A STUDY OF THE MAN – LEOPARD CONFLICT

IN THE JUNNAR FOREST DIVISION, PUNE DISTRICT, MAHARASHTRA

VIDYA R. ATHREYA,

SANJAY S. THAKUR,

SUJOY CHAUDHURI,

ANIRUDDHA V. BELSARE

eCOLLAGE

WILDLIFE PROTECTION SOCIETY OF INDIA

MAHARASHTRA STATE FOREST DEPARTMENT

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For further information on this Report regarding

- The study in general - contact Vidya Athreya (phatrosie@vsnl.net)
- The field-work - contact Sanjay Thakur (c/o sanjaythakur12@rediffmail.com)
- The GIS and related analysis - contact Sujoy Chaudhuri (ecollage@vsnl.net)
- The veterinary aspect - contact Dr. Aniruddha Belsare (anyadoc@hotmail.com).
- The wildlife trade - contact WPSI (wpsi@vsnl.com)

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SUMMARY

The western Indian state of Maharashtra, which reported a population of 513 leopards (*Panthera pardus fusca*) in 2001, has in recent times seen an escalation in man – leopard conflicts in various parts of the state. The highest intensity of conflict has been reported from the Junnar, Ambegaon and Khed talukas of the Junnar Forest Division (JFD), situated in the northwest corner of the Pune district. The conflict in the JFD was restricted to about 1590 km^2 of a total of 4360 km^2 that comprises the affected talukas of the JFD. Fifty-one people were attacked between 2001 and 2003 in the JFD of which 18 people died and 33 were injured. In the same period, 103 successful trapping instances of leopards were carried out by the Maharashtra Forest Department in the JFD.

The available data (since 1993) show differences in the patterns of depredation by leopards in the northern and southern parts of the JFD. Livestock depredation in the southern regions peaked during 1996-97 followed by a decline till 2001 after which it increased. In contrast the frequency of depredation in the northern regions slowly rose from 1995-96 until 2000 after which point it sharply escalated, with a 100 % increase in 2001. The two regions of JFD also differ in topological and socio-economic factors. The south is hillier, contains more reserve forests, grows different crops, does not have as much of an area under sugarcane cultivation and grazing of livestock is as prevalent as stall-feeding. The Narayangaon range in the northern region, which was also a hotspot of conflict (livestock and human depredations) in late 2001 and 2002, supports the largest extent of sugarcane in the JFD. Satellite imagery analyses of 1840 km^2 encompassing the most affected northern ranges (and containing 76 % of the conflict points) indicate an increase in the cultivation of tall crops, including sugarcane, from 4 % in 1973 to 6 % in 1992 but no increase between 1992 and 2000. A similar result is seen for the three categories of forest cover (> 40, > 20 and < 20 %), which declines from a total of 90 % in 1972 to 78 % in 1992 and remains at 77 % in 2000. Moreover, Agriculture Department records for the entire region (from 1960 – 1994) show similar land-use patterns in this human dominated area across the four decades. The above information is particularly relevant with respect to the two most commonly cited factors that are thought to cause man – large carnivore conflict, i.e., loss of habitat and depletion of prey base. From the data we present above, it is unlikely that land-use patterns were the seed cause for the eruption of the conflict in 2001.

We estimated the JFD leopard population to consist of 62 animals based on the number of leopards that were taken out of JFD (far–off translocations, death, captivity) with an area of about 25 km^2 to each individual (given that the conflict was contained in 1590 km^2 of the JFD). It is likely that some of the 103 captures were re-captures since releases of the initially captured animals were carried out at the administrative boundary of the JFD. Rapid vehicle transects carried out across 600 km of the JFD indicated that domestic animals were most numerous. However, our studies showed that domestic animals tended by people provided only about 1/7th of the leopard population's food requirement in the JFD in 2000-2001. We could not estimate the density of stray domestic animals (dogs and livestock) in this short study but it is likely to have formed an important part of leopard diet in the JFD.

The leopards trapped following an incident (either fortuitously in a shed or deliberately in a baited trap) are most often released away from the sites of capture (most likely to be their territories). This is the most common way of dealing with problem leopards and is mandated by the Wildlife (Protection) Amendment Act, 2002, for Schedule I species (the leopard was included in 1983) and is the preferred alternative to lethal control. However, studies on translocated leopards and other similar-sized felids from Africa, the Americas and Europe carried out in the 1980's have shown that this method does not reduce man-leopard conflict; in fact, it is likely to transfer the conflict to areas of translocation. The reason why conflict may not decrease with removal of an odd individual from an area is likely to be due to a fact of felid biology where younger animals in search of territories almost immediately colonise vacant territories.

Nearby translocations (less than 60 km from site of capture) of large numbers of leopards (10 – 25) were carried out in 2001 within the JFD. The level of conflict (livestock and human depredations) in the JFD increased significantly following this local displacement of large numbers of leopards decreasing to historic levels only after an almost complete removal of leopards from the area (far-off translocation, death, captivity) in 2003. A similar pattern was seen in the 95% probability area of conflict which increased by a factor of seven in 2001 compared to historical levels, reducing to pre-existing levels in 2003. We modelled least-cost movement pathways based on vegetation density, starting at the crestline of the W. Ghats and terminating at the capture sites in the JFD. The lowest cost of movement was seen to be along the river valleys with 90% of the actual conflict points (livestock and human depredations, leopard trappings) lying less than 1 km from the modeled pathways. Furthermore, high costs (low vegetation density or open water) impede movement from start points located in the northern areas of JFD to capture sites in the southern ranges of the JFD and vice versa indicating that animals trapped in the southern regions and released in the northern areas of the JFD may not always be able to come back to their territories due to landscape features.

The slowly rising levels of depredations in the northern regions of JFD (from the mid – 1990's) could be due to the sustained releases, of a number of leopards trapped from a wider area, into the Malshej Ghats which is located at the northwestern corner of the JFD. Such continual releases into certain preferred areas (such as Malshej Ghats, Jawahar –Thane Ghats, Chandoli Wildlife Sanctuary [WLS]) can effectively be regarded as "re-stocking" which is generally used to increase wild populations. In the case of the JFD, satellite imagery shows that the highest vegetation density (offered by tall crops like sugarcane) is along the valleys of the rivers flowing (eastward) down from the crest-line and this is the route that leopards may be expected to take away from the over-populated sites of release. Even assuming high mortality of the released leopards, a population increase in nearby areas is inevitable given the large influx (large compared to existing numbers) of leopards.

Leopards trapped in the JFD following 2002 were released in far–off protected areas in the state. However, these sites are few in number and have recorded an influx of about 2 – 17 leopards in the last five years. Twelve leopards were released into Yaval WLS in a span of two years and 16 were released into Melghat Tiger Reserve in two years. Most of these leopards have been from Junnar but there are other Protected Areas where animals from other areas in the state have been released in large numbers (e.g., Chandoli WLS, Kalsubai WLS). Three of the 22 (marked with transponder microchips) Junnar animals were recaptured at their new sites of release after casualties on humans in areas with no prior instances of human-leopard conflict in the memory of the people. Furthermore, large number of leopards introduced could potentially lead to increases in leopard populations and subsequent conflict levels close to these sites of release.

The recommendations provided below are general in nature. We have used the man – leopard conflict in the JFD as a case study and have combined its results with information from felid biology obtained from literature. During the course of our study, we realized that we could not confine ourselves only to the man-made administrative boundaries of the JFD and therefore we have also considered information on man – leopard conflict from elsewhere in the state, and country. Also, the recommendations are made keeping in mind the need to conserve the leopard species in India, where despite seemingly local abundances, it is heavily persecuted to meet the demand of the illegal wildlife trade.

RECOMMENDATIONS

1. Translocations of captured leopards should not be permitted. The only options for leopards trapped in a human dominated area should be permanent captivity or lethal control.

Our study indicates that conflict levels indeed surged following the displacement of many leopards (> 10) within a six month period in the JFD. On the other hand, sustained releases of leopards into a single area over a long period of time is likely to lead to population increase of leopard populations in the best suitable habitat (be it sugarcane, tea plantations or tall crops) in the surrounding area. Our study has also shown that problem leopards translocated from JFD to far away protected areas has resulted in moving the conflict to the site of release. The problem could be exacerbated if a large number of problem animals are moved in a short period of time.

Translocation is most commonly used throughout India while dealing with leopards that have been trapped for whatever reason. Translocation of carnivores used to be carried out in other countries but with data available from various studies (Linnell *et al.*, 1996, 1997; Treves & Karanth, 2003) carried out across different species of carnivores, the general consensus now is that translocation of carnivores into areas which already contain members of the same species is a poor strategy in dealing with potentially "problematic animals".

2. Trapping of leopards should be carried out only after careful consideration and should be stringently controlled by a central authority of the Forest Department. A strict limit should be kept on the number of trap cages available to a Division Office. Leopards falling into open wells that are characteristic of this region appear to occur quite commonly and efforts should be made to cover them or fence them. This will also help in reducing the number of leopard being trapped. For leopards trapped close to fringes of forests where there has been no history of conflict, they should be immediately released back at the SAME site of capture.

Leopards are known to be highly adaptable and will live successfully even in the margins of urban and semi-urban areas (eg. The hills around the city of Pune, fringes of Sanjay Gandhi National Park). There is an example of four leopards trapped in the course of one night in the capital city of Kenya (IUCN – CSG, 1992) when a trap was set for an escaped leopard (which incidentally did not get trapped). There is also another instance where a radio-collared leopard spent the whole day in a shed without people of the village (in Nepal) knowing of its presence, until night-time when it left the shed (Seidensticker & Lumpkin, 1991). Leopards can live without coming into conflict with people even in such areas. Any trapping exercise will also capture many harmless individuals with no guarantee of capturing the problem individual. Each trapping exercise must have a well thought out exercise for handling the many leopards that maybe caught. Leopards trapped accidentally (in a well or shed) in non-conflict areas should be released immediately near the site of capture.

3. Low levels of livestock attacks should not be handled by trapping but by monetary compensation.

The Junnar Forest Department indeed has an excellent track record in the speed and efficiency of disbursal of compensation. The exemplary way in which they handled the situation is probably the most important factor for the lack of any mob anger despite the severity of the conflict, unlike in many other parts of India. The Forest Department officials were present at all times: taking the victim to the medical facilities, speedy disbursement of compensation and this should serve as an example in other parts of India.

4. Leopards should be allowed to feed off the livestock they have killed.

In the JFD, leopards were driven away from their kill in half the instances by people. This possibly leads to multiple attacks. There was an instance in the JFD where after a leopard was chased away from four kills, a human attack was reported in the close vicinity.

5. Monthly monitoring of conflict levels should be carried out by the Divisional Offices.

6. A database of animals in areas with a high conflict potential must be maintained by collecting scat and hair samples and pugmark images/casts. Similar samples should be collected at sites of livestock and human attacks.

DNA analysis of such samples can provide a reference identification library of all the individuals in such an area. The nature of the trapped animal (harmless or culprit) can then be determined and action taken accordingly. The possible institutes which could help in the above effort are the Wildlife Institute of India, Dehradun, Centre for Cell and Molecular Biology (CCMB), Hyderabad and the National Centre for Cell Sciences (NCCS), Pune.

7. Direct shooting of leopards in high conflict areas should not be allowed.

Injured animals are likely to be far more dangerous to human life. Furthermore, shooting could also lead to many innocent animals being killed without any guarantee of bagging the actual problem animal. Lethal control should only be considered after entrapment and confirmation of the identity of the culprit, and should be carried out ONLY under the supervision of senior Forest Officials.

8. Scientifically managed leopard conservation centres in the vicinity of wildlife sanctuaries should be considered.

In our considered opinion, translocation is not an option at all. However leopards are Schedule I animals. If lethal control of problem animals is not preferred such animals maybe released in safari like enclosures on the edges of protected areas (eg., Bhimashankar Wildlife Sanctuary) which are visited by thousands of tourists. These centers maybe run by local communities under the supervision of the Forest Department. Such a scheme would provide visitors a chance to see carnivores in near natural conditions, lessen the tourist pressure inside the protected area for sighting such carnivores, provide employment in the local community and generally further the cause of conservation.

9. Long-term telemetric studies of leopard living at the fringes of human populations should be carried on an urgent footing.

Permits to study endangered carnivores like leopards are often not forthcoming, especially when they involve telemetric studies or even DNA analysis of scats, perhaps fearing adverse publicity in case of a problem. However benefits from such studies, which will go a long way in saving human lives as well as help in the conservation of the species, far outweigh any negative impact. Perhaps the Forest Department should carry out a campaign to highlight this more-or-less complete absence of studies which handicaps them in their effort to strike a right balance between human welfare and conservation measures.

Our study was severely handicapped by lack of sufficient information on the animals that were trapped and released and so we had to make do with information from studies carried out in other countries. To effectively manage any conflict situation, biological information on the species is absolutely necessary. It is imperative that a telemetric study be carried out with an aim of obtaining information on leopards that

live at the fringes of human habitation. Knowing the biology of leopards that live at the fringes of human habitation would perhaps help in avoiding escalation of conflict levels.

10. Education of local people on the consequence of hunting of leopard prey and habitat degradation.

11. In high conflict areas, leopards should be trapped and permanently removed until conflict levels subside.

12. Habitat modification of fragmented Reserve Forests of areas like JFD should be geared towards attracting natural species of plants and wild animals.

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1 INTRODUCTION

In India, recent media reports implicate the leopard as the most common carnivore in man – carnivore conflict. The other carnivores – tigers, lions and wolves (Saberwal *et al.* 1994; Jhala & Sharma 1997, Rangarajan, 2001, Linnell *et al.* 2002) - known to have been commonly involved in large numbers of human deaths in the past are now mostly restricted in range and their impact is not as widespread as the leopard. Wild elephants in India probably kill far more people than any of the above (Karanth & Madhusudan 2002), but there is something provokingly shocking when a leopard is seen dragging away a child from the house. The increase in man-leopard conflict is also likely due to the greater resilience and adaptability of the leopard compared to other carnivores, which allows it to live successfully close to human habitation (Daniel, 1996). Sanjay Gandhi National Park (SGNP), surrounded by the metropolis of Mumbai, India, frequently reports incidences of leopards straying into the urban areas outside the Park. There is a recent instance when a leopard tried to carry away a child over the wall of a upper middle-class residential complex located on the edge of the Park. Their greater adaptability is due to their catholic diet which even includes arthropods, amphibians, rotting carcasses, their lesser dependence on free water (obtaining it from their prey), and their smaller size, which reduces the area needed to sustain a population compared to their larger cousins and makes it possible for them to live closer to human habitation (Daniel, 1996; see Appendix 1).

Historical incidences of man-leopard conflict have been reported from several parts of India, the most famous being the hill regions of Pauri Garhwal, Uttaranchal where hundreds of people were killed by leopards even in the early 20th century (Corbett, 1981; Edgaonkar & Ravi, 1998). Himachal Pradesh and the tea gardens of Bengal are other areas where the problem seems to have been prevalent for a long period of time (WWF-India, 1997). The man-leopard conflict in India also appears to be dependent on very local factors with some areas having very severe conflict levels and other similar areas not reporting a problem. In some cases man-leopard conflicts diminish suddenly after a spurt in attacks possibly because of the complete elimination of the leopard population in that region. In Chikamagulur (Karnataka), 11 people were killed over a period of time in 1995 following which 17 leopards were killed (Karanth & Madhusudan 2002) resulting in an end to human depredations.

The definitions of man-carnivore conflict within and outside India are interesting for their difference. In Africa, Europe and the Americas, conflict usually implies a level of livestock depredation in areas where intensive animal husbandry practices are carried out (Linnell *et al.* 1996, Mizutani 1999, Butler 2000, Stahl *et al.* 2001, Hoogesteijn date na.). In India high levels of conflict usually imply human deaths. Attacks on livestock are tolerated to a large extent and is likely to be due to the inherent attitude of the people (Madhusudan & Mishra, 2003) and in small part due to the compensation paid by the Government in case of livestock depredation. It must be noted that in most part, the rural populace is not aware of the compensation scheme (pers. Obs.).

Various reasons have been put forth to explain the increase in man-leopard conflict levels. The main reasons proposed are depletion of the natural prey base, degradation or fragmentation of leopard habitat, and/or man-made modification of the landscape resulting in suitable habitat for the leopard (e.g., sugarcane, tea plantations, tall crops) and increase in local leopard populations. The lack of any biological studies on the species in its natural and conflict settings in India makes it difficult for us to understand the processes behind the increasing rates of conflict associated with this species. The evidence from studies outside India indicates that a sufficient availability of natural prey in areas with large numbers of livestock would ease the levels of livestock depredation. A study by Mizutani (1999) carried out in the ranches of Kenya found that losses due to leopard attacks on livestock differed substantially in ranches devoid of wild prey compared to ranges which supported populations of wild prey and recommended that presence of wild prey was a good strategy for reducing livestock predation. Areas with good numbers of wild prey could face some degree of

livestock depredation but where natural prey has been depleted, livestock depredation is likely to be inevitable (IUCN – CSG, 1992).

One factor which might be important in allowing leopards to survive close to human habitation in India are the large numbers of stray domestic animals (dogs and cattle) that are synonymous with the Indian countryside. The stray cattle could be those that are abandoned or left free to wander, returning to their homes in the evening and/or are kept only for their dung (an important source of fuel). There is no form of livestock ranching carried out in India that can be compared to other countries. Most of the cattle are grazed in and around village lands and large numbers of stray cattle and dogs can be seen even in the cities. Of late, in some villages, there has been an incursion of high yielding livestock breeds and these are stall-fed. However, in most part, large numbers of livestock and dogs are present everywhere. Population control of stray animals is not routinely carried out in India and cows are not killed because of religious sentiments. Thus it is not surprising that scat analysis of leopards in conflict areas of Sanjay Gandhi National Park, Mumbai, and Pauri Garhwal, Uttaranchal report dogs and livestock to comprise the main component of leopard diet (Edgaonkar & Ravi, 1998; Chauhan & Goyal, 2000).

Crops such as sugarcane, tea plantations and other tall crops have been implicated for providing an "ideal" habitat for the leopard thereby allowing it to live close to humans and consequently engendering conflict. Even tigers are known to litter in sugarcane fields on the periphery of Dudhwa Tiger Reserve (Uttar Pradesh) leading to an increase in human attacks (Karanth & Madhusudan 2002). In Gujarat, the good cover provided by tall crops, such as Jowar (*Sorghum bicolor*) and Bajra (*Pennisetum glaucum*), and in Maharashtra, sugarcane, has been indicted as possible causes for the increase in leopard populations.

Leopards, like other felids have a well-defined land tenure system that is best described by Bailey (1993, *in* Edgaonkar & Ravi, 1998) where the basic layer of land usage is the territory of the adult females. These are strongly defended with little or no overlap with territories of other females. This layer is superimposed with the territories of males which are much larger and which can either contain or overlap with many female territories and again no tolerance is shown towards other males. The final layer is that of the transients, usually sub-adults in search of new or vacant territories. Female sub-adults settle close to their mother whereas males are driven out to search for new territories, a strategy that prevents reproduction among close relatives. This large and constant pool of transients and their habit of ranging far makes the species difficult to manage when some individuals come into conflict with humans.

The land tenure system might also be important in the man-leopard conflict issue especially in India where the most common method of dealing with any leopard that is trapped (either because it fell in a well, was trapped in a house, or trapped in a cage following a threat to human life) is to translocate it to a nearby forest, away from its site of capture. Translocations appear to have been commonly carried out in the Americas, Europe and Africa in the early and late 1980's to deal with felids when they came into conflict with humans (Rabinowitz & Notthingham Jr., 1986; Cat News, 1989; Linnell *et al.* 1996, 1997). Translocations have been widely studied in other carnivores and even in leopards in Africa and is generally believed to be an ineffective management strategy - does not help in the conservation of the species, does not reduce conflict levels and is extremely expensive (see Linnell *et al.*, 1996, 1997; Treves & Karanth, 2003). Studies from a removal experiment conducted in Utah, USA, on cougars (*Puma concolor),* similar in size to leopards, showed that the 12 individuals removed were replaced by 17 ***other*** individuals, most of them younger, which explained why the removal of cougars after livestock depredations did not reduce the conflict in that region (Linnell *et al.* 1996). A study conducted in 1986 (Rabinowitz 1986) on jaguars (*Panthera onca)* found that no territory was left vacant for more than six weeks after the death of the residents. Rabinowitz & Notthingham Jr. (1989) in 1983

radio collared a "problem jaguar" that was translocated to their forested study site. She went back to cattle killing at the edge of the forest and showed a deviant behaviour (a diurnal schedule) compared to other jaguars which mainly fed on wild prey and had a more nocturnal schedule. The ineffectiveness of translocations as a management strategy to reduce conflict by felids are due to (i) the high mortality involved with translocations (about 60 – 70%, see Linnell *et al.,* 1996; Treves & Karanth, 2003) (ii) the large scale homing behaviour exhibited by felids where in the absence of soft release, are seen to almost always leave the area of release immediately (Linnell *et al.,* 1996, 1997; Treves & Karanth, 2003) iii) increased intra-specific aggression and infanticide in case a residents territory is lost to the newcomer (Treves & Karanth, 2003). There are instances of cougars (similar in size to leopards) having traveled over 400 kms back to their site of capture to resume livestock depredation (Linnell *et al.* 1996). Karanth & Sunquist (2000) report of a "problem leopard" caught 120 km away and released in their study site (Nagarhole National Park) in the year 1990 which immediately moved out of the Park. A problem leopard captured in Gujarat and translocated 30 kms away was fitted with a radio collar. It was found to immediately return to its earlier territory and resume livestock depredation (pers. comm. Khalid Pasha). Nevertheless, trapped leopards in India are usually released in nearby forested areas away from their site of capture.

The Junnar Forest Department recorded 103 successful leopard trappings in three years (2001 – 2003) to try and control the rising livestock and human depredation levels in an area of about 4360 km^2. Our investigations (March 2003 – March 2004) aimed at 1) understanding the nature of and the reasons leading to the steep escalation in conflict levels in 2001 in the JFD and to 2) understand the reasons for the localization of the conflict in the JFD. We have also attempted to study and relate the conflict to 1) the role of prey base depletion, 2) changes in the landscape composition, 3) increases in man-made habitat that is conducive for the leopard and 4) the intrinsic increase in leopard populations in the JFD. We used the records of the Maharashtra State Forest Department to carry out semi-structured interviews with all the affected people who lost their livestock (since October 1999) and family members (since 1993) to leopard attacks. Leopard trapping and release records available from February 2001 were also analysed. For all of the above, GPS locations provided an input for a GIS based spatial analyses of the conflict. Information on socio-economic and other parameters related to livestock depredation and attacks on humans, which are likely to have had a bearing on the conflict, were collected and analysed.

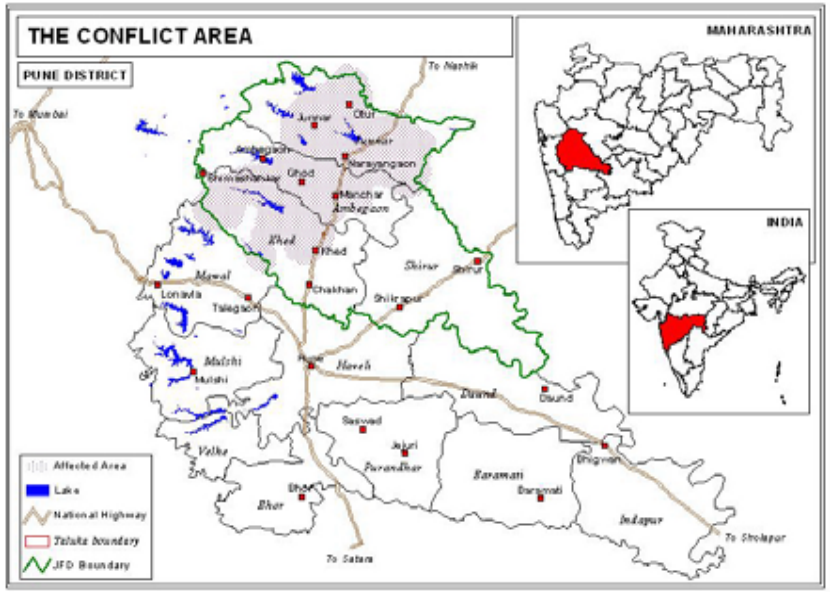
As part of the project 22 leopards trapped in the Junnar (19) and the adjacent Ahmednagar (3) Divisions and slated for translocation to far off protected areas in the state were tagged with passive transponders to test the efficacy of such a management strategy. In order to obtain a more complete picture on the nature of the conflict in the state of Maharashtra, Forest Department records on capture and release of leopards from all other high intensity conflict areas in Maharashtra were analysed. Finally recommendations have been provided which if followed is likely to ease the current levels of conflict and prevent large-scale escalation of conflicts in future.

2 STUDY AREA - JUNNAR FOREST DIVISION (JFD)

2.1 TOPOGRAPHY AND VEGETATION

The Junnar Forest Division (18°27'51.48" – 19°24'03.6"N and 73°31'18.84" – 74°35'09.24"E) lies in the north western corner of Pune district, adjoining Thane and Ahmednagar districts. The affected area is administered by the territorial wing (which implies jurisdiction of non forested lands; plantations, social forestry etc.) of the Maharashtra State Forest Department and comprises Junnar, Ambegaon and Khed Talukas covering an area of about 4360 km^2 (Figure 2.1).

Figure 2.1 : Map of the affected area.



The crest-line of the Western Ghats lies along the western boundary of this region from where the Mina (drains from Chilewadi), Pushpavati, Kukadi, Mina (drains from Wadaj), Ghod, Bhima, Bhama and Arala rivers (from north to south) rivers originate and flow eastwards to join the Krishna (Table A.2.1). Annual rainfall varies from up to 6000 mm on the western scarp of the Ghats to 400-600 mm on the Deccan Plateau. Twelve and a half per cent of the area supports forest (Reserved and Unclassified) (Table 2.1). Most of the remnant forest patches that occur in the region are located in a narrow strip between 5km west and 10km east of the crest-line of the Ghats, marking a 15km wide corridor (Chaudhuri, 2000). The Bhimashankar WLS (19°08'N, 73°33'E), comprising 132 km^2 of forests on and adjacent to the crest-line of the Western Ghats in the south-west corner of the JFD, was notified as a Wildlife Sanctuary in 1985 and is the only Protected Area in the division.

Table 2.1 : Geographical information from the JFD.

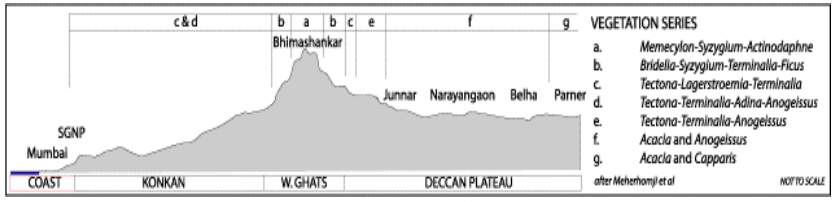
Taluka	Area (km^2)	Reserved Forest (km^2)	USF* (km^2)	Cultivated Area (ha)	Cultivable wasteland (ha)	Wasteland
Junnar	1,616	196	8	43,403	71,588	2,165
Ambegaon	1,157	143	11	6,808	53,791	11,097
Khed	1,402	155	4	8,267	74,530	20,029

***Un-classed State Forest; *Source:* DCF Office, Junnar.**

Champion & Seth (1968) have described the forests of the Western Ghats in this region as the sub-tropical montane broad-leaved type (8A/C2, altitude 1000-1400m, annual rainfall above 6000mm and red soils) and west-coast semi-evergreen type (2A/C2, altitude 450-1050m and annual rainfall between 2000-2500mm). However, the conflict areas in the JFD are not along the crest-line nor near it; no human attacks (a good indicator of the degree of conflict) have been reported in a 15 km-wide strip adjacent to the crest-line.

Vegetation maps (1:1,000,000 scale) published by the French Institute, Pondicherry, (Gaussen *et al.*, 1965) indicate a series of Memecylon-Syzygium-Actinodaphne (evergreen forest); Bridelia-Syzygium-Terminalia-Ficus (semi evergreen or semi deciduous open forest); Tectona-Lagerstroemia-Terminalia (Moist Deciduous forest); Tectona-Terminalia-Adina-Anogeissus (Moist Deciduous Forest) Tectona-Terminalia-Anogeissus (Dry Deciduous forest) and Acacia-Anogeissus (dry form of dry deciduous forest). Acacia-Capparis (thorn forest) in a sequence that progresses eastwards, away from the crest-line of the Ghats (see Figure 2.2).

Figure 2.2 : Profile of vegetation types across a cross-section of the region.



***Source:* Gaussen *et al.*, 1965.**

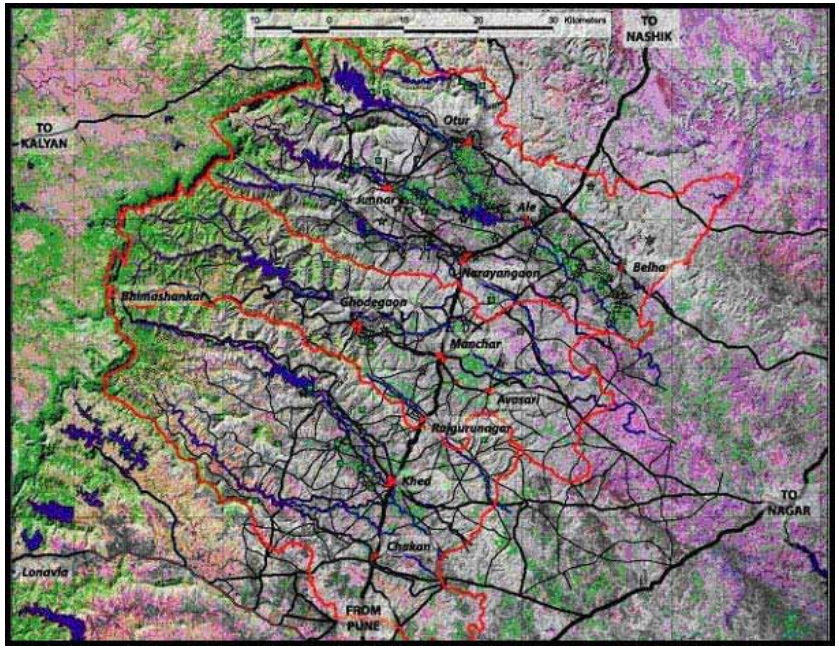
The area gets drier towards the east and originally supported dry deciduous forests. However with the advent of seven irrigation projects in the region, the dominant vegetation consists of fields of sugarcane, grapes, onions, maize, banana and guava plantations and other cash crops. The trees that are present occur near houses or on the bunds of fields, comprising mainly useful species such as mango (*Mangifera indica*), Babul (*Acacia nilotica*), Neem (*Azadirachta indica*), *Zyziphus mauritiana* and *Thespesia populnea*. Hills dot the landscape, but are either devoid of trees or support a highly degraded deciduous scrub or plantations of exotic species such has *Gliricidia sepium* and *Eucalyptus* spp. (pers. comm. Vivek Broome).

2.2 ADMINISTRATIVE AND DEMOGRAPHIC PROFILE

The Junnar Forest Division comprises the Junnar, Ambegaon, Khed and Shirur Talukas of Pune District (Figure 2.3). The man-leopard conflict was concentrated in three of the Talukas (Junnar, Ambegaon and Khed) and our report deals with only these. Administratively, the JFD is sub-divided into eight Range Offices: Junnar, Otur, Narayangaon, Manchar, Ghodegaon, Rajgurunagar, Chakan and Shirur. A Deputy Conservator of Forests is the divisional head and is supported by a staff of 1 Assistant Conservator of Forests, 8 Range Forest Officers and 365 personnel employed as Forest

Guards and van mazdoor (labour). The forest ranges of Junnar, Otur and Narayangaon are contained in the Junnar Taluka, ranges Manchar and Ghodegaon in the Ambegaon Taluka and Rajgurunagar and Chakan in the Khed Taluka.

Figure 2.3 : Map of the JFD with the dams and road networks.



The Census of India, 1991, reported a total rural population of 764,015 (383,615 males and 380,400 females in 133,236 rural and 3,642 urban households) at a density of ca. 185 persons km^{-2} in the three affected Talukas (see Table 2.2).

Table 2.2 : Demographic information from the JFD.

	Junnar	Ambegaon	Khed	Junnar Muncipal Corporation	Total
Population	282,535	186,809	273,255	21,416	**764,015**
Area (ha)	160,576	115,144	138,280	-	**4,14,000**
Density (persons km^{-2})	176	162	198	-	**184.54**
No. of villages	167	136	190	-	**493**
Min. village size (ha)	56	66	48	-	**48**
Max. village size (ha)	7,093	3763	3,747	-	**7,093**

***Source:* Census of India, 1991**

Fifty five percent of the working population is reported to be involved in agricultural activities in this region of which about 1% is involved in animal husbandry (Census of India, 1991). Minor millets

consisting of Jowar (*Sorghum bicolor*), Bajra (*Pennisetum glaucum*) and Ragi/Nachni (*Eleusine coracana*) comprised 70 % of the gross cropped area (GCA) in 1994-95 (Patwardhan *et al.,* 2003) and groundnut 12 % of the GCA in 1994-95. These are by far the most important food crops in the region. The development of a series of irrigation projects between 1976 and 2000 was followed by large-scale introduction of sugarcane, especially in Junnar Taluka (Table 2.3). The Junnar taluka contains the Junnar, Otur and Narayangaon Forest ranges. The Ambegaon taluka contains the Manchar and Ghodegaon ranges and the Khed taluka contained the Rajgurunagar and Chakan ranges.

Domestic animals commonly reared in this region include cows, buffaloes, goats, fowl, dogs and cats. There has been an increase in the presence of the jersey breed of cows but is unlikely to have significantly changed the number of stray cattle or those that are grazed in and around villages. Large numbers of stray pigs and dogs can also be seen in the bigger villages.

Table 2.3 : Area (ha) under important crops in the JFD, 1960-61 to 1994-95.

Taluka	Year	Rice	Wheat	Jowar_k[1]	Jowar_r[2]	Bajra	Ragi/Nachni	Sugarcane
Junnar	1960	5595	4865	3334	18696	35153	961	173
	1970	4969	2992	1384	19463	37849	969	173
	1979	5060	5224	4613	31017	33266	720	570
	1989	7251	513	899	29197	32992	1779	**6549**
	1994	7633	4650	505	29545	24155	510	**2760**
Ambegaon	1960	2960	1967	1642	10870	23750	1891	11
	1970	2180	11	1644	9598	22908	1839	42
	1979	2543	906	2070	18496	18665	2100	76
	1989	3225	5700	0	19000	15529	2701	**0**
	1994	4127	2321	858	12638	21233	1421	**1444**
Khed	1960	6009	1930	5960	12415	21468	2157	41
	1970	4094	638	3286	12032	20354	1303	42
	1979	5799	1124	5014	18296	17525	1726	152
	1989	7728	2330	5149	25858	18690	787	**0**
	1994	7937	4651	1196	21245	18259	1472	**447**

(*Source:* Patwardhan *et al.*, 2003)

k = kharif is the monsoon crop, r = Rabi crop is the winter crop

There have been historical records of leopards and tigers from this region. A police official was felicitated in Ambegaon for killing over a dozen leopards in 1942. This followed an attack by leopards and/or tigers on 100 people. In 1950 the same official was felicitated again for killing 2 tigers (Wargade, 1989a). There is also another report of a person who killed 96 leopards and/or tigers in Junnar region during his lifetime, the last in 1964. There is also a record of a tiger which was killed at the base of the Shivneri Fort, Junnar, in 1924 (Wargade, 1989b). Archives of the local newspaper Sakal has records of leopards that had fallen into well in the JFD in the early and mid-90's (one in 1992, two in 1994, and one in 1995 which was subsequently trapped).

Apart from leopards, some of the other wild mammals present in the region are hyaenas, Indian fox, jackal, jungle cat, small Indian civet, Indian civet, the Indian mongoose, small Indian mongoose and the black-naped hare. Peafowl are also seen (see Table A.2.2). To the west, closer to the crest-line of the Western Ghats, people report crop damage by wild boar, and sambar and barking deer are also present. Records of human depredations since June 93 – September 02 indicate that wild boars (4), wolves (2) and hyaenas (3) have also been involved in attacks on humans (total number of attacks = 80) in the affected areas of JFD. The rest of the attacks were attributed to leopards.

3 METHODS

The main causative factors cited for the increased man – leopard conflict in various parts of India are **1)** the loss and degradation of natural habitat **2)** adaptability of leopards to new habitats created by man (e.g., sugarcane in the JFD, tea gardens in North Bengal, tall crops in Gujarat) **3)** the decrease of the wild prey base in the forests and **4)** local increase in leopard populations. It is very likely that a conflict situation arises from a complex interplay of any or all of these and other known or unknown factors. Nevertheless, we have attempted in this study to throw some light on the relative importance of the above factors in causing the man-leopard conflict seen in the JFD. We have restricted our study to the three affected talukas of the Junnar Forest Division (Junnar, Ambegaon and Khed) since the Shirur taluka has not reported any conflict by leopards prior to 2001. Henceforth "JFD" referred to in the report will imply only the three affected talukas.

We used Geographical information systems (GIS) techniques with satellite imagery and ground-truthing to obtain an idea of the land cover change from historical times, which may be expected to throw some light on the first two factors listed above. The roles played by the last two factors were assessed by analysing the information from the Forest Department records, data from the field, press reports and information from Forest Officers administrating these areas in the early and mid 1990's.

3.1 Analyses of satellite imagery

Administrative boundaries and village locations within Junnar and Ambegaon Talukas were digitised and rectified from maps (1:10,000) procured from the Government Photozinca Press at Pune. Analog maps of Khed Taluka could not be accessed, but were digitized on-screen using low-resolution maps available online. No attempt was made to digitise boundaries of Shirur Taluka because the available data do not report conflict from there. Sub-demarcation of Forest Ranges within each Taluka was not carried out as we were unable to access Range boundary maps. These inputs (especially the administrative boundaries) contain significant errors for a number of reasons and are used henceforth only for visual display.

Topographic data was accessed from GTOPO30 data[1] that provides elevation information at a resolution of 30arc seconds (~1 km^2). In order to assess the magnitude and impacts of habitat change in the affected region, we use pre-projected and ortho-rectified LANDSAT imagery for 1973 (Multi-Spectral Scanner, 60m resolution) and 1992 (Thematic Mapper5, 30m resolution), and ASTER data for 2000 (15m resolution). Imagery was processed using a combination of unsupervised and supervised Maximum Likelihood Classification and SMAP[2] procedures to derive land cover information. Change analysis using temporal imagery is prone to errors resulting from differences in time of data capture, sun and satellite positions, cloud cover and sensitivity of sensor equipment among other factors. Additional problems are related to scanner resolution, registration and ortho-rectification, which can cast considerable doubt on the accuracy of pixel overlays over time. To compensate for these errors, all raw imagery was first converted to radiances and re-sampled to a resolution of 60m to facilitate comparison across time. Six land cover classes 1) lakes and standing water, 2) forest (vegetation density > 40%); 3) tree savanna (density 20 – 40%), 4) standing tall crops, 5) fallows/cleared agriculture and 6) open savanna – sheet rock (vegetation cover with density < 20%) were extracted from the imagery across three decades (1973, 1992, 2002). This classification is purely physiognomic but does

[1] United States Geological Survey Digital Elevation Model, tile E060N040

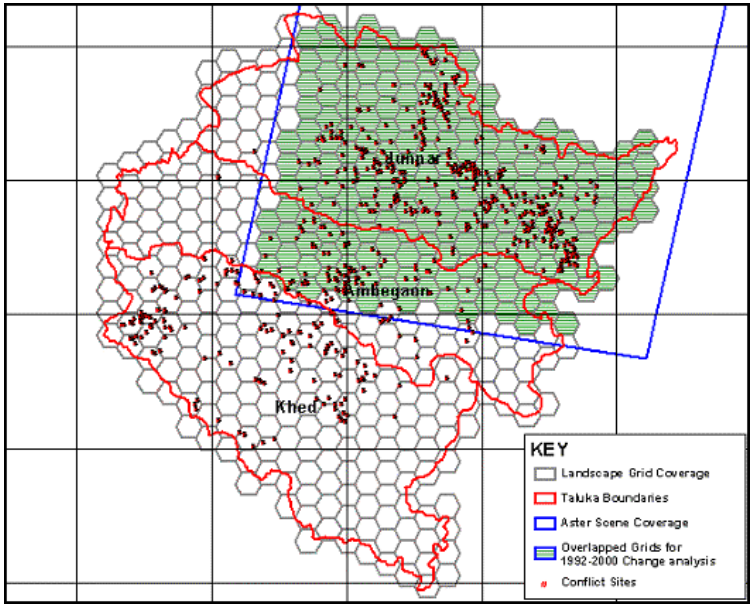
[2] Sequential Maximum APosteriori (SMAP) Classifications, unlike the hard classifiers used in Maximum Likelihood procedures, exploit user specified combinations of different land cover elements to finally decide which class to allocated pixels to based on relationships between different classes.

show close similarities to classifications enumerated by Champion and Seth's (1968) Forest Classification and with vegetation maps of the region developed by Gaussen *et al.* (1965).

For comparison of the landscape composition and change in the spatial patterns of conflict, the landscape was disaggregated into 436 hexagonal grid 'cells' (each of area 9.98 km^2 and a unique code – e.g., Hexid 183) that *completely contain* the Junnar, Ambegaon and Khed Taluka boundaries. Comparison of the landscape was possible for the three decades spanning 1973 – 2000 and the change statistics are reported using these grid cells as units (Figure 3.1). The selection of a ~ 10 km^2 grid cell is arbitrary, but was selected based on leopard home range sizes reported in telemetric studies from Sri Lanka and Nepal (Santiapillai *et al.*, 1982; Seidensticker *et al.* 1990). The opportunity of exploring the data at different resolutions still exists, should the need arise.

"Conflict site" in the GIS analyses is defined as any leopard related incident - depredation on livestock and humans, trapping of leopards, dead leopards found in the region (records available from August 2001 - December 2002). Records are present from April 1993 for attacks on humans and from October 1999 for livestock depredation. Leopard trapping records are present from February 2001. Furthermore, in some cases, only the dates of the conflict were available and in others only the GPS locations were available. 'Reliable leopard trapping' data is based on Forest Department records present since February 2001. Prior to this, trappings did take place and so did translocations (mainly local, i.e., less than 60 km from the capture site) but no records are present. However, in some cases the Forest Department personnel accompanying ST for the fieldwork was aware of the sites and dates of previous leopard trappings and these have also been considered in the data set.

Figure 3.1 : The grid cells, or hexagons used for spatial analysis of the JFD.

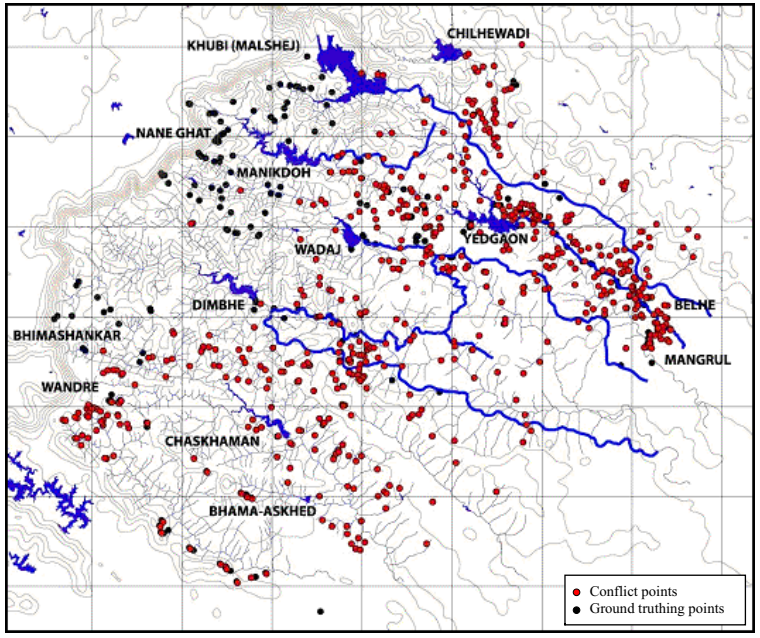


A total number of 744 data points were sampled of which 713 could be dated. Of these, 8 could not be geo-located giving us a final data set of 705 points which were used for the GIS analyses (all human cases, 95 % of the cattle attacks, 89 % of leopard trapping incidences, 55 % of the leopard deaths).

3.2 Livestock and human depredation by leopards

Records of livestock and human attacks and leopard trappings were obtained from the seven Forest Range Offices in the region and formed the main framework of our data set. It has to be noted that the financial year commences in April and ends in March and where we have not used these financial years, care has been taken to specify the months under consideration. Compensation is paid by the Forest Department to a livestock owner only incase of death of the livestock attacked by leopards. We sampled 88% (N = 489; we could estimate the fraction we sampled of the total number of records available for the ranges of Junnar, Narayangaon, Rajgurunagar, Manchar and Chakan) of cases reported between April 2000 and September 2003. It should be noted that the Range Forest Office records each incident of attack whereas the records with the Deputy Conservator of Forest contain information even of multiple animals killed in each attack. We have used each incident as a data point and have not considered multiple animals that may have been killed as a result of a single attack, unless mentioned otherwise.

Figure 3.2 : Locations of conflict points sampled in this study.



At each site of livestock depredation GPS readings were taken, owners interviewed (see Appendix 3 for the questionnaires) and habitat analysis in terms of the dominant landscape features were carried out. In the case of attacks on humans by leopards, even persons with minor injuries are financially compensated by the Forest Department and therefore we could visit almost all the localities and the victims and/or their family - from 1993 until September 2003 (78 out of a total of 83 sites were sampled). Records of leopard trappings have been maintained by the Forest Department since February 2001 and we visited 91 of a total of 103 sites. Nine sites where trapping occurred prior to this date were also sampled with the help of JFD personnel who had knowledge of the sites and dates. However, in most cases the personnel were new and we could not sample the older trapping sites.

Information on the socio-economic condition of people who lost their family members or livestock to leopard attacks in the JFD region as well as on the landscape features at the site of attack were obtained from semi-structured interviews with the affected people (see Table 3.1). It should be noted that not all the people interviewed provided answers to all the questions. The number of people who did answer has been provided along with the relevant analysis. Finally, telephonic interviews were carried out with the Deputy Conservator of Forests administrating the JFD in the early and mid – 1990's to better understand the past patterns in the conflict.

The fieldwork related to the questionnaires was commenced in March 2003 and extended up to July 2003. Vehicle transects were carried out in September 2003 after which data entry, analysis and report writing extended until March 2004.

Table 3.1 : Sampling of depredation and trapping incidents in the current study.

Type of leopard incidence	Period of incidence	# of points sampled
Human attacks	1993 – 2003	78
Livestock attacks	October 99 – July 2003	537
Trapping of leopards	February 01 – December 03	91

In order to obtain a better insight into attacks on humans, we also categorised the attacks subjectively as either accidental or pre-meditated. An attack was defined as accidental if there was no evidence to the contrary (e.g., a person throwing fertilizer in the field was attacked and injured – the leopard could have been hiding in the crops and attacked the person when he came too close). A "pre-meditated" attack was when there were livestock and/or other people present at the time of attack and also when there were other indications that the animal was intent on targeting the human. All the attacks have been described in Appendix 4 and the description of "pre-meditated" attacks are in italicized font and denoted by the symbol Ж.

3.3 Prey species and abundance in the JFD.

Given the short duration of our project it was not possible to carry out extensive sampling for prey species presence and abundance, especially in an area like the Junnar Forest Division which is largely a mosaic of agricultural fields and human habitations. Instead we carried out a rapid assessment of the presence of prey species. Vehicle transects were carried out in the post-dusk and pre-dawn hours since initial analysis indicated that most attacks on livestock by leopards occurred during these hours. A total of 604 km was sampled in the affected areas.

We have attempted to estimate the importance of the livestock component in the JFD leopard population's prey base. An estimate of the leopard population numbers inhabiting JFD was obtained from trapping records from December 2001 after which leopards were taken out of the JFD (far off translocations, death, captivity). The livestock depredation figures obtained from the MSFD records was used as an estimate of the tended livestock that these leopards fed on in the year April 2000 to March 2001 (a period prior to which the conflict escalated and prior to which large scale trapping was carried out). The above two (leopard population estimate and livestock depredation figures) along with the mean weights of livestock species was used to obtain the total livestock mass (kg) that the leopards living in the JFD had fed on. This was then compared to what they required (based on Emmons, 1987 in Mizutani, 1999) to estimate the proportion of livestock in the JFD leopard population's diet.

Scat analysis could not be carried out due to the paucity of scats encountered and the problem of not being able to differentiate between scats of leopard and domestic dog in this area (pers. comm. Shomita Mukherjee) from their appearance, since dogs also feed on the carrion of other domestic animals. Our request for permission to carry out DNA studies from scats that would have allowed for the identification of leopard scats with a good degree of certainty, was not forthcoming for the current project.

3.4 Spatial changes in conflict over time

Numerous probability density estimation methods have been used for measuring home ranges of individual animals as well as populations of a species (Kirkby, 2001; Seaman *et al.,* 1998; http://www.math.ntnu.no/~jarlet/kernel/). We used the GIS programme Animal movement (Hooge & Eichenlaub, 2000) to estimate the "home range" of the conflict over time. This Kernel utilization density model uses nonparametric statistical procedures to calculate the probabilities of an animal being in various locations in space at a particular time. It does not assume that the location points are normally distributed and adjusts the home range boundaries for location variation in frequency of use (see Moorcroft *et al.,* 1999; Kirkby, 2001; Seaman *et al.,* 1998). Instead of telemetric locations that are normally used for home range calculations using the Kernel Utilisation density model (KUD), we substituted all conflict locations (n=570) to estimate the change in area of the conflict over time.

3.5 The conflict in relation to the capture and displacement of leopards in the JFD

In order to find out the possible reasons behind the sharp and sudden increase in conflict in 2001 we plotted month-wise, all leopard related information available from April 2000 to December 2003 (livestock and human depredations, leopards captures, local releases and leopard removal from the JFD). The data on livestock depredation was complete for the ranges of Junnar, Narayangaon, Manchar, Rajgurunagar and Chakan. Only 58% of the data was available from Otur and 80% from Ghodegaon.

We plotted livestock and human depredations against 1) release of leopards caught in the JFD into areas upstream of the affected valleys 2) total trapping carried out in the region and 3) complete removal of leopards from the population (far-off translocations, death, captivity). We have considered the two regions (CRGM and JON) separately; with releases into each region, trapping within each region and removal of leopards from each region.

We also used the Mann-Whitney test to compare livestock depredation for three treatments; pre-release - 12 month period prior to when large number of leopards were released upstream of affected areas; post-release – 12 months following the release; post-removal – removal of leopards from out of the area either due to long distance translocation or death or captivity, for both the regions CRGM and JON.

3.6 Modelling leopard movement pathways in the JFD

Various diffusion models have been used along with spatial information to obtain habitat usage by animals (Walker & Craighead, 1997; Ray *et al.,* 2002; Moorcroft *et al.,* 1999; Carroll *et al.,* date na.). The least-cost model incorporated in the GIS package provides the pathway of movement across the landscape under predefined surface (pixels) costs. The uses are varied and have been used to understand dispersion of individual animals, populations, as well as the most cost effective directions of movement in a landscape (Walker & Craighead, 1997; Ray *et al.,* 2002; Moorcroft *et al.,* 1999; Carroll *et al.,* date na.). We made use of modules present in GRASS 5.01 (GIS package) programme to assign cost values to each 60 m x 60 m cell in the JFD thereby creating a spatial layer of cells with varying costs. Information on vegetation density was derived from the 1992 LANDSAT TM image (resampled

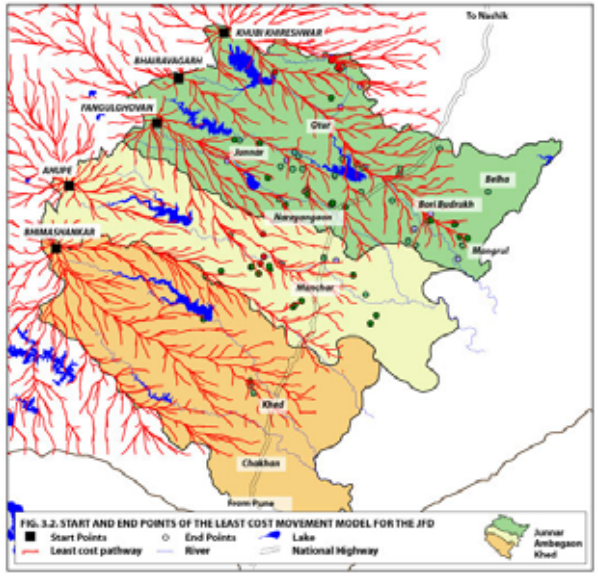
to 60m resolution) using the Normalized Differential Vegetation Index (NDVI). This index uses the spectral characteristics of vegetation in the near IR and Red bands of the spectrum, resulting in a continuous scale of values ranging from -1 to +1 (with water generally represented by NDVI of -1 to 0 and sparsely vegetated though densely vegetated areas with NDVI tending to +1, see Table 3.2).

Table 3.2 : Weights assigned to vegetation cover density obtained from satellite imagery.

Sr. No.	NDVI Range	Vegetation Cover Density	Assigned weight
1	-1.00 < I ≤ -0.19	Water (and precipices)	**100**
2	-0.19 < II ≤ 0.00	Bare (canopy cover <5%)	**25**
3	0.00 < III ≤ 0.10	Open Savanna (canopy cover <20%)	**20**
4	0.10 < IV ≤ 0.26	Tree and shrub Savanna (canopy cover <40%)	**15**
5	0.26 < V ≤ 1.00	Open to Dense Forest (canopy cover >40%)	**1**

Five starting points for the movement models were defined on the crestline of the W. Ghats (forested areas near Khubi Malshej, Bahiravagarh, Fangulghovan, Walunjewadi and Bhimashankar). The reasons for choosing these particular start points are somewhat arbitrary, but four (Khubi Malshej, Bahiravagarh, Fangulghovan and Bhimashankar) lie within 10 km (average = 6 km) of 6 release sites located by GPS readings (see Figure 3.3). Cost surfaces using the GRASS module *r.cost* were constructed from each of the five start point to all the 86 (out of 121) capture points in the JFD. Dispersal paths across the cost surface were then generated using the GRASS module *r.flow*. These paths assume that movement is determined by the easiest and quickest route, defined as the cumulative sum of cell values crossed between start and end points involving the 'least-cost' of dispersal.

Figure 3.3 : The starting and ending points of the least cost movement model for the JFD.



It has to be pointed out that other pathways of movement are as likely to occur across the landscape, however, they are likely to involve higher costs in terms of less dense habitat for movement and to a secretive animal like the leopards this is likely to be very important especially in human dominated area. Many other parameters could also have been included (streams, road density, habitation density, prey density) but would have increased the scope for error in this case due to the lack of biological information on the leopard in the JFD.

3.7 Other aspects of the current study

3.7.1 Marking leopards caught in JFD and meant for release to far off PA's in the state.

All the leopards trapped in the JFD and slated for release in far-off protected areas of the state were tagged with TROVAN ID 100 transponder chips. TROVAN chips are recommended by the IUCN/SSC Captive Breeding Specialist Group (CBSG, 1991) in the use of captive tigers. Nineteen animals trapped in the JFD from December 2002 and March 2003 and three animals from the Ahmednagar Division (trapped in June, July and Aug 2003) which lies to the north of the JFD, were tagged using this method. Eighteen of the JFD animals and the three Ahmednagar animals have been translocated to far-off protected areas in the state.

Any leopard trapped in the JFD is brought to the rescue center at Manickdoh, Junnar, where facilities are present for the care of the animals. We used this facility to insert the chips in the animals while they were restrained in a squeeze cage. The chip was inserted subcutaneously at the base of the tail (where the tail meets the body) by AB. This location on the leopard was used as a site of chip insertion since it was seen on occasion that reading of the chip could be got from the outside of a cage, if the leopard was distracted from the front, without need of restraining it in a squeeze cage or tranquilising it.

At the time the animal was restrained in the squeeze cage for insertion of the chip, the age class (juvenile, sub-adult, adult, old) of the animal was determined from the state of its dentition and in case of males from the size of their genitalia. If the teeth were very white and the canines ended in needle like points, the animals were grouped as juvenile. If canines were white and did not have the sharp points but also did not have the vertical groove, the animals were categorized as sub adult and animals whose canines had the groove were grouped in the adult category. The old were those with very yellow and highly eroded state of teeth. This categorization was used and conveyed to the Forest Department field staff so that rough age categories of the animals could also be obtained in future

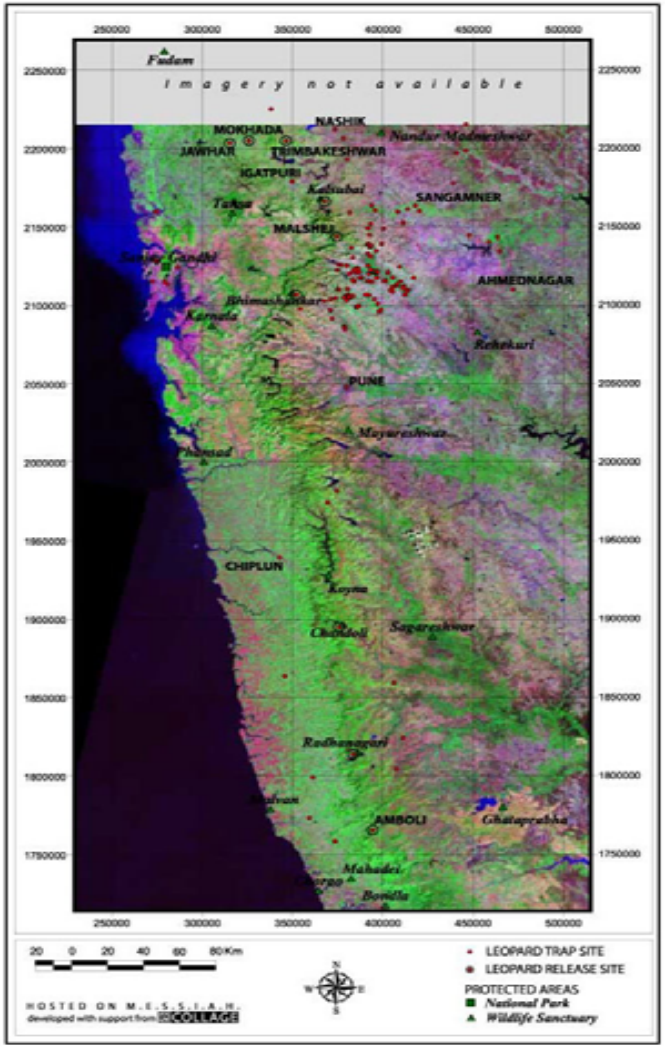
We would ideally have liked to use chemical restraint while dealing with the leopards, which would allow for lesser stress to the animal as well as permit us to obtain morphological information and samples for seropathological studies, serum banking and ecto-parasites. However, permission for these studies was not forthcoming.

3.7.2 Overview of the conflict in Maharashtra.

We used data from other man – leopard conflict sites in Maharashtra to obtain a wider insight into the nature of the conflict (Figure 3.3). The main conflict areas in Maharashtra are in the districts of Nashik (19°32′51″ – 20°55′39.36″N and 73°13′58.08″ – 73°55′16.68″E), Ahmednagar (18°17′26.88″ – 19°59″26.88″N and 73°36′52.2″ – 75°34′8.04″E), Junnar Forest Division, Sanjay Gandhi National Park (SGNP) (18°55′48″N, 75°51′00″E), Eastern Ratnagiri (16°29′12.12″ – 18°03′34.2″N and 73°00′47.16″ – 73°54′12.96″E), Kolhapur (15°46′18.48″ – 17°11′31.56″N and 73°39′38.52″ – 74°46′15.6″E) and Sindhudurg (15°35′04.56″ – 16°37′31.44″N and 73°18′49.68″ – 74°13′38.64″E) (pers. comm., DFO-WL, Office of the PCCF). These are areas where large numbers of leopards are trapped and of these, the most severely affected are the Junnar Forest Division (northern Pune district), the Eastern areas of

Nashik district and eastern and northern parts of Ahmednagar district. The severity was ascertained from discussions with the Forest Department officials and data on leopard captures from these regions. Recently conflict was reported from northern Maharashtra in the Yaval WLS and a short two day investigation (February 2004) was conducted to obtain some basic information at the site of conflict. Finally, data from the WWF- India report (1997) on the man – leopard conflict in North Bengal was collated and used for comparisons with results from the current study.

Figure 3.4 : The man-leopard conflict in Western Maharashtra.



The distribution of red dots on the map (Figure 3.3) clearly indicates the high concentration of leopard trapping in the JFD (east of the Ghats from Malshej to Bhimashanker) . The trapping exercise in this region was aimed at making it a "no-leopard" zone with trapping intensity increased from 5 to 65 cages and traps being laid out on a daily basis. Trapping was not carried out at such a level in any other region in the state.

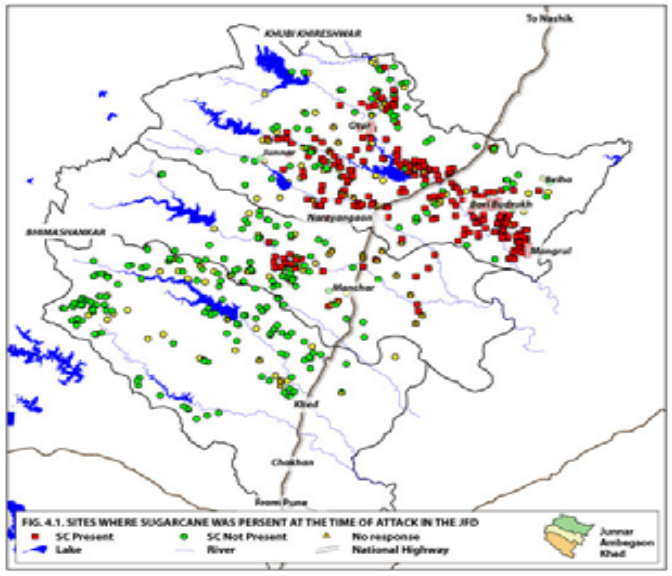
4 RESULTS

4.1 The two regions of the JFD and their land cover.

Since sugarcane was commonly believed to be the single most important factor responsible for the escalation in conflict, our first treatment of the data was to determine the fraction of attacks in which respondents reported sugarcane in the close vicinity. Only 48% of the affected people responded in the affirmative and 52% reported no sugarcane close to the site of attack (n = 551). When these points were overlaid on the satellite image of the area, they grouped into two regions: the northern ranges of the JFD (Junnar, Otur and Narayangaon - JON) where sugarcane was concentrated in the valleys and the southern areas of the JFD (Chakan, Rajgurunagar, Ghodegaon and Manchar ranges - CRGM) where sugarcane was hardly reported near the site of attack (Figure 4.1). Since this is but a perception of the people, one could argue that this separation may not be accurate. However, we found that subsequent analysis of data carried out separately for these two regions (JON and CRGM) was meaningful in relation to the man – leopard conflict in the JFD.

The forest ranges of JON are contained in the administrative unit of the Junnar Taluka, the ranges of Manchar and Ghodegaon in the Ambegaon Taluka and the ranges of Rajgurunagar and Chakan in the Khed Taluka (see Figure 2.2 and 2.3). The JON region essentially lies within the catchment area of one river while the southern ranges are spread over the catchments of four rivers. Topographically too, the two regions separate out with JON having a higher proportion of flat regions and CRGM more sloping land (2 – 16 degrees) (Table 4.1). Both flat and sloping land can be cultivated but sugarcane is mainly restricted to flat areas.

Figure 4.1 : Sites where sugarcane was present (red) and not present (green) at the time of attack: Information obtained from respondents.



The two regions differ in the major crops grown, the method of feeding of livestock and the number of dogs per household as well. For instance, of the respondents who reported cultivating rice as a major crop, 96% (n = 68) were from the CRGM and this was so for people who cultivated onion (72% of respondents, n = 200) and nachni (*Eleusine coracana)* (100%, n = 7) as well. On the other hand, sugarcane (Table 2.3), grape (81%, n = 16) and maize (87%, n = 39) appear to be occur more commonly in the northern valleys.

Table 4.1 : Land categorization of JON and CRGM based on slopes.

Slope category	Degrees (max)	(% area)	
		JON	CRGM
Flat	2	59	46
Gently sloping	4	12	23
Moderately sloping	8	15	20
Sloping	16	10	10
Steep	24	4	1
Very steep	>45	~0	~0

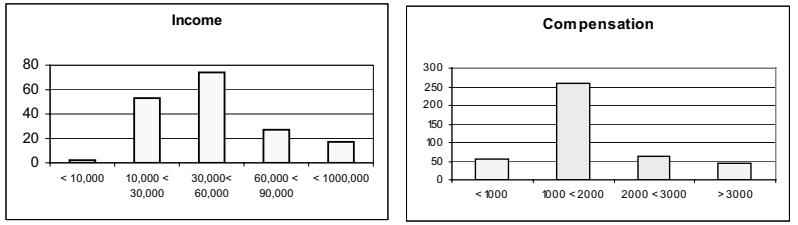
The main occupation of the (directly) affected people is farming in both the regions (90% of respondents, n = 280 in CRGM, n = 269 in JON) and the average number of cows, buffaloes and goats per affected household are also similar in the two areas (see Table 4.2). JON reported an average of one dog per house (range 0 – 4, n = 284) whereas the affected people in the southern ranges of CRGM had one dog to every two households on average (range 0 – 3, n = 223).

Table 4.2 : Average livestock holdings in the northern and southern ranges of JFD.

Average # of	CRGM (Range; N)	JON (Range; N)
Adult cattle	3 (0 – 26; 229)	2 (0 – 18; 308)
Calves	1 (0 – 20; 229)	1 (0 – 5; 308)
Adult buffaloes	1 (0 – 8; 229)	1 (0 – 17; 293)
Buffalo calves	0.3 (0 – 4; 229)	0.3 (0 – 10; 293)
Goats	4 (0 – 50; 114)	5 (0 – 80; 197)

The median value of the annual income obtained from a sample of 173 affected houses was Rs 40,000 (Range Rs 5000 – 200,000 per annum; 1 USD ~ Rs 45). Information from 426 households indicated that the average compensation received for the death of their livestock was Rs 1480 (Range RS 262 – 13,000) per family. This was prior to the more realistic compensation amounts that are being paid since January 2003 (about a factor 3 higher than what they were). From the above we estimated that an average family incurred a loss of roughly 9% of their annual income due to livestock depredation by leopards (Figure 4.2).

Figure 4.2 : Annual incomes and compensation figures in the affected households.



4.1.1 Advent of sugarcane cultivation in the JFD.

Table 4.3 provides the land cover composition of a subset of 184 grid cells (see Figure 3.1) which represent 42% of the affected area of the JFD (but contains 72 % of the conflict points), including the most affected area of JON. Analysis of satellite imagery showed a pronounced difference in land cover (extent of forest, tall crop cultivation) between 1973 and 1992 but with little subsequent change between 1992 and 2000. The extent of tall crop [mainly Jowar (*Sorghum bicolor*), Bajra (*Pennisetum glaucum*), maize and sugarcane] reached its maximum extent in the region as early as in 1992. This can also be seen in Table 2.3 where the area under tall crops (Jowar, Bajri and Sugarcane) have remained at similar levels between 1989 and 1994 in the Ambegaon Taluka even showing a decrease in the Khed taluka. The extent of sugarcane was much higher in 1989 in the Junnar taluka (JON) compared to 1994 (see Table A.2.1).

Table 4.3 : Change in land cover composition, 1973-2000 (for a subset of 184 grid cells).

Land Class	Description	Proportion under land cover class (%)		
		1973	1992	2000
I	Lakes and standing water	0	1	3
II	Forests, cover density > 40%	**4**	**1**	**1**
III	Tree savanna cover > 20%	17	9	10
IV	Open savanna (<20% cover density) and Sheet rock	69	68	66
V	Standing tall crops	**4**	**6**	**6**
VI	Fallows/cleared agriculture	6	15	14

4.2. Overview of the conflict in the JFD (Maharashtra State Forest Department [MSFD] data).

Comparison of livestock and human attacks in the Junnar Forest Division from April 1993 to December 2003 indicates a significant positive correlation between the two ($r = 0.78$, $p < 0.01$, $df = 9$) (Table 4.4). There was a 94% rise in the livestock depredation levels after April 1995 and a further 84% rise commencing in April 2001 compared to the preceding year (Table 4.4). Human attacks, from an average of 4 attacks per year during 1993 – 2001, increased 7-fold to 29 attacks in the year 2001 – 2002). Both of them subsequently returned to the 1993 level in 2003-04.

Table 4.4 : Livestock and human depredation in JFD, 1993 – 2003 (MSFD data).

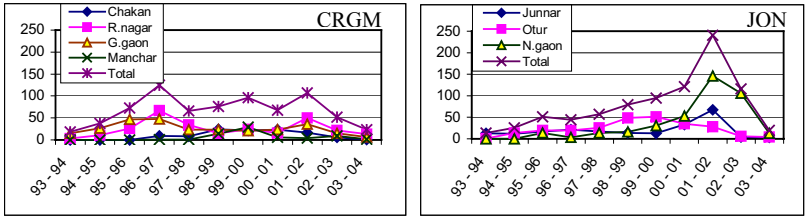
Year (Apr-Mar)	Livestock	Humans
93 – 94	32	2
94 – 95	64	3
95 – 96	124	9
96 – 97	169	6
97 - 98	123	0
98 - 99	155	6
99 - 00	191	6
00 - 01	189	2
01 - 02	348	29
02 - 03	168	18
03 - 04	43	2

Figure 4.3 shows that the southern ranges of Rajgurunagar and Ghodegaon had high conflict levels in 1996 - 1997 which decreased the following year but subsequently resurfaced in 2001. This reduction coincided with a small increase in conflict levels in the adjacent ranges of Chakan and Manchar. The

Ghodegaon (G) range is located in the valley of the eastward flowing river Ghod. Similarly, Rajgurunagar lies in the valley of the river Bhima which also flows east. These two river valleys are separated by the east-west ridge which extends from the crest of the Western Ghats in the general area of the Bhimashankar wildlife sanctuary (see Figure 2.3).

The pattern of conflict seen in the northern ranges of the JFD (Junnar, Otur and Narayangaon) differed from the CRGM ranges. The first major peak in livestock depredations was in 2001 although the intensity had been steadily rising since 1996. Also, Otur range showed an increase in livestock depredations in 1998 which decreased after 2000. The increase in livestock depredations in Otur was also accompanied by attacks on humans with seven people attacked by leopards between April 1998 and November 1999. Although records for leopard trapping were not maintained for this period, we obtained information from the Forest Department staff that five leopards were trapped in Otur between September 1999 and November 1999. They were reported to have been released in the forests of Chandoli WLS. During the heightened period of conflict (2001 – 2002), the level of livestock depredation in the northern ranges of JON was 150% higher than in the southern ranges of CRGM (see Figure 4.3).

Figure 4.3 : Pattern of livestock depredations in the JON and CRGM, 1993 - 2003 (MSFD data).



4.3 Prey species and abundance in the JFD

The main area of conflict in the JFD in the last three years has largely been the valleys of the Narayangaon range which is also the farthest from the Western Ghats (60 km aerial distance) and adjoins very arid areas to the east. The habitat in the JFD has not changed substantially since the late 1980's (see Table A.2.3) with similar areas of forested and cropped lands across the years. The southern ranges are as populated as the JON (see Table 2.2) and data from our study indicates that the number of livestock per family in our sample of affected people does not differ between the two regions (Table 4.2).

A rapid prey assessment of 377 km in the JON ranges and 227 km in the CRGM ranges in the pre-dawn and post-dusk hours reported a large number of domestic animals, especially in the northern ranges as well as some small-sized wild mammal species (Table 4.5). However, the transects were conducted in September, during heavy rains and are not likely to be completely representative of the actual species and numbers which can be obtained from long-term studies.

Table 4.5 : Rapid prey assessment in the JFD.

Common name	Species	CRGM	JON
Indian Fox	*Vulpes bengalensis*	2	0
Indian Hare	*Lepus nigricollis*	4	6
Palm Civet	*Paradoxurus hermaphroditus*	3	0
Golden Jackal	*Canis aureus*	2	0
Mongoose	*Herpestes edwardsii*	0	2
Domestic dog	*Canis familiaris*	52	33
Domestic cat	*Felis catus*	1	10
Livestock	**Cows, buffaloes, goats**	0	numerous
Peafowl	*Pavo cristatus*	12	0

The most common domestic livestock killed by the leopard in the JFD was the goat (Table 4.6), constituting a similar fraction of the total livestock killed in both the regions. A significantly higher fraction of cows were killed by leopards in CRGM ($\chi^2 = 5.4$, df = 1, $p < 0.05$) compared to JON. Multiple killings - more than one livestock killed during a single attack - have also been considered in this analysis.

Table 4.6 : Type of livestock (%) killed by leopards in the JFD, October 99 – July 2003 (88% of MSFD data).

Livestock	CRGM (%)	JON (%)
Buffalo	4	3
Bullock	2	0
Calf	10	11
Cow	23	5.5
Donkey	1	0
Goat	56	74
Sheep	4	6.5
Total N	**255**	**381**

There have been instances of surplus killings in the JFD with a maximum of 13 goats killed during one attack. However, if we consider the number of instances when the leopard was capable of killing more than one animal (when three or more livestock present together at the time of attack), surplus killing occurred in 13% of the incidents in CRGM (178 attacks; mean = 2.5, range 2 - 4) and in 19% of the cases in JON (229 cases sampled in JON; mean = 3; range 2 - 13).

Table 4.7 : Habitat at site of livestock depredation.

Habitat	CRGM (%)	JON (%)
Cattle shed	40	63
Field/farm	15	11
House	12	18
Subtotal	**67**	**92**
Grazing	4	6
RF/malki	**28**	**0.7**
Stream	0.5	0.7
Road	0.5	0.4
Total N	208	281

Most of the livestock attacks took place near human habitation (in a cattle shed, in the field or near the house) in both the regions (Table 4.7). A significantly higher number of livestock attacks occurred in

Reserve Forests or Malki lands (private land which support forest) in the CRGM ranges ($\chi^2 = 14.3$, df = 1, $p < 0.05$).

In the CRGM ranges, grazing of livestock appears to be as common as stall-feeding of animals with a much higher percentage of respondents grazing their cattle compared to the JON ranges ($\chi^2 = 17.4$, df = 1, $p < 0.05$, Table 4.8). A significantly higher number of the affected people stall-fed their livestock in JON ($\chi^2 = 7.3$, df = 1, $p < 0.05$) compared to the people living in the CRGM ranges and only 6 % of respondents in JON report grazing their livestock.

Table 4.8 : Type of feeding carried out for livestock in the JFD.

	CRGM (%)	JON (%)
Grazed	49.8	5.8
Stall-fed (SF)	44.3	88.4
Grazed/SF	6.0	5.8
Total N	201	275

Table 4.9 indicates that in both the regions, the leopard was able to feed off the livestock it had killed only half the time, losing the remaining half to humans who rescued the carcass. Also, 21% of the livestock in the JON ranges were dragged into sugarcane crops by the leopards. The average distance the livestock was dragged (N = 48) in CRGM was 59 m (range 3 – 300m) and was 120 m in JON (N = 115, Range 3 – 1000m).

Table 4.9 : Site of deposition of the livestock carcass following an attack.

Site of deposition	CRGM (%)	JON (%)
Carcass rescued	47	49
Sugarcane	1	21
Stream	8	11
Field/farm	8	6
Hill	3	1
RF/Malki Forest	9	0
Road	1	1
Canal	0	1
Settlement	3	2
Orchard	0	1
Miscellaneous	1	1
Not known	17	5
Total N	**150**	**281**

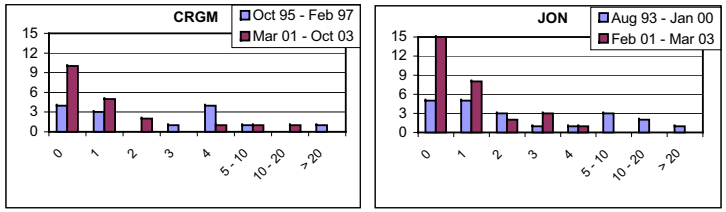
4.4 Analysis of attacks on humans

The JFD reported a total of 83 attacks on people by leopards between August 1993 and October 2003. No human attacks were reported between October 2003 till the submission of the report (May 2004). Of the 83 attacks, 32 took place in the CRGM where 7 were fatal and 25 people were injured between October 1995 and October 2003. In the JON, 17 people died and 34 were injured between August 1993 and March 2003.

In the CRGM there were no attacks on people from April 93 to October 95. Between October 95 and February 97, the median interval between consecutive attacks was one month (Figure 4.4). None of the 12 attacks in this period resulted in the death of the person. The average age of people attacked was 43 (Range 30 - 65). No attacks on humans were reported from the CRGM from February 97 until

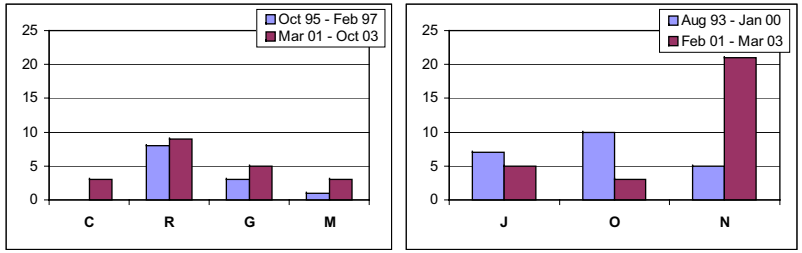
March 2001 after which consecutive attacks occurred once every 15 days (median value) till October 2003. Seven of the 20 people attacked in this time period died as a consequence of the attack. The average age of the people attacked was 27 (Range 2.5 - 70).

Figure 4.4 : Number of months between consecutive attacks on humans in CRGM and JON, 1993 – 2003 (MSFD data).



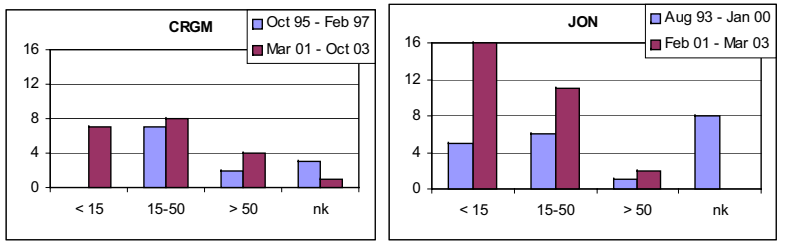
In the JON, attacks on humans occurred once every 2 months (median value) from August 93 to January 00 (Figure 4.4). The average age of the victims was 24 (n = 9, Range 5 – 55) and six of the 22 people died as a result of the attack. No humans were attacked the following year until April 01 after which the median number of days between attacks was 11.5 until March 2003. No human attacks have been reported after March 2003. Twenty-nine attacks were recorded in this time period of which 11 were fatal. The average age of the people attacked in this period was 20.5 (n = 29, Range 3 - 75). Five people were attacked in the Junnar range, 21 in the Narayangaon range and three people in the Otur range.

Figure 4.5: Number of attacks on humans in the different ranges of CRGM and JON, 1993 – 2003 (MSFD data).



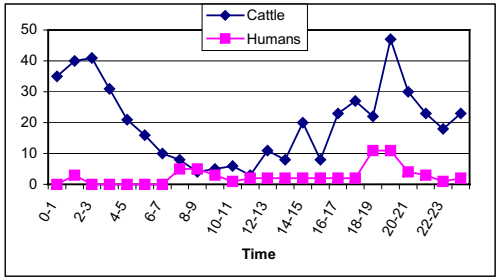
Of the 83 people who were attacked by leopards in the JFD from April 93 – December 03, information on age is available for 67 cases. Forty-two percent of the attacks were on people less than 15 years of age, 46% were between the ages of 15 and 50 and 12% were older than 50 years (Figure 4.6).

Figure 4.6 : Age classes of people attacked by leopards in the JFD, 1993 – 2003 (MSFD data).



The graph of leopard attacks on people shows a small increase between 7 AM and 9 AM which is not accompanied by a corresponding increase in livestock attacks. The larger peak between 6 PM and 8 PM also corresponds to a peak in livestock attacks (Figure 4.7).

Figure 4.7 : The temporal pattern of leopard attacks on livestock (n=480) and people (n=63) in the JFD.



The site of attacks for the humans follows a similar pattern to that for livestock with a large number of attacks in JON occurring near the house or close to fields (Table 4.10).

Table 4.10 : Sites where people were attacked by leopards in the JFD.

Site of attack	CRGM	JON
House	8	20
Field/farm	4	10
RF/malki	8	6
Path/road	3	4
Stream	4	1
Not known	5	10
Total	**32**	**51**

In nine of the 14 instances in JON the body of the person was dragged to a sugarcane field. In the remaining five instances, two into fields and one each to shrubbery, RF, and a hill. The average distance over which the body was dragged was 121 m (Range = 5 – 300 m). All the nine attacks were located at the eastern end of the Narayangaon range, close to where sugarcane cultivation ceases (see Figure 4.1). We have data on the site of deposition for only two attacks on humans in the CRGM and these were in the shrubbery and in a streambed. The average distance the victim was dragged was 42 m (data available for 4 cases, range 17 – 100 m).

It is thought that the crouching position of a person makes them more vulnerable to attacks by leopards. Our study indicates that only 29.6 % of the 64 people that were attacked were in a crouching position (answering the call of nature, working in the field, sitting etc.; Table 4.11). Also, the number of males that were attacked by the leopard is almost twice as much (55) compared to the females (28; n = 83).

Table 4.11 : Proportion of people (%) in a squatting position at the time of attack.

Posture	Number of instances
Crouching	23
Not crouching	48
Sleeping	6
Not known	23
N	**83**

Finally, there appears to be an increase in the number of pre-meditated attacks by leopards towards the end of the conflict, especially in the Narayangaon range where 16 attacks (of a total of 17 in JON) took place between July 02 and March 03. Fourteen of these appear to have occurred in the presence of other people and/or livestock (Appendix 4).

4.5 A temporal analysis of the rise in conflict in relation to the capture and release of leopards from the JFD.

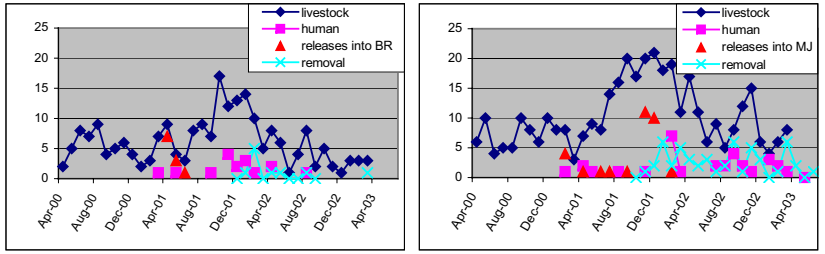
Leopard captures and local releases did occur prior to February 2001 but no records were maintained of the same. However, we were informed that these captures were on a smaller scale. After the first human attack in Otur in February 2001, trapping efforts were increased with the number of cages used increasing from 5 to 65 around the middle of 2001. The leopards captured from the JFD in 2001 were released close to the forests on the Western Ghats adjoining the JFD and were not monitored. Therefore crucial information on the consequences of the displacement of large numbers of leopards is lacking.

Comparison of livestock depredations for three treatments (pre-release – prior to the large number of leopards releases upstream of affected areas; post-release – 12 months following the first date of release; post-removal – removal of leopards from out of the area either due to long distance translocation or death or captivity) for both the regions CRGM and JON shows that number of livestock killed by leopards increased significantly in the ranges downstream of where leopards were released (Table 4.12). There is also a significant decrease in livestock depredation in the CRGM after complete removal of leopards. However, this difference is not significant for JON and probably because a large number of leopards were still present in the area (10 leopards were trapped following January 2003). Also, releases of leopards in the Malshej Ghats (upstream of JON) continued for much longer than in Bhimashankar area (upstream of CRGM) (Figure 4.8).

Table 4.12 : A Mann-Whitney test for increase in livestock depredation following releases of leopards in nearby areas.

CRGM	Period	U (p)	U (p)
Pre-release	Mar 00 – Mar 01	145.5 (< 0.01)	
Post-release	Apr 01 – Apr 02		157 (< 0.0005)
Post-removal	May 02 – May 03		
JON			
Pre-release	Feb 00 – Jan 01	130 (< 0.0005)	
Post-release	Feb 01 – Jan 02		Not significant (α = 0.05)
Post-removal	Feb 02 – Jan 03		

Figure 4.8 : Man-leopard conflict in CRGM and JON ranges in relation to the capture and releases of leopards in the JFD (MSFD data).



# of cubs are included in the releases

Table 4.13 provides the number of leopards involved in releases that took place within or at the administrative boundaries of the JFD in 2001. There are no records of other release sites prior to February, 2001. However, (verbal) information from Forest Department personnel who were present at the time of the release indicated that Wandre (in the Chakan range, close to the conflict sites) had been a site of release in the past. We have heard of leopards from the Ahmednagar Division being released in the past in the Chilewadi area of the Otur range but the veracity of this information could not be confirmed.

Table 4.13 : Details on local translocation of leopards within the JFD in 2001
(1[3]: indicates the number of cubs.).

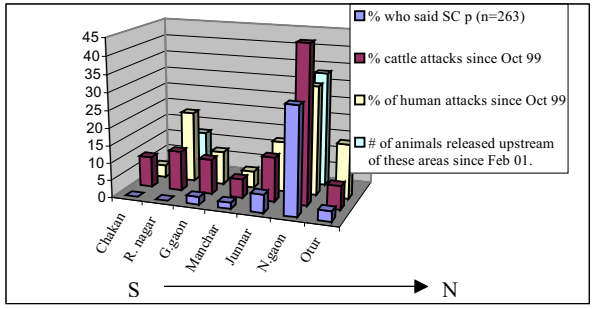
Month	Local releases from JON into		Local releases from CRGM into		Ahmednagar releases into Malshej
	B.shankar	Malshej	B.shankar	Malshej	
February 2001		1,1[2]			
March 2001					
April 2001	3, 1[3]	1			
May 2001	1[2]				
June 2001	1				1
July 2001					1
August 2001					
September 2001			1	1	
October 2001					
November 2001		3		5	2
December 2001		4		3, 1[2]	1
January 2002					
February 2002					
March 2002		1			
April 2002					
May 2002					
June 2002					2
July 2002					1
Total (with cubs)	**11**	**13**	**1**	**12**	**8**

The year 2001 saw a large number of leopard captures and local releases and it was only after December 2001 (with one exception in March 2001) that no translocations within or close to JFD were carried out. The number of animals trapped and taken out of the JFD after December 2001

(translocated to far off PA's, captivity, death) was 12 from CRGM and 50 from JON. This also included seven cubs, all from the Narayangaon range.

Figure 4.9 shows the strong relation of the presence of sugarcane with the livestock and human depredations in the range of Narayangaon which also has the largest extent of the crop. However, when the number of leopards released upstream of the northern and southern regions is considered, far more leopards were released in the Malshej areas compared to the Bhimashankar area.

Figure 4.9 : Range-wise depredation levels in relation to presence of sugarcane and upstream releases of leopards



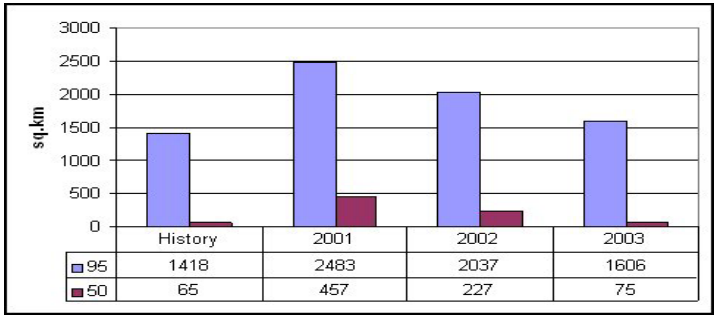
It should be noted that the livestock figures used in the above figure comprise 88 % of the total data set.

4.6 A spatial analysis of the conflict in the JFD

4.6.1 Kernel Utilisation Density Model

The kernels encompassing the 50% probability area of the conflict increased by a factor of seven in 2001 compared to "historical" levels, returning to historical levels in 2003 (Figure 4.10). Despite the intensive trapping exercises conducted in 2002 - 2003, it is interesting to note that the 95% conflict area continues to encompass a vast area. The "historical" time period consists of all conflict incidents that occurred between August 1993 and December 1999 (n = 43), However, it should be noted that this data set consists of attacks on humans (70%) and leopard trapping data (30%) only; inclusion of cattle depredation locations is likely to change the shape of the kernels. A total of 30 attacks on humans were recorded during this period, spaced at intervals ranging from one year (323 days between successive attacks spaced 30 km apart) to multiple attacks in the same location (9 attacks in 4 sites) or multiple attacks at different locations (4 attacks in 3 sites) on the same day.

Figure 4.10 : Kernel Utilization Density estimates of conflict areas from 2001 – 2003 (km²).

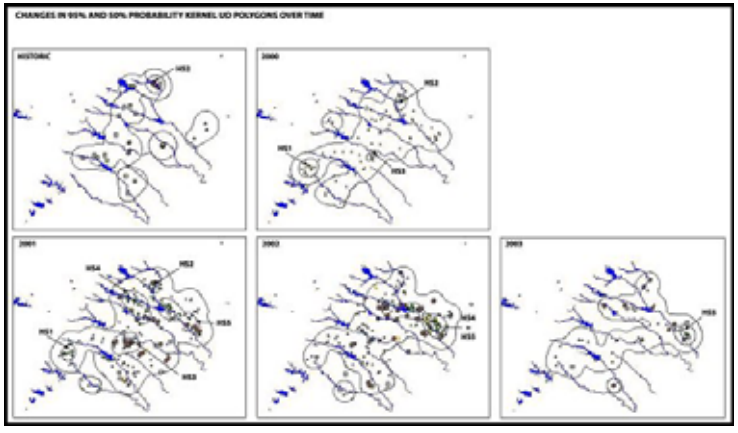


	History	2001	2002	2003
95	1418	2483	2037	1606
50	65	457	227	75

History: calculated for data between 1993 and 2000 in a single run.

The split in the 95% probability UD kernels during "history" into 4 distinct polygons covers an area that reaches the limits of conflict in later years (Figure 4.11). The conflict during "history" was concentrated in two areas (50% kernels are split into two polygons): 60 km² around the Chilewadi Dam site (Otur) and 5 km² around Hivre-tarf-Narayangaon (Narayangaon). Around Chilewadi, one attack in April 1998 was followed by 4 attacks that occurred at two week intervals between September and early November 1999. Four leopards were trapped here during the latter spate of attacks: another leopard had been found dead more than a week before the first attack and within 2 km of the attack sites. Five humans had been attacked at Hivre-tarf-Narayangaon, between July 1995 and September 1998, 3 of whom had been mauled in the same incident on the same day in September 1998, in attacks spaced 8 months apart. Records of leopards trapped close to Hivre-tarf-Narayangaon are not available for this period.

Figure 4.11 : Changes in the movement of conflict in the JFD, Historic – 2003.



The estimated 95 % area of the conflict in 2000 (N = 92; 2 human and 90 cattle depredations, records on trapping not available) is 1,878 km² with the concentrated conflict areas or 'hot spots' contained in 3 distinct polygons: around Viram, Wandre and Bhalewadi in the Chakan Range (64 km², 15

incidents, referred to as HS1); Otur, Tambalemala and Hivre Khurd in the Otur Range (32 km², 8 incidents, referred to as HS2); and around Ghodegaon, Parenda and Kotambdara in the Ghodegaon Range (15 km², 6 incidents, referred to as HS3).

By 2001 the 95 % conflict area (n=264; 19 human attacks, 210 cattle lifts, 33 trappings and 2 dead leopards) ranged across 2,483 km². Conflict was reported at a frequency of every two weeks. A fourfold increase in area under 50% UD kernels to 457 km² (containing 10 (56 %) of human attacks that year) is accompanied by major shifts in the configuration of the component polygons. The three 'hot spots' from the previous year remain, but have changed considerably in shape and size: HS1 has shrunk – moved to the north to 39 km² (16 incidents) and HS2 westwards to 22 km² (6 incidents, 1 human attack). However, HS3 has increased almost tenfold to 110 km² (33 incidents). Two new areas appear in 2001: HS4 (41 incidents), a 136 km² polygon in the upper Kukadi valley, south of the Manikdoh Dam and lying in the valley between the Ganesh Ghat and the Shivneri ridge in the region surrounding the Junnar Municipal Township (Junnar MC) but terminating short of Narayangaon and the highway; and HS5 (41 incidents), a 150 km² area downstream of the Yedgaon dam, straddling the Pune-Nashik highway and reaching right up to Shirur Taluka.

In 2002, the spread of conflict (n=252; 24 human attacks, 174 cattle lifts, 50 trappings and 4 dead leopards) had reduced to 2,038 km². Three hotspots from the previous two years (HS1, HS2 and HS3) had disappeared, and HS4 and HS5 coalesce to a single 227 km² polygon (102 incidents) stretching from Junnar MC to the boundary of the drier Shirur Taluka.

By 2003, areas facing conflict (n=52; 8 human attacks, 30 cattle lifts and 16 trappings) had reduced to pre-2000 levels at 1,606 km² with the remaining hotspot contained in a single 75 km² polygon (13 incidents) around Sakori and Mangrul villages in the Narayangaon range.

4.6.2 Grid cell analysis

In Figure 3.1, the JFD landscape is depicted as a network of 436 hexagons (cells), each of area ~ 10 km². Shaded cells (n=184) represent the area for which comparative habitat composition analysis was possible between 1973 and 2000. Conflict sites (human and cattle attacks, leopard trappings and deaths) are overlaid on the image. The concentration of conflict to the north (Junnar Taluka, comprised of the Junnar, Otur and Naryangaon Forest Ranges) is immediately apparent: 60% of the conflict occurred in only a third of the entire study area. The data which is reliable (dated, mapable and available) shows that the conflict in the JFD is restricted to only 159 grid cells, an area of about 1590 km².

All conflict sites in 2000 (n=92) are contained within 55 grid cells (63% of incidents occurred more than once in the same cell and are located in only 21 cells), with Hexid 184 (Tambadewadi, Chakan) reporting the maximum number of attacks (n=7). Distinct and subsequent attacks in the same cell are separated by a minimum of 2 days (at Ghodegaon-Kotambdara, Ghodegaon), and a maximum of 316 days (at Bhalewadi, Chakan) (see Table 4.14).

All the conflict sites in 2001 (n=264) are located within 118 grid cells (81% of incidents occur in only 68 cells), with Hexid 174 (Sal-Inglewadi) and Hexid 175 (Ghodegaon-Kotambdara) reporting the maximum number of attacks (n=7). Subsequent incidents in the same cell are separated by a minimum of 1 day (Ghodegaon; Nighatchwadi-Manchar; Belhe Ali, Junnar and Chakhan) and a maximum of 274 days (Santwadi, Narayangaon).

Table 4.14 : Grid cell occupancy of conflict points in all the affected ranges of JFD, 2000 - 2003.

Range	Year	Incidents	No cells Active	Incidents ≥ 2	Incidents ≥ 5
Otur	2000	11	7	2	0
	2001	18	9	6	0
	2002	17	8	6	0
	2003	3	3	0	0
Junnar	2000	9	7	2	0
	2001	36	15	10	3
	2002	13	9	2	0
	2003	5	4	1	0
Narayangaon	2000	24	16	7	0
	2001	87	39	24	4
	2002	142	39	30	10
	2003	26	14	5	1
Ghodegaon	2000	12	9	3	0
	2001	32	12	7	3
	2002	28	11	8	1
	2003	2	1	1	0
Manchar	2000	7	6	1	0
	2001	27	17	3	1
	2002	11	10	1	0
	2003	6	4	1	0
Chakhan	2000	22	9	5	1
	2001	23	11	4	1
	2002	11	7	3	0
	2003	3	3	0	0
Rajgurunagar	2000	7	5	1	0
	2001	41	22	11	0
	2002	30	21	9	0
	2003	9	6	2	0
JON	2000	44	28	12	0
	2001	141	60	42	7
	2002	172	54	39	10
	2003	31	21	6	1
CRGM	2000	48	27	9	1
	2001	123	59	24	7
	2002	80	45	23	1
	2003	20	14	4	0

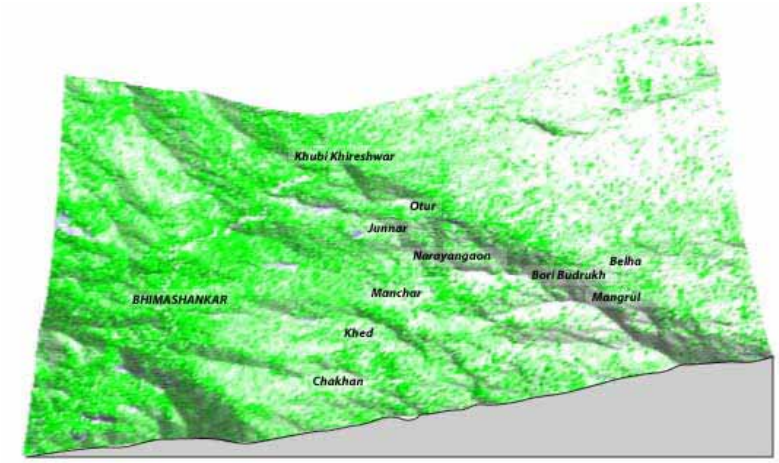
By 2002, all conflict sites (n=252) are contained in only 99 cells (84% of incidents are reported from 62 cells), with Hexid 138 (Belha-Rajuri, Narayangaon) reporting the maximum conflict (n=12). Subsequent incidents in the same cell are separated by a minimum of 1 day (Shiroli Budrukh, Kolwadi and Belha; Narayangaon) and a maximum of 281 days (Autimala, Narayangaon).

Following the massive trapping exercise of the previous years, 2003 reported conflict (n=54) from 35 grid cells (29 incidents are reported from only 10 cells), with Hexid 516 (Mangrul, Narayangaon) reporting the maximum conflict (n=7). Subsequent incidents occurring in the same cell are separated by a minimum of 1 day (Manchar) and a maximum of 111 days (Hapusbagh, Junnar).

4.6 Least-cost movement pathways from the W. Ghats to the conflict areas in the JFD.

A three dimensional representation of the cost surface can be seen in Figure 4.12, where the valleys indicate the lowest cost of movement from the start points. One such valley is seen along the crest-line of the Western Ghats which is also where the largest expanse of continguous forests are located.

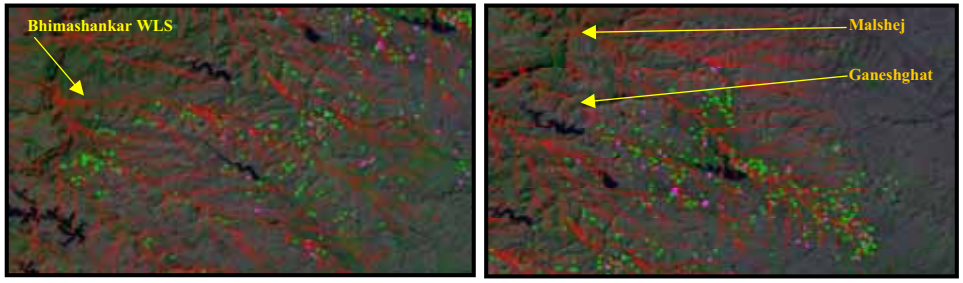
Figure 4.12 : Cost surface for the JFD based on vegetation density. The ridges indicate higher costs of movement and the valleys indicate lower costs.



However, when the end points of the movement pathways are defined as sites of captures, to the east, the cost surface flattens out along the Kukadi valley approximately 8 km upstream of the junction of the Pushpavati-Kukadi rivers formed on the northern banks of the Yedgaon Lake, to lead into the lowest cost surface in the Belha and Mangrul area of the Narayangaon range, region dominated by agriculture and human habitations.

The lines of least-cost-movement clearly link the Malshej Ghats (Khubi Khireshwar) and Bhimashankar areas (where leopards were released; i.e. the sources) to Narayangaon-Mangrul-Belhe and Ghodegaon-Rajgurunagar (where leopards were captured), respectively. The model also indicates that high costs of movement does not allow points starting in the Malshej Ghats to end in the CRGM and points starting in the Bhimashankar area to end in JON (Figure 4.13).

Figure 4.13 : Least cost pathways of movement from the W. Ghats to the JFD.



Ninety one per cent (n=744) of the conflict sites in the JFD are located within 1 km of our model pathways which indicates that the model is a reasonable one.

Table 4.15 : Proximity of conflict sites to low cost movement pathways

Start Point in the model	Actual release sites (GPS locations) distance from modeled start points (km)	% of conflict sites eastwards of the paths from the start points (Number of conflict points).
Khubi-Malshej	Khubi (4)	39 (288)
Bhairavagarh	Madh (10)	12 (88)
Fangulgovan	Near Fangulgovan (2)	14 (106)
Bhimashankar	Terungan (5), Taleghar (10), Rajewadi (5)	26 (196)

4.8 Leopard density estimates for the JFD.

55 adult animals (and 7 cubs) were taken out of JFD (far off translocations, death and captivity following trapping) and seven adults and seven cubs were found dead in the JFD starting January 2002 till November 2003; i.e 62 adults and 15 cubs were using the JFD area. We think that this figure is close to the total number because of the massive trapping exercise that was carried out in this region was aimed at removing all the leopards from the area (a total of 65 cages were deployed at any time). Even after this massive trapping exercise, leopards are still present in the area (one fell into a well on the 23rd of February 2004 in Narayangaon range) and low or non-existant levels of livestock depredations are reported mainly from the Narayangaon and Rajgurunagar ranges.

We have also attempted to obtain a rough idea of the area each leopard (for a total of 62 adults) would have used on average. If the number of hexagons which contain all known leopard related incidents (livestock and human depredations, and trapping of leopards – *see* Table 3.1) are considered we obtain an area of about 1590 km^2 which provides an estimate of an average of one leopard in every 26 km^2.

4.9 The contribution of domestic livestock to JFD leopard population's diet

Leopards are thought to require 35 gm of food per kilo body weight per day (Emmons, 1987 *in* Mizutani, 1999); considering the average weight of 40 kg for the Junnar leopards (pers. comm . Aniruddha Belsare), one animal would require 1.4 kg of food per day. Calculations based the number of livestock killed from April 00 – March 01 (Table 4.16) which is just prior to the surge in conflict along with a more conservative lower estimate of the average weight of livestock killed in the same period and considering that only 75% of an animals body mass which weighs less than 100 kg is consumable (Mizutani 1999), we get the weight of prey consumed by 62 Junnar leopards in April 2000 – March 2001 to be 9200 kgs (using the livestock compensation figures of the MSFD; Table 4.16). If we further include our results which show that only 48% (N = 431) of the times were the leopards able to feed on the livestock they had killed, then only about 4400 kg of livestock body mass was utilized by the Junnar leopards in the year April 2000 to March 2001. Using (i) livestock compensation figures of the MSFD (Table 4.16), (ii) a conservative lower estimate of the body-weight of domestic animals[1] and (iii) the fraction of incidents when a leopard was able to feed on the livestock it killed (48%, n=431), we estimated that 4400 kg of livestock body mass was utilized by the Junnar leopards.

[1] buffalo calf = 80 kg (Range 80-100 kg), calf = 40 kg (40-60 kg), adult goat and sheep = 25 kg (25-30 kg), adult cow = 200 kg (200-250 kg), adult buffalo and bullock = 350 kg (350-400 kg), horse (the small variety) = 250 kg (250-300 kg), donkey = 150 kg (150-200 kg)

Table 4.16 : Number and type of livestock killed by leopards, April 00 – March 02 (MSFD data).

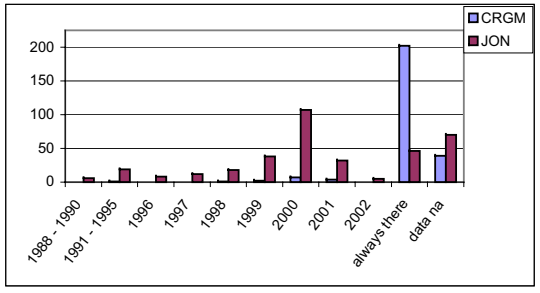
Livestock killed	2000 - 2001	2001 - 2002
Cow	9	24
Bullock	5	6
Buffalo	0	6
Calf	21	42
Buffalo calf	8	11
Juv. Bullock	10	26
Female goat	109	213
Male goat	8	28
Sheep	14	22
Horse	5	3
Donkey	0	1
Total	189	382
Compensation (Rs)	**215370**	**472400**

Sixty two leopards would have required about 32000 kgs of meat a year which indicates that the leopards were obtaining only 1/7th of their food requirements from the tended domestic livestock species in JFD in the year April 2000 to March 2001. The following year after large-scale trapping and local translocation commenced, a total of 382 cases of livestock death were reported, double that of the preceding year (MSFD data).

4.10 People's perception; the conflict and mitigatory measures

The people in the southern ranges of the JFD appear to have been aware of the presence of the leopard in their area much longer than in the northern ranges of JON - 79% of the respondents (n = 256) in CRGM said that leopards have always been present in their area whereas only 13% (n = 361) in JON said the same. These 13% were mainly located in the hillier and western ranges of Otur and Junnar (89% of the 46 respondents). Also 50% of the respondents in JON indicated that leopards were first encountered here between 1999 and 2001 (Figure 4.14).

Figure 4.14 : Year when leopards first occurred in the area: Perception of the affected people.



The perceptions of the respondents on the reasons why the conflict occurred as well as ways to mitigate the conflict were similar between the two ranges with the main reason for the increase in conflict being attributed to the decrease of prey in the forests. The management strategy most

commonly proposed by the respondents was trapping of the leopards and only 9% of them wanted the animals killed (Table 4.17).

Table 4.17 : Reasons for increase in conflict and measures to mitigate it; Affected people's views.

Reasons for	CRGM % (n=259)	JON % (n=361)
Increase in conflict		
Decrease of prey in the forests	57	57
Leopard releases in nearby areas	20	15
No water in the forest	15	11
Decrease in forest area	3	8
Increase in leopard population	4	6
What can be done?		
Trap the leopards	60	57
Increase prey base in the forest	35	13
Kill the leopards	8	9
No releases nearby	3	2

They appreciated the way in which the Forest Department handled the conflict. Ninety seven percent of the respondents in the most affected range of Narayangaon (n = 77) had no complaints against the Forest Department.

4.11 Information from leopards tagged with micro-chips in the JFD

A total of 22 animals captured from December 2002 to November 2003 were tagged with microchips (Trovan ID 100). Of the 22, 19 were from the JFD and three from the Ahmednagar Forest Division (Table 4.18). Eighteen of the 19 JFD animals were released into far-off protected areas in the state and the one individual is unlikely to be released since she is believed to be a "man-eater" and has been in captivity since 1999. One animal that was captured and released in this period was not chipped. The presence and functioning of the chip at the site of insertion was reconfirmed after 3 months for seven of the leopards.

Table 4.18 : Information on leopards marked with micro-chips and slated for release to far-off protected areas in the state

Sr. No.		Date chip was inserted	Division	Site of capture	Forest Range	Date of capture	Site of release	Date of release	Sex	Age (years)
1	00-061F-7569	03-Feb-03	JFD	Bori Budruk	Narayangaon	23-Dec-02	Chandoli	04-Feb-03	m	
2	00-061F-6B5E	06-Feb-03	JFD	Pimpalgaon	Narayangaon	30-Oct-02	Pench	15-Feb-03	f	4
3	00-061F-753E	03-Feb-03	JFD	Pimpalgaon	Narayangaon	31-Dec-02	Pench	15-Feb-03	f	2
4	00-061F-6FE7	03-Feb-03	JFD	Nimgaon Sawa	Narayangaon	26-Dec-02	Yaval	15-Feb-03	f	NA
5	00-063B-48D5	23-Mar-03	JFD	Kalewadi	Narayangaon	22-Mar-03	Bor	25-Jul-03	f	1.5 – 2
6	00-061F-70F8	23-Jul-03	JFD	Kalamb	Manchar	29-Mar-03	Pench	25-Jul-03	m	2
7	00-063B-50FA	11-Apr-03	JFD	Shiroli tarf Ale	Narayangaon	01-Apr-03	Melghat	30-Jul-03	m	8 month
8	00-063B-8F0A	11-Apr-03	JFD	Shiroli	Narayangaon	03-Apr-03	Melghat	30-Jul-03	f	5 – 6
9	00-0617-CECF	06-Jul-03	A.ngr¢	Rampur	Rahuri	27-Jun-03	Yaval	19-Aug-03	m	1.25-1.5
10	00-063A-F1BA	18-Sep-03	A.ngr	Dadh Budruk	Kopargaon	02-Aug-03	Yaval	06-Oct-03	f	2 – 3
11	00-063B-4806	18-Sep-03	A.ngr	Rahimpur	Sagamner	03-Jul-03	Yaval	06-Oct-03	f	2 – 3
12	00-063B-5A64	23-Mar-03	JFD	Bori Budruk	Narayangaon	01-Mar-03	Yaval	19-Oct-03	m	3 -4
13	00-063B-3F95	23-Mar-03	JFD	Shiroli Budruk	Narayangaon	24-Feb-03	Yaval	19-Oct-03	f	1.5 – 2
14	00-0618-20BD	28-Jul-03	JFD	Hapusbaug	Junnar	15-Jun-03	Melghat	21-Nov-03	m	NA
15	no chip inserted		JFD	Kahu	Khed	14-Aug-03	Melghat	21-Nov-03	f	NA
16	00-063B-7263	23-Mar-03	JFD	Botardi	Junnar	23-Mar-03	Chandoli	30 Nov 03	m	1.5
17	00-061F-507B	28-Jul-03	JFD	Kalewadi	Narayangaon	24-Mar-03	Chandoli	30 Nov 03	f	2-2.5
18	00-063B-5957	23-Mar-03	JFD	Mangrul	Narayangaon	16-Mar-03	R.nagari¶	1 Feb 04	f	3 – 4
19	00-0618-29AF	28-Jul-03	JFD	Awsari Ghat		1999	MRC		f	NA
20	00-061F-785A	04-Dec-03	JFD	Avhat	Khed	12-Sep-03	Pench	5 Feb 04	m	3
21	00-061F-5CFA	04-Dec-03	JFD	Otur	Otur	16-Oct-03	Pench	5 Feb 04	f	2 - 2.5
22	00-063B-42E0	23-Mar-03	JFD	Kalewadi	Narayangaon	22-Mar-03	R.nagari	1 Feb 04	m	> 5
23	00-0617-BB0F	04-Dec-03	JFD	Waladh	Khed	27-Nov-03	Pench	5 Feb 04	f	5

¢: Ahmednagar Forest Division ¶: Radhanagari WLS

4.11.1 Sex ratios and age structure of leopards trapped in the JFD (December 2002 – December 2003)

Data from the Forest Department prior to the commencement of this project indicated that the sex ratio of animals trapped since February 2001 was 55 F : 45 M (n = 66). A ratio of 60 F : 40 M was seen in the 19 animals that were tagged with chips as part of this project. The graph of the age structure (obtained from the 19 animals, Table 4.19) showed a population with few young animals. The leopard population we sampled does not indicate one which is undergoing a population explosion. However, it is possible that the trapped animals we sampled (in 2003) are not representative of the original population structure. Forest Department records showed that the number of cubs was much higher in 2001 (25% of captured animals were cubs, n = 57) than in the years January 2002 – January 2004 (9%, n = 46). Although of the 14 leopards found dead in the JFD in 2002 (Jan – Dec), seven were cubs. The youngest cub that was captured with his mother after December 2002 was about 8 months old whereas many instances of multiple cubs and therefore much younger, are present in the leopards trapped earlier.

Table 4.19 : Age structure of the leopards marked with micro-chips.

Age category (years)		Sex	
	Number	Female	Male
Juvenile (< 1.5)	2	0	2
Sub-adult (1.5 < 2)	3	3	1
Adult (2 < 5)	11	6	4
Prime (> 5)	3	2	1
Not known	1		
Total	**20**	**11**	**8**

All the 19 animals we came across appeared to be healthy. The only external wounds were on the foreheads of some of the animals, a consequence of the trapping process.

4.11.1 Recovery of chipped leopards from release areas

Two leopards were trapped in Yaval WLS following six attacks on humans. The presence of chips confirmed that they were the Narayangaon animals which had been released there in October 2003. Our enquiries in four of the six affected hamlets in Yaval indicated that these were the first instances of depredation on livestock as well as on people in living memory and this was also confirmed by the Forest Department officials. The attacks that took place before the male was trapped were less than 10 kms from his site of release and his site of recapture was about 2 kms from the site of release. The female was trapped near the village where a person was attacked, about 15 km from the site of release. No other attacks on humans have been reported from Yaval since the capture of the female (Table 4.20).

Table 4.20 : Yaval: an example of conflict moving with the leopards.

Sr. No.	Division of capture	Capture date	sex	Release date
1	Ahmednagar	21-Jun-02	Na	9-Dec-02
2	Ahmednagar	24-Jun-02	Na	9-Dec-02
3	Ahmednagar	30-Jul-02	Na	8-Jan-03
4	Ahmednagar	4-Aug-02	Na	8-Jan-03
5	JFD-*chipped*	26-Dec-02	F	15-Feb-03
6	Ahmednagar-*chipped*	7-Jul-03	M	11-Aug-03
7	Ahmednagar-	27-Jun-03	M	11-Aug-03
8	Ahmednagar-*chipped*	3-Jul-03	F	6-Oct-03
9	Ahmednagar-*chipped*	2-Aug-03	F	6-Oct-03
10	Ahmednagar	22-Sep-03	F	7-Oct-03
11	JFD-*chipped*	24-Feb-03	F	19-Oct-03
12	JFD-*chipped*	1-Mar-03	M	19-Oct-03
1	Human attack			31-Oct-03
2	Human attack			1-Nov-03
3	Human attack			9-Nov-03
	Recapture of # 12	18-Dec-03	M	
4	Human attack			19-Dec-03
5	Human attack			24-Dec-03
6	Human attack			24-Dec-03
	Recapture of # 11	19-Jan-04	F	

A similar incident occurred in Radhanagari WLS on the 2nd of February 2004 when a boy was attacked by a leopard. The leopard suffered a serious injury (broken skull) when it was assaulted by the father in defense of his child. She was subsequently trapped by the Forest Department and was identified by its chip (00-063B-5957) as a Narayangaon animal which had been released in Radhanagari WLS the previous day with another male. The attack occurred less than 5 km from her release site.

There have also been reports of leopard problems from Melghat and Chandoli forests but we have no concrete information. Junnar and Ahmednagar leopards have been released in these areas also.

5 DATA ON TRAPPING AND RELEASE OF LEOPARDS FROM MAHARASTRA (MSFD RECORDS)

5.1 The high intensity man-leopard conflict areas in Maharashtra

The main conflict areas in Maharashtra are the districts of Nashik, Ahmadnagar, North Pune District (Junnar), Eastern Ratnagiri, Kolhapur and Sindhudurg and the Sanjay Gandhi National Park (SGNP) adjacent to Mumbai. Of these, the most severely affected are the contiguous areas of Junnar Forest Division (northern Pune district), the Eastern areas of the Nashik district, the eastern and northern parts of the Ahmadnagar district. The severity was ascertained from discussions with the Forest Department officials and data on leopard captures from these regions, which are usually related to conflict events (Table 5.1). Except for SGNP, all the other areas straddle the Western Ghats. Also, the problem in Nashik, Ahmadnagar, northern Pune and Kolhapur districts is located to the east of the crest-line whereas in Ratnagiri and Sindhudurg it is largely located to the west of the crest-line (see Figure 3.3). What is also to be noted is the increase in number of leopards captured over consecutive years following nearby translocations. This is particularly evident from the Ahmednagar and Nashik areas where animals were moved locally over four years (Table 5.1). In Junnar, which was the most affected area, 47 were captured in 2002 following the capture of 30 and release of 27 in 2001. However, the trapping effort in Junnar was also increased enormously from the middle of 2001 with about 60 cages being used compared to the five that were in use initially.

Table 5.1: Data on the captures and releases of leopards (cubs not included in figures) from the main conflict areas of Maharashtra (MSFD data).

Area		1999	2000	2001	2002	2003
Ahmednagar, Nashik	Captured	5	11	16	17	20*
	# released nearby	5	11	14	12	4
	# released in far off PA's	0	0	0	2	6
	Other⊗	0	0	2	1	3
Junnar	Captured	NA	NA	30	47	16
	# released nearby	NA	NA	27	1	0
	# released in far off PA's	NA	NA	0	30	16
	Other	NA	NA	1	10	8
SGNP	Captured	NA	NA	NA	8	18
	# released nearby	NA	NA	NA	8	14
	# released in far off PA's	NA	NA	NA	0	0
	Other	NA	NA	NA	0	4
Kolhapur, Ratnagiri, Sindhudurg	Captured	NA	4	19	10	5
	# released nearby	NA	3	3 +1$	3	2
	# released in far off PA's	NA	0	0	0	0
	Other	NA	1	15	7	3

- • 4 released to Melghat TR on 29th Jan 2004. Two are in captivity
- ⊗ Other is captivity, death either natural or due to poaching.
- $ location Khadpade (not known)

< 60 km straightline distance has been considered as a local translocation.

Table 5.2 : The main areas of release of leopards in the state of Maharashtra (MSFD records).

Place of release	Ahmednagar, Nashik					Junnar			Kolhapur, Ratnagiri, Sindhudurg				SGNP		Total
	1999	2000	2001	2002	2003 + Jan 2004	2001	2002	2003 + Jan 2004	2000	2001	2002	2003	2002	2003	
Malshej Ghats			5	3		20	1								29
Jawahar Thane Ghats	1	6	4	7	4										24
SGNP													8	14	22
Chandoli							7	1	3	3 + 1 Khadpade	1	1			17
Kalsubai WLS	4	5	3	2											14
Igatpuri			1												1
Melghat					4		9	3							16
Yaval				2	7		3								12
Bhimashankar						7									7
Koyna							4				1	1			6
Pench							2	7							9
Bor							2	1							3
Radhanagari							3								5
Tadoba							3								3
Amboli					1						1				2
Ramtek							2								2
Wardha							2								2

- ○ Only adult animal numbers are considered since data for cubs is available only for Junnar.
- ○ Data from Junnar available only from 2001.

6 DISCUSSION

In our country, the term "man-leopard conflict" represents a continuum of livestock depredation levels. Large number of cattle graze inside the best of our protected areas (Mishra, 1997; Lal 1992 in Edgaonkar & Ravi, 1998) making some level of livestock depredation inevitable. For example, about 20,000 and 90,000 heads of cattle enter the Mahananda Wildlife Sanctuary and Buxa Tiger Reserve (N. Bengal) each day (WWF – India, 1997). On the other hand, a non-forested and intensively farmed area like Junnar Forest Division (area 4360 km^2), with an estimated resident population of over 60 leopards reported one livestock killed every day and one human attack every 11 days at the height of conflict.

In most places where high levels of man-leopard conflict have been reported, either historically (Uttaranchal, N. Bengal) or recently (Gujarat, Maharashtra, Madhya Pradesh), the underlying assumption is that leopards as a species are increasingly more successful at living close to humans. The heuristic argument for what is essentially an assumption is as follows : Tall crops (especially sugarcane) and tea plantations provide ideal habitats for leopards in the vicinity of human habitation. Such leopards depend on livestock for food and occasionally take to attacking humans, either inadvertently or deliberately. The paucity of wild prey, once abundant in the diminishing forest cover in the area, is believed to be the reason for the leopards moving from the forests to "prey-rich" farmlands. We have tried to examine the validity of this assumption in our study.

There appears to be two separate trends in the man-leopard conflict in the JFD : 1) slowly increasing levels of livestock depredation since the mid-1990's in the northern ranges (JON) and 2) the spike in livestock and human depredation which commenced in April 2001 in JON as well as in the southern region of CRGM. We could not get quantitative records of livestock depredation and leopard trapping/releases prior to October 1999 and therefore we are unable to study the reason for the slow increase. However the causes that we have identified for the post-2000 conflict do provide some idea of the reasons behind depredations seen throughout the 1990s.

Following the human attack in Otur in February 2001, a female leopard was trapped with two cubs and was released about 20 kms away in Malshej Ghats. Furthermore, six adult leopards and five cubs were trapped from the Junnar and Narayangaon ranges (one in February, four in April and one each in May and June) although no attacks on humans were reported close to their site of capture and these were released close to the Bhimashankar WLS. The capture of leopards (37 in all) from within the non-forested areas of the JFD and their release into forested areas along the crestline of the W. Ghats (Bhimashankar and Malshej) adjacent to the JFD occurred throughout 2001. Since the problem did not subside, and in fact actually increased, local translocations (release less than 60 km from site of capture) were stopped in December 2001. The animals captured subsequently were translocated to far-off protected areas in the state. Intensive trapping of leopards and their translocation out of JFD reduced the problem to the early-1990s level.

None of the locally translocated leopards were monitored and therefore there is no information on the impact of the displacement of large numbers of leopards on the displaced individuals as well as the leopard population within the JFD. However, information on felid biology, obtained from studies elsewhere, may be used to understand the factors that aggravated the conflict in JFD in 2001. We know that felids are highly territorial, that they immediately leave the area in case of hard release (i.e. when released without acclimatisation) and head homewards, and that vacant territories are immediately filled by one or more animals from the reservoir of transients (mainly sub-adults) in an area (Linnell *et al.* 1996, 1997). A mountain lion, similar in size to leopards, was known to travel 400 km back to its territory (Linnell *et al.* 1996). A study of a radio-collared leopard in Gujarat, caught because it was implicated in livestock attacks was released 30 km from its site of capture and was

seen to immediately go back to its territory and resume killings (pers. comm. Khalid Pasha). Females with cubs are known to severely restrict their ranging and yet have higher food requirements, implying that they have to be very aware of the food resources present in their territories (Wemmer & Sunquist, 1988; Stander *et al.* 1997). As a consequence, a female translocated with her cubs is likely to be highly stressed while trying to procure sufficient food for her family as well as protect them in an unfamiliar environment. Social disruption including infanticide and increased aggression levels could be a serious problem when new males are introduced into an area (Treves & Karanth, 2003). Studies have reported up to 60-70% mortality amongst translocated felids (Linnell et al 1996, 1997; Treves & Karanth, 2003)

These aspects of felid behaviour are consistent with what was observed in the JFD. According to our least-cost movement model any JON leopard translocated into Malshej would easily be able to return to its site of capture and similarly for the CRGM leopards released into Bhimashankar. Indeed 90% of the conflict sites (attacks + trapping) are within 1 km of the model pathways connecting the sites of release to the sites of capture. Our studies show that livestock depredation in CRGM and JON increased significantly following translocation from these areas into Malshej and Bhimashankar areas. Furthermore, the extent of conflict area (95% probability area) also increased by a factor of seven from 2000 to 2001. There are no records of comparable conflict to the west of the release sites and is likely to be because of the homing instincts of leopards which drive them towards their sites of capture in the eastern valleys of JON and CRGM. Therefore, it appears that the displacement of a large numbers of leopards is likely to trigger off a high degree of conflict, the reasons for which we are not going to be aware of until such individuals are studied using telemetric methods.

Our least-cost movement analysis model also shows that high costs of movement are involved for an animal with a territory in JON and released in the Bhimashankar area to reach back to its home. Similarly, landscape and vegetation features would have impeded movement from Malshej into CRGM. Also, it would be reasonable to assume that the leopard population at Malshej and Bhimashankar areas are at the limit of the carrying capacity; Bhimashankar WLS is known to have a leopard population of about 10 in 2001 (Census records of the MSFD) and 11 JON leopards (including females with cubs) were released close to the Sanctuary area within a period of 3 months (Table 4.1.2). The translocated leopards would have had the options of (i) moving back into JON (precluded by landscape and vegetation feaures) or (ii) remaining in Bhimashankar which would seriously disturb the local leopard population dynamics or (iii) move down the eastern valleys into CRGM.

Even if the translocated animals did not manage to return to their area of capture it is highly likely that their territory will be occupied by 1 or 2 of the transient (mainly sub-adults) leopards present in the area. Transients without territories are known to have high mortality rates either due to poorer hunting success in case of sub-adults (see Appendix 1) and/or can be pursued and killed by resident males (*In.* Cramer & Portier, 2001). A study in Utah, USA, showed that the removal of 12 mountain lions (similar in size to leopards) after livestock depredations did not reduce the conflict because 17 ***different*** individuals moved in to occupy the vacant territories (Linnell *et al.,* 1996). Based on the above information, translocation of a territory holder could even result in an increase in the number of resident leopards at the site of capture.

This study provides some insight into the effect of sustained release of leopards into a single area, viz. Malshej Ghats. According to the forest officials of the JFD in the early- and mid-1990s Bhimashankar area used to be the preferred site of release for leopards during those years. Subsequently, Malshej took over from Bhimashankar as the preferred release site in the mid-1990s, perhaps as a result of leopard problems in CRGM. Our data shows that the conflict in Rajgurunagar and Ghodegaon ranges (which lie immediately downstream of Bhimashankar) peaked in 1995-97. Forest officials of the Ahmednagar division have also indicated that some of their leopards were also released in Malshej in

mid-1990s. Perhaps this is the reason for the gradual increase in livestock depredation in the areas that lie down the river valleys from Malshej through the late 1990s. 25 leopards from Ahmednagar and JON were released into Malshej in 2001 and a further 4 in 2002.

Realising its inefficacy, the Junnar Forest Department stopped local translocations in December 2001 and all subsequent releases were carried out in far-off protected areas. This did indeed solve the problem in the JFD and the conflict level has come down to the level in the early 1990s. However our study shows that this has only transferred the problem from Junnar to the sites of release (Yaval and Radhanagari wildlife sanctuaries - see Sec. 4.10.3 for details), which have had no prior history of man-leopard conflict. It is possible that animals from human-dominated areas like Junnar may actually prefer to move from their sites of release inside wilderness areas to human habitations on the periphery, being more familiar with life in such habitats.

The sustained historical release of leopards trapped from a wider area into particular forested areas on the W. Ghats (such as Malshej Ghats, Jawahar –Thane Ghats, Chandoli WLS) can effectively be regarding as "re-stocking" which is generally used to increase the wild populations. Even assuming high mortality, a population increase of leopards in those areas is inevitable given the large influx (large compared to existing numbers) of leopards. In the case of the JFD, satellite imagery shows that the highest vegetation density is along the valleys of the rivers flowing (eastward) down from the crest-line and this is the route that leopards may be expected to take away from the over-populated sites of release.

The WWF India (1997) report on the man – leopard conflict in N. Bengal identified 24 conflict hotspots based on the livestock and human depredations as well as the capture of leopard cubs. Fifteen of these areas lie within 15 km of Gorumara National Park [NP] and Chapramari WLS – both common sites of release for leopards (19 leopards have been translocated into these protected areas between 1992 and 1997). The remaining nine hotspots are on the fringes of Jaldapara WLS and Buxa TR where 7 leopards were released between 1992 and 1995. A further 30 leopards were trapped but no information regarding their subsequent status is available (Table A.2.4). It appears that the practice of releasing animals caught in conflict situations into Gorumara WLS is still taking place. There was a recent report (Telegraph 22 June 2003) of a leopard trapped in Binnaguri (about 20 kms east of Gorumara NP) which was to be released into Gorumara NP. Tables A.2.4 and A.5.1 give an indication of the minimum number of leopards that are trapped and most probably displaced from their territories throughout India. In Maharashtra alone, the minimum number of leopards that were displaced between 2001 and 2003 is 155 (Table 5.2). Large numbers of local translocations have also occurred in SGNP (Mumbai) where animals trapped for whatever reason in and around SGNP have been released back into other areas of the park (Table 5.2) and it is likely that the conflict that erupts periodically might be related to these releases of leopards. Man – leopard conflict has also been reported from the Baria division of Vadodara Circle, Gujarat (Appendix 7) and interestingly, this division also contains sites of release for leopards (pers. comm. Sujoy Chaudhuri). In conclusion, a consistent pattern is seen in various areas reporting man – leopard conflict (JFD and SGNP, Maharashtra; N. Bengal, Baria Division, Gujarat) and this could be due to their proximity to "preferred" release sites of leopards and/or the displacement of a large numbers of leopards into the area.

When we started this study it was widely believed that sugarcane fields in the valleys of the JFD provided an ideal habitat for the leopards which were dispersing from the W. Ghats. The question to be asked, and answered, is if sugarcane by itself, without the continual influx of translocated leopards, sufficient for the leopard population to increase to the levels that were seen in the JFD. We cannot provide a definitive answer but there are some pointers from our study. The data collected/collated by us (Patwardhan et al 2003 - Table 2.3; Agricultural Department records - Table

A.2.3) show that the extent of sugarcane increased enormously but peaked in the late 1980's in the Junnar-Otur-Narayangaon (JON) area and in fact declined considerably by 1994. It is difficult to envisage a link between the peak in sugarcane then and the spurt in conflict in JON in 2001 without any other factor playing a role. In general, satellite imagery from the years 1973, 1992 and 2000 shows that the area under tall crops - sugarcane, jowar, bajra and maize, all believed to be good leopard habitat - has not changed between 1992 and 2001. CRGM did show a spurt in leopard depredation in 1996 (during the period when Bhimashankar area was the preferred release site according to MSFD officials) but JON which had much more sugarcane did not do so. Furthermore, the presence of sugarcane is not synonymous with incidents of man-leopard conflict : only half of the affected people reported sugarcane in the vicinity of the site of attack in the JFD. Thus we donot have reason to believe that sugarcane is the ***causative*** factor for the increase in leopard population and the conflict.

It is possible that sugarcane and domestic animals have supported a population of leopards in the JFD which was perhaps reflected in the low conflict levels of the early-1990s. The tendency of this population to increase would have been countered by the persecution of these animals by farmers (carcasses laced with easily available pesticides), poachers (skin trade) and the higher stress levels and dangers that one may expect for a large carnivore living in an environment extensively modified by humans - trapped in a well or shed, cubs found in fields, etc. A comparative study on leopards living inside and outside of Chitwan NP, Nepal found that leopards living at the fringes of the Park were not able to replace itself due to high mortality rates (Seidensticker *et al.* 1990).

If sugarcane is truly the principle cause then the JFD is now a good area for testing the hypothesis. Intensive trapping has decimated the leopard population. If no more leopards are released close to Malshej (from anywhere) any increase in leopard population will have to be explained in terms of the farmland of JFD being an ideal habitat for the leopard.

We also examined the possibility that the sharp increase in conflict in 2001 in the JFD was brought about by a sudden decline in wild prey base. The most affected area of JFD, i.e. Narayangaon, is about 60 km from the nearest tracts of forest (on the crestline of the W. Ghat at Malshej and Bhimashankar) which can support a leopard population. The 4360 km^2 of JFD is intensively farmed and has no large tracts of forests within it and the records of the Agricultural Department (Table A.2.3) show that the gross cropped area and the forested area have remained more or less the same during the last 4 decades. Most of the "forested areas" within the JFD consist of exotic tree species plantations. Thus, it is not surprising that a large fraction of potential prey encountered in our rapid assessment were domestic dogs, cats and livestock. Diet appears to be a function of prey availability (Sidensticker *et al.,* 1990; Seidensticker & Lumpkin, 1991; Johnsingh, 1992; Shomita Mukherjee pers. comm.). Studies of leopard diet in areas with low natural prey (SGNP, Mumbai - Edgaonkar & Ravi, 1998) or close to human habitations (Pauri Garhwal - WII-ARS web page; villages in Majhatal WLS, Himachal Pradesh – Mukherjee & Mishra, 2001) and at the fringes of protected areas (Chitwan, Nepal – Seidensticker *et al.,* 1990) indicate that livestock and dogs form an important part of the leopard's prey. A study in Bhimashankar wildlife sanctuary on the south-western periphery of JFD indicates that dogs formed an important constituent of the leopard's diet (pers. comm. Prachi Mehta). Therefore it is likely that dogs and livestock constitute the main prey base of leopards in JFD as well and this is likely to have been the case for several decades. Thus it is unlikely that the prey base of leopards underwent a sharp decline in 2001.

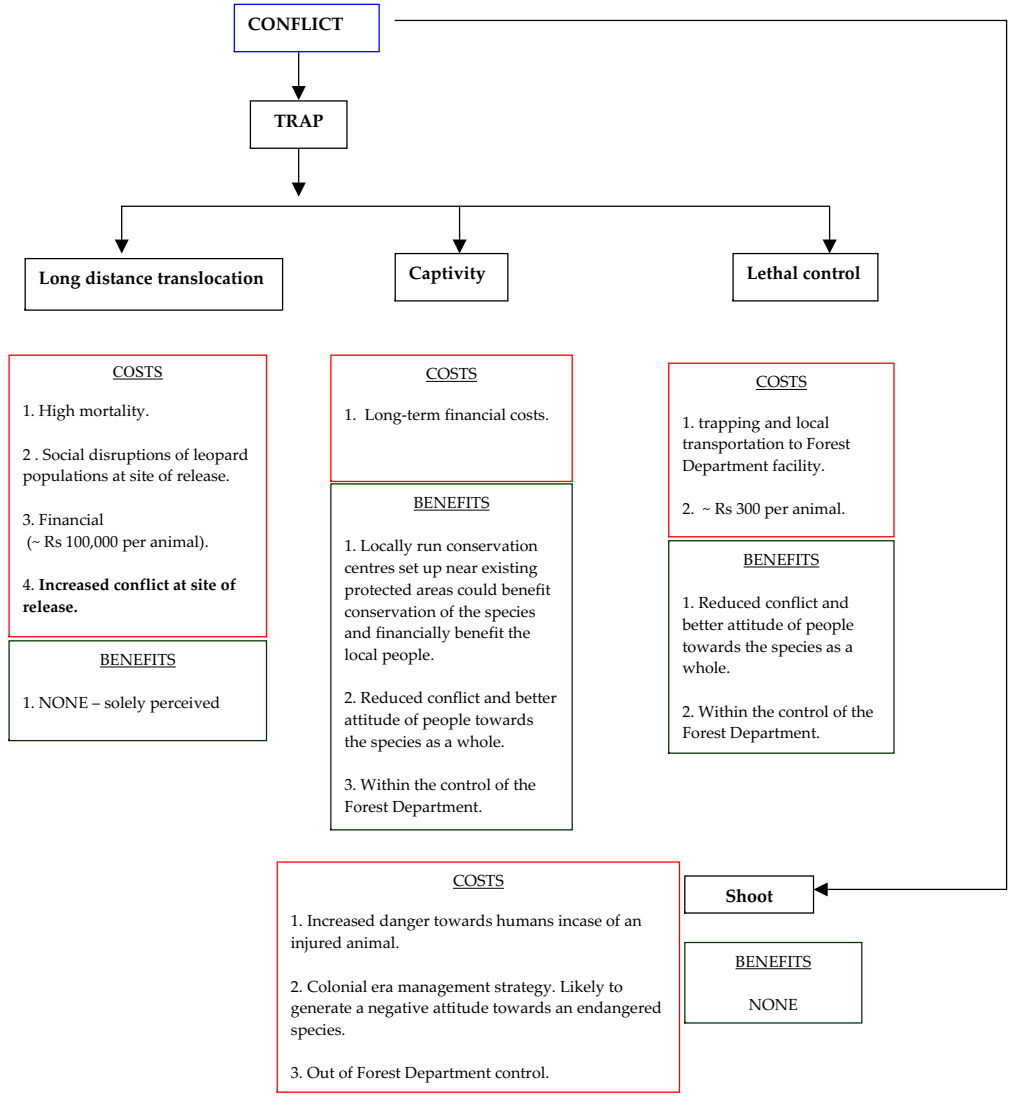
The question that has to be asked is whether we can tolerate the presence of leopards outside protected areas given that they will always be responsible for some level of depredation. Perhaps loss of livestock can be handled by paying adequate compensation. A more serious problem arises when leopards take to attacking humans. That leopards are very successful at living even among dense human habitations without much indication of their presence was seen in Namibia, the capital of

Kenya where a trap laid to capture a leopard that had escaped resulted in four other leopards being trapped (IUCN – CSG, 1992). Leopards have always lived at the fringes of human habitations in our country given that the interface between rural India and forests has been a continuum. This interface has become more sharply defined (in JFD, for instance) but leopards still do survive. The term "a danger to human life" has to be defined more accurately since it is loosely used to mean an attack on a human or simply a sighting near a village.

Given this close proximity between leopards and people there will be many circumstances under which leopards will come in direct contact with people. An odd leopard may fall into a well or walk into an empty shed, another might attack a human accidentally while a third may be a habituated livestock lifter and a fourth deliberately targets humans. Some of these leopards will end up being captured as a consequence. A management plan has to be drawn up to tackle these different categories of leopards in an appropriate manner and moreover its rigorous implementation at the range office level has to be monitored closely. The management plan has to take a balanced view of the threat to people and the financial loss suffered by them as a result of depredation by leopards and the endangered status of the leopard. Trapped leopards which are not implicated in human attacks should be immediately released before their territories are occupied by transients. Low levels of livestock predation may be handled by compensation. Only inveterate livestock-lifters and those involved in attacks on humans must be removed from the population in a permanent manner. They may either be placed in permanent captivity or humanely euthanised by the Forest Department. However, in no case must translocation of captured animals be considered. As we have shown here there is strong circumstantial evidence that local translocations actually aggravates the conflict. Far-off translocations result in the shifting of conflict to areas which did not suffer from it earlier. In any case, it is unlikely that any wilderness area in India can absorb a large introduction of leopards without seriously destabilizing the existing population.

A critical handicap of this study was the almost complete lack of ecological information on Indian leopards especially on animals living close to human habitations. We have had to rely on studies of similar felids from other countries. Telemetric studies are essential for understanding the lifestyle of these secretive animals. It is essential to be able to identify individual animals in conflict areas and areas which have potential for conflict. The department must be in a position to identify if a trapped animal has had a history of livestock or human attacks. This will require regular monitoring of the leopard population which can be done by DNA analysis of scats and leopard hair/tissue obtained from the site of attack. It is often difficult to obtain permits for such studies but in rejecting such proposals the Department has seriously handicapped itself in its efforts to strike the appropriate balance between human welfare and conservation measures.

Figure 6.1 : Flow Chart with costs and benefits of different management strategies for "problem" leopards.



RECOMMENDATIONS

This study focused on the man – leopard conflict in the Junnar Forest Division. However, the results from our study indicate that strong parallels can be drawn to man – leopard conflict elsewhere in the state, and country. Therefore, it is relevant that JFD be used as a case study and the results and recommendations from this report be considered even in other areas facing man – leopard conflict.

1. **Translocations of captured leopards should not be permitted. The only options for leopards trapped in a human dominated area should be permanent captivity or lethal control.**

   Our study indicates that conflict levels indeed surged following the displacement of many leopards (> 10) within a six month period in the JFD. On the other hand, sustained releases of leopards into a single area over a long period of time is likely to lead to population increase of leopard populations in the best suitable habitat (be it sugarcane, tea plantations or tall crops) in the surrounding area. Our study has also shown that problem leopards translocated from JFD to far away protected areas has resulted in moving the conflict to the site of release. The problem could be exacerbated if a large number of problem animals are moved in a short period of time.

   Translocation is most commonly used throughout India while dealing with leopards that have been trapped for whatever reason. Translocation of carnivores used to be carried out in other countries but with data available from various studies (Linnell *et al.,* 1996, 1997; Treves & Karanth, 2003) carried out across different species of carnivores, the general consensus now is that translocation of carnivores into areas which already contain members of the same species is a poor strategy in dealing with potentially "problematic animals".

   Translocation of large felids does not help in the conservation of the individuals nor the species because

   A. of high mortality rates of the translocated individuals (60 – 70% of the individuals die following translocation) - effectively not serving the purpose of "helping" the individual translocated animals.

   B. of increased intra-specific aggression and social instability at new site of release. The taking over of a territory by a new male is likely to lead to infanticide of the cubs present in the area (another well known behaviour of felids) thereby further disrupting the natural system (Treves & Karanth, 2003).

   C. felid populations have large number of transient individuals in search of vacant territories (Bailey, 1993; *in* Edgaonkar & Ravi, 1998). These are usually younger animals with higher mortality rates (*in* Cramer & Portier, 2001; *see* Appendix 1). A study of mountain lions in the USA (similar in size to leopards) found that the removal of 12 different individuals from the area (trapped or killed) did not reduce the conflict because 17 ***other*** individuals, mostly younger animals which may have otherwise died out in the absence of a territory, moved into the vacant territories

   (Linnell *et al.,* 1996). Therefore, removal of a few animals will not help in reducing conflict. What would be more effective in reducing conflict is the identification of individuals involved in large numbers of depredations and their removal.

   D. of homing instincts of the translocated animals and large post-release movements

      a. Strong homing instincts are reported in many carnivore families (bears, golden eagles and felids) and in tigers, leopards, jaguars and mountain lions in the large cats. In Gujarat a radio-collared leopard released 30 km from its site of capture returned back to its capture site and resumed livestock killing (Khalid Pasha, pers. comm.). There is also a report of a mountain lion returning 400 kms to its territory [Linnell *et al.,* 1996]. This is thought to be particularly true of the older animals which have territories at the time of capture. A study in Africa attempted to translocate 107 leopards to an area where there were no other leopards and yet all of them were seen to leave the area of release. Large carnivores roam over large distances (hundreds of kilometers) following translocations (Linnell *et al.,* 1997), and especially in our country, where there is no large area devoid of people, the consequences might be disastrous.

2. **Trapping of leopards should be carried out only after careful consideration and should be stringently controlled by a central authority of the Forest Department. A strict limit should be kept on the number of trap cages available to a Division Office. Leopards falling into open wells that are characteristic of this region appear to occur quite commonly and efforts should be made to cover them or fence them. This will also help in reducing the number of leopard being trapped. For leopards trapped close to fringes of forests where there has been no history of conflict, they should be immediately released back close to the site of capture.**

   Leopards are known to be highly adaptable and will live successfully even in the margins of urban and semi-urban areas (eg. The hills around the city of Pune, fringes of Sanjay Gandhi National Park). There is an example of four leopards trapped in the course of one night in the capital city of Kenya (IUCN – CSG, 1992) when a trap was set for an escaped leopard (which incidentally did not get trapped). There is also another instance where a radio-collared leopard spent the whole day in a shed without people of the village (in Nepal) knowing of its presence, until night-time when it left the shed (Seidensticker & Lumpkin, 1991). Leopards can live without coming into conflict with people even in such areas. Any trapping exercise will also capture many harmless individuals with no guarantee of capturing the problem individual. Each trapping exercise must have a well thought out exercise for handling the many leopards that maybe caught. Leopards trapped accidentally (in a well or shed) in non-conflict areas should be released immediately near the site of capture.

3. **Low levels of livestock attacks should not be handled by trapping but by monetary compensation.**

   The Junnar Forest Department indeed has an excellent track record in the speed and efficiency of disbursal of compensation. The exemplary way in which they handled the

situation is probably the most important factor for the lack of any mob anger despite the severity of the conflict, unlike in many other parts of India. The Forest Department officials were present at all times: taking the victim to the medical facilities, speedy disbursement of compensation and this should serve as an example in other parts of India.

4. **Leopards should be allowed to feed off the livestock they have killed.**

   In the JFD, leopards were driven away from their kill in half the instances by people. This possibly leads to multiple attacks. There was an instance in the JFD where after a leopard was chased away from four kills, a human attack was reported in the close vicinity.

5. **Monthly monitoring of conflict levels should be carried out by the Divisional Office.**

6. **A database of animals in areas with a high conflict potential must be maintained by collecting scat and hair samples and pugmark images/casts. Similar samples should be collected at sites of livestock and human attacks.**

   DNA analysis of such samples can provide a reference identification library of all the individuals in such an area. The nature of the trapped animal (harmless or culprit) can then be determined and action taken accordingly.

   The possible institutes which could help in the above effort are the Wildlife Institute of India, Dehradun, Centre for Cell and Molecular Biology (CCMB), Hyderabad and the National Centre for Cell Sciences (NCCS), Pune.

7. **Direct shooting of problem leopards should not be allowed.**

   Injured animals are likely to be far more dangerous to human life. Furthermore, shooting could also lead to many innocent animals being killed without any guarantee of bagging the actual problem animal. Lethal control should only be considered after entrapment and confirmation of the identity of the culprit, and should be carried out ONLY under the supervision of senior Forest Officials.

8. **Scientifically managed leopard conservation centres in the vicinity of wildlife sanctuaries should be considered.**

   In our considered opinion, translocation is not an option at all. However leopards are Schedule I animals. If lethal control of problem animals is not preferred such animals maybe released in safari like enclosures on the edges of protected areas (eg., Bhimashankar Wildlife Sanctuary) which are visited by thousands of tourists. These centers maybe run by local communities under the supervision of the Forest Department. Such a scheme would provide visitors a chance to see carnivores in near natural conditions, lessen the tourist pressure inside the protected area for sighting such carnivores, provide employment in the local community and generally further the cause of conservation.

9. **Long-term telemetric studies of leopard living at the fringes of human populations should be carried on an urgent footing.**

   Permits to study endangered carnivores like leopards are often not forthcoming, especially when they involve telemetric studies or even DNA analysis of scats, perhaps fearing adverse publicity in case of a problem. However benefits from such studies, which will go a long way in saving human lives as well as help in the conservation of the species, far outweigh any negative impact. Perhaps the Forest Department should carry out a campaign to highlight this more-or-less complete absence of studies which handicaps them in their effort to strike a right balance between human welfare and conservation measures.

   Our study was severely handicapped by lack of sufficient information on the animals that were trapped and released and so we had to make do with information from studies carried out in other countries. To effectively manage any conflict situation, biological information on the species is absolutely necessary. It is imperative that a telemetric study be carried out with an aim of obtaining information on leopards that live at the fringes of human habitation. Knowing the biology of leopards that live at the fringes of human habitation would perhaps help in avoiding escalation of conflict levels.

10. **Education of local people on the consequence of hunting of leopard prey and habitat degradation.**

11. **In high conflict areas, leopards should be trapped and permanently removed until conflict levels subside.**

12. **Habitat modification of fragmented Reserve Forests of areas like JFD should be geared towards attracting natural species of plants and wild animals.**

    Indigenous trees which are animal-friendly (banyan *Ficus benghalensis* and other wild fig trees, *Butea monosperma, Zizyphus mauritiana* and other species of Bor, wild mango trees) should be planted in the existing plantations. *Gliricidia* and *Eucalyptus* dominated stands support few natural fauna. The goal of reforestation should be the regeneration of the original assemblage of trees which in turn would augment the natural prey base. Also, good protection should be offered to these areas which are usually heavily grazed by livestock.

A.1 Appendix 1 – Natural History of the leopard.

A.1.1 Introduction to *Panthera pardus*

The leopard *Panthera pardus* is a large felid that inhabits a wide range - from sub-Saharan Africa through the Indian subcontinent till the Russian Far East. Earlier studies based on morphological features put the total number of leopard subspecies as 27 with 14 of them occurring in Asia and four in India (Daniel, 1996; Seidensticker & Lumpkin 1991). However recent studies using mitochondrial DNA and microsatellite markers have put the number of leopard subspecies, worldwide, at nine (Uphyrkina *et al.* 2001; Miththapala *et al.* 1996) of which the subspecies *Panthera pardus fusca* inhabits the entire Indian subcontinent, except Sri Lanka, which is home to a unique subspecies *P.p.kotiya.* Africa is thought to be the origin of the species with a migration into Asia and further eastwards, occurring around 170,000 to 300,000 years ago (Uphyrkina *et al.* 2001).

The leopard is probably the most successful large felid which still holds on to most of its historical range and inhabits various habitats: from moist tropical forests to dry deserts. It occurs throughout the length and breadth of the Indian subcontinent, from Kashmir in the north to Sri Lanka in the south and from the Sindh province in the West to the eastern most states. The fact that it is a not as large as the tiger, is very catholic in its diet and is not dependant on free water is likely to have allowed it to be so successful (Anderson, 1982; Daniel, 1996; Gee, 1964; Tikader, 1983; Seidensticker & Lumpkin 1991; Rabinowitz, 1989 & 1990). However, despite its adaptability, it does face threats throughout its range due to the hunting for its pelt and other body parts, loss of its prey base for meat and shrinking habitat. The rarest of the leopard subspecies is the Amur leopard (*Panthera pardus orientalis)* that occurs in the easternmost region of its global range. In India, despite its wide range and pockets of what might appear as local abundance of the species, the leopard is a Schedule I species as defined by the Wildlife Protection Act (1972) (Wild Life Protection Act, 2003). This accords it the highest protection status in India. Habitat loss and fragmentation are one of the important reasons for the decline of this species since like other large solitary felids, they follow a land tenure system where males and females have their own territories and therefore require large areas to sustain a breeding population.

A.1.2 Natural History for the species *Panthera pardus*

Leopards or panthers as they are also referred interchangeably, belong to the order Carnivora, Family Felidae and subfamily Pantherinae (Anderson, 1982). There is a wide variation in the ground colour of their coat: from grey to ochre with some variants also being black in colour (Anderson, 1982). The latter are usually denizens of moist tropical forests and not a different subspecies. In India, E.P. Gee (1964), states that there are variations in the body size and coat colour depending on the habitat the leopards live in with the animals in drier and more open areas being smaller and lighter coloured. The length of the body and head varies from 95 – 150 cm, tail lengths vary from 60 – 95 cms, height at shoulder is about 60 cm and body weight varies from about 25 – 90 kgs. Males weigh about 37 – 90 kg whereas females usually fall in the 25 – 60 kg range (Seidensticker & Lumpkin, 1991; Prater & Barruel 1971; Stander *et al.* 1997). A study conducted in Thailand found the male weights to be around 60 and 70 kg and female weight around 21 kg (Rabinowitz, 1989). No seasonality in breeding is seen in the warmer tropics (Gee, 1964; Prater & Barruel 1971). The oestrus cycle is every 45 days and lasts for about 7 days. The gestation period is in the range of 84 – 105 days (Tikader, 1983; Anderson, 1982). Cubs weigh about 0.5 kgs at birth and their eyes open after 10 days (Seidensticker & Lumpkin 1991). Litter sizes from the wild have been recorded at 2 – 3 (n=16) (Anderson, 1982). Cubs accompany their mothers from about 4 – 6 months old and remain with their mother till they are about 1.5 – 2 years old. There are instances of siblings staying together for several months before separating. The average

age at which the female leopards in the wild reproduce is about 3 years and the males first reproduce on average when 2 – 3 years old (Anderson, 1982; Gee, 1964; Seidensticker & Lumpkin 1991).

The mortality rates recorded for sub-adult and younger leopards are much higher than recorded for the adults, with 41% mortality for those under the age of one year. Average annual mortality for subadults (1.5 – 3.5 years of age) estimated for the African leopards is at 32% with the females having a mortality rate of 40% and males 20%. This high rate of mortality for the subadults is thought to be due to poorer hunting success. At the same study site, adult annual mortality averaged 19% (Old males 30%, prime males 17%, old females 17% prime females 10%). In the wild, leopards live upto 10 – 15 years (http://lynx.uio.no/catfolk/sp-accts.htm.).

A.1.3 Home ranges of leopards

Generally, home ranges of male leopards contain or overlap with the ranges of many females and home ranges of the females are exclusive with little overlap, shared only by a female's offspring until they become independent. After independence, male subadults are known to disperse across larger distances in search of their territory than the females who could occupy areas close to their maternal range (Seidensticker & Lumpkin, 1991). There have been very few instances of radio tracking studies on the Indian leopards. One such study was conducted in Nagarhole, Karnataka, India, where two radio collared leopards were seen to have home ranges between 20 – 30 kms^2 (Karanth & Sunquist, 1995 & 2000). Home range sizes for leopard studied in Nepal and Sri Lanka vary from 8 – 40 kms^2 (Mizutani & Jewell 1998, Santiapillai *et al.,* 1982, Seidensticker *et al.* 1990). In Chitwan NP, Nepal, the home rage of an adult female leopard living within the park was 7 kms^2 and for two adult females living outside the Park, home ranges were 6 and 13 kms^2 (Seidensticker *et al.* 1990). Schaller's studies in Kanha NP, India, found that in the center of the Park where tigers were more numerous leopards were not permanent residents but were common around the villages located at the periphery of the park (Seidensticker & Lumpkin 1991; Seidensticker, 1976(a) & (b)).

Overall, it appears that commonly, home range sizes vary from about 15 – 50 kms^2 (Jenny, 1996). Studies from Serengeti NP found a leopard with cub to occupy a home range of 16 kms^2. In another region of Serengeti, leopards had larger home ranges of 40 – 60 kms^2 (Bertram, 1982). Travelling speed at 1 km/hour (n = 22) is seen to be similar for males and females although males cover larger distances (Jenny, 1996). In a livestock ranch in Kenya, adult females had home ranges of 17 kms^2 and 37 kms^2 was the home range for adult males (Mizutani & Jewell, 1998). In Thailand, females had ranges of 11 – 17 kms^2 and males have ranges of 27 – 37 kms^2 (Rabinowitz, 1989). However, home ranges of leopards are seen to vary enormously in different study sites [from 3 kms^2 to about 1160 kms^2 (Jenny, 1996; Stander *et al.* 1997) and are likely to be dependant on the food resources present in the area.

A.1.4 Prey items of leopards

A felid weighing 45 kg requires 1.5 – 2.5 kg/day of food (Wemmer & Sunquist, 1988) or as Emmons (1987) in Mizutani (1999) states it in more general terms, 35 gms of meat per kg body weight per day is required. Average prey weight ranges between 5 – 70 kg (Ray & Sunquist, 2001; Stander *et al.* 1997; Rabinowitz, 1989) and usually less than 50 kg (Seidenticker *et al.* 1990, Johnsingh, 1992) with mean prey weight as obtained from scat analysis being 24.6 kg in Zaire (Hart *et al.* 1996). Prey items of leopards are very variable, with a range from small insects, crustaceans to large ungulates (Prater & Barruel, 1971; Daniel, 1996; Bertram, 1982; Stander *et al.* 1997). There is a report of an adult male eland (which can weigh 900kg) being taken by a leopard (http://lynx.uio.no/catfolk/sp-accts.htm.; WWF-India, 1997; Bertram, 1982).

Studies in Nagarhole, India, found the range of prey weights to vary from 31 – 175 kgs with the mean prey weight being 38 kg (Karanth & Sunquist, 1995, 2000) and it was also seen that wild boar were under represented in the leopard diet. Leopard kills in Chitwan NP, Nepal were in the 25 – 50 kg range with the average prey weight being 28 kgs and on average leopards made their kills in less than once in 6 days (Seidensticker, 1976(b); Seidensticker & Lumpkin, 1991). Mean prey weight of leopards in a forest in Zaire was seen to be 25 kg (Hart *et al.* 1996) with ungulates and primates being the most common prey items identified from scat analysis. However, in a study based on scat analysis in the Central African Republic, average prey weight of leopards was much less than reported elsewhere at 7 kgs whereas in Congo it was seen to be 25 kg (Ray & Sunquist, 2001). Overall, it appears from literature that principal prey items are likely to be related primarily to the available prey base. In some sites, primates form an important component (Rabinowitz, 1989), in others rodents and in yet others medium sized ungulates (Rabinowitz, 1989; Khorozyan & Malkhasyan 2002). However, it does appear that in habitats where wild prey is available in good numbers, the diet of the leopard consists mainly of the wild species (Khorozyan & Malkhasyan 2002, pers. comm. Advait Edgaonkar, Seidensticker *et al.* 1990).

Incidences of leopards taking livestock, and dogs are quite common in the Indian subcontinent where leopards live in the fringe areas of villages (WWF-India, 1997; Daniel, 1996; Gee, 1964; Santiapillai *et al.* 1982; Maskey & Bauer, date na; Tikader, 1983; Johnsingh, 1992; Prater & Barruel, 1971). At the fringes of a village in Bandipur TR, India, a two years study by Johnsingh (1992) found 26 % (n = 58) of leopard kill to consist of domestic cattle and dogs, the remaining consisting of wild prey species. In Himachal Pradesh, scat analysis of leopard prey items the Majhatal WLS found a high rate of predation on domestic animals (cattle, dogs and goats in that order) despite an abundant presence of wild prey species. However, the Sanctuary was also home to about 750 humans (17 villages) who reared livestock (Mukherjee & Mishra, 2001). In Chitwan, a comparative study of leopards living inside Chitwan National Park found that the leopard prey consisted of mainly wild species of weight less than 50 kgs while leopards that lived outside the Park fed mainly on domestic prey species under 50 kg (Seidensticker *et al.* 1990). Leopard are also known to feed from dead and rotting carcasses and if disturbed at their kills they are known to return therefore making them more susceptible to being poisoned (Seidensticker & Lumpkin, 1991).

A.1.5 Legal status of the leopard in India

The leopard was accorded full protection by awarding it the Schedule I status in 1983 which gives it the highest protection in India. This would have resulted in better protection for the leopards from hunters who may have killed them for sport however, illegal trade in its body parts is still rampant and with high monetary stakes, greater accessibility and networking, it is the leopard that is increasingly being persecuted for its body parts compared to the tiger (pers. comm. Khalid Pasha). The population estimate for the leopard is India is about 14,000 (Wildlife Institute of India unpublished data *in* Nowell & Jackson 1996).

A.2. APPENDIX 2 – Miscellaneous Tables.

Table A.2.1 : The year of construction and completion of the dams in the JFD (Irrigation Dept).

Name	River dammed	Year construction was started	Year construction was completed	Surface area in 1992 (ha)	Surface area in 2000 (ha)
Pimpalgaon Joge	Pushpavati	1992	2002	0	1876
Chilewadi	Mina*	1988	on going	0	0
Manickdoh	Kukadi	1975	1984	939	1112
Yedgaon		1970	1978	870	1025
Wadaj	Mina *	1976	1982	361	413
Dimbhe	Ghod	1977	2002	507	1425
Chas Khaman	Bhima	Date na	Date na	361	1669
Bhama Askhed	Bhama	1993	On going	0	306

*different rivers with the same name

Table A.2.2 : List of possible wild prey species of the leopard in the JFD.

Species	Mainly found in (WG-W.Ghats, CRGM, JON)
Indian Hare *(Lepus nigricollis)*	JFD
Common Mongoose *(Herpestes edwardsii)*	JFD
Palm Civet *(Paradoxurus hermaphroditus)*	JFD
Small Indian Civet *(Viverricula indica)*	JFD
Leopard Cat (*Prionailurus benghalensis*)	WG
Jungle Cat *(Felis chaus)*	JFD
Rusty spotted Cat (*Prionailurus rubiginosus*)	JFD
Bandicoot *(Bandicota indica)*	JFD
Porcupine *(Hystrix indica)*	JFD
Mouse Deer *(Moschiola meminna)*	WG
Sambar *(Cervus unicolor)*	WG
Barking Deer *(Muntiacus muntjak var.)*	WG
Common Langur *(Semnopithecus entellus)*	WG (occasionally in JFD)
Bonnet Macaque *(Macaca radiata)*	WG (occasionally in JFD)
Indian Pangolin *(Manis crassicaudata)*	WG
Malabar Giant Squirrel *Ratufa indica)*	WG
5 striped Squirrel *(Funambulus pennatii)*	WG
3 striped Squirrel *(F. palmarum)*	JFD
Golden Jackal *(Canis aureus)*	JFD
Indian Fox *(Vulpes bengalensis)*	JFD
Striped Hyaena *(Hyaena hyaena)*	JFD
Wolf *(Canis lupus)*	Occasionally in JFD
Indian Gazelle or Chinkara *(Gazella bennettii)*	Shirur, N.gaon
Four-horned Antelope or Chousingha *(Tetracerus quadricornis)*	Belhe, Ane (thorn forest)
Rodents	JFD
Peafowl *(Pavo cristatus)*	JFD
Partridges	JFD
Grey Jungle Fowl *(Gallus sonneratii)*	JFD
Quails	JFD
Monitor Lizard (*Varanus bengalensis)*	JFD
Frogs	JFD

Source: **Sanjay Thakur. Nomenclature from Ommer (2000)**

Table A.2.3 : Changes in land use (km²) in the JFD, 1960-1994.

Taluka	Year	Fallows	Forest	Gross Cropped Area	Permanent Pastures	Total
Junnar (JON)	**1960-61**	88	217	1062	45	1412
	1980-81	88	218	1018	35	1359
	1990-91	30	200	1369	17	1616
	1994-95	148	209	1031	17	1405
Ambegaon (GM of CRGM)	**1960-61**	26	239	745	14	1024
	1980-81	84	240	679	77	1080
	1990-91	126	247	617	52	1042
	1994-95	64	243	672	30	1009
Khed (CR of CRGM)	**1960-61**	60	184	1028	28	1300
	1980-81	33	156	1033	78	1300
	1990-91	67	199	998	37	1301
	1994-95	132	201	963	95	1391
Total	**1960-61**	174	640	2835	87	3736
	1980-81	205	614	2730	190	3739
	1990-91	223	646	2984	106	3959
	1994-95	344	653	2666	142	3805

Source: **Agriculture Department Records (*in* Patwardhan *et al.* 2003).**

Table A.2.4 : Release of leopards caught in conflict situations in N. Bengal.

Area of capture	Period	# leopards trapped	Protected Area [PA] into which animals were released
Terai	1996	1	Data on release not available
W. Duars	1994	1	Chapramari WLS (just north of Gorumara – W. Duars)
	1997	1	
	1992	3	Gorumara NP (W.Duars)
	1994	3	
	1995	3	
	1996	4	
	1997	5	
	1992	1	Jaldapara WLS (E. Duars)
	1993	2	
	1995	1	
	1995	2	Buxa TR (E. Duars)
	1996	1	
	1992	2	Data on release not available
	1993	3	
	1994	2	
	1995	8	
	1996	5	
	1997	1	
E. Duars	1992	1	Data on release not available
	1994	2	
	1995	3	
	1996	2	

Source: **WWF – India report, 1997.**

A.3 Appendix 3 – Description of attacks by leopards on people, in the JFD. (Ж indicates a "pre meditated" attack)

A.3.1 JON

A.3.1.1 Junnar

1 Aug 93: The 27 year old man was throwing fertilizer in the field when he was attacked by a leopard. His hands and legs were injured. This was at Nirgude.
21 Jan 94: not known. This was at Kewadi.
1 Apr 94: A 5 year old girl was tending her goats when she was attacked. There was a jowari field (*Sorghum bicolor)* and a stream nearby. Her hands and legs were injured. This was at Pimpalgaon Sidnath.
1 Apr 94: A man was injured at Khamgaon. However no details are available.
21 Feb 96: A man died due to a leopard attacks. No details available.
3 Jan 00: This was at Parunde. No details available.
3 Jan 00: This was at Parunde. No details available.
Ж 10 Apr 01: *The 35 year old man who was sleeping outside his house was attacked by a leopard at 1:30 AM. He started shouting at which the leopard ran off towards the village. The person's face was injured. Three – four people present and livestock present at time of attack in the nearby vicinity.*
Ж 10 Apr 01: *15 minutes later, about 60 m away, a 75 year old man who was sleeping outside, near the door of his house, was also attacked and his face was injured. He also started shouting and the leopard escaped. This was at Manickdoh. No other person present but livestock present at time of attack.*
30 Aug 01: The 8 year old boy went to answer the call of nature at the Otur – Junnar Road at 7 PM when he was attacked by the leopard. His left leg and calf were injured. This was at Golegaon. It was dark, raining and there were sugarcane and grape fields nearby. (He was not killed therefore it is not considered to be a pre-mediated attack).
5 Mar 02: This 35 year old man was driving by on his scooter when he alighted at the edge of the road to answer the call of nature He was in the field when the leopard growled and the man in a panic ran and got himself injured at the barbed wire fencing. This was at Dhonket.

A.3.1.2 Otur

25-Mar-95: At 8 PM the 10 year old girl was killed by the leopard – no details – old case.
9-Apr-95: At 9 AM the person who was cutting firewood was killed – no details – old case.
20-Apr-98: The leopard was driven down from the forests on the hills because of the construction of trenches on the hill and attacked the 14 year old boy it found on its way. This took place at 4 PM. The boy was injured.
15-Aug-98: The man was walking back alone to his village at 9:30 PM when he was attacked. The man was injured.
14-Dec-98: At 9:30 AM the 39 year old lady was cutting grass in the RF when she was attacked. She was injured.
25-Sep-99: At 7 PM the lady was returning home along with her dog. Near the Reserve Forest [RF] and stream (2 m away), the leopard tried to attack the dog which escaped and so the leopard caught the ladies leg. People from a nearby house chased the leopard away. She was injured at the leg.
Ж 10-Oct-99: *The 7 year old boy took his cattle for grazing in the RF. At 5 PM, while returning, his brother went ahead whereas the boy stopped to collect Zyzhiphus fruits. He was picked up by a leopard from there. Other details not known. Head and one hand found the next day.*
23-Oct-99: At 6 in the evening the person bent down to tie bullock when leopard attacked from the

front. His mother shouted and the leopard ran off. The person was injured. (It is not certain whether the leopard was intent on attacking the boy or the bullock)
☒ **6-Nov-99:** *At 7 in the evening, the 55 year old woman was washing utensils outside her house. The leopard attacked her and dragged her. She was mother of the Forest watchman. Next day a leopard was trapped on the other side of the stream. The woman died. There were other people near the site of attack but no livestock.*
6-Feb-01: At 10 PM the 25 year old man was attacked by a leopard while he was at the side of a stream. He pushed the leopard down the bank of the stream and due to the loose soil the leopard could not climb up. She was with cubs. The man was injured. No information on whether the person was alone.
☒ **8-May-01:** *The 2.5 year old boy was playing with the water outside his house while his parents were filling up water. This was at 8:30 PM. The leopard then attacked the boy at which the father threw a spade on the leopard. The boy was rescued. There were other people as well 20 sheep in the nearby sugarcane field.*
24 Feb 02: Two men (aged 32 and 43) were injured due to leopard attacks at Otur Kolambla. However no details are available.

A.3.1.3 Narayangaon

22 Jul 95: The hens were creating a ruckus so Dagdu came out with a stick thinking it was a dog troubling the hens and the leopard attacked him. He was injured. This was in Shindewadi.
26 Mar 96: The person was harvesting tomatoes in the field when the leopard attacked. The leopard was coming down the hill and people saw it and started shouting when the affected person was sitting harvesting tomatoes and stood up to see what was happening and the leopard who was very close, pawed her and went off. The person was injured. This was in Pimpalgaon tarf Narayangaon.
18 Sep 98: Three attacks on the same day. In the first, the leopard had gone for the hens and the 36 year old lady threw something at the leopard who then attacked her. The leopard then went and attacked the other two who were working on a nearby farm, about 150 m away. This was in Hivre tarf Narayangaon.
☒ **6 Nov 01:** *The 3 year old girl was outside her house at 9 PM and was running towards her house when she was picked up. She was dragged to a sugarcane field about 200 m away where her skeleton was found 4 months later after the sugarcane was cut. This was in Belha. No other person present but livestock present.*
27 Feb 02: Shiroli Budruk. At 7 AM, a 37 year old man had gone to supervise the sugarcane cutting and on his way back was answering the call of nature near a sugarcane field when he was attacked. After which a person cutting the sugarcane was attacked. Subsequently, the Forest Department personnel arrived with cages and started searching for the leopard. A farmer walking by the sugarcane field was then attacked but did not get any compensation possibly because he was not injured. When Thorve, a 35 year old man happened to go close to where the leopard was, with a FD personnel, the leopard attacked him. The leopard was hit severely on its head with a stick by a Forest Department personnel after which it escaped through the sugarcane plants. It then attacked a 28 year old woman who was sleeping in her house. It ran off after she shouted and was trapped at the same place the same night. Post mortem of the animal showed that it was starved.
☒ **26 Jul 02:** *At 7:30 PM, this five year old girl was standing at the door of her house with her brother, there were no lights and it was raining. Her uncle was washing his feet outside the house when her brother shouted but she was taken away from her doorstep into the sugarcane field about 150 m away. She died. This was in Bori Budruk. Three people as well as livestock present at time of attack.*
☒ **12 Aug 02:** *The 11 year old girl was on her way to school, walking on a mud road bordered by sugarcane at about 10 AM, accompanied by her sister. It was raining. She was rescued but died enroute to the hospital. This was in Rajuri. This and the preceding human attack were 3 kms from each other. Two other people were present at the time and place of attack but no livestock was present.*
☒ **16 Aug 02:** *The attack happened at 6 PM. The 6 year old boy was taken from near his house into the sugarcane field. It was raining. He was dragged about 15 m. He was rescued immediately but died. The straightline distance from the above attack is about 11.5 kms. This was in Mangrul. A person as well as livestock present at time and place of attack.*

☒ **28 Aug 02:** *The 10 year old girl was answering the call of nature at 1:30 AM and was sitting in front of the door while grandmother was also nearby, when she was attacked. Her neck and face were injured. This was at Bori Budruk. A person as well as livestock was present at time and place of attack.*
☒ **12 Sep 02:** *At 7:30 PM the 6 year old boy was tying his cattle near the cattle shed at home when the leopard took him. He was dragged about 100 m through a banana plantation into the sugarcane field. The next day only his body parts were recovered. This was at Bori Budruk. The area was dominated by sugarcane fields and is next to the canal. Another person as well as livestock was present at time of attack.*
☒ **14 Sep 02:** *At 6 PM a 13 year old girl dhangar (shepherd) girl was taking some vegetables from one dhangar camp to the other, about 20 m away, when the leopard attacked her. She was rescued but died before she reached the hospital. This was at Wadgaon kandli. Other dhangars and livestock were present in the vicinity of attack site.*
☒ **15 Sep 02:** *At 9 PM, a 22 year old lady was answering the call of nature behind her house when she was attacked. She was dragged about 100 m through chickoo plantation and deposited in sugarcane. She died. This happened in Nimgaon Sawa. No other human was present but livestock was present in close vicinity of attack site.*
☒ **16 Sep 02:** *At 5:30 PM, a 8 year old girl was coming back from school along a road which had RF on both sides and a river nearby. She was attacked and sustained injuries on her head. Other children screamed and she was the rescued. This was at Mangrul. Two other children were with her but no livestock present.*
☒ **7 Oct 02:** *At 6:45 PM, a 5 year old girl was attacked behind her house and dragged about 100 m through farmland and sugarcane where she was deposited. She died. This was in Belha. Another person was present as well livestock were present at site of attack.*
☒ **29 Oct 02:** *At 6:45 PM the lights had gone and just come back. The 5 year old boy child was in the front of his house with his uncle and his mother. He went out of their sight momentarily and they heard a scream. The people went in search of him but did not find anything. The next day the body was found. He was dragged about 300 m through farmland and deposited in the sugarcane. This happened in Wadgaon Anand. The leopard had attacked goats the previous night in three different places but could not eat any of them. Two adults were present as well as livestock in the close vicinity of the attack site.*
7 Nov 02: The lady was sitting on the sugarcane field bunds waiting for brother and husband. No other person nor livestock was present. She was injured. (Note: this could have been a premeditated attack, however for lack of more information we have not categorized it as one).
☒ **2 Jan 03:** *At 11:30 PM a 8 year old dhangar girl was sleeping in the ploughed field amidst the rest of the dhangars when she was attacked but their dog saved the girl. She had injuries on her head and right shoulder. This was in Belha.*
14 Jan 03: at 12:30 PM the 35 year old man went to rescue his calf which was being attacked by the leopard and he was injured in the arm in the process. This was at Sakori.
☒ **24 Jan 03:** *The 6 and a half year old boy was just outside his house answering the call of nature when he was taken at 7 PM. He was dragged about 100 metres through harbara (chick pea – Cicer arietinum, or pigeon pea) and maize fields towards the hill. Subsequently two leopards were trapped. There are caves in the hill overlooking this settlement where ST has seen dog skulls and old pugmarks. This was in Hapusbaug. A week before the boy's 12 year old sister was mock charged by a leopard near the house. There were five other people as well as livestock in the close vicinity of the attack site.*
☒ **7 Feb 03:** *The 8 year old boy was playing outside his house at about 7 PM while his grandmother was washing utensils in front of house. The lights had gone. He saw something behind the bushes and shouted and ran towards his grandmother who was on the other end of the courtyard. The leopard attacked the boy from behind the bushes. The grandmother then screamed and held onto the child while the leopard had the childs leg in its mouth. The mother also came outside and shouted after which the leopard ran off. The grandmother was*

felicited by the minister for her bravery. This was at Shiroli Budruk. Livestock was also present in the close vicinity.
☠ 19 Feb 03: *At 6:30 PM, the 6 year old dhangar boy was settling his cattle in the farm next to the sugarcane when he was taken. He was dragged to the sugarcane field. The Forest Department personnel tried to search for the boy but could not and in a mob generated anger, the locals burnt down the field of sugarcane and the body was found. Also two leopards were seen to come out of the sugarcane patch. This was at Mangrul, Zapwadi. It is likely that other dhangars were also present as it is usually with them, but livestock was present at time of attack.*

A.3.2 CRGM

A.3.2.1 Chakan

5 Jan 02: The 11 year old boy had gone to the malki forest with his parents to cut grass and was sitting under a tree when the leopard attacked. He was injured. This was 12:30 PM and occurred at Talewade. No livestock was present at time of attack. (Since the boy was alone at the time of attack, and we have no other information, we have not considered this as a pre-meditated attack).
24 Aug 02: This attack also took place in Talewade. The 45 year old woman had gone with 4 other people to cut grass at about 7:30 PM when she went to answer the call of nature. The leopard attacked her but ran off when the people shouted, however the lady was dead by then.
1 Sep 03: a little girl was injured. No details available.

A.3.2.2 Rajgurunagar

10 Oct 95: This happened at Walad, Sawat Ale. Namdeo Sawat, a 57 year old man was cutting grass at 8 AM when the leopard which was driven by people from the other side of the stream found the man on its path and attacked him. The man was injured.
☠ 12 Nov 95: *This happened at Ghanwatwadi, Ghubadi. At 8:30 AM the 47 year old man had gone to the RF with his cattle for grazing. The leopard attacked him but his bullock in turn attacked the leopard thereby saving the mans life.*
25 Nov 95: Early in the morning some person hit the leopard with a stone. It then went and hid at the outskirts of the village Wada, Pawadewadi, in the corner of a cattleshed. The whole village assembled near the shed and after much commotion the leopard came out and in the process of fleeing attacked and injured a 65 year old man and another man present in the crowd.
21 Feb 96: This happened in Wada, Dhagad wadi. Vishnu Ghige, a 47 year old man was sitting next to the stream when his dog was charged by the leopard and the dog came towards the owner because of which the owner was injured.
20 Sep 96: Awat, Walunj Dara. Dondibhau Walunj, a 35 year old man was going towards the stream when he was attacked by a leopard at 7 PM. He was injured in the process. No other person nor any domestic animal was with him. Lack of more information does not allow to determine if it was a pre-mediated attack.
29 Jan 97: 2 attacks - This was at Dehane, Shindurli. Two 30 year old men were at the forest near the hill slope collecting fuelwood at 7 AM when they were attacked. Both were injured.
21 Apr 01: Two attacks on the same day. Not much details available. One took place at Daunde and the other at Kadus. The one at Daunde took place when the person was cutting sugarcane and the second was a 19 year old boy who was attacked when he was cutting bajri.
15 Nov 01: The attack took place at Ranmala when the whole village had gone to see a leopard which was cornered and attacked while trying to escape. This was at about 8:30 AM and a 14 year old boy

was injured.
☠ 7 Dec 01: *the 51 year old lady was drunk and going home from bazaar when she sat to have tobacco and was attacked. She was fully eaten. This was in Kahuchi Thakkawasti. She was alone.*
☠ 17 Dec 01: *Vafgaon, Mandalwadi. At 6:45 PM, the leopard jumped the wall and took the 4 year old girl. She was dragged around 20m but because of the noise made by the people the leopard ran off. She was a small child about 2 feet tall. She was injured. There were other people as well as livestock in the close vicinity of the attack.*
5 Jan 02: Jhaulke Khurd, Thakkarwadi. Sunil Gowade was going hunting at about 4 PM and was near the forested hill. He was attacked and sustained injuries on the chest and belly. No details available.
14 Jan 02: The man was at the jowari field when the leopard attacked from behind. He died due to injuries on the neck and a broken spine. This was at Wadgaon Patole. He was alone. No details available.
19 Jan 02: Mohakal, Devwasti. Bhamabai Raut, a 55 year old woman was tying the door of her house from the inside at about 8:30 PM when she was attacked from the outside. Her hand was caught by a leopard and she was injured.
13 Aug 03: the man was walking on the path when he saw a herd of cattle occupying the path and moved away from the path, taking a detour on the hill slope. He came between the leopard and the cattle just when the leopard was about to jump on the cattle. This happened in the evening (6 PM). The leopard is said to have held on to him and dragged him for a distance despite being shouted at by people. The man died later in the hospital.

A.3.2.3 Ghodegaon

1997: Three cases in Gangapur on Jan 97, Feb 97, Feb 97. Could not find the affected people.
☠ 19 Nov 01: *This happened at Kotamdara at Shivachiwadi. Ashwini Asawle, a 2.5 year old girl was playing outside her house at about 7:30 PM under the supervision of her grandfather when the leopard who was crouching behind a wall near the house took her and dragged her to the jowari (Sorghum bicolor) field. She got away with injuries to her right shoulder. She now cannot move her head nor has full use of her left side. Livestock were also present at time of attack.*
21 Nov 01: This happened at Ghodegaon, Tiwaldara. At 10 AM the 8 year old boy was bringing the buffalo calf to the front of the house when the leopard tried to attack the buffalo but injured the child in the process. The grandfather who was sitting 2 m away rescued the child.
22 Nov 01: This 22 year old man was sitting at 6 PM in the field, cutting grass, when the leopard who was being driven by people jumped on him. He was injured on his palm. This was at Ghodegaon, Tiwaldara.
☠ 29 Dec 01: *The 5 year old girl was walking on the road around 7 PM when she was killed. This was in Koldara. She was coming back from the cattle shed to get an axe for her father to cut the wood when she was attacked. Immediately her father and other people ran towards her, she was rescued but died on the way to the hospital. The girls sister was with her at the time of attack as well as livestock were present in the near vicinity.*
☠ 7 Feb 02: *Jijabai, a 14 year old girl went with another lady for grazing the cattle at about 8 AM. In the scrub jungle, the leopard attacked her and took her. The lady with her shouted and other villagers gathered but she was found to be dead, with the leopard guarding her. This was at Supewadi. Later on two leopard were trapped in the area. She was the only child of poor parents, both of whom are deaf.*

A.3.2.4 Manchar

14 Mar 01: At 11 PM, the 32 year old man was asleep when the leopard attacked his dog who then hid under his bed resulting in injury to the face of the person.
25 May 01: At 8:45 AM the 70 year old man was shutting off the street lights when he saw the leopard drinking water down at the river. He pointed at the leopard and shouted which is thought to have annoyed the leopard which then climbed up the river bank and attacked the man. He was rescued by other people.
16 Sep 01: At 6:30 PM, the 40 year old woman who was drunk, was going home from the bazaar when she was attacked. She died. She was alone. (Note: we have not included this as a "not accidental" attack since we do not have more details).
12 Nov 01: *At 6 PM, the 25 year old man went to get his bullock from RF where it was grazing when the leopard attacked. He was saved by other people. Other livestock were present.*

Appendix 4 – Questionnaires used in this study

A.4.1 Questionnaires for livestock attacked by leopards

Village_____ **Vanparekshetra**_____ **Taluka**_____

Cattle Dead / Injured _____ Date_____ **General** Dead / Injured _____ Date_____

Other **Dead / Injured** _____ **Date**_____

Name of interviewed:_____Relation to affected:_____

Age:_____

Address: Occupation: _____

Monthly salary:_____ **GPS** location of house (where cattle belonged): _____

houses in settlement: _____

Extent of sugarcane near settlement: _____ Major crop in the area:_____

family members of affected house: _____AM_____SAM_____YM

_____AF _____SAF_____ YF (A>18, Y<11)

 # cattle: _____AM_____SAM_____YM

average weight of _____AM_____ SAM_____YM

cattle _____AF_____ SAF_____YF

average weight of _____AF_____ SAF_____YF

Estimated # of cattle in settlement: _____

Trend in cattle population (↑↓↑) 1990_____1995_____2000_____

 # buffalo: _____AM_____SAM_____YM

average weight of _____AM_____SAM_____YM

buffalo: _____AF_____ SAF_____YF

average weight of _____AF_____ SAF_____YF

Estimated # of buffalo in settlement:_____

Trend in buffalo population (↑↓↑) 1990_____1995_____2000_____

dogs in house:_____(colours) # in surrounding houses:_____(colours)

dogs in village:_____ Dogs have collars?_____

pigs in village:_____

#poultry in village:_____

others:_____

Any significant trends for other domestic animals (↑↓↑) 1990_____1995_____2000_____

For attacked cattle:

Date of attack:_____Time of attack:_____

Age of cattle:_____ Sex:_____ Colour:_____

Compensation received:_____

Health of cattle:_____ Stray or stall fed:_____

Variety of cattle:_____

# of other cattle present during attack:_____ Their age groups:_____

Activity of cattle during attack:_____

If human present:_____(y/n) dog present:_____(y/n)

Bell present around neck:_____(y/n)

Usual time of going out:_____Time of returning:_____

Status of sugarcane crop at time of attack:_____

(height of crop): no crop_____< 1m _____ 1 – 3 m _____> 3 m_____

***Behaviour of leopard during attack*:**

How many days prior to attack was leopard sighted in vicinity?: _____

Attack was accidental _____ OR stalked?_____Face on?_____From back?_____

Which habitat was the cattle attacked_____**GPS** reading of attack site_____

where was it dragged_____ **GPS** reading of site where dragged to _____

What was the habitat through which it dragged the prey_____

d (prey was dragged): _____

Habitat analysis of site of attack:

Terrain: Steep_____Gradual_____Flat_____Valley_____

d (nearest hill from attack site): 0 – 100m _____100 – 500m _____500 – 1000m _____> 1 km_____

direction of nearest hill from attack site:_____(using compass)

d (nearest RF from attack site): 0 – 100m _____100 – 500m _____500 – 1000m _____> 1 km_____

direction of nearest RF from attack site: _____(using compass)

at site of attack:

count # of houses around_____House in farm_____ In small hamlet_____

d (road) –kacha_____pakka_____ d (nearest hill) _____ d (sugarcane)_____

d (nearest river/stream bed)_____ d (valley)_____ d (canal)_____

Habitat analysis of site where prey was dragged:

Terrain: Steep_____Gradual_____Flat_____Valley_____

d (nearest hill from site where prey was deposited): 0 – 100m _____100 – 500m _____500 – 1000m _____> 1 km_____

direction of nearest hill from site: _____(using compass)

d (nearest RF from where prey was deposited): 0 – 100m _____100 – 500m _____500 – 1000m _____> 1 km_____

direction of nearest RF from site of deposition: _____(using compass)

at site of deposition:

draw various landscape features within 250 m radius for a circle around you at the back of this questionnaire

d (road) –kacha_____pakka_____ d (nearest hill) _____ d (sugarcane)_____

d (nearest river/stream bed)_____ d (valley)_____ d (canal)_____

Past history of area:

When did attacks start (month & year): _____When was it most severe (month and years):_____

Did severity of attacks co-incide with maximum sightings?_____

t (roads - K or P) started:_____t (canals):_____

t (sugarcane cultivation was started): _____crop pattern:_____

initiation of diary development and hybrid cattle:_____time they started protecting their cattle:_____

time electricity arrived:_____

Increase or decrease in nearby RF (↑↓):_____

Uses of RF (y/n): Fuelwood_____Minor Forest produce_____Grazing (# cattle that use it per day)_____Hunting_____

Latrines present or any schemes:_____

Other schemes:

Why problem started?

What solution?

Date:_____ Place:_____ Sign:_____

ST sign:_____

A.4.2 Questionnaires for people attacked by leopards

Village **Vanparekshetra** **Taluka**

Human Dead / Injured Date_____Comp^{n}_____ General Dead / Injured Date_____Comp^{n}_____

Other Dead / Injured Date_____Comp^{n}_____

Name of attacked: _____Age:_____ Sex:_____

Address: Status of house:_____

Occupation:_____ Monthly salary:_____

Compensation received:_____

Activity at time of attack:_____ # of people with affected:_____

Date of attack:_____Time of attack:_____

Which habitat was person attacked_____**GPS** reading of attack site_____

where was human was dragged_____ **GPS** reading of site where dragged to _____

If site is close to settlement then
# houses in settlement:_____

Extent of sugarcane near settlement:_____

family members of affected: _____AM_____SAM_____YM

_____AF _____SAF_____ YF (A>18, Y<11)

cattle: _____AM_____SAM_____YM

_____AF_____ SAF_____YF

Estimated # of cattle in settlement: _____

Trend in cattle population (↑↓↑ for 1990, 1995 and 2000):_____

buffalo: _____AM_____SAM_____YM

_____AF_____ SAF_____YF

dogs in house:_____(colours) # in surrounding houses:_____(colours)

dogs in village:_____# pigs:_____

#poultry:_____# others:_____

Status of sugarcane crop at time of attack:_____(height of crop)

d (road) -kacha_____pakka_____ In farm_____ In small hamlet_____

d (nearest hill) _____ d (sugarcane)_____

d (nearest river/stream bed)_____ d (valley)_____

***Behaviour of leopard during attack*:**

How many days prior to attack was leopard sighted in vicinity?: _____

Attack was accidental _____ OR stalked?_____Face on?_____From back?_____

Which habitat was the cattle attacked_____**GPS** reading of attack site_____

where was it dragged_____ **GPS** reading of site where dragged to

_____

What was the habitat through which it dragged the prey_____

d (prey was dragged): _____

Habitat analysis of site of attack:

Terrain: Steep_____Gradual_____Flat_____Valley_____

d (nearest hill from attack site): 0 – 100m _____100 – 500m _____500 – 1000m _____> 1 km_____

direction of nearest hill from attack site:_____(using compass)

d (nearest RF from attack site): 0 – 100m _____100 – 500m _____500 – 1000m _____> 1 km_____

direction of nearest RF from attack site: _____(using compass)

at site of attack:

count # of houses around_____House in farm_____ In small hamlet_____

d (road) -kacha_____pakka_____ d (nearest hill) _____ d (sugarcane)_____

d (nearest river/stream bed)_____ d (valley)_____ d (canal)_____

Habitat analysis of site where dragged to:

Terrain: Steep_____Gradual_____Flat_____Valley_____

d (nearest hill from site where prey was deposited): 0 – 100m _____100 – 500m _____500 – 1000m _____> 1 km_____

direction of nearest hill from site: _____(using compass)

d (nearest RF from where prey was deposited): 0 – 100m _____100 – 500m _____500 – 1000m _____> 1 km_____

direction of nearest RF from site of deposition: _____(using compass)

at site of deposition:

draw various landscape features within 250 m radius for a circle around you at the back of this questionnaire

d (road) -kacha_____pakka_____ d (nearest hill) _____ d (sugarcane)_____

d (nearest river/stream bed)_____ d (valley)_____ d (canal)_____

Past history of area:

When did attacks start (month & year): _____When was it most severe (month and years):_____

Did severity of attacks co-incide with maximum sightings?_____

t (roads - K or P) started:_____t (canals):_____

t (sugarcane cultivation was started): _____crop pattern:_____

initiation of diary development and hybrid cattle:_____time they started protecting their cattle:_____

time electricity arrived:_____

Increase or decrease in nearby RF (↑↓):_____

Uses of RF (y/n): Fuelwood_____Minor Forest produce_____Grazing (# cattle that use it per day)_____Hunting_____

Latrines present or any schemes:_____

Other schemes:

When problem first started in area?_____

Why problem started?

What solution?

Date:_____ Place:_____ Sign:_____

ST sign:_____

A.4.2 Questionnaires for leopard trappings

Sighting:_____ Date:_____ GPS reading:_____

Forest Compartment:_____ Vanakshetra:_____

Habitat where sighted:_____

Age of leopard:_____ Sex:_____(M/F) If F then with cubs? _____(# and age)

Person who informed:_____ Forester in charge:_____

Health of Leopard:

Injured_____ Dead_____ Alive_____

Trapping information:

Date trapped:_____ Location trapped:_____

How many trap days before it was caught:_____ How many trap set:_____in how much radius:_____

Other information:

A.5 Appendix 5 - Nationwide information on the man-leopard conflict and illegal trade in leopard body parts.

A.5.1 Man-leopard conflict in India

The high intensity leopard conflict areas in the country appear to be located mainly in Uttaranchal, Maharashtra, Himachal Pradesh, Gujarat and Madhya Pradesh (Table A.5.1, also see Appendix A.6 for information on Gujarat). Nepal too has leopard problems reported in the Midhill region in the late 1990's (Maskey & Bauer 2000). The tea plantations of North Bengal have also had a history of the conflict since the early 1990's and it appears that the leopards are using the tea gardens for littering with an average of 8 cubs (range = 1 – 25) being found every year in the tea plantations of the Eastern and Western Duars from 1992 – 1997 (data from WWF report, 1997). The table A.5.1 also gives an idea of how many animals are likely to have been trapped and released in places away from their site of capture.

Table A.5.1 : Country-wide overview of man-leopard conflict obtained from media clippings (Source: WPSI).

State	2000		2001		2002		Total
	No	Yes	No	Yes	No	Yes	
Uttaranchal			15	5	9	4	33
Maharashtra			4	3	18	2	27
Madhya Pradesh	1		1	2	7	2	13
Himachal Pradesh			3	1	5	2	11
Gujarat			2	4	2	1	9
Assam		1	1	3		2	7
Karnataka			3		2	2	7
Uttar Pradesh			2	3		1	6
Chhattisgarh			2		2		4
Kerala				4			4
Andhra Pradesh				2	1		3
Tamil Nadu			2		1		3
Haryana			1		1		2
J&K			1			1	2
West Bengal			1	1			2
Bihar			1				1
Goa					1		1
Orissa			1				1
Punjab			1				1
Rajasthan				1			1
Grand Total	**1**	**1**	**41**	**29**	**49**	**17**	**138**

Yes or No: leopard was killed or not.

A compilation of man-leopard conflict incidences were carried out from media reports (Table A.5.2). These have not been corroborated but it definitely indicates where the hotspots of conflicts in India lie. Uttaranchal, the most highly affected state has had a history of this conflict since the beginning of the 20th century (Corbett 1991 *in* Edgaonkar & Ravi, 1998). The problem lies largely in the 5444 km² area of the Pauri District. The reasons behind the chronic nature of the problem in this region are not well known but an on-going study on the problem there by the Wildlife Institute of India indicates that the density of leopards is extremely high at 3 – 4 animals per 10 km² (Chauhan, http://www.wii.gov.in/ars/2003/devendra.htm).

Table A.5.2 : Data from across the country on man-leopard conflict.

Place	Affected area (km²)	Leopard census figures	Period	Total # of people attacked	# of the total attacks which resulted in death	# livestock killed	# leopards		Period of escalation in leopard attacks	Source
							trapped	killed		
Uttaranchal		2090 in 2003 1961 in 2001 690 in 1984	2000 – 2003	484	120	3571				Indian Express 4 Jan 2002
			May 2000 – May 2001	95	60					Kalpavriksh data
Pauri District (Uttaranchal)	5444		1988 – Aug 2000		141			93		WII technical report
North Bengal (Terai, W. Duars, E. Duars)			1990 – 1997	121	10	335	52	39	1995 – 1997	WWF – India report
			1990 - 2003		18	287		53		Forest Department Data
Andhra Pradesh		253 in 2003 248 in 2002	2003	Chief Wildlife Warden is quoted as saying conflict due to tigers and leopards in the state has decreased despite increase in populations.						Newstime Hyderabad Jun 03
Tirumala (Andhra Pradesh)	325	12	2003							Deccan Herald - internet
Himachal Pradesh (Districts of Kangra, Mandi, Solan and Shimla)			1997 – 2003				70			Newstime Hyderabad Jun 03
Himachal Pradesh		- 120 in1984 - 972 out of PA in 1997 - 193 within PA in 1997	Jan 03 – Jun 03	39	6					Newstime Hyderabad Jun 03
			2002 – 2003	75	9					Tribune Oct 03
Nepal			Sep 97 – Sep 99	60						(Maskey & Bauer)
	100	40	2002 - 2003	23	15					India Today Nov 03
Sanjay Gandhi National Park (Mumbai)						12				Indian Express Jun 03
							6			Indian Express Oct 03

A.5.2 Illegal trade in leopard skins and parts

Another facet of the man-leopard conflict and the reason for the threat to the leopard despite its "high density" in some parts of the country is the high demand for the skin and body parts in the illegal wildlife trade. Table A.5.3 give us an insight, albeit small, into the number of leopards that are being killed for the trade in some parts of our country.

Table A.5.3 : Information on illegal trade in leopard skins and body parts.

Date	Item	Number	Site of seizure	Origin of skins	Source of information
October 03	Skins	581	Republic of China	India	WPSI
October 03	Skins	2	Mahartashtra	Gondia, Maharashtra	
June 03	Skins	1	Kerala	Kannur, Kerala	
May 03	Bones	1	Maharashtra	Gadchiroli, Maharashtra	
May 03	Skins	7	Haryana	Uttaranchal	
April 03	Skins	14	Indo Nepal border		
February 03	Skins	20	Siliguri, West Bengal		
January 03	Skins	12	Lucknow, Uttar Pradesh		
May 02	Skins	4	Delhi		
February 02	Skins	4	Kerala	Nilambur, Parambikulam –Nelliyanbatti, Kerala	
January 00	Skins	70	Khaga, Uttar Pradesh	Thought to be Orrisa	
	Claws	18000 (900 leopards)			
December 99	Skins	50	Ghaziabad, Uttar Pradesh	Thought to be Orrisa	

The only data we have on any incidences of illegal poaching from near the conflict areas in Maharashtra is from the Forest Department records of Ratnagiri, Kolhapur, Satara and Sawantwadi, where 12 animals were killed for the trade from October 2000 to March 2003. Of the 14 that were trapped and released to nearby protected areas (mainly Chandoli and one to Amboli), 5 were trapped because they were perceived as a danger to human life, 5 had fallen in open wells, two were caught in rope snares, and two had entered human inhabitations and subsequently died due to weakness or wounds (Table A.5.4).

Table A.5.4 : The capture and death of leopards from the Forest Divisions of Kolhapur, Sindhudurg and Ratnagiri (MSFD data).

Forest Division	# trapped and released to nearby PA's (May 00 – Mar 03)	# dead due to poaching (Oct 00 – Mar 03)	# dead due to other reasons (Jan 01 – Mar 03)
Chiplun	9	5	5
Kolhapur	2	0	1
Satara	0	0	2
Sawantwadi	3	7	4
Total	**14**	**12**	**12**

A.6. Appendix 6 - Important considerations for post capture management of leopards.

While keeping leopards trapped from the wild in temporary captivity, the following points have to be considered:

- Generally a wild animal will avoid humans. But animals, especially leopards, kept in cages with constant exposure to human (especially the source of its food being a human, visitors coming to see the leopard, veterinarian treating the leopard, etc.) may loose the inhibition and attack humans once they are released. ***Also, the more the time in captivity, the more are the chances of this happening.***
- Leopards might get injured during the trapping or afterwards while in cage. Certain injuries, especially broken or fractured canines will make the leopard unfit for release /translocation.
- Leopards in captivity are prone to ectoparasite and endoparasite infestations. Also certain viral diseases might be transmitted by the pet/stray animals especially cats.
- Leopards can contract certain zoonotic diseases while in captivity from the humans especially tuberculosis.

Following measures should be taken to avoid post release complications:

1. Least time in captivity.
2. Minimum exposure to humans.

- Visitors to be **strictly** prohibited.
- Enclosure to be covered from at least three sides. Hiding place to be provided to the leopard in the enclosure.
- Keeper to be instructed to clean the enclosure after shifting the leopard to another part. Having a lifting door or a sliding door that can be operated without the leopard seeing the keeper can facilitate this. Keeping the food in this part of enclosure will condition the leopard to enter without much trouble.
- Leopard should be anaesthetized immediately after capture. Also to be anaesthetized for treatment and during translocations. Use of physical restraint (squeeze cage) should be avoided.

3. Following strict hygienic procedures especially proper cleaning of enclosure, providing good quality and balanced diet, periodic fecal testing and routine deworming, ensuring that the enclosures are rodent proof and stray animal proof and the most important of all ensuring that the keepers are disease free and also free of vices like eating tobacco and spitting.
4. A log or wooden plank must be provided so that they donot have to sit continuously on a concrete floor.
5. Transponder microchip to be inserted in each leopard.

Dr.A.V.Belsare
B.V.Sc &A.H

A.7. Appendix 7 – A study on the man-leopard conflict in Gujarat.

MAN – LEOPARD CONFLICT

**IN THE BARIA FOREST DIVISION,
VADODARA CIRCLE, GUJARAT.**

eCOLLAGE *Sujoy Chaudhuri*

Information contained in this document is based on three reports of the man – leopard conflict by the Offices of the Deputy Conservator of Forests, Baria Forest Division and Chief Conservator of Forests, Vadodara Circle.

Some of the analyses were made after a field visit by members of Ecollage, Dr. Aniruddha Belsare and the author, between 13 – 10 and 14 – 10 2003, that was arranged and coordinated by the Wildlife Protection Society of India (WPSI).

Published at eCOLLAGE

11 A, 203/2A Rajiv Nagar (S)
Viman Nagar, Pune 411 014
Maharashtra

November, 2003.

Since the first counting of the leopard in Gujarat in 1984, the population has increased consistently: from 498 in 1984 to 699 in 1989, 796 in 1993, 803 in 1997 and 1000 in May, 2002. Five districts, viz., Junagadh (287), Amreli (96), Dohad (149), Vadodara (80) and Panchmahals (93) account for over 71% of the total leopard population in the State. Only a third of the population (349) is reported from 9 Protected Areas, the rest being reported from areas outside formal PAs.

From 'Growing Man-Leopard Conflicts in Gujarat State, India'
H.S.Singh, Conservator of Forests, Vadodara Circle

The leopard is more resilient than the tiger or the lion in the face of expanding human pressure.

John Seidensticker

The following sections have been abstracted from three reports of the Offices of the Deputy Conservator of Forests, Baria Division and the Chief Conservator of Forests, Vadodara Circle.

THE PROBLEM

Fourteen people have been killed and 64 injured by leopards in the Baria Forest Division since April, 2003. Thirteen of the deaths and 25 injuries occurred in a single taluka – Dhanpur.

Shooting orders were passed twice, and two leopards were eliminated on the 21st of August and the 4th of October, 2003. Trackers from Gir were called in to help identify the problem animals. There have been no reported incidents of either human injury or death from the region since the second animal was shot.

The State Forest Department initiated concentrated attempts to reduce leopard population densities in and around 49sq.km of the Ulkadar Forest region, the most severely affected area, using baited cage traps. Twenty cages have been placed and five animals (two males and three females) have been trapped since September, 2003. These animals have been moved to the Sakkarbaug (Junagad) Zoological Park, where they are to be maintained in captivity.

Live bait has been spread around approximately 36 sites and a troop of monkeys from Junagad was released into the Ulkadar Forests in attempts to supplement what is considered to be a tremendous shortage of naturally available prey.

The Forest Department began taking pug mark casts using POP in an attempt to be able relate successive (or past) incidents to specific animals.

HISTORY

Six people were killed by leopards in the Dhanpur region during the '98-'99 financial year. Trap cages were set and three animals were captured. No further deaths were reported and the problem was considered successfully dealt with.

We were informed that between 15 and 20 leopards had been captured and released within the limits of the Baria Forest Division in the years preceding 2003. No details of capture or release sites are available at present.

ANALYSIS

From details of compensation[1] paid annually over eleven years across three districts[2], the Department reports maximal conflict levels during May and June. The average number of livestock kills/month is reported at 22 over the last five years, almost double the figure (13) reported for the six years preceding. A similar increase in the average number of human attacks/month is also observed (See Graph __).

The Department relates the apparent seasonality of livestock predation (increasing through summer, below average after the monsoon and through winter) to the following factors:

(i) Migratory pastoralists from Saurashtra move into the region during the winter and stay till early summer, presenting leopards with an increased prey base. Depredations on migratory livestock are largely unreported and therefore not recorded.

(ii) Tall crops like maize and millets grown during the monsoon are harvested in October, breaking cover continuity between forested areas and the villages, thus reducing chances of conflict.

[1] The Department cautions: "*In the absence of a study, it is not possible to estimate the food supply by migratory livestock, especially sheep and goats. Also, people in remote villages do not claim compensation as they are not aware of the provisions or find difficulties in claiming compensation.*"

[2] Vadodara, Panchmahals and Dohad

CAUSATIVE FACTORS IN CONFLICT

1. Hyper-dense leopard populations

Census figures tabulated for the Dohad District reveal a leopard population increase by 40% between 1993 and 1997 and a further 36% increase from '97 levels by 2002.

The last Census exercise of the Baria Forest Division (May, 2002) reported 64 leopards from a Reserved Forest area of ca. 196sq.km. Population densities, based on these figures, have been reported at one animal for every 3sq.km. Age classes of the censussed animals and territory usage by animals have not been reported. There are indications, however, that a single animal was responsible for six different lethal attacks, spread across an area of ca. 14sq.km.

2. Habitat loss and changing patterns of predation

The Department reports dwindling ungulate populations in the Ratanmahal Wildlife Sanctuary. Smaller mammals like the black-naped hare are also reported to be fast disappearing and Wild boar are not reported in large numbers from the area. The Department is of the opinion that dwindling natural prey in forested areas has led to increased levels of depredation on cattle. Hunting by local tribesmen are blamed for the loss of natural prey.

3. Tall crops

Tall crops, especially maize and millets are grown in agricultural fields that surround each household during the monsoon months. The reduced interface between human inhabited areas and the forests are believed to play an important role in the rise in conflict levels during this period.

The Department states in its report: '*This was a good rainfall year. The entire area, except riverbeds, roads and the compounds of official buildings had a thick cover of tall crops (maize etc.) and grasses. Every house was surrounded by maize crops. The leopard could observe movements of people in the daytime, hiding only a few meters away from the house. The animal had full shelter in the crop fields even in the daytime. This provided an opportunity for success of leopard to kill humans outside as well as inside the houses'.*

4. House clustering

Houses are not clustered together to form single village clusters: the people prefer to live independent of others and their houses are solitary, often by more than 200m (see pictures). In another report, the Department notes that 11 of the 14 attacks on humans occurred when the house was solitary; two attacks were on two-house clusters and only one attack on a cluster of three households. They note that no attacks were made in house clusters of more than four units.

5. Changing behavior patterns of the leopard and Man-eating

Analysis of attack incidents at Dhanpur by the Office of the Chief Conservator of Forests, Vadodara Circle indicates that in each case, attacks were intentional: victims were either lifted from inside the house or from the immediate vicinity of the household and were at least partially eaten before the bodies were recovered. Nine of the 14 fatal attacks in the past 6 months involved children under the age of 13, four involved adult women and one a mentally challenged adult male. In nine cases, a leopard entered a dwelling and was able to drag the victim away from the site. Three cases occurred within 15m from the dwelling and in no cases did the attack occur on Reserved Forest lands during resource collection or grazing. The victim's body was recovered in all cases but one, where despite intensive tracking by Department personnel, only the scalp of a 5 year old girl could be recovered, ca. 3km from the attack site.

STRATEGIES FOR MANAGEMENT

1. Population management

Leopard populations are believed to be hyper-dense in the affected area. The Department estimates leopard populations in the 55sq.km Ratanmahal Wildlife Sanctuary at only 19-20 animals, but believes that between 40-50 animals frequent the ca. 49sq.km around the Ulkadar Reserved Forest. The increased density of leopards around human inhabited areas is believed to be a fall-out of the disappearing natural prey available even in core sanctuary areas.

In the immediate short-term, a reduction in density by trapping and removing between 24-36 animals from the area, is thought appropriate to bring leopard populations to '*…the level of human tolerance limit*'.

The Department proposes to initiate a detailed scientific study, using radio telemetry to study behavior, predation patterns and to identify possible breeding sites in the region. Through such a study, they hope to estimate a '*reasonable population limit*' of leopards to be managed in the area. Problem animals would be continually trapped and removed as and when complaints arose thereafter.

The Department also states: '*Proposals for culling of leopards from problem areas is debatable, but this has to be considered seriously'.*

2. Restoration of prey-bases and 'feeding centers'

Chousingha (four-horned antelope) and barking deer comprise natural prey for leopards in the region, but since their numbers in captivity are low, they are not considered suitable for re-introduction to restore depleted prey bases.

The Department intends to translocate wild boar, from populations reported as pests[3] by people from areas in north Godhra and some districts of north Gujarat and Saurashtra. Pigs and langurs, reported in high concentrations in some urban centers are also believed to be good sources of animals that can be translocated to supplement leopard prey bases.

Plans for establishing cage facilities to hold pigs and/or other prey animals are being discussed. The Department is aware of surplus killing by leopards, and plan to establish 'feeding centers' where only a few animals at a time are available to the leopards, while the majority are maintained in close protective conditions.

3. Maintenance of water holes

Since water becomes a limiting factor in summer, the Department plans to establish a series of water holes in strategically located sites to provide for wildlife through this period.

4. Leopard Captivity Center

The current process of capturing leopards and removing them to the Sakkarbaug (Junagad) Zoo is both expensive and potentially harmful to the animal being transported, so the Department has proposed the establishment of a permanent Leopard Captivity Center in Vadodara District, with a minimum capacity for holding two dozen animals. A wild boar breeding center is to be established within the facility to provide food for the captive animals.

5. Training and extension

The frontline staff of the Gir National Park and WLS has some expertise in handling leopard conflict situations. A preliminary training program has already been conducted where staff from Gir introduced local frontline staff to pug mark identification, tracking, trapping and handling of captive animals. The Department intends to continue such programs, specifically targeting Foresters and Forest Guards from the region. Forest Department staff have continually made rounds of all dwellings in the affected area, and made suggestions to householders on improving/repairing/replacing defects in house constructions and on safety measures to be taken. A 'comprehensive educational package' for local communities is also in preparation.

[3] Largely because of crop damage by wild boar and human attacks by langurs

ANALYSING THE CONFLICT

All information from the Office of the Conservator of Forests, Vadodara Circle, Gujarat

Table 1. Forest Department Census figures for Leopards in 3 districts

	Gujarat State	Panchmahals	Dohad	Vadodara
May, 1984	498	NA	NA	NA
May, 1993	699	58	57	55
May, 1997	803	50	95	57
May, 2002	1000	93	149	80

Table 2. Livestock depredation by leopards, Vadodara Circle

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1992	2	2	7	12	13	16	17	13	11	14	9	7	123
1993	6	5	14	10	11	7	15	12	5	6	13	6	110
1994	11	7	3	14	10	14	12	10	5	12	18	18	134
1995	9	4	16	12	19	20	18	15	14	10	14	20	171
1996	24	10	14	18	17	16	10	9	12	9	21	10	170
1997	10	5	8	18	29	37	26	27	20	13	19	26	238
1998	13	11	15	20	26	20	22	24	26	19	26	22	244
1999	22	6	14	21	33	34	11	16	10	16	9	15	207
2000	21	7	14	13	39	40	39	23	19	20	10	8	253
2001	17	29	32	29	37	43	32	29	31	43	27	26	375
2002	28	20	22	24	32	20	22	22	21	27	19	12	269

Table 3. Human injury and death by leopards, Vadodara Circle

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1992	1	0	3	2	3	4	0	0	6	3	2	2	26
1993	6	0	8	2	1	3	2	3	0	0	2	7	34
1994	1	3	2	4	8	2	3	2	2	4	1	1	33
1995	5	2	3	5	13	2	10	4	3	0	4	2	53
1996	2	3	5	11	12	14	10	10	4	7	1	6	85
1997	7	13	4	10	8	14	10	6	8	7	4	4	95
1998	16	5	12	15	7	5	8	8	5	3	4	4	92
1999	2	3	11	6	9	21	2	15	6	4	2	3	84
2000	13	7	2	14	10	5	21	8	11	3	7	20	121
2001	9	6	8	10	23	16	13	8	2	5	5	17	122
2002	12	7	1	13	14	10	6	7	7	2	12	14	105

Table 4. Human deaths by leopards, 2003

No.	Date	Victim	Age	Time	Village
1	28th April, 2003	Kumari Dholkiben Babubhai Baria	9	0000	Amlimenpur
2	3rd June, 2003	Smt. Maniben Walchanbhai Bamnia	65	0400	Amlimenpur
3	11th August, 2003	Sanjaybhai Ratansinh Koli-Patel	4	0300	Antela
4	25th August, 2003	Rakeshbhai Parsubai Palas	13	0300	Raivan
5	25th August, 2003	Rakeshbhai Amarsinh Mavi	12	2215	Dhanpur
6	2nd September, 2003	Kumari Kasamben Shanubhai Dharwa	13	0400	Limbdi Mendri
7	4th September, 2003	Smt. Kamtiben Desinhbhai Rathwa	65	0300	Gadvel
8	16th September, 2003	Smt. Kasiben Bhanabhai Manabhai Dharwa	65	2030	Limbdi Mendri
9	18th September, 2003	Smt. Kesriben Mulabhai Bamnia	50	0200	Raivan
10	18th September, 2003	Rasubhai Lallabhai Bhuria	40	0300	Raivan
11	23rd September, 2003	Kumari Rekhaben Ratansinh Palas	11	2000	Amlimenpur
12	27th September, 2003	Anjuben Simlabhai Sangod	11	0630	Pav
13	27th September, 2003	Rakeshbhai Rupsinh Sangod	6-7	1730	Kantu
14	2nd October, 2003	Kasamben Kanabhai Sangod	5	2115	Ulkhadar

Table 4a. Descriptions of fatal attacks in the Baria Forest Division

No.	Description
1	Victim was asleep in house with parents and younger siblings. Grandfather was sleeping outside. Door made of bamboo – a leopard entered through a gap in the door, caught the victim by her neck and dragged her 50m away towards a pond. Hearing the noise, the Grandfather woke and raised an alarm. The leopard had left the and moved away from the site. The victim was alive but died 14hrs later.
2	Asleep alone at home. Small hut, with bamboo door which had a gap below. A leopard entered through the gap, attacked the woman and dragged her 200m away to the forest. Nobody knew since of the attack since she was alone, and an alarm was only raised when her husband returned the next morning. Blood trail and drag marks led villagers to the body.
3	Sleeping between parents outside house. A leopard caught the victim by the head, but the noise woke the parents who were able to chase the animal away. Victim died on 11.08.03 at 2215 hrs.
4	Asleep with family inside house on the floor. The door was not closing properly so the grandfather was sleeping at the doorway. A leopard entered from below the bed at door, attacked the child in the center of the house and dragged him to the third maize field away from the house in the rain. Alarm was raised, but the body was not found in the dark. The leopard was seen sitting near the kill in the morning.
5	Victim went to the hand pump 10-12m in front of house surrounded with vegetable and maize fields (see picture). A leopard attacked the boy from the front and dragged him N 70m towards a date palm tree. An alarm raised when the boy did not return, and his body was found near the tree.
6	Asleep with elder sister (27) in osri outside house near a 1.5m high wall. A leopard jumped the wall, avoided the sister and attacked the child. Sister raised an alarm, but the child was dragged to maize field along S pathway for 1.5km. The body was only found the next morning.
7	Asleep with daughter-in-law just in osri just outside house. A leopard attacked and dragged the victim 200m away into maize fields. An alarm was raised and on 04.09.03 1m inside maize fields, villagers found the victim's left hand. Sri Baria, Sri. Dahod and other Forest Department staff entered the fields and saw the animal near toddy fields and a sitaphal grove. Shooters were called, but the leopard moved away to fields to the South. A beat was organized, but the animal moved into another field E. The animal was followed and chased back to original field, then again to a maize field to the S where the body was found. The leopard had been shot at with local ('country-made') guns, but managed to escape. The entire episode lasted almost 12 hours.
8	Victim went to the loo and squatted with her granddaughter standing next to her with a lamp. A leopard attacked and dragged her to a maize field first 5m away and then a further 15m away.
9	Victim went to the loo and was attacked outside the doorway. Dragged to maize field (1m deep).
10	The victim (mentally challenged) was asleep with his father (visually impaired) on the ground in a house with no door. A leopard entered, attacked and dragged the victim into the forest. An alarm was raised by his brother the next morning, and blood and drag marks led villagers to his body in the forest.
11	Asleep on the ground with parents and others in a house with a bamboo door. Father asleep nearest the door, then mother, then child. Goats and other cattle were also inside the dwelling. A leopard entered from below the door, caught the child's neck and dragged her from under the door into maize fields 20m away. An alarm was raised, causing the leopard to drag the victim a further 300m away into another maize field where it began to eat the kill. A search was launched that lasted for 2 hrs, brought to house, at 0400 hrs attacked hse near by – clear 4.5ft wall, but could not attack because people awake
12	Went to loo with father, dad went right, child standing outside door. Came from maize fields, attacked neck dragged 7-8m away. Alarm raised, dropped child and ran E to pav forest.
13	At play, with 6-7 other kids. Came from maize fields, attacked neck and dragged into maize fields. Alarm raised, left body and animal left N to Kantu Forest
14	Asleep with elder brother (9yrs) on cot, parents around, attacked from above wooden wall, pushed door and dragged child towards E. Found undies some distance away, blood trail leading to N Forests. Staff and dog squad unable to find body. Scalp recovered 13.10.03

Observations on the attacks by Shri Vihol and Shri Bhabor, ACFs, Vadodara Circle

1. 9 victims between 4-13 years, 4 between 50-65 years and one 40 years old.
2. 5 of 14 attacks occurred after 0200 and before 0400hrs; 4 between 2000 and 2230hrs; 3 between 0500 and 0630; 1 at 1700 and 1 at 0000hrs
3. 11 attacks were within 1km of Reserved Forest boundaries
4. 11 attacks were in solitary houses; 2 in 2 house clusters and 1 with 3 houses
5. In 6 of the attacks, the victim was not eaten/ was found before being eaten
6. 9 victims were asleep; 3 were attending nature's call and 1 was washing
7. 6 victims were males (5 children) and 8 were females (4 children)
8. On 25.09.03, a leopard was shot at Sajoi. The animal had been shot at on 18.09.03 and had killed 1 person on 2/9, another on 16/9 and 2 on 18/9: this was verified from pugmarks and charra in the dead animal.
9. The leopard responsible for an attack at Antela on 11.08.03, was trapped in cage at Raiabar, 1500m away on 22.09.03.
10. No pugmarks were found near attack sites on 27.04.03 and 3.06.03.

Table 5a. Pug mark measurements at different human kill sites, 2003

No	Village	Date	Time	PML	PMB	Remarks
1	Pav	20.9.03		8.3	6.8	Taken near nala. Connection to human death unknown.
2	Sajoi	21.9.03	1800	7.9	9.2	Male, killed by shooters
3	Pav	23.9.03	0200	7.7	7.0	Animal entered house and injured women
4	Amlimenpur	23.9.03	2000	9.2	8.1	One of these three animals entered house, killed and dragged child into fields
5	Amlimenpur	23.9.03		8.8	8.6	
6	Amlimenpur	23.9.03		9.8	9.3	
7	Pav	29.9.03	1600	9.9	9.3	Fresh, near cave
8	Amlimenpur	1.10.03		8.8	7.9	Taken near live bait (killed and dragged)
9	Kantu	3.10.03		9.4	9.0	200m from foresters quarters. Dam with cubs spotted on night before attack
10	Amlimenpur	4.10.03		8.7	7.1	Female, killed near Zabu
11	Amlimenpur	4.10.03		9.1	7.8	Was with shot female and another animal

Table 5b. Pug mark measurements at different human kill sites, 2003

No	Village	Date	PML	PMB	PT	TT	Soil	Remarks
1	Amlimenpur	24.9.03	9.5	8.3	6.0	6.5	Sandy	Near victim's house
2	Amlimenpur	24.9.03	9.0	8.9	5.5	7.2	Loamy	Near victim's house
3	Amlimenpur	24.9.03	9.2	8.5	5.5	7.5	Loamy (wet)	Field victim was dragged into
4	Ulkadar	3.10.03	9.0	9.0	5.6	7.2	Sandy	
5	Kanakuwa	4.10.03	9.2	9.3	5.5	7.0	Loamy (wet)	In maize field
6	Pav	20.9.03	8.4	6.8	5.2	5.5	Loamy	Near cave
7	Pav	29.9.03	10.2	9.5	6.0	7.5	Loamy	Near cave
8	Zabu*	5.10.03	8.8	7.4	5.9	6.1	Muddy	
9	Kanakuwa	7.10.03	7.8	8.0	5.0	6.1	Sandy	Near water source
10	Zabu	5.10.03	9.0	6.7	6.2	5.0	Sandy	Tuwar field where leopard was shot
11	Amlimenpur	9.10.03	8.0	7.0	4.5	5.5	Sandy	Near taken open bait
12	Kanakuwa	9.10.03	9.3	9.1	5.6	7.5	Sandy	Near trap cage

The following sections are based on inputs provided by Ecollage to the Baria Forest Division

Analysing man-leopard conflict: information collection mechanisms

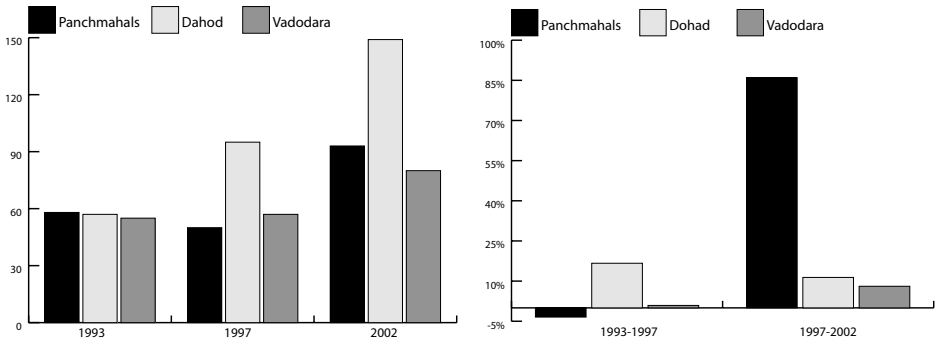


Fig.1(a) Leopard census figures in the Vadodara Circle, Gujarat (b) Rates of population increase in each Division

Census estimates indicate that leopard populations increased by 18.8% between 1993 and 1997 and by a further 59.40% by 2002. Annual rates of population increase, however, have been different in each Division: decreasing from 16.67% to 11.37% in Dahod; increasing dramatically from -3.45% to 86% in the Panchmahals and more modestly from 0.91% to 8.07% in Vadodara.

Conflict from fringes of Protected Areas appear to be related to individuals dispersing from source populations within the PA (see J.D.C. Lindell), but in Baria and the Ratanmahal Sanctuary, prey base density is reported as severely depleted, indicating that the source population is dispersed in areas outside the PA.

The seven leopards (five have been trapped and two shot) removed from the population presently inhabiting the Baria area we visited, indicate a male-female sex ratio of ca. 40:60. Clearer pictures of sex ratios in the population might be accessed from the 15-20 instances of capture-release conducted in the region prior to 2003. That the population is breeding is evident from (i) pug marks collected (see also photographs), (ii) sighting of a dam with two cubs the evening before an attack and (iii) three animals that were seen moving together (a dam with juveniles?) before one of them was shot when shooting orders were first passed. Of twelve animals reported so far, four have been cubs/juveniles.

Both livestock depredation and human attacks summed over all three Divisions in the past decade coincide well (r=0.86 and 0.83) with increasing leopard populations (see Fig. 2) but need to be analysed at the Division level: it would be interesting to see if conflict in the Panchmahals rose as dramatically as the leopard population.

Separating the conflict data into pre- and post 1997 levels reveals a near doubling in the average number of incidents witnessed (Figure 3). Man-leopard conflict in the Junnar Forest Division does not appear to follow the same patterns of seasonality, but might merely reflect the difference in scale of measurements (the Gujarat data sums conflict over three districts, while the Junnar Forest Division is comprised of only three talukas) though conditions in both areas are comparable (Figure 4). Figures 5 and 6 depict the changing patterns of conflict in the Vadodara Circle through the decade.

Far more detailed analysis needs to be conducted before any definite assumptions can be made of critical causative factors responsible for conflict. But questions posed by the limited data available are interesting: why have leopard populations increased dramatically despite reportedly rapidly decreasing natural prey? can large populations of leopards now not only live in close proximity to humans but begin to exploit the habitat successfully enough to double their numbers in ten years?

The challenges posed to managing leopard conflicts are then substantial: the removal (lethal or otherwise) of only a few of the animals from such a region would serve little long term control benefit.

The speed at which data is collected and analysed, especially in conflict situations, is often critical to making effective management decisions. Man-wildife conflict analysis is currently based almost entirely on records of compensation paid to claimants by State Forest Departments. The 'panchanama' process, required to be conducted before compensation is paid, is a detailed one, recording not only the time and place of the attack, but also the type of livestock lifted, age, weight, habitat and other details (such as whether the conflict animal was permitted to eat, distance to nearest RF etc). As with other accounting procedures, however, these are only compiled and analysed at

the end of the financial year, and ignore several aspects critical to understanding man-wildlife conflict in favor of summing up the total amount of money paid to victims. Not only does the information contained in the panchanamas become dated, but the conflict is then left to be analysed on the basis of secondary and even tertiary data sources rather than primary ones.

Leopards are known to range widely and occur infrequently over large parts of their home range. Monitoring population trends are even more difficult to analyse. The annual animal census conducted by State Forest Departments is thus often inadequate, because the exercise is only conducted on lands legally notified as either RF or PA. Administrative boundaries (imaginary lines drawn on paper) are never appreciated by wildlife, and there is a need to base methodologies on ecological gradients instead. Census reportage also needs to incorporate population information such as sex and age classes to be effective in analysing conflict. Pug-mark recognition software, developed at the Wildlife Institute of India, could be used to standardise analysis and build databases of collected plaster impressions and/or photographs.

Camera phototraps and powerful statistical methods have been employed to quantitatively monitor populations of cryptic, wide-ranging carnivores when individuals of the species can be identified (Karanth and Nichols, 2002). Concurrently, prey populations can also be monitored using the same phototraps. With long-term use camera phototraps enable monitoring of changes in populations over time. Activity patterns can be determined, even for mammals that cannot be individually identified. IR trap units have been developed at low cost in Pune, and might be procured for testing in the area.

The initiative taken by the Baria Division in tracking leopard attacks on humans through pug-mark collection is appreciable. Through this simple technique, the Department was able to identify two animals (one shot and one trapped) responsible for at least __ of the 13 attacks. The usual problems of substrate unfriendly to making plaster impressions and the lack of expertise in making casts continues to hamper the initiative. Digital photography presents a cost effective alternative to POP casts and does not require training for proficiency in use. There are a number of digital cameras available in the market at costs lower than Rs. 10,000.

Rather than depend on guesstimates of prey composition from financial records of livestock depredation, scat analysis would reveal truer scenarios. Unfortunately, scat collections are neither made nor is presence recorded unless a 'scientific research project' is undertaken. This needs to be rectified immediately, especially in conflict areas, and can be done at little or no cost to the Department.

Methodologies have been developed that now also permit the determination of phylogenies through DNA sequencing of intestinal epithelia from scat. Details can be accessed from F.Palomares, J.A.Godoy, A.Piriz, S.J.O'brien & W.E.Johnson's 2002 paper, '*Faecal genetic analysis to determine the presence and distribution of elusive carnivores: design and feasibility for the Iberian Lynx*' in Molecular Ecology (11:2171-2182); a 2002 paper by H.B.Ernest, E.S.Rubin & W.M.Boyce, '*Fecal DNA analysis and risk assessment of mountain lion predation of bighorn sheep*' in the Journal of Wildlife Management (66:75-85); and a 2000 paper by H.B.Ernest, M.C.T.Penedo, B.P.May, M.Syvanen & W.M.Boyce, '*Molecular tracking of mountain lions in the Yosemite Valley region in California: genetic analysis using microsattelites and faecal DNA*' in Molecular Ecology (9:433-441). Though the method has yet to be standardized for leopards in India, it holds tremendous promise in terms of being able to identify not only the species, but also individual animals, lending itself to assessments of both leopard density and ranging behaviour. The National Center for Cell Sciences at Pune (a National Center for Excellence) has in the past expressed a willingness to be involved in the standardization process and further analyses. Their expertise could be utilised if similar facilities cannot be accessed within Gujarat. The Wildlife Institute of India is currently in the process of establishing a laboratory for the same purpose, and this facility can also be accessed.

Encouraging participation by local communities in data collection and reporting could help strengthen relationships with the Forest Department. Members of local communities co-opted into the process would also help bridge shortfalls in manpower faced by the Department, and could report leopard presence, sightings, dog and livestock predation, scats and pug-marks on a daily basis. The Division at Baria has accepted and immediately implemented one such information collection process, whereby a specified individual from each village is to be paid daily wages for reporting. The Department could take the data collected through these sources and discuss them periodically with local communities to further build on relationships.

Trap Cages: placement, construction and design

One instance of capture in the Kantu Round illustrates the pressing need for improving trap cages in man-leopard conflict areas: a large animal that had been caged, pried apart the weakened weld of a single bar, and was able to escape through a gap not wider than 9 inches. The Baria Division has some 20 trap cages, most of which are old and weigh upwards of 400kgs. Faced with the difficulties associated with moving heavy cages to effective capture sites over complex terrain, the Department has been experimenting with newer trap cages that are both collapsible and light weight.

Two prototypes have emerged: a telescopic cage (as used in Gir, which we were unable to see) and a triangular, collapsible cage. The triangular cage concept is promising, but requires minor modifications. The spring-loaded door that is currently mounted to set off from inside the cage, should be changed to an exterior mount which is released by a combination of springs and gravity, increasing chances of succesful closing without injuring the trapped animal.

Trapped animals invariably bang their heads repeatedly against the bars of the cage, and some simple modifications might be made to prevent these injuries. Cages fabricated by the Junnar Forest Division used FRP sheets for walls rather than the more traditional bars, to develop cages that provided several advantages, including protecting trapped animals from post-capture injury, reducing overall weight and limiting exposure of the trapped animals to humans. Removable FRP sheets could similarly be used to line the *interiors* of the collapsible triangular cages being developed in Gujarat.

The placement of trapping cages is critical to capture: local information networks and frequent data analysis that feeds into the trapping program are the only low-cost approach to minimize effort (and expenses) in cage movement while increasing probability of capture. The trapping situation at Junnar was augmented by local people, acting not only as information sources but also providing vehicles and manpower for cage movement.

Home improvements

Tribal homes in the Baria region, built of locally available materials, have never been specifically designed to keep leopards out. As in other tribal areas, livestock are usually bedded inside the dwelling. The Department records seven cases in which a leopard was able to enter dwellings because of defects in construction. They have already suggested implementation of Household Improvement Programs to the State Government, and this is an area where the non-government sector could provide valuable input. 'Improvements' (often a euphemism for reconstructions) need to be sensitive to individual household needs, and should be based on participatory processes rather than implement preset, urban-centric ideas of development. Architects like Laurie Baker have excelled at this and could be encouraged by the WPSI to guide the program.

The Department records 11 of 14 fatal incidents where dwelling units were isolated, sometimes by more than 200m. Maize, grown on individual holdings, often reaches the walls of houses. Providing households in the region with low range, two-way mobile radio sets could help reduce the effects of isolation and quicken response time significantly enough to help save lives (Chinese manufactured units are now available at low cost in the open market).

Community Exchange Programs

In the last three years, the frontline staff of the Junnar Forest Division in Maharashtra has been exposed to astounding levels of man-leopard conflict. They have trapped over a hundred leopards and the strong support they continue to receive from local communities stands testament to their success in dealing with people. Levels of expertise have been built in areas of cage design, trap placement, movement and recovery, captive holding facilities, maintenance in captivity and in creating spaces for interaction with local communities.

The WPSI and ECOLLAGE could facilitate a week-long (inclusive of travel) Experience Exchange Program between frontline staff of the two Divisions. Although personnel at Baria have already been exposed to training by experienced trackers of the Gir Protected Area, an exchange of experiences with staff at Junnar could provide several learning opportunities at little or no cost to either Department. Such a Program would require permissions to be granted at the PCCF level in both States since it involves the movement of personnel across State borders.

Organizing exchange programs between peoples affected by wildlife conflict could augment community interface building measures by the Forest Department. Making possible and providing space for interaction between a small group of Maldharis from Gir and local communities at Baria might yield greater benefit in terms of building community support for Departmental actions, than in attempting to conduct community interactions alone.

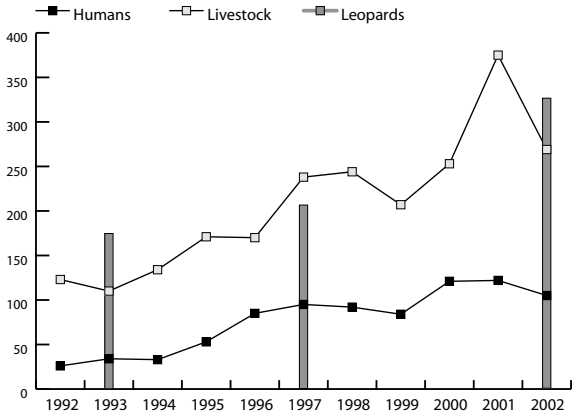


Fig.2. Leopard population increase against increasing livestock depredation and human attacks

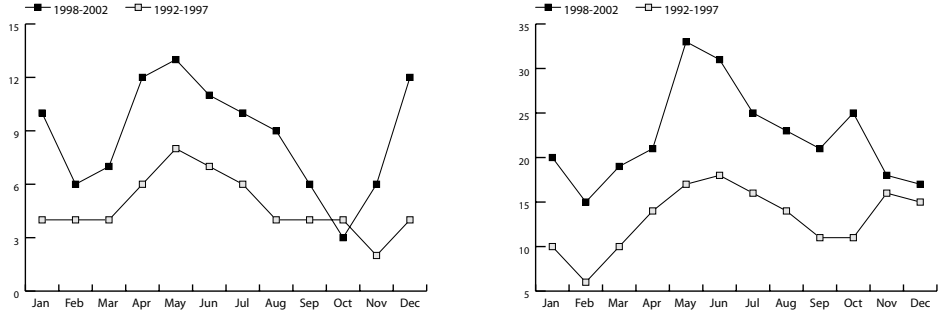


Fig.3. Conflict averaged by month over two time spans 1992-1997 and 1998-2002 (a) Human attacks (b) Livestock kills

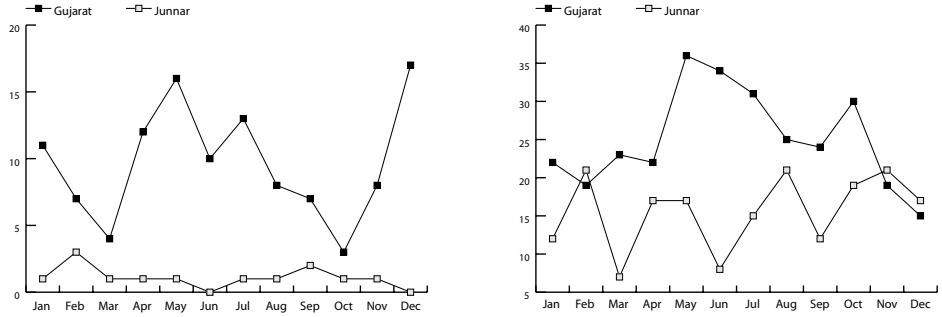


Fig.4. Seasonality of conflict in the Baria (Gujarat) and Junnar (Maharashtra) Forest Divisions averaged between 2000-2002 (a) Human attacks (b) Livestock depredation

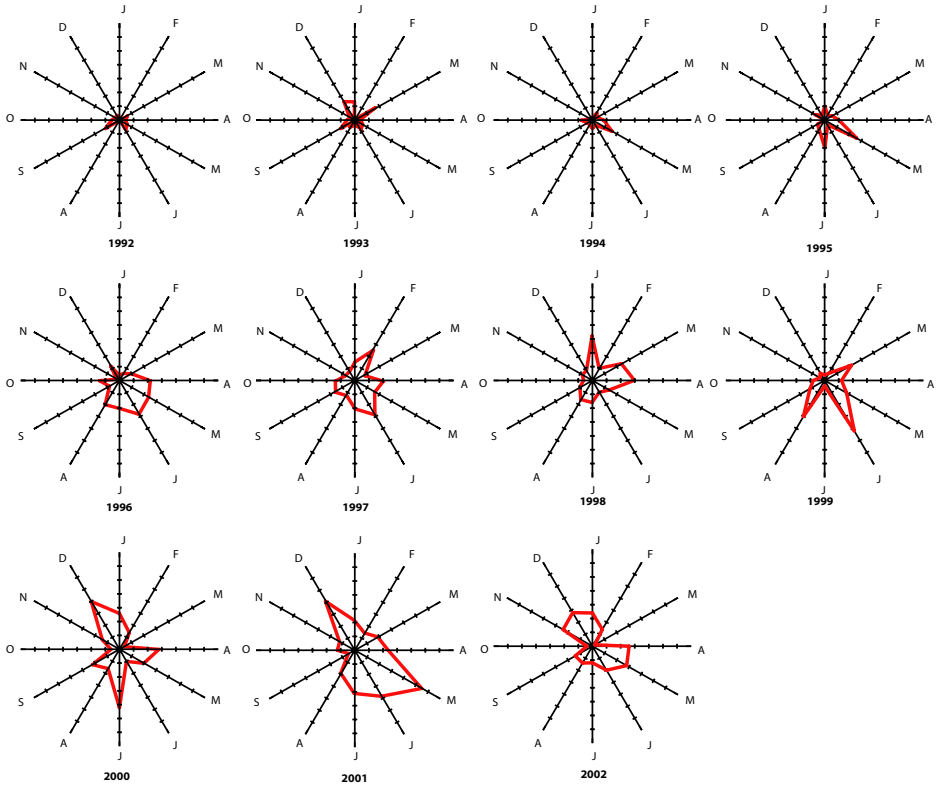


Fig.6. Human attacks by leopards between 1992 and 2002. Each division represents 5 victims.

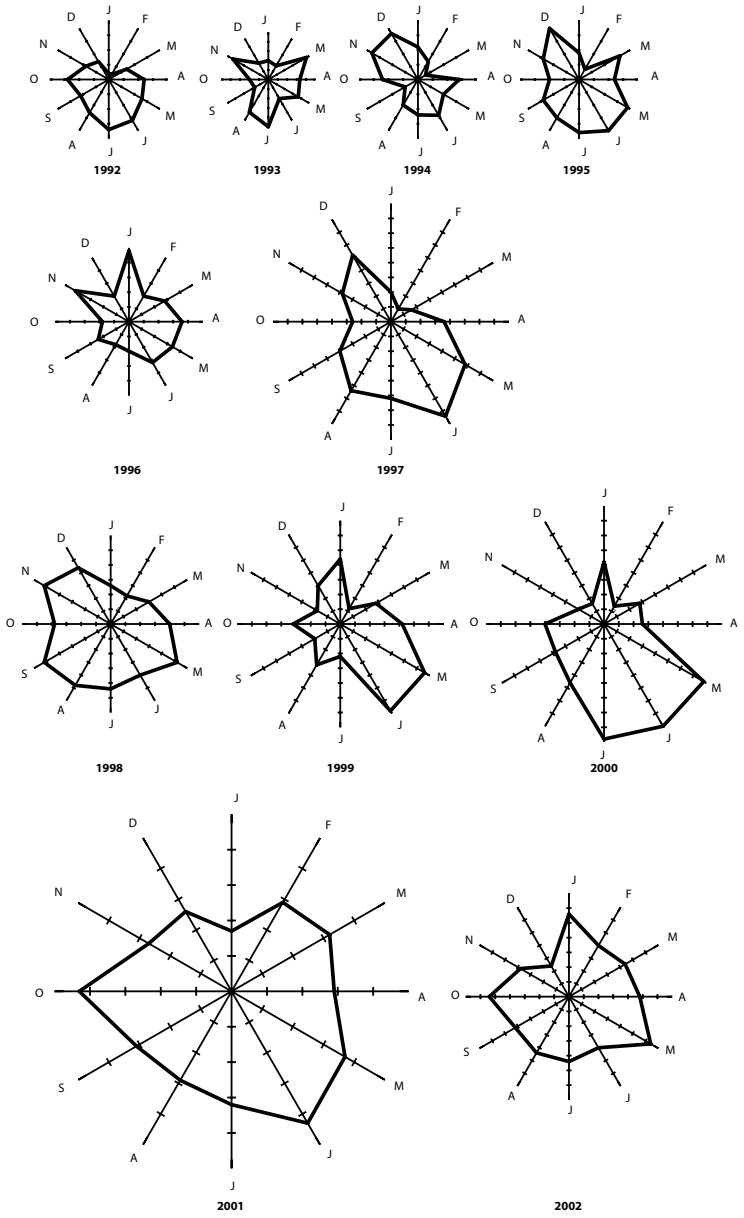


Fig.6. Livestock depredaton between 1992 and 2002. Divisions represent 5 kills except in 2001, where each division = 10 kills.

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