
Jabal Samhan Nature Reserve	0.4		Oman	Spalton <i>et al.</i> (2006)
Southwest Primorski Krai	1.2	0.2	Russia	Kostyria <i>et al.</i> (2003)
Ruhuna	17.86		Sri Lanka	Santiapillai <i>et al.</i> (1982)
Wilpattu National Park	3.3		Sri Lanka	Eisenberg and Lockhart (1972)
Global	0.5-37.04		Global	Carbone and Gittleman (2002)

¹ With the possible exception of the Russian study, all studies outside India included here cover habitat conditions likely to occur in India.

Although no reliable population figures or trends are available for the entire country, there has been a long standing anxiety among biologists and conservationists that the Leopard in India is in serious decline (Talwar and Aziz, 1996; Chellam, 2010). It is noteworthy that these reports are separated by 14 years yet they have expressed similar concerns.

In the 1990s, perception of Leopard as a problem animal was widespread, as it is now. Talwar and Aziz (1996) point out that in 1995 the Government of Himachal Pradesh had made a formal request to India's Ministry of Environment and Forests, to cull 270 Leopards, one-third of the State's putative 821 Leopards at that time, which they considered in excess of what the State could support, and hence, responsible for Leopard-human conflict. It is noteworthy that no reliable population estimate of Leopards in Himachal Pradesh was available then (or now). There is still a disproportionate emphasis on the problem that the Leopard causes in comparison to the crisis that the Leopard is facing.

The population of Leopards found outside the network of PAs is highly vulnerable. When living near human populations, they are often regarded as dangerous owing to livestock depredation and posing a threat to humans. This has been documented by case studies in the Indian subcontinent (Athreya *et al.*, 2011; Chauhan and Goyal, 2000; Negi, 1996), including examples of high intensity conflict in Pakistan (Lodhi, 2007; Dar *et al.*, 2009). Conflict has been documented in two protected areas in the Himalayan regions of Bhutan, (Sangay and Vernes, 2008) and in Bardia National Park, Nepal (Tamang and Baral, 2008). The volume compiled by Loveridge *et al* (2010) includes a national overview of large carnivore conflict in Bhutan as well as a global perspective of how wild felids interact with humans. In some States in India, Leopard-human conflict has reached serious proportions. The Forest Department of the State of



Kalyan Verma

Maharashtra reports 902 human injuries and 201 deaths due to Leopard attacks in six years (1999-2005, [Athreya *et al.* 2011]). According to reported official statistics in Uttarakhand, during the 11 years between 2000 and 2011, 363 persons were injured and 204 killed in Leopard attacks. Ninety Leopards were declared man-eaters during this period, with the majority of these animals being killed (Kimothi, 2011). Leopards are often harmed by humans when they predate on livestock and are killed, with increasing frequency in recent times, because of actual or perceived threats to human life. Thus Leopard-human conflict is also a significant source of mortality of Leopards.

Leopards receive considerable protection along with co-existing carnivores within PAs, acknowledging that this is dependent on the effectiveness of patrolling and law enforcement, but there are no clear management strategies to conserve individuals residing outside PAs.

It is also noteworthy that there is evidence that areas with good Tiger densities are often low density Leopard habitats, presumably due to competition from Tigers (Odden *et al.*, 2010). Some research findings show that Leopard densities have been observed to decline as Tiger populations start to recover (Simcharoen and Duangchantrasiri, 2008; Harihar *et al.*, 2011).



1.2 Background information on illegal trade

Although there are insufficient data to characterize the extent of illegal trade in Leopard parts in the 1990s, some indication can be obtained from the seizures carried out during this period. Talwar and Aziz (1996) record seizures of at least 262 Leopard skins between July 1993 and December 1994, including a single seizure of 87 skins from Darjeeling district in the State of West Bengal. They also extensively discussed the rampant poaching and easy availability of Leopard skins in the illegal market in the early 1990s.

The years 1999 & 2000 saw some high volume seizures such as the seizure of 50 Leopard skins in 1999 in Ghaziabad, Uttar Pradesh (The Times of India- 20th December 1999), two seizures in Uttarakhand during May 2000 yielding 80 Leopard skins (Indian Express 11th and 24th May 2000)



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and a seizure of 70 Leopard skins and 18 000 claws belonging to at least 1000 Leopards² in January 2000, in Khaga, Uttar Pradesh (The Hindu 13th January 2000). The seizure in Khaga was the largest seizure of Leopard body parts ever recorded globally. This particular seizure changed the overall understanding of illegal wildlife trade dynamics in India. It revealed the massive scale and level of organization within the illegal trade network and a continuing demand for Leopard products. These records alone represent at least 1392 Leopards killed and in illegal trade during 1991-2000.

In traditional Chinese medicine, Leopard body parts are sometimes prescribed as substitutes for Tiger body parts (Pringle *et al.*, 1999; Sellar, 1999; Nowell, 2000) and this persistent belief in traditions, whether medicinal or folk-based, that Leopard or other felid bones bring health or vigour to potential consumers, may further increase pressure on the Leopard. In India, a key concern is the illicit trade of Leopard body parts to other countries in Asia. Several prosecutions involving illegal trade in wildlife products have occurred in Nepal, which acts as a transit route for wildlife trade between India and China (Shah *et al.*, 2004). In April 2003, police in Syoyambhu region of Nepal seized 109 Leopard skins from a bus headed towards Dhanding, which is a traditional route between Nepal and China (Shah *et al.*, 2004).

Several investigations have suggested that the majority of Leopard skins in trade originate in India, especially those in the ethnic Tibetan regions of China (Anonymous, 1986; Barnes, 1989; Heinen *et al.*, 1995; Nowell and Jackson, 1996; Kumar and Wright, 1997; Wright and Kumar, 1999). In October 2003, China seized a very large consignment containing 32 Tiger skins, 579 Leopard skins and 665 Otter skins in the Tibetan Autonomous Region of China (Banks and Newman, 2004). These items were recovered from two Nepali nationals and many of these skins were suspected to have originated in India. Nepal's role as a transit country is largely due to the fact that large stretches of India's international border with Nepal is porous. A variety of items, including Tiger and Leopard parts and products, are smuggled across by experienced porters who know the paths to avoid guard posts (Pringle *et al.*, 1999).

Oswell (2010) found that many of the Leopard (and Tiger) parts on sale in northern Myanmar and northern Laos were reported to have originated in India and were then smuggled across the Indo-Myanmar border. Shepherd and Nijman (2008) also found Tiger and Leopard parts reportedly being smuggled by air to Yangon from India and then overland to Tachilek in northern Myanmar.

² 18000 claws = 1000 Leopards, since a Leopard like all cats has only 18 claws, (Nowak 2005).

1.3 Objectives

With this background, the following objectives were defined for this study to understand and highlight the pattern and trends in Leopard trade in India in the decade of 2001-2010:

1. Estimate the magnitude of trade in India of Leopard parts.
2. Describe the geographic spread of India's trade in Leopard parts and identify 'hotspots' of trade.
3. Analyse the temporal trend of the trade in Leopard parts.



TRAFFIC India

Leghold trap used to trap big cats including Leopard and Tiger



WWF-India

2. METHODS

Axel Gebauer

2 METHODS

A database of seizure incidents involving Leopards for 10 years (2001-2010) was compiled. Information on the status and extent of illegal trade in Leopard body parts in India was collected from published literature: reports (including annual reports from the CITES Management Authority of India³), books, journals, scientific articles and newspapers. Forest departments of eight States which showed high levels of Leopard-related crime (Haryana, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Uttarakhand, Uttar Pradesh, and West Bengal) as well as the National Capital Territory of Delhi provided data on Leopard seizures from their jurisdictions. Data from the forest departments cover the period of 2002-2008. This added a valuable 120 unique incidents to the database⁴. Care was taken to eliminate records duplicated in the media and forest department records.

The chief source of data however remains the newspaper reports of seizures involving Leopard body parts. Newspapers comprising national and regional dailies published between 2001 and 2010 were scanned for any news item relating to illegal trade in the species. Thus, all records in the database are backed by news reports published by print or electronic media in the public domain. The database recorded date and location of seizure and type and quantity of Leopard parts seized. No other record of mortality either reported as natural or due to conflict with people was included. *Thus the data exclusively reflect incidents and mortality related to illegal trade in Leopard parts.* Some limitations of the data are that some regions like north-east India seem poorly covered, and data are sparse in particular in the first half of the decade. Regrettably these limitations are unavoidable in an analysis of wide spatio-temporal spread, with Verheij *et al.* (2010) using a similar methodology for analysis of trends in Tiger trade. The analytical results were interpreted with these limitations in mind.

2.1 Spatial analysis.

2.1.1 Assigning seizure data to standard locations

All data were geo-referenced and brought into a geographic information system (GIS) for visualization and further analysis. Based on the information available in the reports each incident was geo-referenced to the closest point possible, e.g. places in large cities were geo-referenced using Google Earth. However this strategy leads to a non-standard list of localities, as it is difficult to define a “location”. The location of seizures is reported at various levels of resolution, e.g. a single location can be reported as a specific building (a hotel), a street address or an administrative sub-unit. However it is important to define what is meant by a “location” such that each seizure record is accurately assigned to a predefined unit. This makes comparisons possible and analysis replicable.

Assigning incidents to sub-districts, known as *talukas* in Indian administrative terminology, leads to greater aggregation and hence loss of information, therefore a point database of populated places of India (from Gridded Population of the World database

³ Although the UNEP-WCMC CITES trade database records two seizures of Leopard body parts from India by the United States during this period, these incidents have not been included in the analysis.

⁴ Analysis was done both with and without including the additional data set received from the Forest Departments. The overall geographical pattern from both analyses shows close correspondence.

<http://sedac.ciesin.columbia.edu/gpw/>) was used as the ‘standard’ list of localities in India and each record was assigned to one of these. After removing duplicate coordinates there are 3539 ‘standard locations’ of populated places in India (defined as “locations with 1000 or more persons”). These may be considered equivalent to ‘large villages’. Voronoi polygons were built based on these points, by joining the lines dividing the distance between two points in equal halves⁵. Thus it provides a convenient way of assigning points to the nearest ‘standard location’. Regions with high population density get smaller polygons and vice versa. A point was assigned to a locality if it fell inside the polygon of that location. The 420 incidents were thus assigned to a total of 209 locations. The process is depicted in Figure 2.1, showing assigned localities around Delhi.

2.1.2 Delineating hotspots of illegal trade in Leopard parts

A simple depiction of seizure locations provides an approximate understanding of where concentrations of illegal trade are likely to be. However to delineate these concentrations of illegal trade or ‘hotspots’ of illegal trade in Leopard parts, inferences about the intervening space between two points must be made.

This situation is analogous to analysis of animal space use, where inferences are made about concentration of activity (utilization of area) based on locational data gathered by simple observations or radio-tracking. Kernel Density



Xu Ling/TRAFFIC East Asia

Estimation (KDE), statistical data smoothing methods (Crawley, 2007) are highly recommended methods of animal space use analysis (Worton, 1989, Hooge and Eichenlaub, 2000). KDE has been used for mapping crime hotspots as well (Chainey & Ratcliffe, 2005; Chainey *et al.*, 2008).

KDE applied in two dimensions (such as with locational data with latitude and longitude coordinates) generates a continuous space filling model that estimates the relative concentration of points. In case of animal space use KDE gives a probabilistic map based estimate of relative amount of time the animal subject spends in a given area and hence the probability of it being present in that area. The area enclosing the 50% probability zone is considered the core area within a home range. The area enclosing the 95% probability is almost the entire home range of the animal. It can also be said that there is a 50% probability of finding the given animal in the area enclosing the 50% probability zone and so forth. Applying this approach to locations of seizures of Leopard body parts, we can identify areas which are most intensively used by criminals dealing with illegal trade in Leopard parts.

⁵ Voronoi polygons have a unique property that any location within the polygon is closer to its ‘central’ point than to the ‘central’ point of any adjacent region (see the central points, in this case populated localities [represented by blue dots] in Figure 2.1). Thus if a seizure location falls within the Voronoi polygon enclosing a populated locality, it can be reliably said that the seizure location is closest to this particular populated locality and not the adjacent.

Thus extending this approach to mapping criminal activity, the areas enclosing the respective probability zones based on locations of seizure incidents reflect the probability of a seizure occurring in the enclosed area.

Analyses for this study were performed in Arcview version 3.2 using the animal movement extension, developed for ecological analysis of home ranges and movement patterns of wildlife (Hooge and Eichenlaub, 2000). It is worth noting that some professional criminologists also find the animal movement extensions software useful for criminological data analysis (Levine, 2007).

Figure 2.1

Assigning seizure data to standard locations



The example illustrates the method by which geo-referenced points were assigned to standard location database. The figure shows seizure points in and around Delhi, and the Voronoi polygons to which these points were assigned. Note that it is possible for a 'standard location' to be within an adjoining State if the seizure location is nearest to a populated locality in that neighbouring State. However, for all tabulations done to compare State-by-State, the exact seizure locations relative to State geographical boundaries were used.

2.2 Estimating the magnitude of trade

2.2.1 Estimating minimum number of Leopards killed from the seizure of body parts.

It is possible to arrive at a minimum number of Leopards involved in each incident based on the seizure records (see Shepherd and Nijman, 2008). For example, if 5 skins and 180 claws were recovered, the minimum number of Leopards killed is 10, since the number of claws account for 10 individuals at least. In one instance weight of claws seized was given with no indication of numbers (seizure of 3 kg claws besides 39 skins and other parts, reported from Patelnagar, New Delhi on 1st February 2005). The weight was converted into numbers by using average weight of a single claw without bone ($1.12 \text{ gm} \pm 0.4$, $N=10$)⁶. This translated to 149 Leopards⁷.

In cases of recovery of bones, 6 kg of bones is assumed to account for one individual, assuming adult Leopard live weight as 60 kg and bone weight to comprise 10% of the body weight of the animal. This is in line with Prange *et al.* (1979), who derived an equation for skeletal mass of mammals:

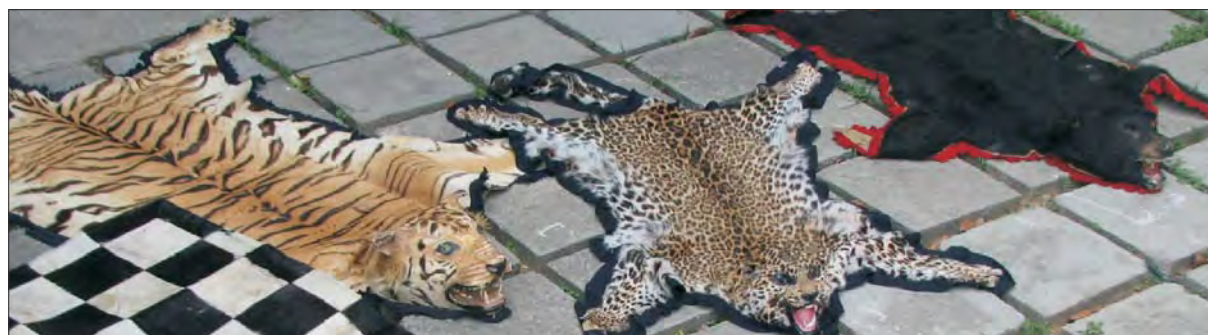
Skeletal mass = $0.061 \text{Bodymass}^{1.09}$, where mass is in kg, $r^2 = 0.984$, which is effective for a mass ranging from 6 gm to 6000 kg.

Using this equation, bone mass of a 60 kg adult Leopard is calculated as 5.4 kg (9% of adult weight), thus it is a reasonable approximation to use 6 kg of bones to comprise one individual.

2.2.2 Estimating the undetected fraction of Leopard trade.

An important characteristic of illegal wildlife trade is that much of it is difficult to observe and hence the true magnitude of trade is unknown. Two key descriptors of illegal trade in Leopard parts are the number of seizure localities involved with this trade and the total number of Leopards killed and traded during 2001-2010.

Since seizure data provide part of the picture, the analytical approach is aimed at estimating the undetected fraction of the trade. This is arrived at by a two-step process. First the total number of localities is estimated through mark-recapture analysis, which accounts for the undetected localities (see Section 2.2.2.1). Secondly the estimated number of localities is multiplied with the average number of Leopards accounted for by seizures within a locality, to arrive at the estimate of total number of Leopards killed and traded during 2001-2010 (see Section 2.2.2.2).



⁶ Data kindly provided by Dr. S.P Goyal, Head, Wildlife Forensics Lab, Wildlife Institute of India

⁷ It is assumed that in a seizure report, the correct numbers of Leopard parts have been documented and there is little uncertainty regarding conversions from body parts to number of individuals; most seizures recorded whole Leopard skins, rather than pieces.

2.2.2.1 Estimating the total number of localities in illegal trade using Mark-Recapture statistics

The seizure incidents represent an unknown fraction of the actual magnitude of trade, both in terms of the number of locations where illegal trade incidents took place and by extension the number of Leopards killed. Some locations have been involved in multiple incidents while many locations occur only once in the database.

In another words it can be said that *localities associated with Leopard trade are imperfectly detected*. Since it can be logically assumed that new spots of crime emerge as well as older ones are abandoned, the data mimic an ‘open population’, where new locations can be ‘born’ and older ones ‘die’ during the continuous sampling duration (10 years, uniform sampling intensity assumed since daily records of news were scanned and recorded). Thus this information is amenable to ‘open population models’ of mark-recapture literature. Specifically the POPAN models (Schwarz and Arnason 1996) were used, as implemented in software MARK version 5.1 (Cooch and White, 2010), with RMARK version 2.0.4 (Laake, 2011), an interface of MARK in the R language (R Development Core Team, 2010).

Mark-recapture statistical methods were developed for estimation of animal populations when it is not possible to count all individuals due to imperfect detection (Williams *et al.*, 2002). These methods have now found application in fields as diverse as epidemiology (Tilling *et al.*, 2001) and software testing (Ebrahimi, 1997). This approach is congruent to application of mark-recapture methods on sessile objects, for example the work by Alexander *et al.* (2009) which estimated the numbers and survival of patches of a cryptic plant *Asclepias meadii* across several years, while Williams *et al.* (2011) estimated the number of nests of asynchronously breeding water birds. Both these studies used open population models.

The data were aggregated by year thus generating a ‘capture matrix’ or a ‘seizure matrix’ of 209 locations for 10 years. If a seizure incident occurred in a given location in a particular year it was recorded as ‘1’ otherwise as ‘0’. The localities were grouped in five geographical zones: Central,

Eastern, Northern, Southern and Western, (see Figure 2.2) This enabled derivation of estimates of total number of localities active in Leopard trade during the past decade, for each region as well as aggregated totals for the entire country.

Twenty eight mark-recapture models were fitted to the seizure locality data to estimate the total number of unreported localities. Geographical zones were used as a group variable.

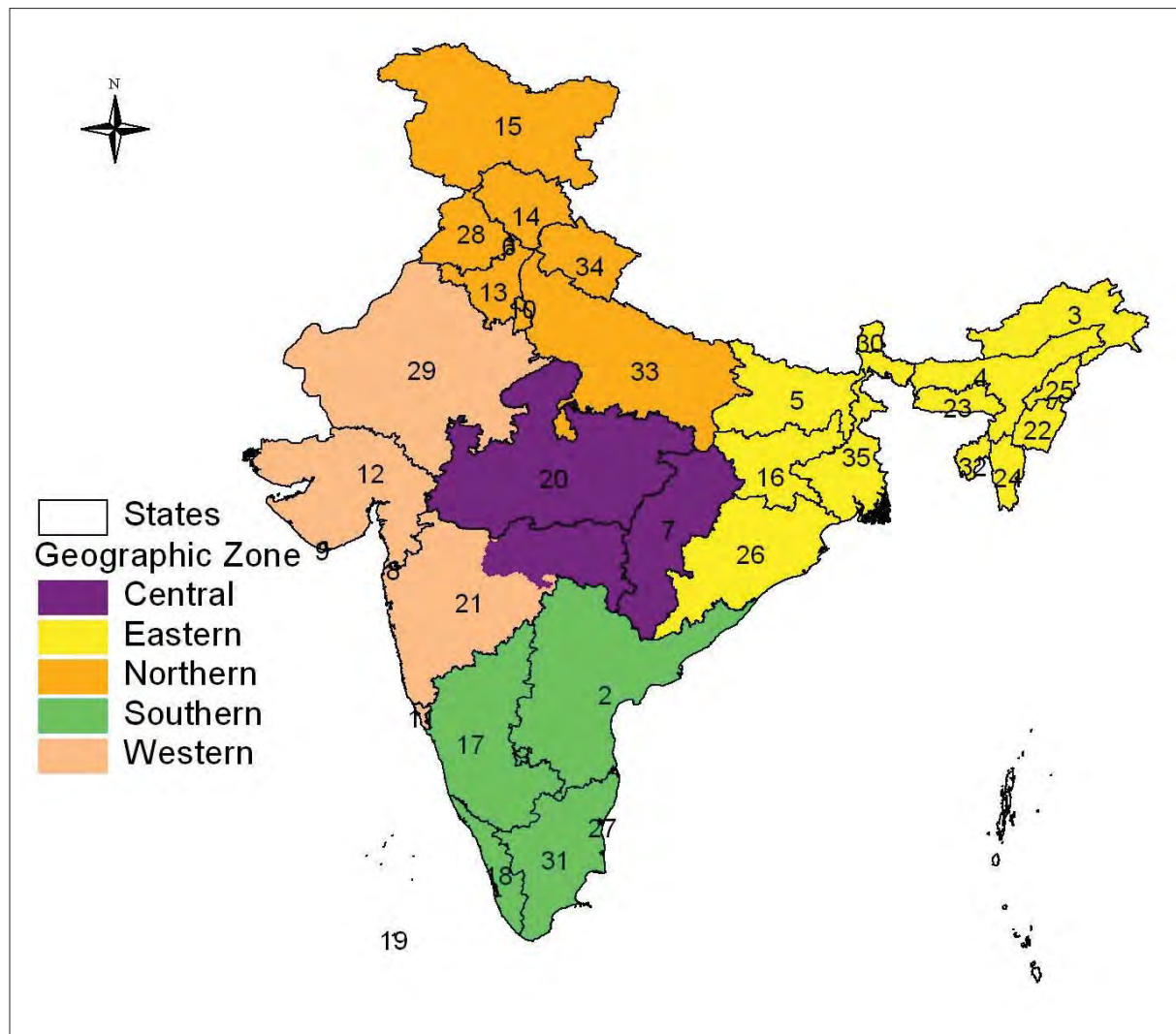


Amritpal Singh

Detection parameter p , population entry parameter $pent$ and survival parameter phi (φ) were modelled with an intercept ($p.$, $pent.$ and $\varphi.$). These parameters were allowed to vary with time as a factor ($p.time$, $pent.time$ and $\varphi.time$) and as a function of geographical zones ($p.zone$, $pent.zone$ and $\varphi.zone$).

Figure 2.2

Map of India showing the geographic zones, States and territories.



The geographic zones were used for aggregating the seizure data for mark-recapture analysis.

Names of States and territories are given below, against their respective numbers on the map.

1-Andaman and Nicobar, 2-Andhra Pradesh, 3-Arunachal Pradesh, 4-Assam, 5-Bihar, 6-Chandigarh, 7-Chhattisgarh, 8-Dadra and Nagar Haveli, 9-Daman and Diu, 10-Delhi, 11-Goa, 12-Gujarat, 13-Haryana, 14-Himachal Pradesh, 15-Jammu and Kashmir, 16-Jharkhand, 17-Karnataka, 18-Kerala, 19-Lakshadweep, 20-Madhya Pradesh, 21-Maharashtra, 22-Manipur, 23-Meghalaya, 24-Mizoram, 25-Nagaland, 26-Orissa, 27-Pondicherry, 28-Punjab, 29-Rajasthan, 30-Sikkim, 31-Tamil Nadu, 32-Tripura, 33-Uttar Pradesh, 34-Uttaranchal, 35-West Bengal.

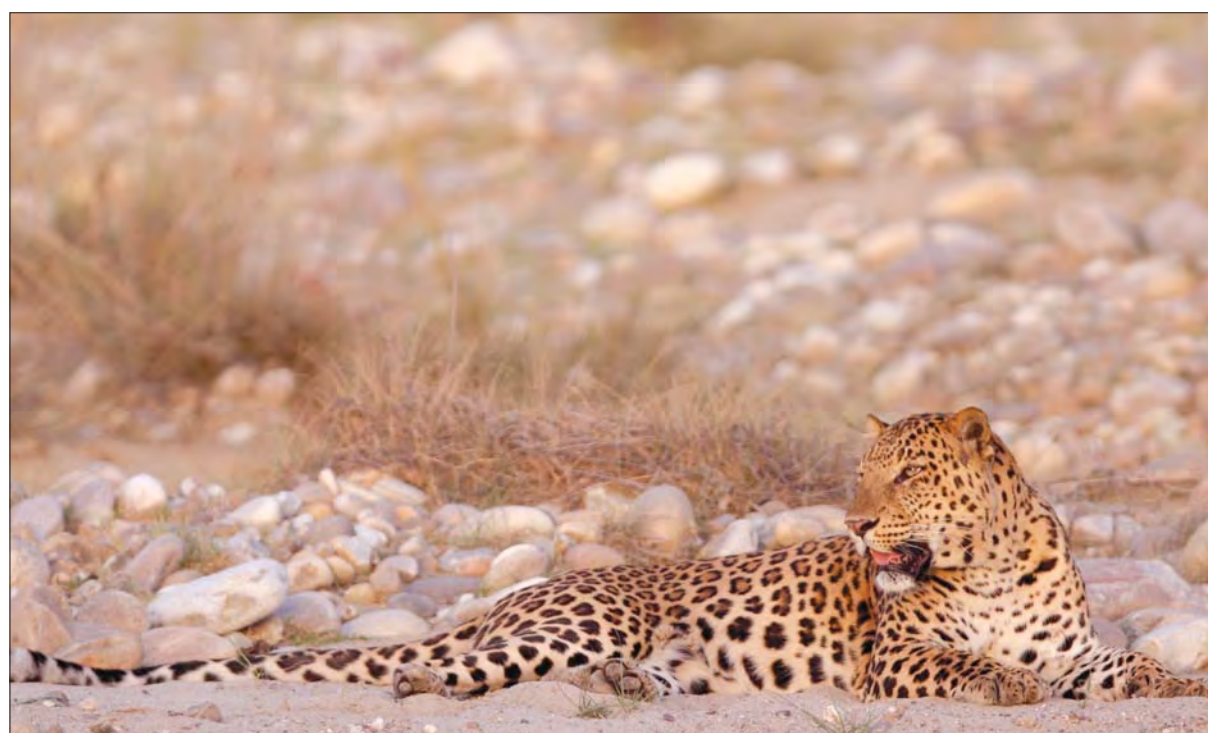
Models fitted in the mark-recapture analysis were ranked based on Akaike information criterion for small samples (AICc) weights⁸ (Table 2.1), and model averaged estimates of, the derived “population” of locations (the $\hat{N}$ population estimate in mark-recapture literature) for each zone was estimated. Based on these, the sum total number of locations for the country and its variance was calculated manually (see Table 3.4).

Table 2.1

Fitted Mark recapture models

Model	AICc	Δ AICc	AICc Weight	-2log Likelihood	Num. Par
$\phi. p.time pent.zone N.zone$	886.38	0.00	0.58	841.34	21
$\phi. zone p.time pent.zone N.zone$	887.07	0.69	0.41	832.74	25
Saturated model				1188.76	

With these interlinked parameters, a total number of Leopards killed was derived by extrapolating the observed numbers of Leopards killed to the total estimated number of locations. Thus it was possible to place a new *lower limit* on the magnitude of illegal trade in Leopards in India (see Section 2.2.2.2 below).



G. S. Bhardwaj

⁸ Akaike information criterion (AIC) is a measure of the relative goodness of fit of a statistical model, based on information theory. AICc is a modification of AIC for cases where the sample size is small or there are a large number of parameters in the model.

2.2.2.2 Estimating the total number of Leopards in illegal trade based on estimated total number of localities.

Most locations have had a single seizure and account for a single Leopard killed, a small fraction of locations have a high frequency of seizures and/or account for bulk seizures (see Table 2.2). Thus the data have a high positive skew with a very long tail on the right (see Figure 2.3). Data of these properties can be approximated by a gamma distribution (Crawley, 2007). A gamma distribution was generated for the *total estimated number of locations* from the mark-recapture analysis using the rate and shape parameters of the observed kills per location data (thus incorporating the mean and variance of the observed data). The sum of these values is the estimated minimum number of Leopards killed in the past decade (2001-2010). This process was simulated 100 000 times. The mean number obtained from these simulations is the estimated total number of Leopards killed, and 95% confidence limits were generated from

these simulations. The uncertainty in the estimate of total number of locations was incorporated by allowing the number of locations to be selected for the simulation to vary according to a normal distribution with mean and standard deviation as the mark-recapture estimated mean and standard error. Simulations were carried out in the R language (R Development Core Team, 2010).

These estimates are proposed as a new lower limit of the magnitude for illegal trade in Leopards. Considering that gaps in the data remain, it is reasonable to say that the numbers (number of localities in trade and number of Leopards killed) are at least this numerous: probably higher but unlikely to be lower than these estimates. Thus the mean numbers from mark-recapture analysis and simulations, in combination with their confidence intervals, are the estimates of a new enhanced lower limit of magnitude for Leopard trade.



WWF-India

Table 2.2

Distribution of numbers of Leopards killed as per localities

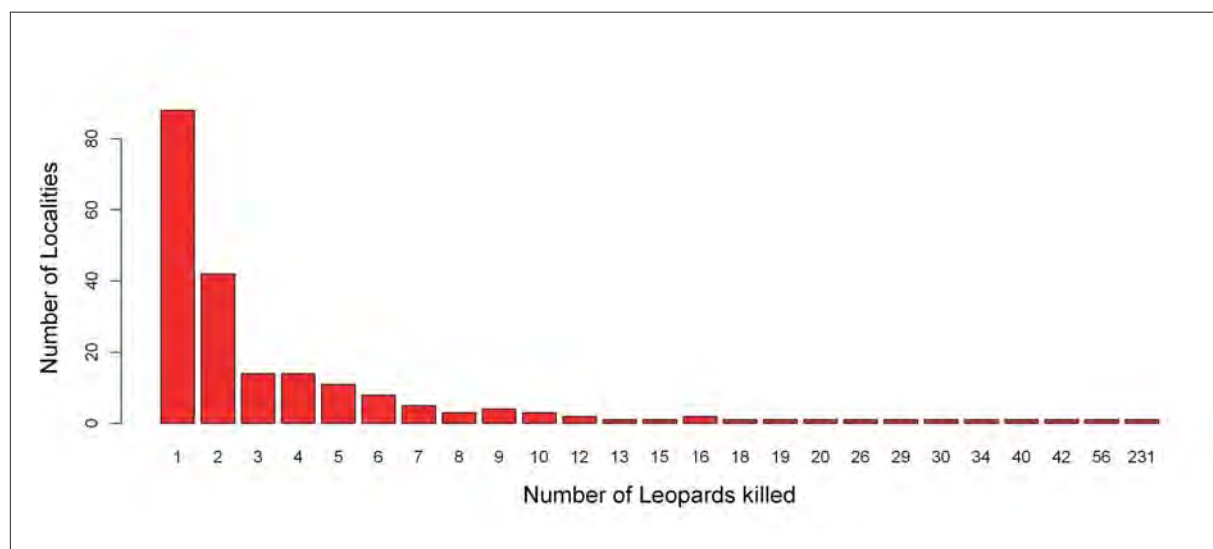
Leopards killed (range)	Number of seizure localities
1-10	192
10-20	9
20-30	3
30-40	2
40-50	1
50-60	1
200-231	1

Most localities record seizures of body parts accounting for 1-10 Leopards. The highest numbers are for Delhi, and represent 231 Leopards.

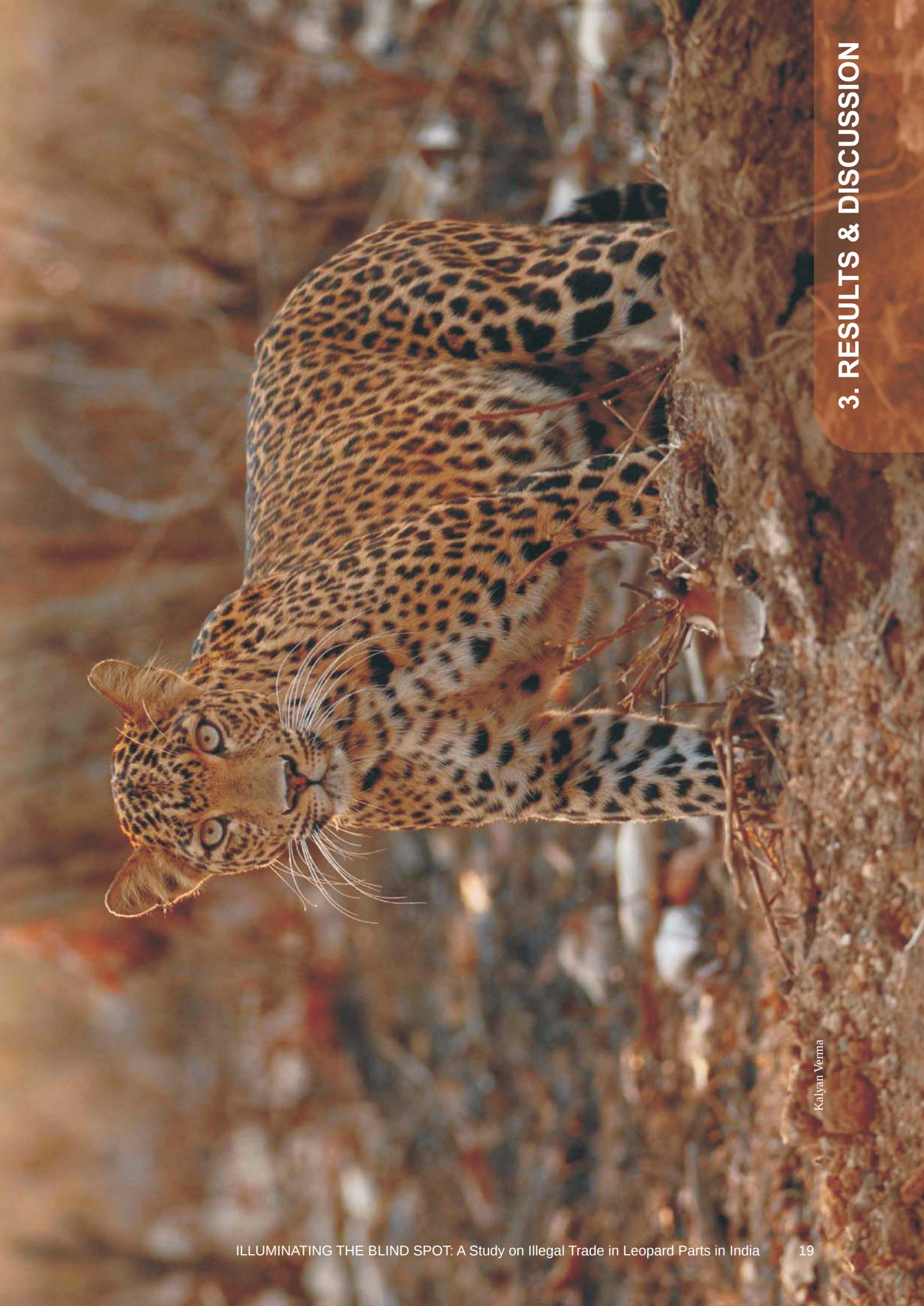
Mean = 5.4, S.D = 17.2, Median = 2, Min = 1, Max = 231.

Figure 2.3

Bar graph of localities accounting for numbers of Leopards killed and in trade.



Most localities account for smaller numbers of Leopards, as in Table 2.2 above, only 8 localities account for 20 or more Leopards killed and in trade.



Kalyan Verma

3. RESULTS & DISCUSSION

3 Results & Discussion

3.1 Volume of trade

During 2001-2010, a total of 420 incidents of seizures of Leopard body parts were reported from 209 localities in 20 out of 28 States and the National Capital Territory of Delhi (see Tables 3.1 & 3.2). Most of the States (71%) have reported seizure incidents, 123 out of 593 districts (20.2%), 189 out of 5451 Tehsils (3%) and 209 out of 3539 of total populated localities (6%) have reported one or more seizures during the past 10 years (see Table 3.3 for zonal summary). Six out of eight states with no reports of seizures are in north-eastern India (Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura, the other two States are Goa and Sikkim). It is unlikely that the absence of seizure records from these States is due to an absence of poaching, rather it may reflect under-reporting in the public domain or an actual lack of seizures.



Samir Sinha

The reported seizures account for an observed 1127 Leopards poached and in illegal trade. Leopard skins are the dominant Leopard part in the illegal trade, 371 (88.3%) seizure incidents involved only skins. An additional 23 (5.5%) incidents involved skins accompanied by other parts such as claws, bones or skulls. Seizures of bones are a very minor fraction whether alone or with other body parts. Nowell (2000), when analysing seizure data from India during the period 1990-98, had also found that Leopard bones were seized in much lower quantities by comparison with Tiger bones, although Leopard skin seizures were much higher than Tiger skin seizures during the same period.

Conducting mark-recapture analysis to estimate the undetected fraction of the trade substantially increased the estimates of the magnitude of illegal trade.

The total estimate of localities involved in Leopard trade during 2001-2010 is 424.95 ± 33.97 Standard error (S.E), (95% Confidence Interval, 358.37- 491.53, See Table 3.4). These values (mean no. of localities $\pm$ SE) were used in conjunction with the parameters of the observed number of Leopard kills in 209 seizure localities, in the simulations to derive the estimated total minimum number of Leopards killed. Simulation (as detailed in Section 2.2.2.2) results give the ***total estimated number of 2294.54 $\pm$ 496.26 standard deviation*** (95% confidence interval, 1565.86 - 3139.0) of Leopards poached and in illegal trade in the decade 2001-2010 .

These results more than double all Leopard trade related statistics (i.e. total number of localities involved in trade and the total number of Leopards killed and in trade). However keeping in mind the nature and limitations of the data, these estimates are conservatively presented as an improved lower limit of the magnitude of Leopard trade in India.

Table 3.1

State-wise annual summary of Leopard body part seizure incidents

State	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Andhra Pradesh				1			1	1	3	1	7
Assam								1	4		5
Bihar			1					1			2
Chhattisgarh		1		1			2		6	1	11
Delhi	6	10	6	4	4	3	2	3	4	2	44
Gujarat		2	1				1			3	7
Haryana		1	3	3	2	1					10
Himachal Pradesh		6	1	6	2			1	4	5	25
Jammu and Kashmir								2	2	4	
Jharkhand		1									1
Karnataka		2	4	5	8	1	6	7	3	5	41
Kerala		1	1		3		1	1			7
Madhya Pradesh		5	5	2	7	6	3	2	1	2	33
Maharashtra	3	7	5	4	6		3	3	6	3	40
Orissa				2	4	1	4	1	2		14
Punjab						1					1
Rajasthan		1			2	1			1		5
Tamil Nadu			1	2	3		2		6	2	16
Uttar Pradesh	4	5	4	2	7	6	2	2	9	6	47
Uttarakhand	4	8	20	10	14	8	2	1	6	11	84
West Bengal		2	4		6	3	1				16
Total	17	52	56	42	68	31	30	24	57	43	420

In northern India, Delhi and adjacent States of Himachal Pradesh, Uttarakhand and Uttar Pradesh record high numbers of seizure incidents. Maharashtra and adjacent Madhya Pradesh in central India form another zone with high numbers of incidents. In southern India, Karnataka alone has a high number of seizure incidents.

Table 3.2

Reported Leopard body part seizure data summary by State and Union Territory for 2001-2010

State (Geographic zone)	Seizure locations	Seizure incidents (%)	Minimum killed (%)	Districts affected	Sub-districts (Tehsil) affected
Andhra Pradesh (S)	6	7 (1.7)	9 (0.8)	5	6
Assam (E)	5	5 (1.2)	6 (0.5)	5	5
Bihar (E)	1	2 (0.5)	3 (0.3)	1	1
Chhattisgarh (C)	9	11 (2.6)	12 (1.1)	6	9
Delhi (N)	8	44 (10.5)	297 (26.4)	1	2
Gujarat (W)	7	7 (1.7)	17 (1.5)	5	7
Haryana (N)	7	10 (2.4)	46 (4.1)	5	5
Himachal Pradesh (N)	11	25 (6)	54 (4.8)	5	11
Jammu & Kashmir (N)	3	4 (1)	5 (0.4)	3	3
Jharkhand (E)	1	1 (0.2)	1 (0.1)	1	1
Karnataka (S)	25	41 (9.8)	89 (7.9)	11	24
Kerala (S)	4	7 (1.7)	14 (1.2)	3	5
Madhya Pradesh (C)	18	33 (7.9)	50 (4.4)	15	18
Maharashtra (W & C)	16	40 (9.5)	57 (5.1)	9	17
Orissa (E)	12	14 (3.3)	23 (2.0)	7	12
Punjab (N)	1	1 (0.2)	2 (0.2)	1	1
Rajasthan (W)	3	5 (1.2)	6 (0.5)	3	4
Tamil Nadu (S)	12	16 (3.8)	18 (1.6)	9	12
Uttar Pradesh (N)	23	47 (11.2)	184 (16.3)	15	20
Uttarakhand (N)	30	84 (20)	176 (15.6)	9	21
West Bengal (E)	7	16 (3.8)	58 (5.1)	4	5
Grand Total	209	420	1127	123	189

Note that although Delhi has recorded 10.5% of all seizure incidents, these seizures account for 26.4% of Leopards in trade, seizures in Delhi involve larger numbers of Leopards. In contrast, Uttarakhand accounts for 20% of all seizure incidents but only 15.6 of Leopards in trade. This suggests Delhi as a major centre of accumulation and trade in Leopard parts and Uttarakhand as an area from where Leopard parts are being sourced.

C-Central, E-Eastern, N-Northern, S-Southern, W-Western.

Table 3.3

Data summary of the reported Leopard body part seizures by geographical zones for 2001-2010

Zone	Seizure Locations (%)	Seizure incidents (%)	Minimum Killed (%)
Central	38 (18.20)	67 (16.0)	94 (8.3)
Eastern	26 (12.4)	38 (9.0)	91 (8.1)
Northern	83 (39.7)	215 (51.2)	764 (67.8)
Southern	47 (22.5)	71 (16.9)	130 (11.5)
Western	15 (7.2)	29 (6.9)	48 (4.3)
Grand Total	209	420	1127

Table 3.4

Estimated number of localities involved in Leopard trade during 2001-2010

Zone	Observed	Estimate	Standard Error	95% Lower confidence Limit	95% Upper confidence Limit
Central	38	74.01	11.02	52.41	95.62
Eastern	26	64.14	16.64	31.53	96.74
Northern	83	148.15	16.74	115.33	180.96
Southern	47	111.54	21.00	70.39	152.70
Western	15	27.10	5.89	15.55	38.66
Total for India	209	424.95	33.97	358.37	491.53

* LCL- Lower confidence limit, UCL - Upper confidence limit

3.2 Spatio-temporal Trends

3.2.1 Hotspots

Delhi is clearly the most important hub of Leopard trade with 26.4% of all Leopards accounted for in seizures. It is followed by Uttar Pradesh and Uttarakhand. Together with the neighbouring states of Himachal Pradesh and Haryana (which also recorded a sizeable volume of seizures) this northern region forms the epicentre of trade in Leopard parts (see Table 3.2). Uttarakhand leads in the number of incidents of seizures involving relatively small numbers of poached Leopards, indicating that this State is a major source. This is in contrast to Delhi, where large volume seizures have taken place; this suggests that Delhi is a major centre of collection of Leopard body parts. It is noteworthy that there is no significant population of Leopards in Delhi or its immediate surroundings; therefore the Leopards parts seized here originate from other States.

Data summarized by geographic zones clearly indicate that major areas of Leopard trade are in the north. India's Northern zone accounts for more than half of all seizure incidents and accounts for 67.8% of Leopards in illegal trade (see Table 3.4). The estimated number of locations also mirrors the pattern in the observed data, although the estimated numbers nearly double those reported. The relative rankings of respective zones remain the same in both the reported and estimated data sets.

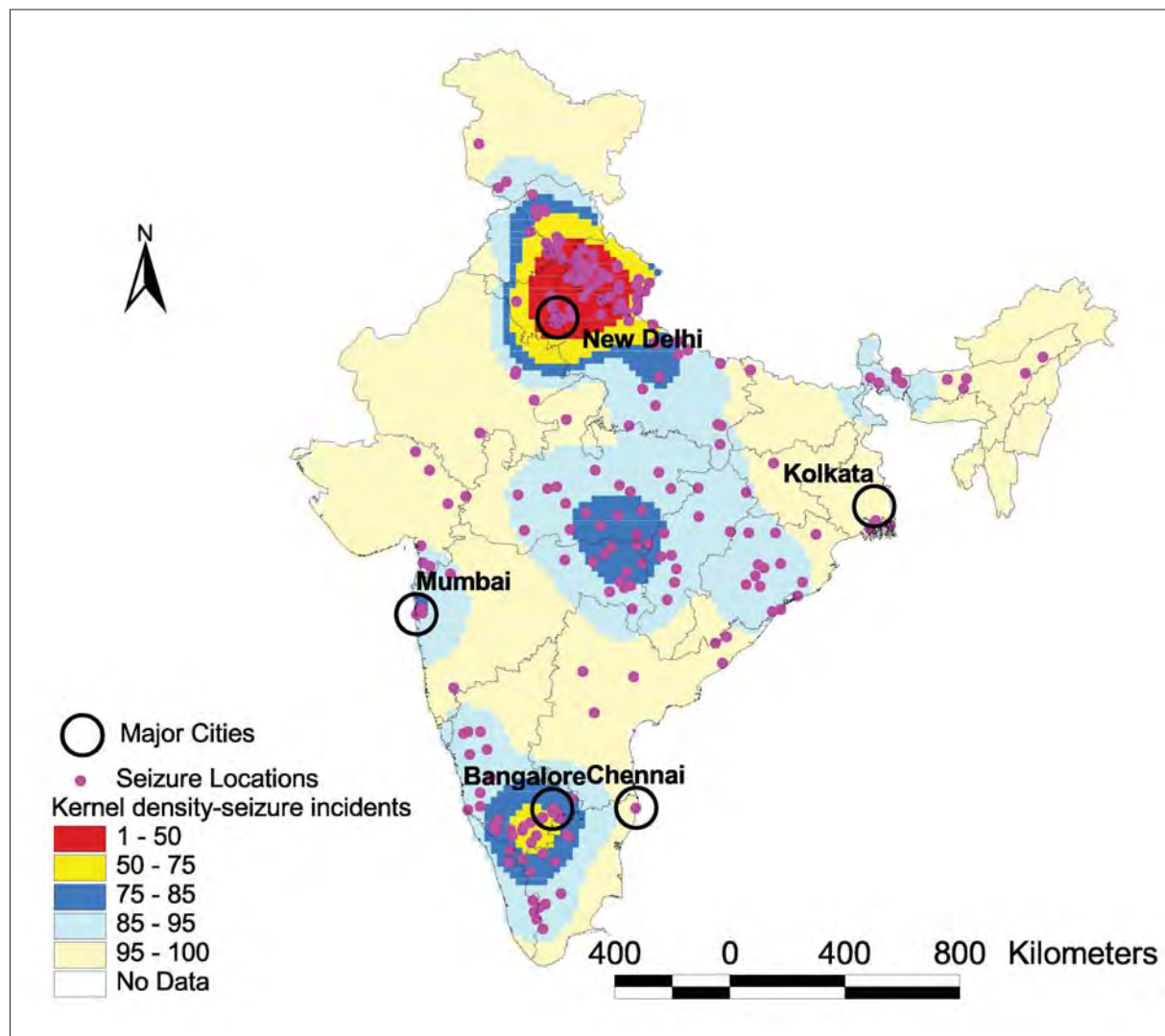


The observed patterns of seizures are unlikely to be random. Seizures are likely to take place at several key points along the trade chain: close to the location of killing, along the transportation route(s), at the point of processing (for skins, particularly), at points of collection (including warehouses) or location of sale. All these features are likely to contribute for the high concentration of seizure locations in the northern zone. Northern India also shares long international borders with Nepal and China, including mountainous terrain which is difficult to monitor and thus provides an opportunity for smuggling of Leopard parts along with other high-value wildlife products.

Spatial analysis of concentration of seizure records further illustrates the high chances of a locality active in Leopard trade occurring in India's northern region, in particular along the Himalayan region of Uttarakhand and Himachal and in and around Delhi (see Figure 3.1). A second zone of concentration is centred on Bangalore in southern India. In central India, a region straddling the border of the States of Madhya Pradesh, Maharashtra and Chhattisgarh shows a concentration of seizure locations. Although the pattern of high concentrations of localities in northern India is quite clear, lower levels of reporting or relatively weaker law enforcement effort and effectiveness may obscure patterns in other regions. These results should be read with these caveats in mind. This is especially true for north-eastern India from where very few seizure records are available.

Figure 3.1

Concentration of seizure locations and kernel density map



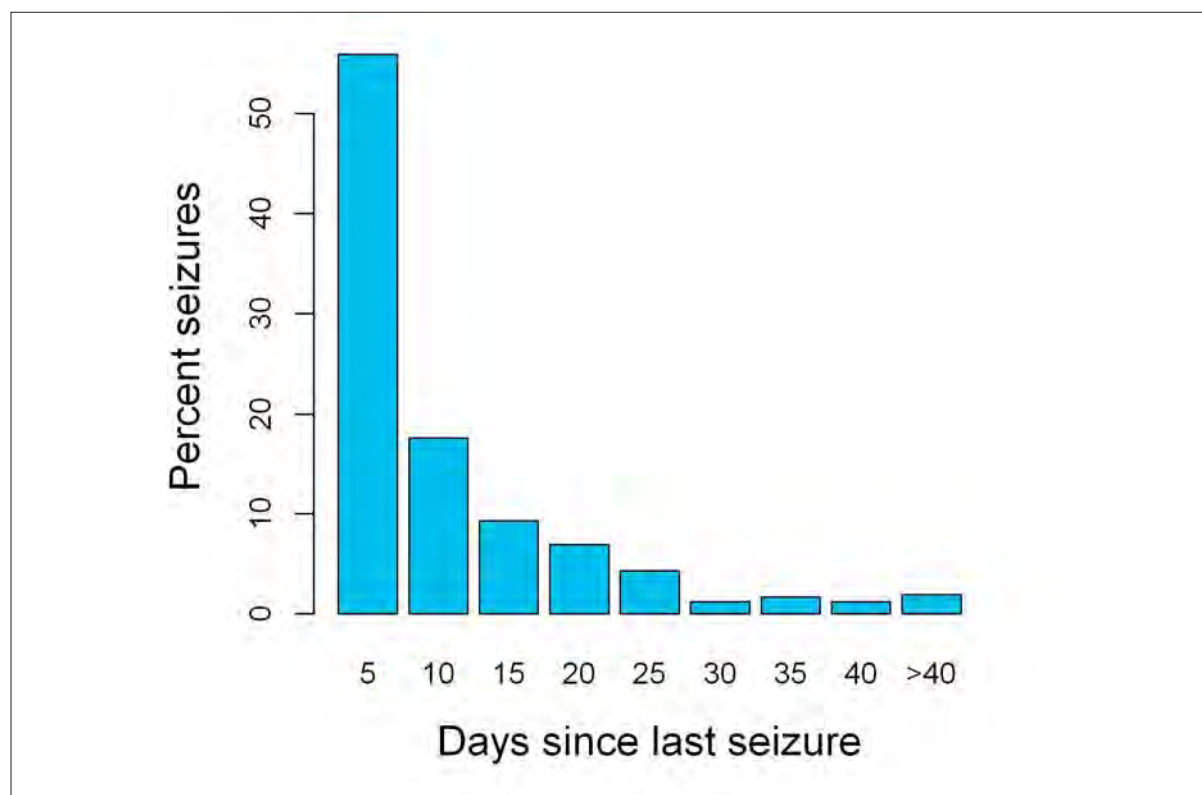
Kernel density map is a probabilistic surface covering the entire area and summing to 1 or 100%. Thus the red shaded area (50% kernel density) indicates that there is a 50% chance of a locality active in Leopard trade occurring in the enclosed area. The red and yellow shaded areas combined indicate that there is a 75% chance of such a locality occurring in these two zones and so forth. The 50% kernel zone covers 3.1% of the geographical area of India and the 75% zone an additional 3.85%. Thus 75% of localities in trade of Leopard body parts are likely to be concentrated in 7% of the country.

3.2.2 Temporal Trends

The mean number of days separating any two seizure incidents is 8.6 days; however 56% of seizures are separated by just five days or less. In fact more than 70% of seizures have occurred within 10 days of each other (see Figure 3.2). This is a remarkable frequency of crime related to Leopards.

Figure 3.2

Successive seizures with respect to days separating them



The 10-year trend in Leopard trade-related statistics is provided in Figure 3.3. Both the number of incidents of seizures and the number of locations involved in seizures have shown an increase in the past two years with a corresponding increase in the number of Leopards killed. From a high point in 2005, Leopard trade-related indicators decreased for three consecutive years before rising from 2009 and continuing to increase in 2010.

The trend in the estimated number of localities “active” each year for 2001-2010 shows an increasing trend throughout the decade (see Figure 3.4 a). The trends, when broken down by zones, reveal geographical differences. While the Northern zone has remained relatively stable with about 60-70 localities remaining active each year, the Southern zone has shown an increasing trend for much of the decade, though for the past four years the number has remained between 40-50 (see Figure 3.4 b).

Figure 3.3

Trends in illegal trade in Leopards, 2001-2010

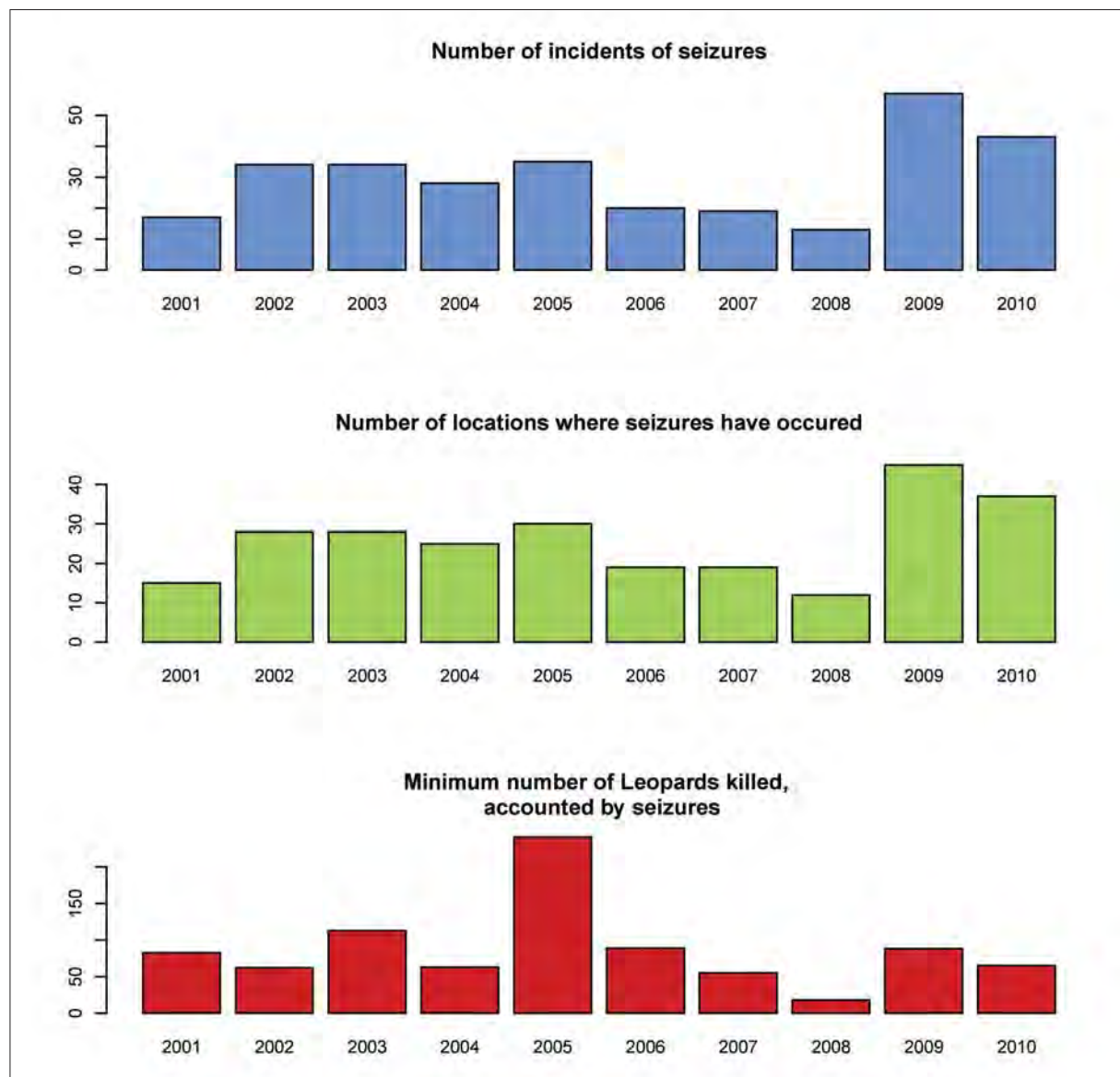


Figure 3.4 a

Estimated trend in localities active in Leopard trade in India

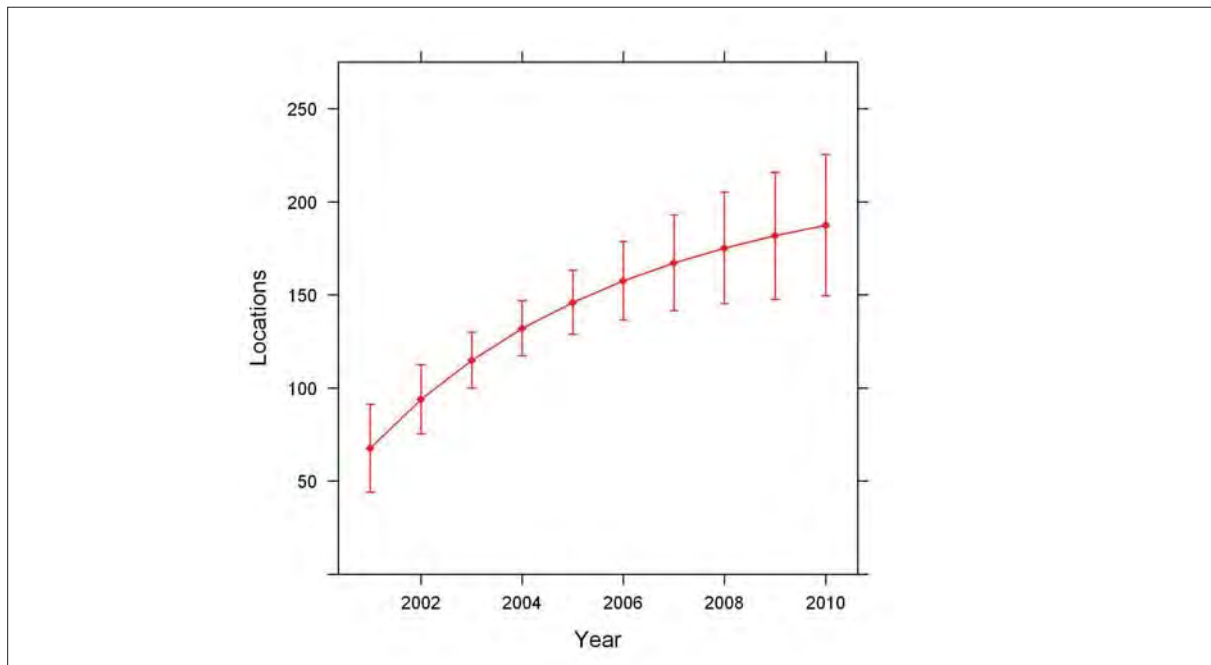
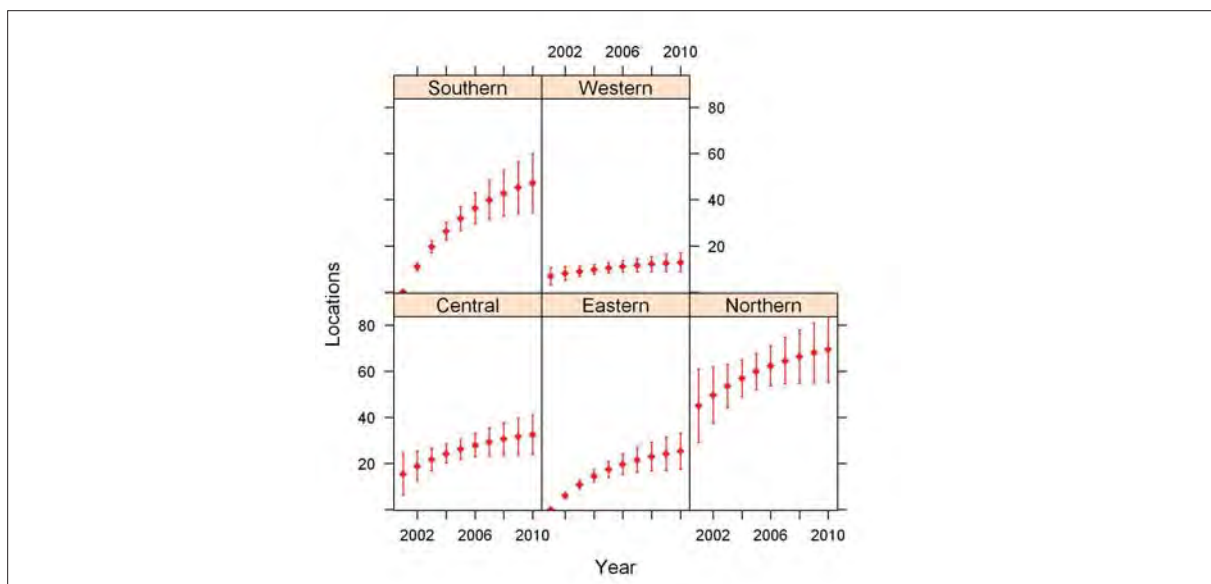


Figure 3.4 b

Estimated trend in localities active in Leopard trade by geographic zones



Points are mean number of localities active in trade of Leopard parts estimated through mark-recapture methods. Bars represent standard error.

3.3 Conclusions

TRAFFIC has documented and analysed the magnitude and trends in illegal trade in Leopard body parts for 10 years, from 2001-2010. Due to its covert nature, much of the trade remains undocumented. Statistical techniques of mark-recapture were used to estimate the undetected fraction of this trade.

Based on the above, the key findings of the report are listed below:

- Trade in Leopards has been widespread with 21 out of 28 States in India recording seizures of Leopard body parts. A total of 420 seizures in 209 localities have been recorded during 2001-2010.
- The public domain records of reported seizures account for a minimum of 1127 Leopards killed. Based on further statistical analysis, an *estimated* number of 2294.54 ± 403.34 Leopards have been killed. This translates to a *reported* 2.2 Leopards killed per week (i.e. based on publicly reported seizures) and an *estimated* 4.4 Leopards killed per week (i.e. after statistical analysis) for illegal trade over the past 10 years.
- Wildlife crime associated with Leopards occurs on average at a frequency of 3.5 seizure incidents every month (based on reports over the past 10 years); a majority of the seizures (70%) have occurred within 10 days of a previous seizure.
- The northern jurisdictions of Delhi, Uttar Pradesh, Uttarakhand and Himachal Pradesh are most associated with illegal trade in Leopard parts. In the south of the country, the State of Karnataka is most associated with illegal trade in Leopard parts.
- Overall the geographic hotspot of Leopard trade is centred on northern India, incorporating 3.15% of India's geographical area, 50% of locations involved in Leopard trade are likely to occur here. Thus focusing law enforcement efforts in this region is likely to be more successful in targeting traders and syndicates involved in illegal trade of Leopards.
- A total of 209 unique localities have been recorded as being active in Leopard trade at some point over the past 10 years. Following statistical analysis, the *estimated* number of localities to have ever been active in Leopard trade during this period is 428.04 ± 34.81 . There has been an overall increasing trend in the number of localities reported as active each year, but southern India appears to be growing fastest, pointing to a need for increased law enforcement effort in that region in the near future.

Since the data are based on a collation of published information on seizures, it has limitations in terms of uneven temporal and spatial coverage leading to possible under-reporting. The use of advanced analytical methods has been pursued in the attempt to overcome these limitations. However, these results are conservatively proposed as an improved estimate of the lower limit of illegal trade in Leopards. Coupled with better recording and documentation of wildlife crime, such use of advanced statistical tools can vastly improve the ability of law enforcement agencies to analyse patterns of criminal activity.



4. RECOMMENDATIONS

Mrudul Godbele

4 RECOMMENDATIONS

Based on the research and analysis conducted under this project, TRAFFIC has the following recommendations:

4.1 Improve understanding of Leopard trade dynamics in India

- A large amount of information related to Leopard mortality, seizures and associated trade is available in the public domain but this information is rarely available in one place in a credible form where it is collated analysed and made available for decision making. The Ministry of Environment and Forests should consider the establishment of a national database on mortality and seizures of Leopard and other key wildlife species; along the lines of tigernet (<http://www.tigernet.nic.in>) which will yield valuable, verified information over a period of time. Compiling such information in a systematic fashion would thus support more detailed analysis towards effective targeting of law enforcement efforts to prevent Leopard killing and increase arrests and prosecutions of criminals involved in such activities.
- Information should also be shared by law enforcement authorities across various locations to address a source-to-end market continuum for trade in Leopard products. Use of modern scientific tools, including forensic techniques, should be encouraged to gather better information. Adapting modern statistical and analytical tools for analysis of wildlife trade is likely to greatly enhance the understanding of India's wildlife trade in general, and that of high-value targets such as Leopards and other big cats in particular. National and State Law enforcement agencies should consider regular upgrading of capacity in these fields.
- It is generally assumed that the drivers for Leopard trade are similar to those which drive trade in other Asian big cats, especially because they share the same set of poachers, middlemen and traders. However, human-Leopard conflict is a major driver for Leopard mortality and while it has not been analysed for the purposes of this study, it would be realistic to assume that such conflict would also be a major contributor to supplying the trade. This is also supported by the fact that some of the States identified as major sources for Leopard parts are also identified as hotspots for human-Leopard conflicts. It is recommended that the Ministry of Environment and Forests co-ordinate further research in order to evaluate how human-Leopard conflict may be related to poaching of Leopards and illegal trade in their parts.

4.2 Strengthen Wildlife Law Enforcement

- Despite some recent steps, such as the establishment of a national Wildlife Crime Control Bureau, wildlife law enforcement continues to be seen as a low priority component of overall crime management and control in India. This needs to change. Wildlife crime, including that involving Leopards, has increasingly been identified as a form of transnational organized crime. Any response to organized crime should also necessarily be organized. Syndicates involved in wildlife crime are increasingly being seen as also engaged in other forms of crime including those threatening national security, such as trafficking of arms, narcotics and humans. Several elements are thus recommended for action:

- Improved levels of training and resources should be provided to law enforcement agencies to counter such threats, including the pursuit of intelligence-led enforcement strategies. All offences interdicted should be followed to a logical conclusion, i.e. case preparation of wildlife crime incidents must be professionally conducted in order to support efforts by the judiciary to prosecute to the full extent of the law.
- In the States of Delhi, Uttarakhand, Uttar Pradesh, Himachal Pradesh, Maharashtra, Madhya Pradesh and Karnataka, where illegal trade in Leopard parts is identified as a major issue, a special task force needs to be created to analyse patterns in such crime and target key offenders in a systematic and sustained manner to curb this problem. This should have representatives across multiple agencies such as the Forest Department, Police, Paramilitary, Army, Railway Protection Force, Central Bureau of Investigation and the Wildlife Crime Control Bureau, to coordinate such actions. At the local level, NGOs such as TRAFFIC/WWF, Wildlife Trust of India, Wildlife Protection Society of India and Aaranyak, amongst others who work on wildlife trade issues, can also be valuable partners in such efforts.
- Given that illegal trade in Leopard parts generally flows to end-use markets outside India, engaging with regional partners is imperative to make a long-term and significant impact on stemming this illegal flow. The South Asia Wildlife Enforcement Network (SAWEN) and India's bilateral agreements on biodiversity conservation with various countries including Nepal (MoU on trans-boundary biodiversity conservation cooperation) and China (MoU on forestry cooperation) are good opportunities to build upon such regional collaboration and support. It is to be emphasised that many of the issues flagged above, especially those related to strengthening of wildlife law enforcement, are not specific to Leopards alone but, if implemented systematically, will also have a likely positive impact on management and control of overall illegal wildlife trade.

4.3 Improve scientific knowledge on Leopards

There is still a large gap in the scientific understanding of behavioural and ecological aspects of the Leopard in India, despite several years of perceived focus on management and scientific issues. However, other than human-Leopard conflict, there is a very limited body of work on Leopards available in the public domain. In other words, while there is still some information on what the Leopard *does*, especially in human-dominated landscapes, there is little knowledge on what the Leopard *is*. Aspects of the Leopard's life such as prey-predator relationships, breeding cycles, age and sex-specific survival rates are poorly known. There is no recent scientific information on Leopard distribution, density or population across the country. This means that the analysis of Leopard poaching and trade has no baseline against which to assess the impact on wild populations.

- Country wide distribution and abundance surveys on the lines of the population estimation exercise for Tigers is urgently required. Since Leopard and Tigers occur together in many areas, there is an opportunity for the Ministry of Environment and Forests to synergize these efforts.

References

- Alexander, H., N. Slade, W. Kettle, G. Pittman, and A. Reed, 2009. Detection, survival rates and dynamics of a cryptic plant, *Asclepias meadii*: applications of mark-recapture models to long-term monitoring studies. *Journal of Ecology* **97**:267–276.
- Anonymous, 1986. Cat skins on sale in Lhasa. *Cat News* **4**.
- Athreya, V., M. Odden, J. D. C. Linnell, and K. U. Karanth, 2011. Translocation as a Tool for Mitigating Conflict with Leopards in Human-Dominated Landscapes of India. *Conservation Biology* **25**:133–141.
- Athreya, V., S. Thakur, S. Chaudhuri, and A. Belsare, 2004. *A study of the Man-Leopard Conflicts in the Junnar Forest Division, Pune District, Maharashtra*. Report prepared for the Forest Department, Maharashtra, and the Wildlife Protection Society of India, New Delhi. Technical report, Kati Trust, Pune.
- Athreya, V., S. Thakur, S. Chaudhuri, and A. Belsare, 2007. Leopards in human-dominated areas: a spillover from sustained translocations into nearby forests? *Journal of Bombay Natural History Society* **104**:45–59.
- Banks, D. and J. Newman, 2004. *The Tiger Skin Trail*. Environmental Investigation Agency, UK.
- Barnes, L., 1989. *The overt illegal fur trade in Kathmandu, Nepal* - Inverness Research Associates, Inverness, California.
- Carbone, C. and J. Gittleman, 2002. A common rule for the scaling of carnivore density. *Science* **295**:2273.
- Chauhan, D. and S. Goyal, 2000. *A study on distribution, relative abundance and food habits of leopard Panthera pardus in Garhwal Himalayas*. Technical report, Wildlife Institute of India, Dehradun.
- Chauhan, D., A. Harihar, S. Goyal, Q. Qureshi, P. Lal, and V. Mathur, 2005. *Estimating leopard population using camera traps in Sariska Tiger Reserve*. Technical report, Wildlife Institute of India-Dehradun, India.
- Chellam, R., 2010. India's Leopard problem. Is *Panthera pardus* vanishing faster than *Panthera tigris*? *Sanctuary Asia*.
- Chainey, S. & Ratcliffe, J. 2005, *GIS and crime mapping*, John Wiley & Sons Inc.
- Chainey, S.; Tompson, L. & Uhlig, S. 2008, The utility of hotspot mapping for predicting spatial patterns of crime, *Security Journal* **21**(1), 4–28.
- Cooch, E. and G. White, 2010. *Program MARK: a gentle introduction*, 9th edition. Colorado, State University, Fort Collins, USA.
- Crawley, M. J., 2007. *The R book*. John Wiley & Sons.
- Daniel, J. C., 1996. *The Leopard in India: A Natural History*. Nataraj Publishers, Dehradun.
- Dar, N., R. Minhas, Q. Zaman, and M. Linkie, 2009. Predicting the patterns, perceptions and causes of human-carnivore conflict in and around Machiara National Park, Pakistan. *Biological Conservation* **142**:2076–2082.
- Datta, A., M. Anand, and R. Naniwadekar, 2008. Empty forests: Large carnivore and prey abundance in Namdapha National Park, north-east India. *Biological Conservation* **141**:1429–1435.

- Ebrahimi, N., 1997. On the statistical analysis of the number of errors remaining in a software design document after inspection. *IEEE Transactions on Software Engineering* **23**:529–532.
- Edgaonkar, A., 2008. *Ecology of the leopard Panthera pardus in Bori Wildlife Sanctuary and Satpura National park, India*. Ph.D. thesis, University of Florida.
- Eisenberg, J. and M. Lockhart, 1972. *An ecological reconnaissance of Wilpattu National Park, Ceylon-Smithsonian Contributions to Zoology*, volume 101 of *Smithsonian Contributions to Zoology*.
- Ghoddousi, A., A. Kh. Hamidi, T. Ghadirian, D. Ashayeri, and I. Khorozyan, 2010. The status of the Endangered Persian leopard *Panthera pardus saxicolor* in Bamu National Park, Iran. *Oryx* **44**:551–557.
- Harihar, A., B. Pandav, and S. Goyal, 2011. Responses of leopard *Panthera pardus* to the recovery of a tiger *Panthera tigris* population. *Journal of Applied Ecology* **48**:806–814.
- Heinen, J. T., P. B. Yonzon, and B. Letsure, 1995. Fighting the illegal fur trade in Kathmandu, Nepal. *Conservation Biology* **9**: 246–248.
- Hooze, P. and B. Eichenlaub, 2000. Animal movement extension to arcview version 2.0. *US Geological Survey, Alaska Science Center-Biological Science Office, Anchorage, USA*.
- Jhala, Y., Gopal.R, and Q. Q, editors, 2008. *Status of Tigers, Co-predators and Prey in India*. Number TR08/001. National Tiger Conservation Authority and Wildlife Institute of India.
- Johnsingh, A., H. Panwar, and W. Rodgers, 1991. Ecology and conservation of large felids in India. In N. Maruyama *et al.*, editor, *Wildlife conservation: present trends and perspectives for the 21st century*. *Proc. Intl. Symposium on Wildlife Conservation in Tsukuba and Yokohama, 21-25 August 1990.*, pages 160–166.
- Khan, M. A. R., 1986. The status and distribution of the cats in Bangladesh. In S. Miller and D.D.Everette, editors, *Cats of the world: biology, conservation and management*, pages 43–49. National Wildlife Federation, Washington, D.C.
- Khorozyan, I., A. Malkhasyan, and A. Abramov, 2008. Presence–absence surveys of prey and their use in predicting leopard *Panthera pardus* densities: a case study from Armenia. *Integrative Zoology* **3**:322–332.
- Kimothi, P., 2011. Sanitation is U’khand’s key to solving man-leopard conflict. *The Pioneer*, 15 April, page no. 4, Delhi edition
- Kostyria, A., A. Skorodelov, D. Miquelle, V. Aramilev, and D. McCullough, 2003. *Report on a census of far-eastern leopards using camera traps in south-west Primorskii province, winter 2002-2003*. Technical report, Wildlife Conservation Society.
- Kumar, A. and B. Wright, 1997. Tiger skins seized in Calcutta. *Cat News* **27**.
- Laake, J., 2011. RMark: R Code for MARK Analysis. R package version 2.0.1.
- Levine, N., 2007. CrimeStat: A Spatial Statistics Program for the Analysis of Crime Incident Locations (v 3.1). Ned Levine & Associates, Houston, TX, and the National Institute of Justice, Washington, DC.
- Lodhi, A., 2007. *Conservation of Leopards in Ayubia National Park, Pakistan*. Master’s thesis, University of Montana, Missoula, MT.

- Loveridge, A. J., S. W. Wang, L. G. Frank, and J. Seidensticker, 2010. People and wild felids: conservation of cats and management of conflicts. In D. W. Macdonald and A. J. Loveridge, editors, *Biology and conservation of wild felids*. Oxford University Press.
- Negi, A., 1996. Man-eating Leopard of Garhwal. *Cheetal* **35**:22–24.
- Ngoprasert, D., 2004. *Effects of Roads, Selected Environmental Variables and Human Disturbance on Asiatic Leopard Panthera pardus in Kaeng Krachan National Park*. Master's thesis, King Mongkuts University of Technology Thonburi.
- Nowak, R., 2005. *Walker's Carnivores of the World*. Johns Hopkins Univ Press.
- Nowell, K., 2000. *Far from a Cure: the Tiger Trade Revisited*. TRAFFIC International, Cambridge, UK.
- Nowell, K. and P. Jackson, 1996. *Wild Cats: Status Survey and Conservation Action Plan*. IUCN, Gland, Switzerland and Cambridge, UK.
- Odden, M., P. Wegge, and T. Fredriksen, 2010. Do tigers displace leopards? If so, why? *Ecological research* **25**:875–881.
- Oswell, A.H. 2010. *The Big Cat Trade in Myanmar and Thailand*. TRAFFIC Southeast Asia
- Prange, H.; Anderson, J. & Rahn, H. 1979, Scaling of skeletal mass to body mass in birds and mammals, *The American Naturalist* **113**: 103–122.
- Pringle, C., C. Murgatroyd, and M. Mangal, 1999. *CITES Compliance in Nepal*. Technical report, British Embassy, Kathmandu, Nepal.
- R Development Core Team, 2010. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.
- Rabinowitz, A., 1989. The density and behavior of large cats in a dry tropical forest mosaic in Huai Kha Khaeng Wildlife Sanctuary, Thailand. *Natural History Bulletin of the Siam Society* **37**:235–251.
- Sangay, T. and K. Vernes, 2008. Human-wildlife conflict in the Kingdom of Bhutan: patterns of livestock predation by large mammalian carnivores. *Biological Conservation* **141**:1272–1282.
- Santiapillai, C., M. Chambers, and N. Ishwaran, 1982. The leopard *Panthera pardus fusca* (Meyer 1794) in the Ruhuna National Park, Sri Lanka, conservation. *Biological Conservation* **23**:5–14.
- Santiapillai, C. and W. Ramono, 1992. Status of the leopard *Panthera pardus* in Java, Indonesia. *Tiger Paper* **19**:1–5.
- Schwarz, C. and A. Arnason, 1996. A general methodology for the analysis of capture-recapture experiments in open populations. *Biometrics* **52**:860–873.
- Seidensticker, J., M. Sunquist, and C. McDougal, 1990. Leopards living at edge of the Royal Chitwan National Park, Nepal. In J. Daniel and J. Serrao, editors, *Conservation in Developing Countries: Problems and Prospects*, pages 415–23. Bombay Natural History Society, Bombay, India: Oxford University Press, London.

- Sellar, J., 1999. *Tiger technical missions report. Technical report*, Presented at 42nd meeting of the CITES Standing Committee, Lisbon, Portugal.
- Shah, K. B., T. B. Thapa, and P. B. Budha, 2004. *Status survey of the forest leopard Panthera pardus Linnaeus, 1758 in Nepal*. Technical report, WWF Nepal Program Kathmandu, Nepal.
- Shepherd, C. R. and Nijman, V. (2008). *The wild cat trade in Myanmar*. TRAFFIC Southeast Asia, Petaling Jaya, Malaysia.
- Simcharoen, S. and S. Duangchantrasiri, 2008. Monitoring of the Leopard Population at Khao Nang Rum. In Huai Kha Khaeng Wildlife Sanctuary. *Thai Journal of Forestry* **27**:68–80.
- Spalton, J., H. al Hikmani, D. Willis, and A. Said, 2006. Critically endangered Arabian leopards *Panthera pardus nimr* persist in the Jabal Samhan Nature Reserve, Oman. *Oryx* **40**:287–294.
- Talwar, R. and T. Aziz, 1996. The Leopard in trouble. *WWF-India Quarterly* **7**: 6–9.
- Tamang, B. and N. Baral, 2008. Livestock depredation by large cats in Bardia National Park, Nepal: Implications for improving park people relations. *The International Journal of Biodiversity Science and Management* **4**: 44–53.
- Tilling, K., J. Sterne, and C. Wolfe, 2001. Estimation of the incidence of stroke using a capture-recapture model including covariates. *International journal of epidemiology* **30**:1351–1359.
- Verheij, P., K. Foley, and K. Engel, 2010. *Reduced to Skin and Bones: An Analysis of Tiger Seizures from 11 Tiger Range Countries (2000-2010)*. TRAFFIC International, Cambridge, UK.
- Vijayan, S. and B. Pati, 2002. Impact of changing cropping patterns on man-animal conflicts around Gir Protected Area with specific reference to Talala sub-district, Gujarat, India. *Population & Environment* **23**:541–559.
- Wang, S. and D. Macdonald, 2009. The use of camera traps for estimating tiger and leopard populations in the high altitude mountains of Bhutan. *Biological Conservation* **142**:606–613.
- Wegge, P., M. Odden, C. Pokharel, and T. Storaas, 2009. Predator-prey relationships and responses of ungulates and their predators to the establishment of protected areas: A case study of tigers, leopards and their prey in Bardia National Park, Nepal. *Biological Conservation* **142**:189–202.
- Williams, B., J. Nichols, and M. Conroy, 2002. *Analysis and management of animal populations: modeling, estimation, and decision making*. Academic Press.
- Williams, K. A., P. C. Frederick, and J. D. Nichols, 2011. Use of the superpopulation approach to estimate breeding population size: An example in asynchronously breeding birds. *Ecology* **92**: 821-822.
- Wright, B. and A. Kumar, 1999. *Update on the Trade in Tiger Parts*. Unpublished report to the CITES Tiger Technical Mission, New Delhi, India.

TRAFFIC, the wildlife trade monitoring network, works to ensure that trade in wild plants and animals is not a threat to the conservation of nature. It was established in 1976 and since then it has developed a considerable international reputation for helping to identify and address conservation challenges linked to trade in wild animals and plants. TRAFFIC India carries out research and provides analysis, support and encouragement to efforts aimed to ensure that wildlife trade is not a threat to the conservation of nature in India.

For more information contact:

TRAFFIC India
c/o WWF-India Secretariat,
172-B, Lodi Estate,
New Delhi-110003,
India
Tel: (91) 11 41504786; 43516290
Fax: (91) 11 43516200
Email: trafficindia@wwfindia.net
Website: www.trafficindia.org or www.traffic.org

TRAFFIC International,
219a Huntingdon Rd,
Cambridge CB3 0DL,
UK
Tel: +44 (0)1223 277427
Fax: +44 (0)1223 277237
Email: traffic@traffic.org
Website: www.traffic.org

