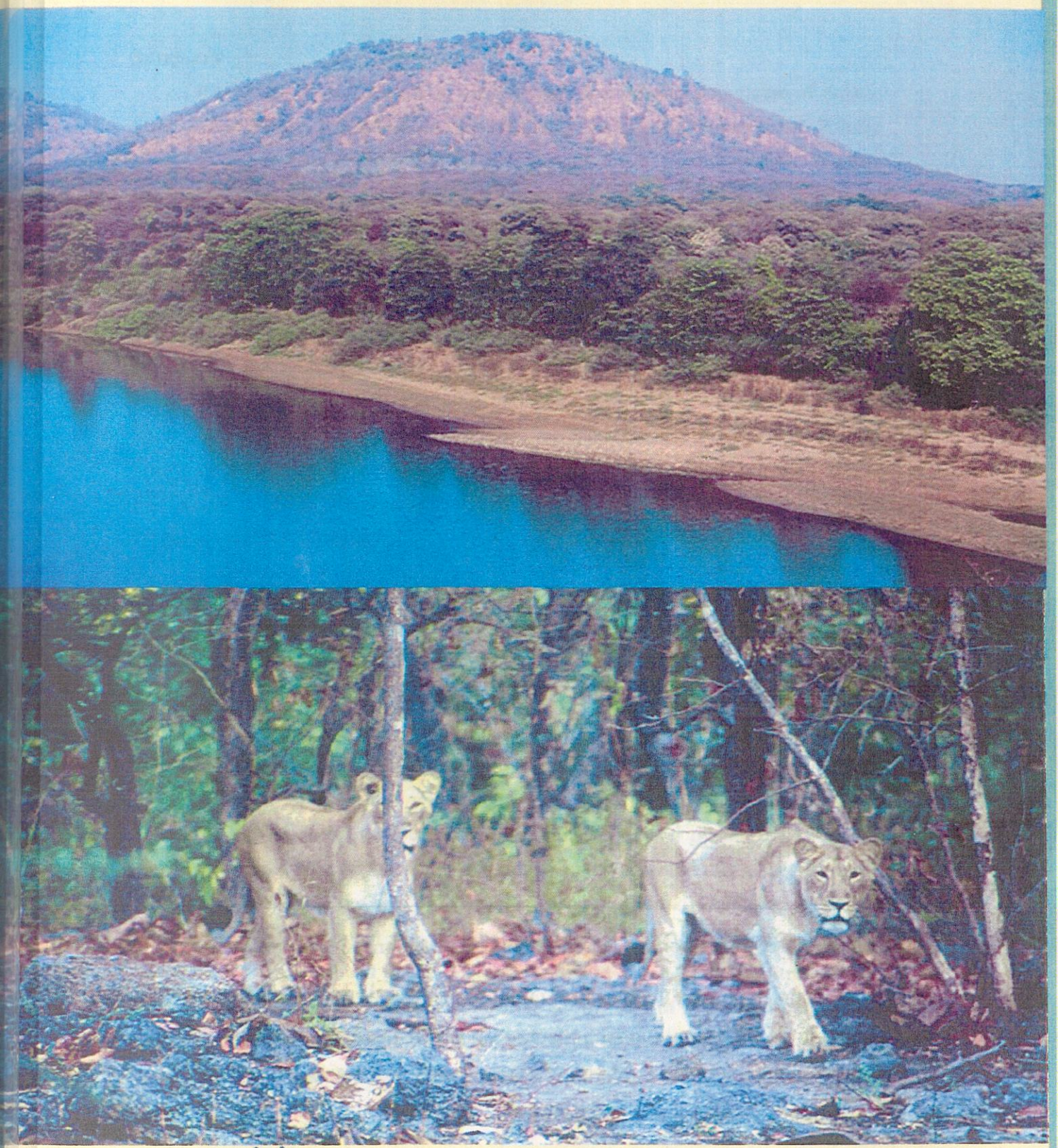
Assessment of prey populations for lion re-introduction in Kuno Wildlife Sanctuary, central India



भारतीय वन्यजीव संस्थान
Wildlife Institute of India

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Cover photos : Kuno river and Tongra (480 m asl). & lions in Gir Protected Area

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Photos : **Dr. A.J.T. Johnsingh**

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Summary

Realizing that it is unwise to keep the only free-ranging population of Asiatic lions (*Panthera leo persica*) in one location (Gir forests), the Government of India made an effort to establish the second population in Chandraprabha Wildlife Sanctuary (WLS, 96 km²), Uttar Pradesh, in 1957. This effort, for various reasons, did not succeed. In 1993-94, with the aim of finding a second home for the lions, a team from Wildlife Institute of India (WII) surveyed three wildlife habitats in the states of Rajasthan and Madhya Pradesh. Among the three, Kuno WLS (345 km^2) was identified as the most suitable site. With assistance from the Government of India, a twenty-year project was initiated in 1995, to establish a disturbance-free habitat here for reintroducing lions. Between 1996 and 2001, twenty-four villages, with about 1547 families, have been translocated from the Sanctuary by the Madhya Pradesh Forest Department. The Madhya Pradesh Government has also demarcated a 1280 km^2 Kuno Wildlife Division, encompassing the Sironi, Agra and Morawan forest ranges around the Sanctuary.

In order to assess whether the Sanctuary has sufficient wild prey base, the WII was requested to asses the availability of prey in early 2005. With the assistance of 34 forest staff 17 transects totaling 461 km were surveyed over an area of 280 km^2. The density of catchable wild prey (chital, sambar, nilgai, wild pig) by lions was 13 animals/km^2. There are about 2500 cattle, left behind by the translocated people which are considered to be the buffer prey for lions to tide over the likely problem of drought periodically killing wild ungulates. With the implementation of the recommendations such as the control of poaching, grassland management, building rubble wall around the Division and water augmentation, we predict a substantial rise (ca.20 animals/km^2) in the wild prey base for lions by end of 2007. **This prey density would be able to support the first batch of five lions (three females and two males) to be reintroduced in the beginning of 2008. Even if all the three females raise cubs, there will be sufficient wild prey by the end of 2009 to support them. Meanwhile efforts should be made to implement all the recommendations given in this report with immediate effect and get the whole hearted support of Gujrat Government to make this historic venture a success.**

Assessment of prey populations in Kuno Wildlife Sanctuary, Central India, for lion re-introduction

The only free-ranging population of ca. 350 Asiatic lions (*Panthera leo persica*) exists in the Gir Wildlife Sanctuary (WLS, 1154 km^2), Gir National Park (259 km^2) and surrounding Protected and Unclassed Forests (470 km^2), totaling 1883 km^2, in the state of Gujarat, western India ((Ravi Chellam and Johnsingh 1993, Singh 1996, Johnsingh *et al.* 1998, Jhala *et al.* 1999). Animal populations, which are small and restricted to single sites, face a variety of extinction threats from genetic and environmental factors. Theories of conservation biology (Gilpin and Soule 1986) warn us against such threats. Catastrophes like an epidemic could result in the extinction of an endangered species when it is restricted to a single site. That this threat is very real has been proved by the outbreak of canine distemper in the lions of Serengeti NP, Tanzania in 1994 (Roelke-Parker *et al.* 1996). It was estimated that 85% of the Serengeti lion population had Canine Distemper Virus antibodies and at least 30% of the Serengeti and Mara lions died due to the infection. Compared with Gir, the lion population in the 40,000 km^2 Serengeti-Mara ecosystem is large, with about 2500 lions (Bauer and Van Der Merwe 2004). If an epidemic of this scale were to affect the lions in Gir, it would be very difficult to save them from extinction, given the much smaller area of the Gir forests, and the smaller lion population. The disease can easily spread to the pockets of habitat such as Girnar, Mityala, Rajula and Kodinar, 10-30 km from the Gir protected area. These pockets may have a maximum of 10 to 15 lions each. This is sufficient justification to have a second free-ranging population of Asiatic lions far away from Gir. This would go a long way in ensuring the continued survival of Asiatic lion populations in the wild.

In fact, an attempt was made in 1957 to establish such a population in the 96 km^2 Chandraprabha WLS, in Uttar Pradesh (Negi 1965). However, lack of understanding on adequacy of prey base, crucial habitat requirements and the insufficiency of protection, habitat management and monitoring resulted in the failure of this reintroduction programme.

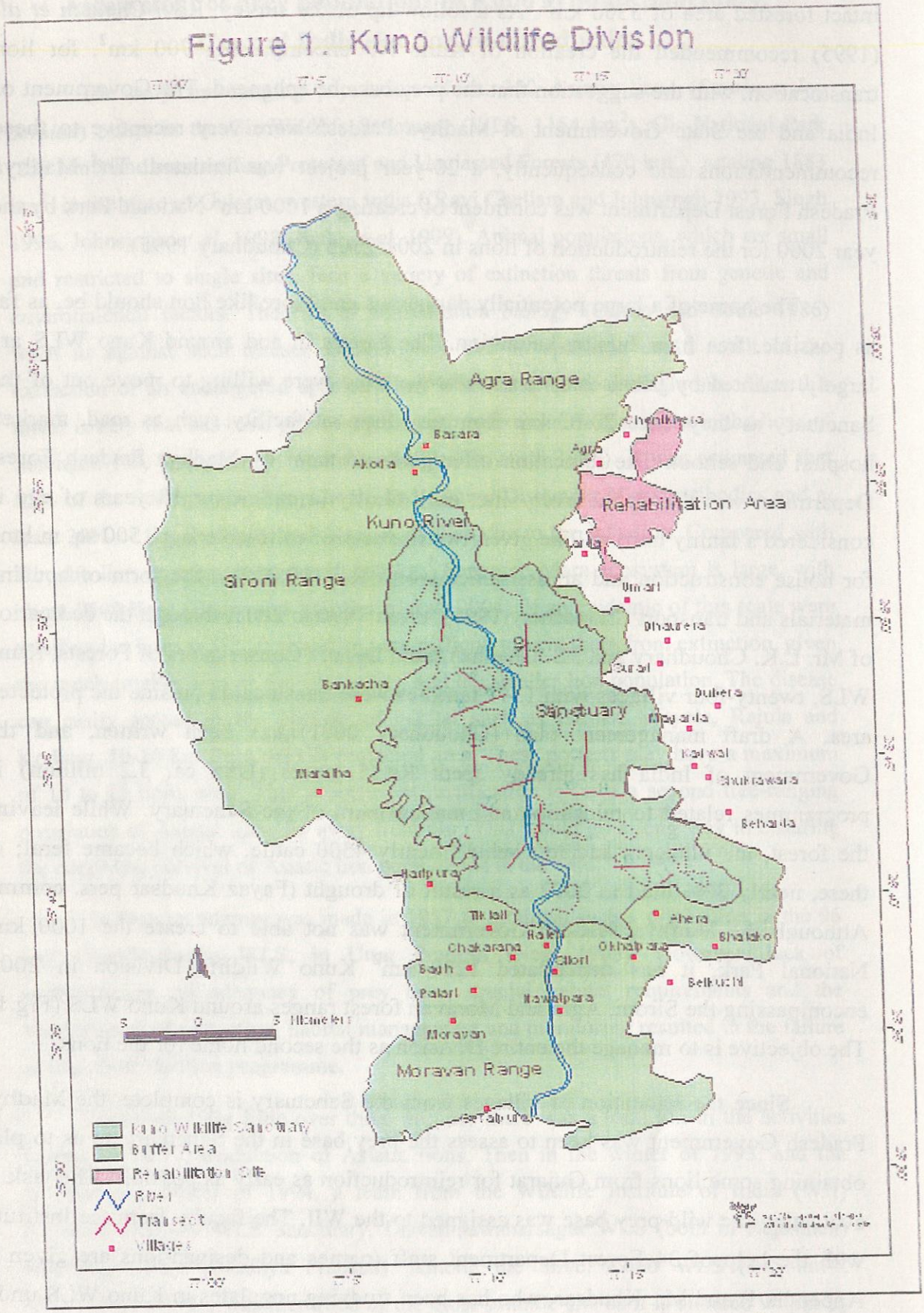
Thereafter, for little over three decades there was a total lull in the activities related to the reintroduction of Asiatic lions. Then in the winter of 1993, and the summer and winter of 1994, a team from the Wildlife Institute of India (WII) surveyed Sitamata WLS Sanctuary, Darrah-Jawaharsagar WLS (both in Rajasthan) and Kuno WLS (Madhya Pradesh). Among the three, Kuno WLS (345 km^2), established in 1981, was identified as the most suitable site as it is situated within an

intact forested area of 3300 km^2. As a follow-up of the survey, Ravi Chellam *et al.* (1995) recommended the creation of Kuno NP encompassing 700 km^2, for lion translocation, with the suggestion that the prey base be enhanced. The Government of India and the State Government of Madhya Pradesh were very receptive to these recommendations and consequently, a 20-year project was initiated. The Madhya Pradesh Forest Department was confident of creating a 1000 km^2 National Park by the year 2000 for the reintroduction of lions in 2001-2005 (Choudhary 1995).

The home of a large potentially dangerous carnivore like lion should be, as far as possible, free from human habitation. The forests in and around Kuno WLS are largely tenanted by tribals known as *sahariya* who were willing to move out of the Sanctuary as they were 20-30 km from any form of facility such as road, market, hospital and school. The relocation offer given to them by Madhya Pradesh Forest Department was that at the every site, each family (a male over 18 years of age is considered a family unit) will be given two hectares of cultivable land, 500 sq. m land for house construction and an assistance worth Rs. 100,000 in the form of housing materials and transport (Choudhary 1995). From 1996 to 2001, through the dedication of Mr. L.K. Choudhary and J.S. Chauhan, both Deputy Conservators of Forests, Kuno WLS, twenty-four villages with 1547 families were translocated outside the protected area. A draft management plan (Choudhary 2001) has been written, and the Government of India has already spent Rs.15 crores (US$ ca. 3.2 million) in programmes related to relocation and management of the Sanctuary. While leaving the forest, the villagers had left behind nearly 4500 cattle, which became feral; of these, nearly 30% died in 2002 as a result of drought (Fayaz Khudsar pers. comm). Although the Madhya Pradesh Government was not able to create the 1000 km^2 National Park, it has demarcated 1280 km^2 Kuno Wildlife Division in 2002, encompassing the Sironi, Agra and Moravan forest ranges around Kuno WLS (Fig.1). The objective is to manage the entire Division as the second home for the lions.

Since the relocation of villages from the Sanctuary is complete, the Madhya Pradesh Government was keen to assess the prey base in the Sanctuary so as to plan obtaining some lions from Gujarat for reintroduction as early as possible. The task of evaluating the wild prey base was assigned to the WII. The faculty from the Institute, with the help of 34 Forest Department staff (names and designations are given in Appendix I) and Mr. Khudsar, who has been studying ungulates in Kuno WLS under the guidance of Dr. Raghu Chundawat, carried out the prey assessment exercise from 2nd to 8th January and 8th to 13th February 2005.

Figure 1. Kuno Wildlife Division



On 2nd January, the staff were briefed about the purpose of this exercise, and were given some training to use the compass and visually estimate the angular sighting distances of large mammals seen from the transect lines. Seventeen transects (Fig. 1), spread over an area of ca. 280 km^2 of the Sanctuary, ranging in length from 1.8 to 3.2 km, were walked 17 times each, and the total distance walked was 461 km. No tiger pugmark was seen during this period although a few tigers were reported earlier. The density of catchable wild prey (chital, sambar, nilgai, wild pig) by lions was 13 animals/km^2 (Table 1, Appendix II.1 – II.4), and this gives an availability of about 3609 animals. Population estimation of cattle, which occur in large groups confined to certain locations, by line transect method is not reliable, and therefore we used the population estimate given by Mr. Khudsar, who by counting them at the yarding sites, report a minimum of 2500. Including cattle, the total potential prey was 6109 animals. In this exercise of assessing whether Kuno WLS is ready to receive lions, we made conservative estimate by considering cattle as a buffer prey, and the arboreal langur, the low-density chowsingha (four-horned antelope) and open-country living fleet-footed chinkara as prey rarely available to lions.

Table 1. Density estimates of wild ungulates and livestock in Kuno Wildlife Sanctuary, January-February 2005.

Species	Group and Individual Density	Density Estimate (no/sq. km^2)	% CV	Confidence Interval 95%	
				Lower	Upper
CHITAL	GD	2.32	24.25	1.41	3.81
	ID	6.22	25.11	3.73	10.34
NILGAI	GD	1.38	22.31	0.88	2.18
	ID	3.28	23.67	2.03	5.29
SAMBAR	GD	0.36	35.62	0.17	0.74
	ID	0.58	39.75	0.26	1.27
WILD PIG	GD	0.80	27.20	0.46	1.40
	ID	3.19	31.16	1.72	5.93
CATCHABLE WILD PREY	ID	12.89	19.27	8.72	19.05
CATTLE	GD	1.05	46.31	0.41	2.66
	ID	5.02	51.26	1.86	13.58
CHINKARA	GD	1.46	20.89	0.95	2.25
	ID	2.60	21.89	1.66	4.06
CHOWSINGHA	GD	0.22	85.39	0.05	1.05
	ID	0.28	86.20	0.06	1.37

Note:- GD = Group Density, ID = Individual Density, Effort = 461 km .

A female tiger kills about 40-45 ungulates per year, consuming about 2000 kg of meat (or about 3000 kg of live prey) just for maintenance. The quantity of live prey consumed by adult males is higher (4000 kg/year) and by juveniles and cubs less. A tigress raising three cubs needs about 60-75 prey/year (Schaller 1967, Sunquist 1981, Sunquist *et al.* 1999). We assume that 50 wild catchable ungulates can support a lion for a year. If we bring in five lions (three females and two males) in the early summer of 2005, they will need about 250 wild ungulates/year. All predators (lion, leopard, cheetah, wild dog and spotted hyena) in Serengeti removed 9-10% of estimated prey biomass per year (Schaller 1972). It is assumed that the number of wild ungulates that can be sustainably hunted from the existing population of 3609 in a year will be around 360. This suggests that even now (early summer of 2005) the existing wild prey number can support 5 lions. The entire area (280 km^2) may not initially be occupied by lions. We have estimated the number of lions 100 km^2 of Kuno WLS can support (Appendix III). We visualize four scenarios based on three different calculations; number of lions the prey base in 280 km^2 can support, number of lions in 100 km^2 based on Carbone and Gittleman (2002) formula for lions and Karanth *et al* (2004) for tigers (we have considered a tiger equivalent to a lion in terms of metabolic requirements).

Scenario I: All the three females give birth towards the end of the summer of 2005 and raise two cubs each to adulthood. If this happens the number of animals needed to support 11 lions at the end of 2006 will be 550 and at the 10% harvestable rate the prey base required in Kuno WLS should be 5500 animals. This means the existing population should increase from 3609 to 5500 (1.52 times) in 18 months, which would cover two breeding seasons. Based on logistic growth model, the expected prey population in year 2006 will be around 4452 (Fig.2, Appendix III). There will be a shortage of 1048 animals. The lion number following a conservative estimate can support only 3 lions/100km^2 (Fig.6. and Appendix III). Therefore, we do not recommend release of lions in 2005.

Scenario II: Two females give birth in the summer of 2005 and raise two cubs each, to adulthood. In this scenario, the number of ungulates needed to support nine lions at the end of 2006 will be 450, and at the 10% harvestable rate, the prey base required in Kuno WLS should be 4500 animals (Fig.2, Appendix III). This is short of

48 animals. The lion number estimated in this scenario is also low 4 lions/100km^2 (Fig.6. and Appendix III).

Scenario III: Two females give birth in the summer of 2005. One raises one cub and the other two cubs. In this situation, the number of kills needed to support eight lions at the end of 2006 will be 400, and at 10% harvestable rate, the prey base should be 4000 animals (Fig.2, Appendix III). Surplus animals in this scenario will be 452. The lion number estimated in this scenario is also low (Fig.6. and Appendix III).

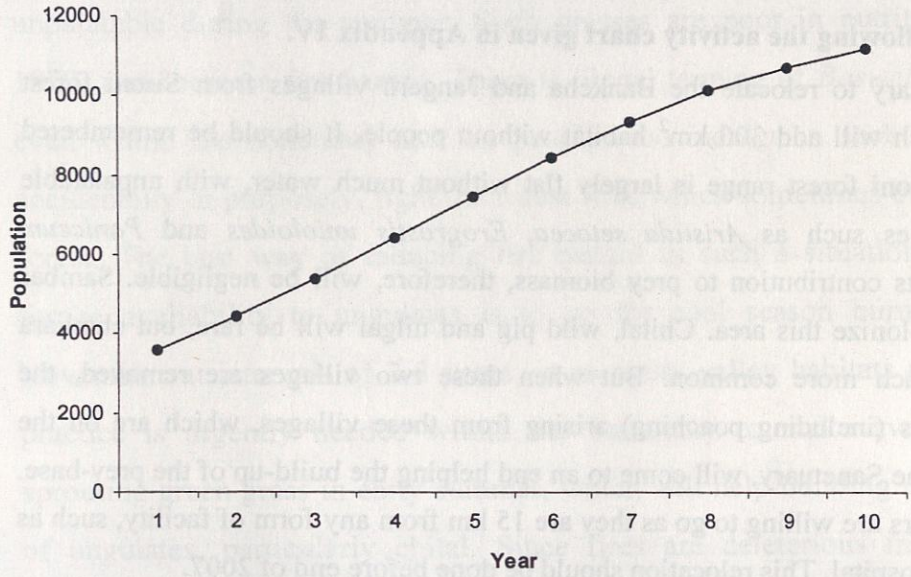


Fig. 2. The logistic growth rate of catchable lion prey (chital, sambar, nilgai and wild pig). Base year for modeling is 2005.

Scenario IV: Based on the logistic growth model, one can assume that the wild prey base for lions by end of 2007 will be 5403 animals which can grow to 7469 at the end of 2009. This prey base can easily support the first batch of five lions (three females and two males, prey required 250 animals) which could be brought in the beginning of 2008 and the likely population of 11 to 14 animals (prey required 700 animals) by the end of 2009 (Fig. 2, Appendix III). This scenario can support five lions even by conservative estimate (Fig.6. and Appendix III).

Reported average heterozygosity and polymorphism in Asiatic lions is 0.087 and 0.19 respectively. This is low when compared to African lions which have a value of 0.567 and 1 respectively (Uphyrina and O'Brien, 2003). This makes it imperative to replace old males from Kuno WLD with new young males from Gir Protected Area

(Ravi Chellam *et. al.* 1995). This should be done preferably when the females have grown up cubs as the new males have the habit of killing the young sired by other males (Schaller 1972). It is also desirable to periodically bring a few females from Gir Protected Area to enhance genetic vigour. Cattle are not included in estimating lion number the area can support and kept as buffer prey to tide over the likely problem of drought which can lower wild prey availability and in such a situation the livestock can serve as a supplementary prey. **Planning reintroduction in the beginning of 2008 will give us sufficient time to get the whole-hearted support of the Gujarat Government. It is vital that the given recommendations are implemented before 2008 closely following the activity chart given in Appendix IV.**

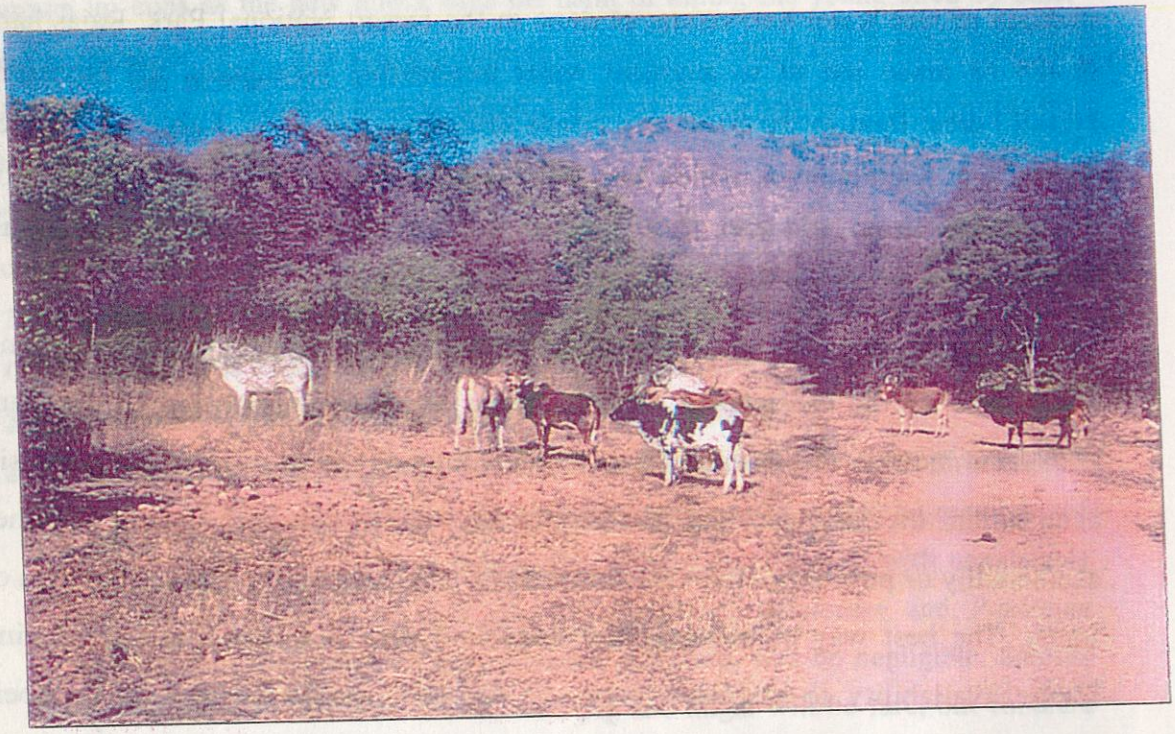
- It is necessary to relocate the Bankcha and Jangarh villages from Sironi forest range, which will add 300 km^2 habitat without people. It should be remembered that the Sironi forest range is largely flat without much water, with unpalatable grass species such as *Aristida setacea*, *Erogrostis unioloides* and *Paniceum antidotle*. Its contribution to prey biomass, therefore, will be negligible. Sambar may not colonize this area. Chital, wild pig and nilgai will be rare, but chinkara will be much more common. But when these two villages are removed, the disturbances (including poaching) arising from these villages, which are on the border of the Sanctuary, will come to an end helping the build-up of the prey-base. The villagers are willing to go as they are 15 km from any form of facility, such as school or hospital. This relocation should be done before end of 2007.
- Sheopur district, in which Kuno WLD is situated, has a cattle population of 4,28,462 cattle (Anon 2001). Further, the District has an enormous inflow of migratory livestock from Rajasthan in the months of September and October. Therefore, to protect the habitat, the entire Division, which already has about 2000 livestock in 10-12 villages (Choudhary 2001), should be protected by a rubble wall before end of 2007. Now the wall protects the Sanctuary only partially. A public awareness and conservation education campaign needs to be initiated, especially regarding the problem of depredation on livestock and co-existence with a large potentially dangerous carnivore (Kellert *et al.* 1996). A policy could be instituted that no compensation will be paid to the cattle killed by predators within the Sanctuary.
- Several *nallahs* which were perennial in the past have now become ephemeral (Choudhary 2001). In May 2006, using Global Positioning System and toposheets, a survey for all the perennial waterholes should be done throughout the Sanctuary.

Entire Division should be surveyed in April-mid June 2006. Thereafter, innovative methods of rain water harvesting, as done in the Desert National Park, Rajasthan, should be made use of to augment water availability throughout the Division. Tiktoli Forest Beat in the Sanctuary needs immediate attention. Large open water bodies, e.g. Kaimtailaiya, which lead to enormous loss of water through evapo-transpiration in an arid area should never be established. Instead, several small waterholes, dispersed in the habitat, should be developed.

- The Sanctuary now has an abundant growth of grass, which becomes dry and unpalatable during the summer. Such grasses are poor in nutrition (Eltringham 1979) and increase fire hazard. There is illegal tapping of *Boswellia serrata* resin even within the Sanctuary and the people who indulge in such activities, either accidentally or purposely, light the forest fires which sometimes burn vast tracts of forest. The best way of reducing fire hazard in such a situation and improving forage availability to ungulates is to go for cool season burning in October-November, at intervals of 2-3 years, in as many valley habitats as possible. This practice is urgently needed within the Sanctuary to make available nutritious sprouting green grass in early summer, which will help building up the population of ungulates, particularly chital. Since fires are deleterious in an arid habitat (Eltringham 1979) we recommend that the suggested cool season burning is monitored to record its impact on the habitat.

- Weeds reduce the capacity of a habitat to support ungulates (Pierson and McAuliffe 1994). The Sanctuary has an abundance of weeds and unpalatable species such as *Cassia tora*, *Cleome viscosa*, *Xanthium strumarium*, *Ludwigia octovalvis*, *L. perennis*, *Acanthospermum hispidum*, *Pupalia lappacea* and *Argemone mexicana* (Rawat 2003).

- Sustained efforts should be made to eradicate the weedy species from the grasslands. Another threat is the encroachment of grasslands in the abandoned villages by woody unpalatable species such as *Vitex negundo* and *Butea monosperma*, which can reduce the productivity of the grasslands. Succession into dense growth of *Zizyphus nummularia* woodlands is another threat. Such dense growths need to be regularly thinned so as to enable the existence of grasslands, a much needed habitat for chital, nilgai and wild pig.



Feral cattle are considered to be the buffer prey of lions

Fleet-footed chinkara, although common, will be seldom caught by lions

Water scarcity is a hallmark of Kuno Wildlife Division. Livestock and people around a hand pump in Bankcha village

A rubble wall around the entire Kuno Wildlife Division is a must to protect the vegetation from the ravaging livestock. Mr. Fayaz Khudsar, who has been studying ungulates in Kuno WLS, is in the picture.

- The Sanctuary has suffered a lot in the past, as a result of poaching by the local people, particularly the *Moghia* tribals. There are reports of them still sneaking into the Sanctuary to shoot wild animals. So as to reduce poaching by the use of guns in future, making use of the provisions in The Wildlife (Protection) Act 1972, new gun licenses within a 10-km belt from the Sanctuary should not be issued. Efforts should be made to confiscate guns from persons known to poach.

- The Wildlife Division is short of nearly 20 staff, and recruitment of appropriate staff should be made at the earliest. In order to motivate the staff, they should be sent on study tours to places like Chilla Range in Rajaji National Park (Uttaranchal) and Bhadra Tiger Reserve and Nagarahole National Park (Karnataka), where good models of relocation, research and prey recovery can be seen. The staff should also be given special training in anti-poaching measures, especially in collecting information using informers, and in ambushing poachers.

- The monitoring of prey population and habitat condition should be carried out by the methods proposed in Appendix II which has the details of data collection (Appendix II.1 and II.2), analysis (Appendix II.3 and 4) and modeling (Appendix III). The Wildlife Institute of India and other agencies working in Kuno WLD should be involved in this work which should be carried out in 2006 and 2007. At the end of 2007 status of wild prey, habitat and conservation measures taken should be assessed before release of lions.

- There is a greater need of commitment and action on the part of various Government Agencies to take care of the livelihood requirements of relocated people which should be stringently monitored. The problems faced by the relocated people, as reported by Bunsha (2005), should be reversed as early as possible.

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Appendix I: Name of the staff and resource persons who walked the transects.

S.No.	Transects	Distance in km	Degree	Name of the staff & resource persons
1	Kathhal to Hanumanji	2.34	282^0	Shri Raju Barbar Shri Virendra Singh Pironia
2.	Tiktoli *taliya* to Khalai	2.01	35^0	Shri Sukhrav Jaatav Shri R.K.Nakhariya
3.	Badiya *nala* to Saambarsoda	2.3	71^0	Shri Kashi Lal Shri Ram Bihari Rawat
4.	Manak *Chowk* to Pohari	2.2	100^0	Shri Mahavir Bhagat Shri Qamar Qureshi
5.	Kudi Kheda to Koyla *ghati*	3.00	180^0	Shri Shashijone Bhinj Dr. A.J.T. Johnsingh
6.	Palpur to Neemkhot	2.00	311^0	Shri Ram Dayal tribal Dr. S.P.Goyal
7.	Lakhauda to Sarkatoriya	1.8	182^0	Shri Ajay Kumar Bhagat and a labourer
8.	Ladar *tiraha* to Ghurredi	1.7+1	249^0	Shri Sukh Singh Kunwar Shri Khudsar
9.	Lagdar *tiraha* to Kuno river	2.48	70^0	Shri Jagdish Kuzur Shri Surendra Kumar Sharma
10.	Tongra to Taparpura	3.00	180^0	Shri Tarun Kumar Thakue Shri Ram Sharma
11.	Ahera to Ahirwani	2.00	60^0	Shri Munni Lal Kadere Shri Raju Gaur
12.	Khajuri to Ghaungha nala	3.00	180^0	Shri Avdesh Parashar Shri Narayan Singh Kanwar
13.	Taleya to Bansabavadi	2.2	271^0	Shri Amar Singh Jaatav Shri Lekhpat Dhakad
14.	Pirota to Kadwai	2.4	95^0	Shri M.P.S.Chauhan Shri Ram Kishan tribal
15.	Khalai to Barred	2.35	185^0	Shri Krishan Nakhariya Shri Kaushik
16.	Pirauta to Rampuraka *Danda*	1.7+1	270^0	Shri Sushil Parashar Shri Gaya Lal Dhakur
17.	Barunala to Tipara	1.3 +1	296^0	Shri Om Prakash Sharma Shri Siya Ram

Appendix II.1: Monitoring Protocols

It is important to develop monitoring protocols to determine the distribution, abundance, and composition of prey species and changes in the above parameters over a period of time. Keeping in mind the capability of the staff and the infrastructure available with the Kuno WLD we describe methods which are simple and scientifically robust.

I) Estimation of wild ungulate populations

(a) Seventeen transects have already been laid for sampling prey abundance in Kuno WLS. The Sanctuary staff should clear and mark (with red and yellow paint) these transects every year in October-November. Similar transects, a minimum of 21, should be marked in the buffer zone covering the Sironi, Agra and Moravan ranges in consultation with WII.

(b) These transects should be walked eight times (morning and evening, total 16 times) during winter (December-January) as well as in summer (April-May). Prescribed format (Appendix II.2) should be used for recording data.

(c) The Divisional Forest Officer (DFO), Kuno WLD, should pool all the data and calculate encounter rate for each species (number of animals seen /per km walk). Encounter rate data are very useful in monitoring prey abundance between the years and over a period of time. Appendix II.3 outlines the methods for calculating related statistical parameters.

d) Once the transect data are collected the DFO should mail the hard and soft copies of the data to Wildlife Institute of India for analysis and interpretation.

(e) Wildlife Institute of India will analyze the data and results of the winter data will be provided every year in March and summer data in July.

(g) One set of hard and soft copies of the data collected should be maintained by Kuno WLD and one person, preferably the Range Forest Officer of Kuno WLS, should be given the task of coordinating data collection..

II. Feral ungulates

(a) Identify yarding sites for feral and domestic ungulates in Kuno WLD.

(b) Identified teams should count feral animals in the morning and evening at yarding sites. Care should be taken that animals are either counted when most of them arrive at yarding sites in the evening or disperse from the sites early in the morning. This exercise needs to be repeated till the Coefficient of Variation (CV) is less than 15 percent (see Appendix- II. 3 for methods to calculate CV). Estimation of wild ungulate populations and count of final ungulates should be done, without any lapse for 2006, 2007 & 2008.

III. Mapping

(a) Natural resource mapping of Kuno WLD should be done for the following:

(i) Vegetation types – repeat this excise every five year.

(ii) Map terrain features (drainage and contour) once.

(iii) Using GPS map water holes, artificial and man-made, and monitor them every summer (May-June).

(iv) Hire a hydrologist once to map water shed and ground water availability.

(v) Map areas that get burnt every year using GPS.

(vi) Administrative layers (namely Range, Beat, Block, Compartment) Road, Fire line, *Chowkis* should be mapped once and updated as and when needed.

Kuno WLD Head Office should have compatible computer and softwares to maintain aforesaid information and a suitable person should be identified for this job.

Appendix II. 2 : The Transect data sheet

ट्रांज़ेक्ट लाइन पर जानवरों की गणना

संकलनकर्ता :.....

ट्रांज़ेक्ट लाइन क्रमांक.....

दिनांक : .....

वनवृत्त : .....

रेंज : .....

लम्बाई : .....

समय प्रारम्भ :.....

समय अन्त : .....

मौसम : बादल/खुला.....

वनमंडल : .....

बीट : .....

प्रारंभ जी.पी.एस. **Lat:.....N;** **Long:.....E.**

अंत जी.पी.एस. **Lat:.....N;** **Long:.....E.**

खण्ड क्रमांक	समय	प्रजाति	कुल संख्या	समूह रचना	दूरी (कोणात्मक)	जानवर का कोण	वासस्थल	टिप्पणी

Appendix II.3: An example of calculation of Mean, Standard Error, Coefficient of Variation and Confidence Interval based on three counts of cattle.

$\overline{X}$ = Mean $= \frac{\sum xi}{n} = \frac{179+220+191}{3} = \frac{590}{3}$

where xi = Individual data value

n = Number of data values (observation)

$= 196.6$

SD = Standard deviation $= \frac{\sum (x_i - \overline{x})^2}{n-1}$

$= \frac{(179 - 197)^2 + (220-197)^2 + (191-197)^2}{3 - 1}$

$= 21.1$

SE = Standard Error $= \frac{SD}{\sqrt{n}}$, where SD = 21.1 and n = 3

$= 12.2$

CV = Coefficient of Variation in percent $= \frac{SD}{\overline{x}} = \frac{21.1}{197} \times 100 = 10.71$

C.I = Confidence Interval at 95% $\overline{x} \pm 1.965 \times SE$ (note 1.965 is Z value at 95% level)

$= 197 \pm 1.965 \times 12.2 \quad = 24$

$= 197 - 24 \quad = 173$ (lower limit)

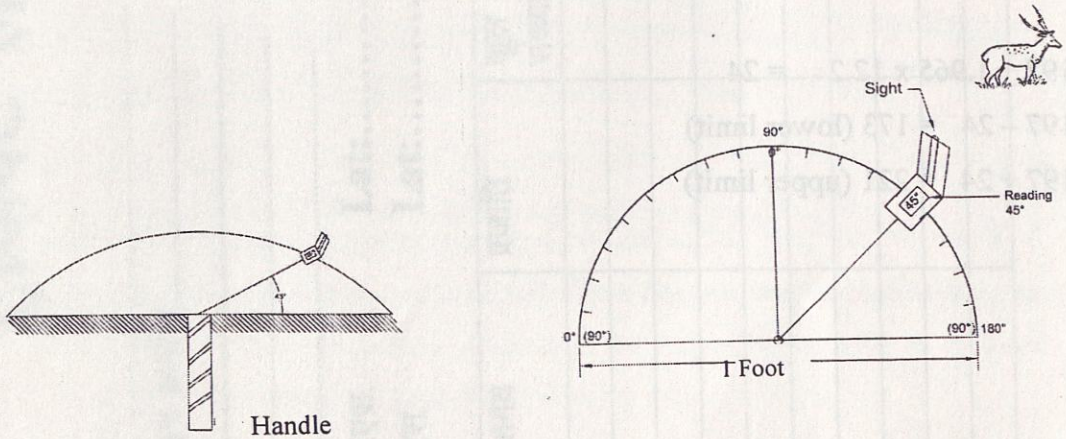
$= 197 + 24 \quad = 221$ (upper limit)

Appendix II.4: Transect data collection and analysis

(a) **Training of staff in Line transect methods.**

Staff should be trained in use of compass for angle estimation. In the absence of compass one can use a modified protractor (Fig. 3). Ocular distance estimation exercise needs to be conducted for staff by marking 10 trees at distances ranging from 10 to 150 m. The distance estimation exercise should be repeated minimum thrice, without telling the actual distance, after knowing the actual distance and practicing distance estimation of new sets of objects other than that used in training. During our training exercise in Kuno WLS in January 2005 we observed the staff to be correct in distance estimation up to 30 m, 20% staff wrongly estimated distances ranging from 30 to 100 m, and 50% of the staff were inaccurate when the distances were above 100 m. Errors in assessing distances were largely due to the fact that the staff guessed distances. Errors in estimating distances drastically declined when the staff were trained to make more objective assessment by breaking distances in smaller units of 5, 10 or 20 m. This exercise of estimating distances should be practiced every season before undertaking field data collection.

Fig. 3. Use of modified protractor for recoding angle in case compasses are not available.



(b) Generally we found the staff, serving in Kuno WLS, largely correct in identification of large mammals and their signs. This capability which is a must to

get a reliable count of prey animals should be nurtured and strengthened. A good knowledge of animal signs can help the staff to evaluate habitats based on evidence.

(c) Analysis of transect data was based on the Distance based model (Buckland *et.al.* 1993) using distance software (Laake *et.al.* 1994) – The parameters used in estimating strip width is given in Table 2, the fitted model in Fig. 4 and the analysed data in Table 3, 4 and 5.

Table 2. The model parameters for estimation of effective strip width

Effort	:	481km
# samples	:	17
Width	:	101.0m
# observations	:	218

Model

Half-normal key, k(y) = Exp(-y**2/(2*A(1)**2))

Cosine adjustments of order(s) : 2

Parameter	Point Estimate	Percent Coefficient of Variation	Confidence Interval (95%)	
			Lower	Upper
f(0)	0.20	7.35	0.017416	0.023249
P	0.39	7.35	0.34	0.45
ESW	49.70	7.35	43.01	57.42

f(0)- Value of probability density function at zero for line transects

P- Probability of observing an object in defined area

ESW- Effective strip width

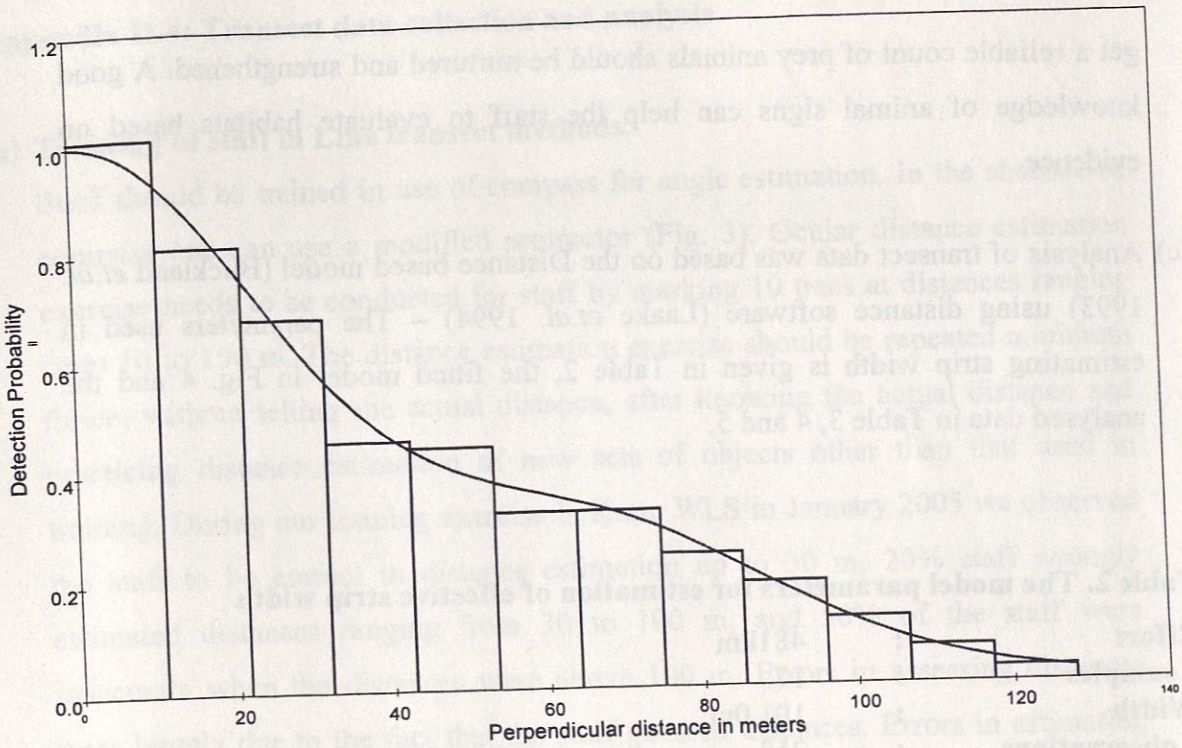


Fig. 4. **Detection probability based on Half normal Cosine Model.**

Table 3. **The density estimates of wild ungulates and livestock in Kuno Wildlife Sanctuary, January-February 2005.**

Species	Group and Individual Density	Density Estimate (no/sq. km)	% CV	Confidence Interval 95%	
				Lower	Upper
CHITAL	GD	2.32	24.25	1.41	3.81
	ID	6.22	25.11	3.73	10.34
NILGAI	GD	1.38	22.31	0.88	2.18
	ID	3.28	23.67	2.03	5.29
SAMBAR	GD	0.36	35.62	0.17	0.74
	ID	0.58	39.75	0.26	1.27
WILD PIG	GD	0.80	27.20	0.46	1.40
	ID	3.19	31.16	1.72	5.93
CATCHABLE WILD PREY	ID	12.89	19.27	8.72	19.05
CATTLE	GD	1.05	46.31	0.41	2.66
	ID	5.02	51.26	1.86	13.58
CHINKARA	GD	1.46	20.89	0.95	2.25
	ID	2.60	21.89	1.66	4.06
CHOWSINGHA	GD	0.22	85.39	0.05	1.05
	ID	0.28	86.20	0.06	1.37

Note:- GD = Group Density, ID = Individual Density, Effort = 461 km

Table 4. The group sizes of wild ungulates in Kuno Wildlife Sanctuary, January-February 2005

Prey Species	Average Cluster Size	% CV	Confidence Interval 95%	
			Lower	Upper
CHITAL	2.68	6.53	2.36	3.05
NILGAI	2.37	7.89	2.03	2.78
SAMBAR	1.63	17.65	1.12	2.36
WILD PIG	3.97	15.19	2.92	5.40
CATTLE	4.79	21.99	3.10	7.42
CHINKARA	1.78	6.54	1.56	2.02
CHOWSINGHA	1.30	11.75	1.00	1.69

Table 5. The encounter rates of wild ungulates in Kuno Wildlife Sanctuary, January-February 2005

Prey Species	Encounter Rate/km	% CV	Confidence Interval 95%	
			Lower	Upper
CHITAL	0.23	22.71	0.14	0.36
NILGAI	0.13	20.63	0.09	0.21
SAMBAR	0.04	34.59	0.02	0.07
WILD PIG	0.08	25.84	0.05	0.13
CATTLE	0.10	45.72	0.04	0.26
CHINKARA	0.15	19.56	0.10	0.30
CHOWSINGHA	0.02	85.07	0.005	0.10

Appendix III: Modeling population growth of wild ungulates and lion number

Modeling population growth is a useful exercise in ecology and conservation. The models are useful to understand real systems and to develop management scenarios. We have used logistic models and simulated them with random growth rates. The logistic equation used for prey population modeling is

Population Model

$$\frac{dn}{dt} = r_m N\left(\frac{K - N}{K}\right)$$

$$N_{(t+1)} = N_t + \frac{dn}{dt}$$

where r_m = Population growth rate

N = Population

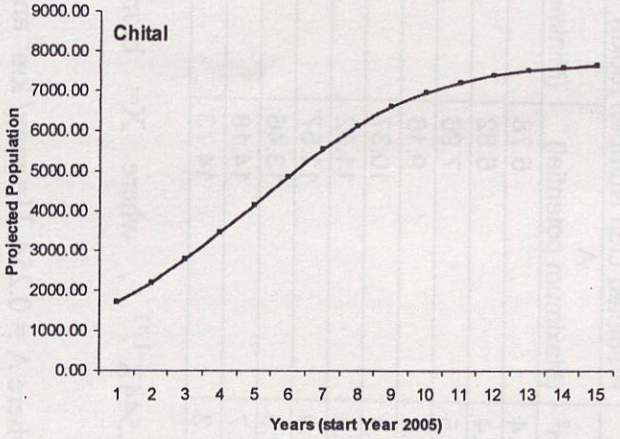
K = Carrying capacity (was modeled on the basis of the density of ungulates in Sariska and Ranthambore Tiger Reserves due to the close ecological resemblance between Kuno WLS and these Reserves)

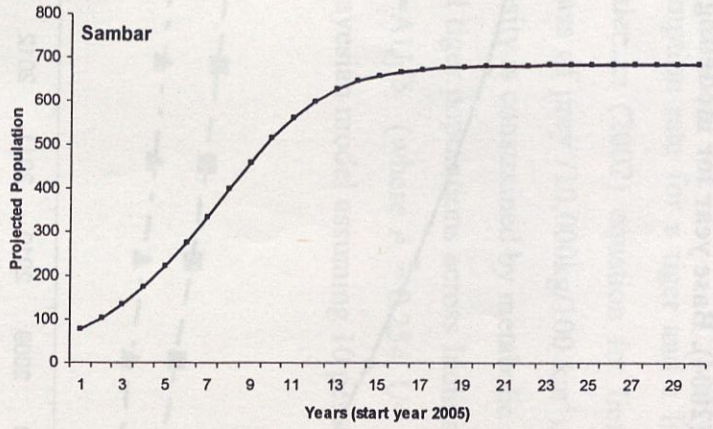
The population growth rate is modeled for catchable lion prey, chital, sambar, nilgai, and wild pig. The parameters used for modeling are given in Table 6. The chital, sambar, nilgai and wild pig growth models are given in Fig. 5 and of catchable wild ungulates in Fig. 6. The predicted population growth of all catchable lion prey is given in Table 7.

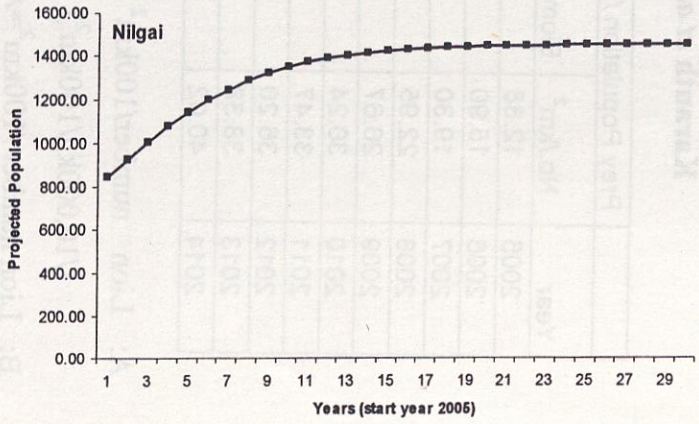
Table 6. Parameters used in logistic growth models of catchable wild ungulates.

Species	Initial Population	Potential Growth Rate	Carrying Capacity
Chital	1705	0.37	7728
Sambar	146	0.23	683
Nilgai	846	0.23	1453
Wild Pig	910	0.41	2363

Fig. 5. The logistic growth model for four wild ungulates catchable by lions.







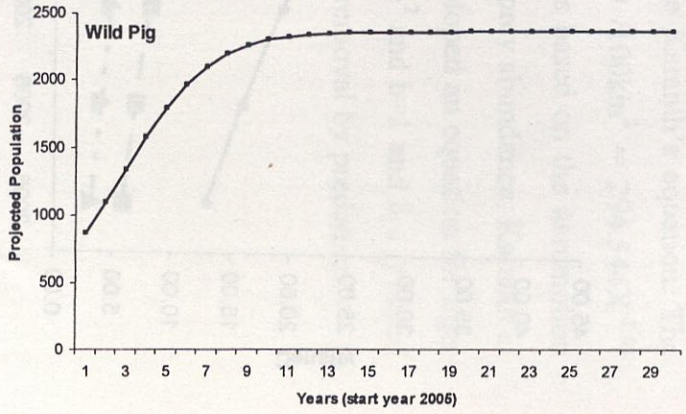


Fig. 6. **The logistic growth rate of catchable wild ungulate lion prey/km^2 (—•— chital, sambar, nilgai and wild pig) and lion number/100 km^2 based on (A) —■—Carbone and Gittleman (2003) and (B) —▲ - Karanth *et al* (2004). Base year for modeling is 2005.**

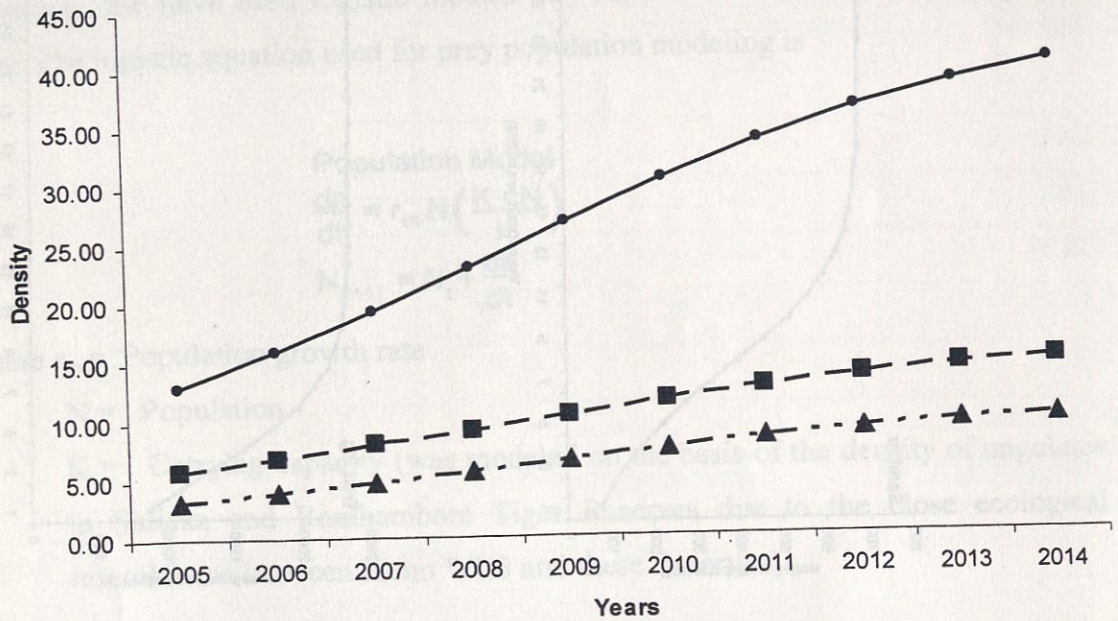


Table 7. **Predicted population growth of catchable wild prey (chital, wild pig, nilgai, and sambar) based on logistic growth model and lion number based on (A) Carbone and Gittleman (2003) and (B) Karanth *et al* (2004).**

	Prey Population / Biomass		Predicted Lion Number/100km^2	
Year	No./km^2	Biomass/100km^2	A (Maximum potential)	B (Minimum potential)
2005	12.88	100655.4	5.78	3.18
2006	15.90	118792.4	6.82	3.93
2007	19.30	138639.5	7.96	4.77
2008	22.95	159565.1	9.16	5.67
2009	26.67	180655.4	10.37	6.59
2010	30.24	200837.5	11.52	7.47
2011	33.47	219084.9	12.57	8.27
2012	36.20	234639.8	13.46	8.94
2013	38.38	247162.7	14.18	9.48
2014	40.02	256741.3	14.73	9.89

A: Lion number/100km^2 = $294.544X^{-1.03}$, where X= biomass of prey (/10,000kg/100km^2)

B: Lion number /100km^2=$AU_j^b\delta_j$, where A = 0.254, U= prey/ km^2 and b=1 and $\delta_{j=1}$.

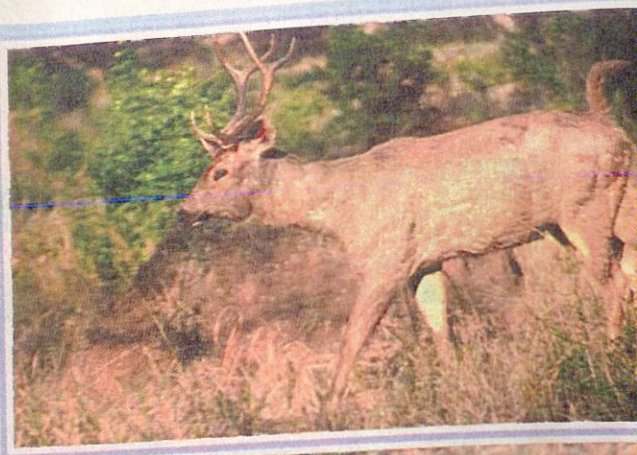
The lion number estimation was done on the basis of equations developed by Carbone and Gittleman (2002) for lions and Karanth *et al* (2004) for tigers. We have assumed equal prey consumption rate for a tiger and a lion to use Karanth's equation. The Carbone and Gittleman (2002) equation for lion density /100km^2 = $294.544X^{-1.03}$,(where X= biomass of prey /10,000kg/100 km^2), which is based on the assumption that carnivore density is constrained by metabolic rate and prey abundance. Karanth *et al* (2004) sampled tiger populations across India and developed an equation for tiger number/100 km^2 =$AU_j^b\delta_j$ (where A = 0.254, U= prey/ km^2 and b=1 and $\delta_{j=1}$) based on hierarchical Bayesian model assuming 10 percent prey removal by predators.

Appendix IV: Tasks that need to be accomplished before and soon after the release of lions in Kuno Wildlife Division.

S.No.	Activity	2005		2006		2007		2008	
		1-6	7-12	1-6	7-12	1-6	7-12	1-6	7-12
1.	Review of report submitted by the Wildlife Institute of India (WII) on assessment of prey abundance in KWS by Forest Department, Government of Madhya Pradesh and Ministry of Environment and Forests (MoEF), Government of India.								
2.	Meeting organized by MoEF for the participation of Forest Departments of Government of Gujarat and Government of Madhya Pradesh, and WII to review the overall progress of the programme.								
3.	MoEF to organize a meeting of Head of the States of Gujarat and Madhya Pradesh to agree upon the transfer of lions from Gujarat								
4.	Meeting with Air Force (Western Air Command) for use of cargo plane (AN 32) to transfer five lions from Jamnagar to Gwalior								
5.	Assessment of prey abundance in KWS under the supervision of WII								
6.	Translocation of Bankcha and Jangarh villages								
7.	Habitat improvement(water, fire and grassland management, building of rubble wall around Kuno Wildlife Division), recruitment and training of staff, control of poaching								
8.	Construction of exclosure for pre-release of lions at KWS								
9.	Identification, capture, radio - clloar and translocation of lions under the supervision of WII.								
10.	Release of lions from the exclosure								
11.	Monitoring of radio - collared animals by Madhya Pradesh Forest Department and WII.								

A lioness stalking in Gir Protected Area

Survey team atop *Tongra*. Pipal Baodi site, relocated in 2002, forms the background.



Lions with four catchable wild ungulate species

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