Status of the snow leopard Panthera uncia in Northwest India

Joseph L. Fnx, Satya P. Sinha, Raghunandan S. Chundawati, Pallav K. Das

INTRODUCTION

The snow leopard *Panthera Uncia* is known to occur above about 3200m across the Himalayan regions of India, including the western stales of Jammu and Kashmir, Himachal Pradesh, and Uttar Pradesh, and the eastern states of Sikkim and Arunachal Pradesh (Prater, 1972). Although sportsmen have provided some anecdotal information on snow leopard presence in various parts of the Indian Himalaya (Burrard, 1925; Burton, 1926; Stockley, 1928), only recently has more detailed information begun to accumulate on this species'status in India (Dang, 1967; Green, 1982; Mallon, 1984, 1988).

Following directives to investigate the status of endangered species outlined in 1983 in India's National Wildlife Action Plan (Anon., no date, «V the government of India agreed to an internationally cooperative project to initiate fulfilment of these requirements in the case of the snow leopard (Fox & Freeman, 1984). Our principal aims were (!) to assess the current status of snow leopard in northwest India, including that of its large ungulate prey; and (2) to select an area in which to initiate more intensive investigations of snow leopard ecology.

SURVEY AREAS

India's northwest Himalaya encompasses an area of over 100000km^2; it was therefore necessary to select a limited number of sites for survey. The areas chosen provide a comprehensive array of representative snow leopard habitat from trans-Himalayan ranges at the edge of the Tibetan plateau in the north, southward across the Himalaya to its southern slopes. All locations were either under consideration, proposed, or established as national parks or wildlife reserves, and from all areas we had recent reports of snow leopard presence. The survey sites ranged from the rugged steppelands of the Zanskar mountains in central Ladakh, southward through the moister alpine Himalayan crest region, to the moist alpine and subalpine meadows and timberline forest on the southern slopes of the Himalaya in northern Utlar Pradesh and the Pir Panjal range in Himachal Pradesh (Dhar & Kachroo. 1983; Polunin & Stainton, 1985). The northwest Himalayan region exhibits a sleep gradient in annual precipitation, from 2500mm on the south side of the Himalaya to about 100mm in the upper Indus valley of central Ladakh (Polunin & Stainton, 1985). In contrast to the central and eastern Himalaya where precipitation is concentrated in the summer monsoon, in the western Himalaya winter storms and summer monsoon provide nearly equal amounts. Typical mid-winter

snow depths at an elevation of 4000m range from over I in on the south side of the main Himalaya to less than IOcm in central Ladakh. Elevalions surveyed were predominantly between 3300m and 4500m.

The areas selected for survey were (1) the Hemis National **Park,** Shang Wildlife Reserve, and Khurnak valley in central Ladakh; (2) the upper Suru, Doda, andTsarap Lingti valleys in southern Ladakh; (3) the upper Beasand Purbiili catchments in the vicinity of Kulti-Manali in Himachal Pradesh; and (4) theGovind Pashu Vihar Wildlife Sanetuary in the upper Tons valley in the northwest corner of Utlar Pradesh (Fig. 1). The latter two sites are on the south side of the Himalaya.

All the survey areas were in rugged mountainous terrain characteristic of known snow leopard habitat in the Himalaya (Jackson & Ahlborn, 1984). Habitats in Uttar Pradesh and Himachal Pradesh ranged from alpine meadows *(Koclcriti, Slipu, Polygomtm, I'otentitlti)* to timberline shrubland *(Rhododendron, Vihtirnum, Juniperux)* and forest *(Ccdru.i, Ahie.i, Quemix)* (Schweinfurth. I9C>N; Pohmin & Slainton, 1985). In Jam mu and Kashmir, the

Fig. I. Luealion of snow leopiird survey ureas in northwest India 11) central Ladakh; (2) sou them Uidukh;(_l) Kulu-Manali; and |4] (iovjiul I'ashu Vihar The hitter two are south of Ihe main Himalaya.

region we refer to as 'southern Ladakh' is just north of the main Himalayan crest, where annual precipitation is about midway between the south side of the Himalaya and central Ladakh. Vegetation is primarily alpine meadow *(Koeleria, Stipa, Polygomini, Leontopodium)* grading northward into subalpinc steppe, and no continuous forest is present (Kachroo *et a!.,* 1977; Hartmann, 1983). Central Ladakh has primarily steppe vegetation *(Caragana, Arleittixia. Siiiciiys, Ephedra)* with shrubland *(Hippophae, Satix, Myricaria)* along the lower river courses both here and in southern Ladakh (Kachroo <•/ <//., 1977; Hartmann, 1987).

METHODS

Surveys were conducted between November 1985 and July 1986. All field work was done on foot, travelling over 1100 km along the major and minor valley systems within the selected areas. Data gathering, based primarily on locating snow leopard scrape markings and tracks, was concentrated along valley bottoms because of case of travel and indications that the densest concentrations of this sign could be found in such locations (Jackson & Ahlborn, 1984). One side of a valley was searched for snow leopard sign, although in narrow valleys we often shifted from one side to another to facilitate our travel. Searching was conducted predominantly at the juncture of the valley bottom with its side slopes. From the valley-bottom survey routes, wild ungulate prey species were observed and counted on both sides of the valley. Two of the areas were surveyed in both winter and summer to document any seasonal effects on sign frequency. Differences in both track

and scrape frequency among the principal areas of survey (southern side of Himalaya, southern Ladakh, central Ladakh) were determined using chi-square analysis to test the null hypothesis of no difference between areas (Zar, 1984).

Although the surveys were all conducted in mountainous country known to have snow leopard, we wanted to obtain indications of general habitat preference related to the occurrence of scrapes, tracks and prey abundance that might be helpful in designing further work. Habitat characteristics were therefore estimated over 5-km sections of the valleys along the survey routes. These attributes included elevation, slope angle and percent cliff composition of the valley sides, percent of valley bottom bounded by cliffs, valley width, snow cover on slopes and snow depth on valley bottoms. Relative preference of snow leopard and ungulates for the various habitat attributes was inferred using multiple comparisons (Tukey test, Zar, 1984) to contrast the habitat occurrence of snow leopard sign and ungulates relative to average habitat values. Additional wildlife observations and habitat use information were recorded and are reported elsewhere (Fox *et al,* 1988).

Accompanying the survey team were local wildlife rangers from the respective State wildlife departments in whose jurisdictions we were working, and whom we interviewed regarding snow **leopard and** ungulate status. We also enquired among the local inhabitants regarding recent snow leopard sightings and incidents of predation on livestock.

RESULTS

Relative abundance of snow leopard

As expected, evidence of snow leopard presence was found in each of the regions surveyed. There was, however, a trend toward decreasing amounts of snow leopard sign southward from central Ladakh to the southern side of the Himalaya. Evidence of presence along 920km of the main valley survey routes, separated by the regions of survey and by dates, is summarized in Table 1.

Snow leopard sign, with scrapes providing the most abundant data, was most common in Ladakh, especially in the central region. Figure 2 shows a snow leopard sighled in March in the Markha valley in central Ladakh. It is apparent from Table 1 that there were seasonal differences in sign frequency within both regions of Ladakh, with tracks more prevalent in winter and scrapes more prevalent in summer. This difference was primarily a result of the presence of snow cover, which tended to conceal scrapes and enhance track visibility. We therefore only made comparisons between areas with data from similar seasons.

During winter and spring, scrape frequency was different among all three areas ($p<0.01$), highest in central Ladakh, less in southern Ladakh. and

TAB1.K 1

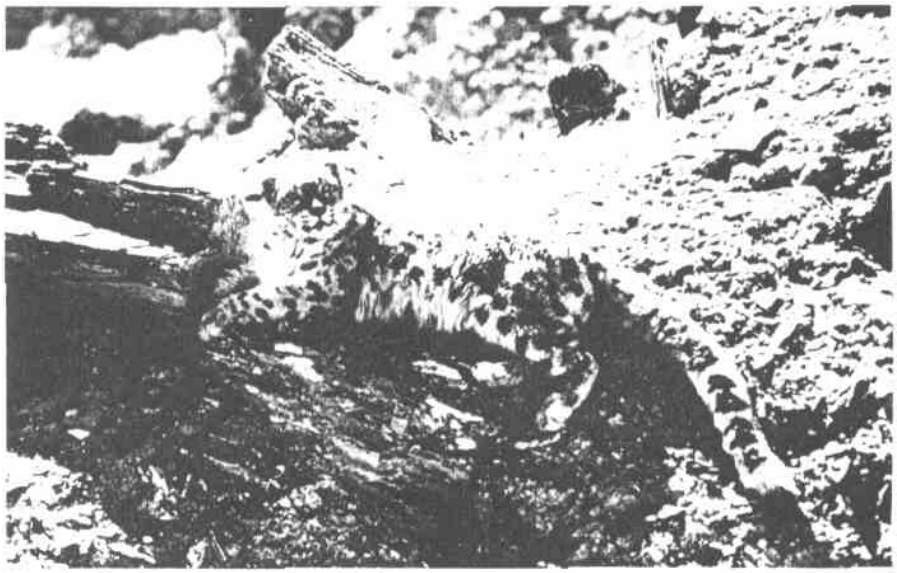
Frequency of Snow Leopard Sign along Major Valleys in l-our Regions of India's Northwestern I Himalaya

Survey Ion/thin	*Month*	*Km u/ survey travelled per track found*	*Frequent'? of sign — Km Scrapcs per km*

Central Ladakh	July	130	44	*2-6*
	January March	265	8	1-1
Southern l.adakh	June-July	255	64	0-2
	November-December	45	23	**0*1**
Kulu-Manali"	May	95	48	**none**

" Tracks and scrapes arc mosl probably of snow leopard (sec text).

Govind Pashu Vihar"	April	80	40	f>01



Kig. 2. A snovv leopard seen during the surveys in March at aboul 4000m on ctilTs above the Markha valley in central Ladakh. (Reproduced by permission of the International Snow Leopard Trust.)

least on the south side of the Himalaya. Snow leopard tracks in **winter** also showed u similar trend toward lower frequency from central to southern Ladakh (/?<(H)5), hut there was no difference in truck frequency belween southern Ladakh and the spring surveys on the south side of the Himalaya. Scrape frequency in the summer surveys was also greater *(p* < 0-01) in central than in southern Ladakh. During summer few tracks were found and no difference in track frequency was detected between central and southern Ladakh. This demonstrates either that snow leopards make little use of major valley bottoms at this lime of year, or simply the difficulty in observing their tracks without snow cover. Nevertheless, with the scrape data we have a clear indication of important differences in sign frequency among the major survey zones.

Habitat

The importance of rugged terrain to snow leopard distribution is indicated when we consider their habitat preference as reflected in the location of sign. Figure 3 shows typical snow leopard and blue sheep habitat in the Markha Valley. General habitat characteristics associated with (racks and scrapes encountered along the valley survey routes are presented in Table 2. Compared to the average components of habitat encountered along the survey route (last column in Table 2), tracks and scrapes were **found at** about

Fig. 3. Typical snow leopard and blue sheep habitat in the Markha valley, as seen from the resting spot of the snow leopard In Fig. 2. Note the cultivated fields and shrub vegetation restricted to the valley floor. (Reproduced by permission of the International Snow Leopard Trust.)

average elevations, in steep-sided valleys with many hills, and especially along valley bottoms bounded by cliffs. Narrow valleys were much more likely lo have sign and, as described above, tracks were positively, and scrapes negatively, associated with presence of snow. It is apparent here, as in west Nepal (Jackson & Ahlborn, 1988), that abundant snow leopard sign is associated with extremely rugged terrain.

The density of snow leopard sign is associated with certain terrain characteristics, e.g. scrapes are often placed at the base of cliffs. In both areas of Ladakh scrape frequency was highest in steep narrow valleys. According to our habitat criteria, the valleys surveyed in southern Ladakh and the south side of the Himalaya were, on average, much wider and less bounded by dills than in central Ladakh. Other factors being equal, this would lead us to expect the lower sign frequencies that were found in the southern areas. However, even when only similar steep-sided and narrow valleys from each region are compared, we still have the significant differences (/xO-01) in scrape frequency among all three areas.

Wild ungulates were found at relatively high elevations and in narrower than average valleys, but otherwise they occurred in proportion to available habitat along the survey routes (Table 2). Thus, snow leopard sign was associated with somewhat more rugged areas than the typical habitat for their wild ungulate prey. With competition for the latter from wolves *Canis*

TABLE, 2

Average Habitat Characteristics over 5-km Survey Sections Associated with the Occurrence of Snow Leopard Sign and Wild Ungulates

Category	.Snow *leopard scrapes*	*Snow leopard tracks*	*Ungulates*	*Surrey habitat*
	n = 673	n = 45	n = 1 426	n = 184
Elevation of valley bottom (m)	3800	3850	390<>*	3750
Valley side slope angle O	43*	41*	36	35

Percent of valley bottom with clifTs	*51**	48*	29	27
Percent of valley slopes with cliffs	45*	45*	36	35
Valley width (m)	66*	76*	161*	225
Percent snow cover on vallev sides	26	59*	30	28
Snow depth on valley bottom (cm)	*2*	7	5	5

Means marked with * are different (p<0.0), Tukey multiple comparison test, Zar 1984) from thatl for the overall survey habitat.

lupus and wild dogs *Cuon alpinus,* the snow leopard may he selecting the more rugged areas.

Prey abundance

The large ungulate prey species of the snow leopard, most commonly blue sheep *I'M'itiloifi naytiur* and Asiatic ibex *Capru ihc.*\ in the present study, are still widely distributed in the Himalayan and Irans-Himalayan regions surveyed. Both are associated with relatively rugged terrain (Sehaller, 1977). We found them in very similar habitats in different geographical locations, with only limited areas of overlap. Their combined population densities appeared to be somewhat lower in the more southern areas surveyed.

Although the number of ungulates seen per km of survey was not different between southern Ladakh and the south side of the Himalaya (1-2/km of survey), it was less (/?<0-0f) than that found in central Ladakh (2-0/km of survey). Assuming we were surveying to 1-km distance on either side of the valley, this translates into approximate wild ungulate densities of l-O/km^2 in central Ladakh and 0-6/km^2 in southern Ladakh and the southern side of the Himalaya. We presume these to be acceptable density estimates because they arc comparable to the only mountain ungulate census results available for (he regions—l'5/km^2 in (he 1200km^2 Hemis National Park of central Ladakh, and 0-4/krn^2 in 1600km^2 of southern Ladakh (Anon., no date, />; Fox *el al.,* unpublished data). All these density estimates are based on actual counts, and thus to some degree under-represent the population numbers because of missed animals. Relative differences are, however, still valid. The lower wild ungulate densities in the southern areas were also associated with

a noticeable increase in these species' wariness toward humans, especially on the southern side of the Himalaya where they are apparently more commonly hunted.

DISCUSSION

On the north side of the Himalaya, the only other moderately large felid present is the lynx *Lynx lynx* Although we found some evidence of its presence in central Ladakh. it is known to be quite rare in the regions of our survey and we are confident that the sign and tracks reported here are of snow leopard. On the south side of the Himalaya, however, the common leopard *Panthera pardus* is found throughout the forested elevations. During our April and May surveys in Himachal Pradesh and Uttar Pradesh, although recent snow leopard presence was known, we also had reports of common leopard sightings in villages and forest up to 3000m. We were unable definitely to distinguish between sign of snow leopard and common leopard; however, the sign found near and above timberline (> 3200m) suggests

that it was from the former, and is included in our results (Table 1).

Although snow leopards do occur on the south side of the Himalaya, the greater abundance of their sign suggests that they are more common on the northern side. Ahlborn & Jackson (1988) have indicated that scrape-mark frequency provides a reliable index of relative snow leopard occurrence within an area. However, several qualifications must be acknowledged in using scrapes as a measure of relative abundance between areas. The production of scrapes by snow leopards is apparently greatest during the breeding season of January and February (Ahlborn & Jackson, 1988). For this reason the timing of comparative surveys is important, and surveys conducted soon after February should have the highest sign frequency for the site, especially in areas where livestock trampling or seasonal flooding can destroy many of the scrapes produced each year. On this basis the April-May surveys on the south side of the Himalaya could be expected to have a seasonal high in scrape frequency (i.e. soon after breeding and before livestock arrival) as compared to a slightly lower seasonal level for the January-March surveys in central Ladakh. The opposite trend in our survey results thus strengthens the conclusion of a difference in snow leopard abundance between the two areas.

The canyon-like valley bottoms surveyed in central Ladakh provided travel corridors and ideal marking sites (cliffs along dry river gravels) which were not as consistently found in similar-sized valleys in the other regions investigated. It is possible, then, that valley bottoms are used less frequently and scraping is done in other locations in the less precipitous terrain surveyed in southern Ladakh and south of the Himalayan crest. **However,** on the basis of our less comprehensive search ing of alternative sites for snow leopard marking (e.g. small tributary valleys, valley-side bluffs, and ridges), southern Ladakh and the south side of the Himalaya still did not have comparable amounts of sign relative to similar sites in central Ladakh. ll is also conceivable, however, that the rate of scraping could rise wilh increasing snow leopard density, because of u greater need to ma in lain social structure among animals wilh overlapping ranges. This could result in an underestimation of relative snow leopard abundance, on the basis of scrape frequency, in relatively low-density areas. Lastly, il is a ho possible thai snow leopards simply scrape-mark less frequently in less rugged habitat.

Whereas the factors outlined above may serve to militate against some of the extremes in sign abundance observed, they are unlikely to be sufficient to explain the order of magnitude dilTerences in scrape frequency among our survey areas. Acknowledging a high degree of variability in the occurrence of snow leopard sign over the survey routes, the relatively high intensity indicated for central Ladakh appears to reflect a real difference in snow leopard abundance. The occurrence of our only two snow leopard sightings (Fox & Chundawat. 1988), and the substantially greater amount of sign found in central Ladakh. suggests that this area has the best snow leopard populations of those surveyed to date in India.

Several possible explanations a re proffered for dilTerences in snow leopard abundance among our survey areas. Heavy snowfalls on the south side of the **Himalaya** may result in some movement to the drier northern side during winter. If so, then some individuals may be using the southern slopes of the Himalaya primarily in summer, when marking behaviour (e.g. the production of scrapes) is low. This could help to explain both a lower frequency of

reported snow leopard interaction with local people during winter, as compared to summer, and the small number of scrapes that we found on the south side of the Himalaya in Ultar Pradesh and Himachal Pradesh. Secondly, human population density is higher on the south side of the Himalaya and may result in higher snow leopard mortality. Thirdly, with regard to the lower sign frequency in southern Ladakh relative to central Ladakh, it is possible that more wolves may be present in the comparatively open valleys surveyed in southern Ladakh, thus resulting in lower snow leopard densities.

Snow leopard population estimates

On the basis of wild ungulate density alone (increased by 25% to account for missed animals in survey counts), and estimates of mountain ungulate populations of about 200 individuals required to support one **adult** snow leopard on an annual basis (Jackson & Ahllborn, 1984; Wemmer & Sunquist. 1988), snow leopard density would be restricted to 1/160 km^2 in central Ladakh and 1/270 km^2 in the more southern areas surveyed. However, as Schaller *ft al.* (1988) point out, smaller mammals such as the marmot *Marmota* spp. can contribute as much as 45% of (he summer food (23% of annual requirements). Where marmots are abundant and constitute a significant proportion of snow leopard diet, as was (he case in central Ladakh **(R.** Chundawat. unpubl. data), the number of wild ungulates needed to support a snow leopard is consequently lowered. Domestic ungulates must also be considered as diminishing snow leopard dependence on wild ungulates in some areas (Schaller. 1977). If wild mountain ungulates were required for 70% of snow leopard diet, then predicted snow leopard densities become 1,110km^2 in central Ladakh and 1/190km^2 in southern Ladakh. Mallon (1984) and Schaller <•/ *al.* (1988) have suggested a general snow leopard density of I/100 km^2 over better-than-avcrage areas of their habitat in western China and (rans-Himalayan India.

Dang (1967) suggested that there were possibly 400 snow leopards in the entire 'Himalayan region'. Mallon (1984) and Dar & Gaur (no date) have each estimated about 200 in Ladakh alone, indicating that the total in the Himalaya is greater than 400. In the Nepal Himalaya, for example. Jackson (1979) estimated a snow leopard population of about 350 in 30000km^2 of suitable habitat. Chundawat *el al.* (1988) estimate 95000km^2 of snow leopard habitat in India, with 72000km^2 in the three northwestern stales. This figure, however, includes some 20000km^2 of habitat in Jammu and Kashmir currently controlled by either Pakistan or China. Using a rough breakdown of the remaining 52000km^2 into 30000km^2 of relatively good snow leopard habitat (density = 1/110km^2) in Ladakh and the inner valleys of Himachal Pradesh, and 22000km^2 of lower quality habitat (density = 1/190 km^2) in southern Ladakh and other Himalayan regions, we arrive at an estimate of about 400 snow leopard in northwestern India. Extrapolating the lower density figure to the 23000km^2 of Himalayan main range and southern slope habitat in the northeast slates of Sikkim and Arunachal Pradesh gives a total of about 500 snow leopard for all of India.

On the basis of fresh tracks in snow, we initially estimated 5-10 snow leopards in the 1200 km^2 Hemis National Park in central Ladakh (Fox *cl al.,*

1988). Using available prey (70% wild ungulates) to calculate carrying capacity, we would predict this area to support about 14 snow leopards. More recent preliminary evidence (R. Chundawat. unpubl. data) indicates that both these numbers may be somewhat low, and will demand a subsequent re-evaluation of our overall population estimates. It is apparent that small patches of prime habitat in Ladakh may have snow leopard populations approaching the 1/15 km^2 density found in a small area of high

1984). During a 12-month period of 1985-86 in an adjacent area of central Ladakh, snow leopards were reported to have killed about 65 out of a total of 2800 livestock, mostly sheep and goals (Fox *et al.,* 1988). In these same areas between *5* and 10 snow leopards are believed to have been killed as livestock predators during the years 1983-88, although in 1986 one leopard captured at a government sheep station was released back to the wild (Fox, 1989). Osborne et al(1983) reported 5 snow leopards killed in the Sum valley of southern Ladakh during the years 1978-82.

In India, state governments have primary jurisdiction and management responsibilities for wildlife conservation, including that in national parks and reserves. This has often led to somewhat different conservation strategies and protection area selection criteria among the different stales. Under directions outlined in India's 1983 Wildlife Action Plan, the Wildlife Institute of India has undertaken efforts to ensure the protection of representative biogeographic diversity throughout India. Thus, the adequacy of areas of high Himalayan habitat for species preservation (including snow leopard) has been assessed and recommendations made for increasing the amount of area under protection (Rodgers & Panwar, 1988). There are currently about 5800km^2 of protected areas in snow leopard habitat in northwest India, with another 9400 km^2 of proposed areas (Chundawat *et al.,* 1988). However, even given the relatively large areas encompassed by the existing and proposed parks and reserves (some quite large by Indian standards), the number of snow leopards protected within these areas (perhaps 150) is insufficient to maintain a viable population in the long term, especially if interchange among these areas is cut off. It is therefore imperative that conservation measures be taken in regions outside as well as within national parks. In this regard, there have been management proposals to provide villagers throughout Ladakh with the necessary construction materials to protect their household livestock pens from entry by snow leopard (Mallon & Chering Nurbu, 1988).

In October of 1986 the Indian central government, the State government of Jammu and Kashmir, the International Snow Leopard Trust and the US Fish and Wildlife Service sponsored the Fifth International Snow Leopard Symposium in Srinagar, Jammu and Kashmir. As a result of this meeting, an outline was agreed upon regarding a recovery programme for snow leopard in the wild. Subsequently, the State of Jammu and Kashmir announced the inclusion of the Hemis National Park (with proposed expansion), the Kisthwar National Park on the southern side of the Himalaya, and a proposed Karakoram Wildlife Sanctuary in northern Ladakh as initial components of a 'snow leopard recovery programme' in the region. The Hemis National Park is clearly the most promising in terms of practical achievements in conservation, and management plans are currently being

developed. Furthermore, it is within this park that we selected an area for further research and the Wildlife Institute of India has now begun an

intensive study of snow leopard ecology.

The cent nil government of India has also recently made plans to fund a new 'Project Snow Leopard" over a five-year period beginning in 1990. This conservation effort is modelled after the successful 'Project Tiger' and will provide funds for management of reserves within snow leopard habitat in each of India's Himalayan stales (Anon., 198S).

ACKNOWLEDGEMENTS

The surveys were carried out under the auspices of the Wildlife Institute of India. Funding was provided through the Government of lndia (Ministry of Environment and Forests), United States Fish and Wildlife Service, International Snow Leopard Trust. World Wildlife Fund-US. Chicago Zoological Society, and National Wildlife Federation (USA). The state governments of Jammu and Kashmir, Himachal Pradesh, ;and Uttar Pradesh provided both logistical and personnel support during the field work.

Numerous officials and other individuals provided administrative and logistical assistance. We would like to express our appreciation, among many others, to Dr M. K. Ranjitsinh and Mr Samar Singh (current and former Joint Secretary-Wildlife, Ministry of Environment and Forests), Mr H.S. Pun war (Director, Wildlife Institute of India), Mr David Ferguson(US Fish and Wildlife Service), Mrs Helen Freeman (International Snow Leopard Trust), and Mr V. V. Nanda (Science Office. US Embassy. New Delhi). In the field work, Capt. Alok Chandola ably coordinated overall logistics and Mr Chering Nurbu and Mr S. K. Gularia (Wildlife Range Officers) provided energetic support for our work within their jurisdictions.

REFERENCES

Ahlhorn, (i & Jackson. R. (1988). Marking in free-ranging snow leopards in west Nepal: a preliminary assessment. *I'roc. Fifth Int. Snow Leopard Syi>i[i.,* Inlernalional Snow Leopard Trust and Wildlife Institute of India, pp. 25--49.

Anon. (1 988). *The Sntm Leopard Conservation Scheme.* Ministry of Environment and Forests, Government of India, New Delhi.

Anon, (no dale, *a)*. *National Wildlife Action Plan.* Department of Environment, Government of India, New Delhi.

Anon, (no dale. />). *Snow Leopard Recovery Programme for Hemis High Altitude National I'urk 1986 -87 10 19KV 911.* Jamimi and Kashmir Government, Srinagar.

Burrard, G,(I925). *Big Game Hunting in tht> Himalayan and Tibet.* Herbert Jcnkins, London.

Burton. R (1926). Three months up the valley of the Sullej River. *J. Ronihav Nat.HIM. Soc.*. **31,** 22-39, 352 67.

Chundawal, R,, Rodgcrs, W. & 1'anwar, H.(I988). SUHus report on snow leopard in India. *Proc. Fifth iiu. Snow Leopard Svmp.*< International Snow Leopard Trust and Wildlife Institute of India, pp. 113- 20.

Dang, H. (1967). The snow leopard and its prey. *Cheetal.* **10,** 72 84,

Dar. M. & Gaur. R, (no date). Ladakh. In *'flu- Wild/iff «/' Jamimi & Kashmir.* A Sanctuary Publication for Department of Wildlife Protection, Jammu and Kashmir Government, Srinagar, pp. 25-39.

Dhar, U. & Kachroo, P. (1983). *Alpine Flora of Kashmir Himalaya.* Scientific Publisher, Jodhpur.

Fox, J. (1989). *A Review of the Status and fccology of flic Snow Leopard (Punlhera* uncia). International Snow Leopard Trust. Seattle. Washington.

Fox, J. & Chundawal, R. (1988), Observations of snow leopard stalking, killing and feeding behavior. *Mammalia.* 52, 137 40.

Fox, J. & Freeman, H. (1984). An internationally cooperative study of the snow leopard in northern India, *tut. Ped. Book Snow Leopards, 4.* 39-42.
Fox, J., Sinha, S., Chundawal, R. & Das, P. (1988). A field survey of snow leopard presence and habitat use in northwestern India. *Proc. Fifth Int. Snow Leopard Syrup.,* International Snow Leopard Trust and Wildlife Institute of India, pp. 99-111
Freeman, H. (1989). The view from here. *Snow Lint- {Newsletter of (lie International Snow Leopard Trust),* **17,** 2-3.
Green, M. 11982). Status of snow leopard in northwestern India, *inf. Ped. Hook Snow Leopards,* 3, 6 -10.
Hartmann, H,(1983). Pflanzengesellschaftenentlangder Kashmir Route in Ladakh. *Jh. Ver. Scluili der Bergwelt.* **1983,** 131 73.
Hartmann, H, (1987). Pflanzengesellschaften trockencr Slundorte aus der subalpinen und alpinen Stufe im siidlichen und ostlichen Ladakh. *Candollea,* 42. 277-326.
Jackson, R. (1979). Snow leopards in Nepal. *Oryx,* 15, 191 5.
Jackson, R. & Ahlborn. G. (1984). A preliminary habitat suitability model for the snow leopard, *Punthera uncia,* in west Nepal. *Int. Ped. Book Snow Leopards, 3,* 25-39.
Jackson, R. & Ahlborn, G. (1988). Observations on the ecology of snow leopard in west Nepal. *Proc. Fifth Int. Snow Leopard Syrnp.,* International Snow Leopard Trust and Wildlife Institute of India, pp. 65-87. Kachroo, P., Sapru, B. & U. Dhar. (1977). *Flora of Ladakh. an Ecological and Taxonomica! Appraisal.* **Bisen** Singh & Mahendra I'al Singh, New Delhi.
Mallon, D. (1988). A further report on the snow leopard in Uulakh. *Proc. Fifth. Int. Snow Leopard Svinp.,* International Snow Leopard Trust and Wildlife Institute of India, pp. 89-97.
Mallon, D. &Chering Nurbu(1988). A conservation program for the snow leopard in Kashmir. *Proc. Fifth In!. Snow Leopard Svmp.,* International Snow Leopard Trust and Wildlife Institute oflndia, pp. 207-14.
Osborne, B., Mallon, D. & Fraser, S. (1983). Ladakh, threatened stronghold of rare Himalayan mammals. *Oryx,* 17. 182-9.

Polunin. O. & Stainton, A. (1985). *Flowers ofihe Himalaya.* **Oxford** University **Press,** New Delhi.
Prater, S. (1972). *The Book of Indian Animals.* Bombay Natural History Society, Bombay.
Rodgers. W. & Panwar, H, (1988). *Planning a Wildlife Protected Area Network.* Wildlife Institute of India, Dehra Dun.
Schallcr, G, (1977). *Mountain Manarchs: Wild Sheep and Goats of the Himalaya.* University of Chicago Press. Chicago.
Schaller, **G., Reti** Junrang & Qui Mingjiang (1988). Status of the snow leopard *Ptiiithera uncia* in Qinghai and Gansu Provinces, China. *Biol, Cotiserv.,* **45,** 179 94.
Schweinfurth. U. (1968). *Vegetation of the Himalayas.* Sudasien Institute, Univcrsitai Heidelberg.
Stocklcy, C. (!928). *Big (Jame Shooting in the Indian Eiii/>irt>,* Constable, London.
Wemnier. C. & Sunquisi, M. (1988). Felid reintroduclions: Economic and energetic considerations. *Proc. Fifth Int. Snow Leopard Svmp.,* International Snow Leopard Trust and Wildlife Institute of India, pp.' 193-205.
Zar. J. (1984). *Hiostatistical Analysis.* 2ndedn. Pi en t ice-Hall, Englewood Cliffs, New Jersey.